NATIONAL OPEN UNIVERSITY OF NIGERIA

FACULTY OF SCIENCES

COURSE CODE: BIO 304

COURSE TITLE: GENERAL ECOLOGY

Course Code & Title **BIO304; General Ecology**

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Course Guide

Introduction

General Ecology is a one semester, 21 Units course. It will be suitable to all students to take towards the core module of B.Sc. (Hons) Biological Sciences. It will also be suitable as an elective course for any student in Faculty of Sciences who does not want to complete an NOU qualification but want to learn about Biology and Environmental Science. The course involves basic concept and definition of ecology, ecosystem at community level, ecological classification of habitat types, terrestrial and aquatic biomes, with their specific features. The other contents include natural disasters, interaction of communities and their success, and aspects of energy and nutrient flows through natural cycles, and dynamics of population.

Course Competencies

This course aims to enable you to know/understand the basic concepts of ecology , life support and ecosystem. It will guide your understanding of various natural phenomena in the planet earth

Course Objectives

The Comprehensive Objectives of the Course as a whole are to;

1. Explain the meaning, scope and basic concepts in ecology and ecosystem.
2. Describe the major types of habitats, ecosystems and biomes.
3. Discuss the natural disasters and their management
4. Understand the cycles of energy and nutrient flows in the ecosystem.
5. Identify the various community interactions
6. Explain the processes of population dynamics.

Working Through this Course

To successfully complete this course, you are required to read each study unit, read the textbooks and other materials provided.

Reading the reference materials can also be of great assistance. Each unit has self –assessment exercise which you are advised to do.

There will be a final examination at the end of the course. The course should take you about 8 weeks to complete.

This course guide provides you with all the components of the course, how to go about studying and how you should allocate your time to each unit so as to finish on time and successfully

Study Units

The study units in this course are given below:

BIO 304 GENERAL ECOLOGY (3 UNITS)

Module 1: General Ecology and Ecosystems

Unit 1: Ecosystems Ecology
Unit 2: Functioning Ecosystem
Unit 3: Productivity of Ecosystems
Unit 4: The Cycling of Nutrients in Ecosystems
Unit 5: Interactions Within Ecosystems
Unit 6: Patterns of Community Structure

Module 2: Population Dynamics

Unit 1: Population Ecology
Unit 2: Population Patterns and Measurements

Unit 3 Population Growth
Unit 4: Population Regulation
Unit 5: Human Population Growth

Module 3: Biological Communities
Unit 1 Ecological Communities
Unit 2: Community Organization and Functioning
Unit 3: Biogeography
Unit 4: World Biomes
Unit 5: Marine and Freshwater Biomes

Module 4: Man and the Environment
Unit 1: Relationship between Man and the Environment
Unit 2 Pollution, Types, Sources and Characteristics
Unit 3 Effects of Pollution on the Environment
Unit 4: Pollution: Effects, Prevention and Control
Unit 5: Human, Environment and Health

References and Further Readings

You would be required to read the recommended references and textbooks as provided in each unit of the course.

Presentation Schedule

There is a time-table prepared for the early and timely completion and submissions of your TMAs as well as attending the tutorial classes. You are required to submit all your assignments by the stipulated date and time. Avoid falling behind the schedule time.
Assessment

There are three aspects to the assessment of this course. The first one is the in-text questions and the second is self-assessment exercises, while the third is the written examination or the examination to be taken at the end of the course. Review the exercises or activities in the unit by applying the information and knowledge you acquired during the course. The work submitted to your tutor for assessment will account for 30% of your total work. At the end of this course you will have to sit for a final or end of course examination of about a two hour duration and this will account for 70% of your total course mark.
How to get the Most from the Course

In this course, you have the course units and a course guide. The course guide will tell you briefly what the course is all about. It is a general overview of the course materials you will be using and how to use those materials. It also helps you to allocate the appropriate time to each unit so that you can successfully complete the course within the stipulated time limit.
The course guide also helps you to know how to go about your in-text questions and Self-assessment questions which will form part of your overall assessment at the end of the course. Also, there will be tutorial classes that are related to this course, where you can interact with your facilitators and other students. Please I encourage you to attend these tutorial classes.

This course exposes you to Introductory Ecology, a sub-discipline and very interesting field of Biological Sciences.
Online Facilitation

Eight weeks are provided for tutorials for this course. You will be notified of the dates, times and location for these tutorial classes.
As soon as you are allocated a tutorial group, the name and phone number of your facilitator will be given to you.
The duties of your facilitator is to monitor your progress and provide any necessary assistance you need.
Do not delay to contact your facilitator by telephone or e-mail for necessary assistance if
You do not understand any part of the study in the course material.
You have difficulty with the self-assessment activities.
You have a problem or question with an assignment or with the grading of the assignment.
It is important and necessary you attend the tutorial classes because this is the only chance to have face to face contact with your facilitator and to ask questions which will be answered instantly. It is also a period where you can point out any problem encountered in the course of your study.

Online Facilitation

Online facilitation for this course will hold once in a week for the period of eight weeks. The time and day for the online facilitation will be one hour as indicated in the time table

Course Information

Course Code:BIO304
Course Title: GENERAL ECOLOGY
Credit Unit: 2
Course Status: Elective
Course Blub: This course is designed to enable students to understand the basic concepts of ecology, life support and ecosystem. It will also provide them to with the knowledge of the various natural phenomena on earth
Semester: 2 SEMESTERS
Course Duration: 13 WEEKS
Required Hours for Study: 65 hours

Module 1: General Ecology and Ecosystems

Module Structure

In this module we will discuss about the ecosystems and ecosystems ecology with the following units:

Unit 1: Ecosystems Ecology
Unit 2: Functioning Ecosystem
Unit 3: Productivity of Ecosystems
Unit 4: The Cycling of Nutrients in Ecosystems
Unit 5: Interactions Within Ecosystems
Unit 6: Patterns of Community Structure
Glossary
End of the module Questions

Unit 1: Ecosystems Ecology

Unit Structure

1.1 Introduction
1.2 Intended Learning Outcomes (ILOs)
1.3 Ecosystems Ecology
    1.3.1 The Meaning of Ecosystem Ecology
    1.3.2 General characteristics of an ecosystem:
1.4 Classification of Ecosystems
1.5 Subdivisions of Modern Ecology
    1.5.1 Functions of an Ecosystem
    1.5.2 Ecological Concepts
1.6 Summary
1.7 References/Further Readings/Web Sources
1.8 Possible Answers to Self Assessment Exercises

1.1 Introduction

You will be introduced on the meaning and functioning of ecosystems ecology. The functioning of which reflects the collective life activities of plants, animals, and microbes and the effects these activities - feeding, growing, moving, excreting waste, etc. - have on the physical and chemical conditions of their environment. You will study also that there are basically two types of ecosystems under which any other sub-ecosystem falls.

1.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you should be able to:

Explain the meaning of ecology and ecosystems functioning
Describe the different types of ecosystems
Describe the different categories of freshwater ecosystems

1.3 Ecosystems Ecology

Ecology is the branch of science that examines how living things interact with one another and with their physical surroundings. From the perspectives of (1) the environment and the demands it throws on the organisms living there or (2) organisms and how they adapt to their environmental situations, ecology can be studied. An ecosystem is made up of a collection of creatures that interact with one another and their surroundings, exchanging materials in a generally circular way. Along with energy sources and pathways for the exchange of materials and energy, an ecosystem also consists of physical, chemical, and biological components. A certain organism's habitat is the setting in which it exists. The term "niche" refers to an organism's function within its surroundings.

1.3.1 The Meaning of Ecosystem Ecology

The study of ecosystem components and interactions is referred to as ecosystem ecology. In a nutshell, the study of interactions between biotic (living) and abiotic (non-living) elements within an ecosystem framework is known as ecosystem ecology. We must research the elements, traits, and categorization of ecosystems. So let's get started. An ecosystem is a dynamic system in which biotic and abiotic elements constantly operate and react upon one another, causing changes in a community's structure and functionality. Thus, British ecologist A.G. Tansely is credited with coining the term "ecosystem" initially (1935). "A community and its abiotic surroundings form a complex, interacting system known as an ecosystem." Ecosystems are made up of distinct structural elements, such as creatures and the physical environment, which interact with one another through processes like energy flow and material cycle to achieve the objective of maintaining life. All of the ecosystems are linked in some form; none of them are autonomous. There are two basic mechanisms involved in this eating and being eaten connection among living things. First off, only green plants and a small number of autotrophic bacteria can create their own food by using solar radiation energy (light) to bind basic molecules of O_2, H_2O, and other elements like N, P, Ca, K, Mg, and S.

$$6CO_2 + 12H_2O \xrightarrow[\text{Sunlight}]{\text{chlorophyll}} C_6H_{12}O_6 + 6O_2 + H_2O$$

The flow of energy: the energy used by the plants passes through various organisms and is ultimately lost as heat. It is called the flow of energy. Bio-geochemical cycling: The energy and chemical substances pass through the organism but become available for use again and again. Therefore, the process is known as biogeochemical cycling. What are the two processes that bind the organisms (eating and being) and their environment into an interacting complex unit?

1.3.2 General Characteristics of an Ecosystem:

Smith (1966) highlighted the following common characteristics of the majority of ecosystems: An important structural and functional component of ecology is the ecosystem. An ecosystem's structure and species diversity are related. Energy flow and material cycling through and within an ecosystem are related to its ability to perform its intended purpose. An ecosystem's structure determines the proportion of energy required to keep it functioning. The less energy anything need to maintain itself, the more complicated it is. Ecosystems develop as they transition from simpler to more complicated states. Early phases of such succession feature a relatively high energy flow per unit biomass and excess potential energy. Later (mature) stages accumulate less energy and have a greater variety of components through which they pass. Every ecosystem has a finite environment and energy supply that cannot be exceeded without having significant negative effects. The population must adapt to selective forces brought on by changing circumstances. The environment is changing, and organisms that can't change with it must disappear.

Self-Assessment Exercise 1

1. What is ecosystems ecology?
2. What are the viewpoints upon which the study of ecology rest?

1.4 Classification of Ecosystems

In ecosystem classification, only the general categories, which comprise similar types of organisms, can be used. There are two types of ecosystems:

1. Natural Ecosystem – These are ecosystems that develop spontaneously and are capable of surviving without assistance from humans. Mountains, rivers, and other natural landscape features are examples of ecosystems. According to the concept of a natural ecosystem, it is an ecosystem found in nature in which organisms can freely interact with other elements of their surroundings. The fact that this ecosystem is self-sufficient is one of its key features. For instance, both herbivores and carnivores can be found in forests. Fruits, seeds, and grass are consumed by herbivores. The carnivores subsequently eat them. When carnivores perish, their bodies dissolve into the soil and replenish it with vital nutrients that promote the development of trees and grass, which herbivores eat. Thus, the biological cycle continues.

2. Human-Made or Artificial Ecosystem – Artificial ecosystems are ones that humans either develop on their own to mirror the natural environment or adapt an already existent ecosystem to suit their needs. The fact that manmade ecosystems require ongoing maintenance because they are not self-sustaining is one of the key distinctions between natural and artificial ecosystems. A few examples of this kind of habitat are aquariums, agricultural areas, gardens, and dams.

Categories of Natural Ecosystems

There are two types of natural ecosystems:

A). Terrestrial Ecosystem: These refer to the ecosystems found on land. They can be classified based on climate and temperature. These are discussed in detail below:

i). Forests: They make up around 31% of the Earth's total land area. There are three different types of forest ecosystems throughout the world, depending on the climate and type of forest. These include coniferous forest, temperate forest, and rainforest. A tropical rainforest can be found in places that receive a lot of rain. Contrary to temperate forests, which develop in locales with cold winters and pleasant summers, coniferous forests can be found in chilly mountainous places. Being the highest terrestrial biodiversity in the world, they provide as habitats for a wide range of animals, birds, insects, and other species. We also depend on woods for a variety of other things.

ii). Deserts: Deserts come in two varieties: hot and cold. These ecosystems experience extreme weather, including dry air, temperatures that are excessively hot during the day and too cold at night, and little to no rainfall. Because of this, there is little vegetation and not many animals in the desert. A few insects and animals that can be found in a desert are camels, desert snakes, and scorpions.

iii). Grasslands: Temperate grasslands and tropical savannahs are a couple of examples of this sort of natural environment. Tall grass and a few bushes and trees make up the substantial vegetation. The grasslands are home to a variety of animals, including wolves, zebras, gazelles, and rabbits. What are the three types of ecosystems under which any other sub-ecosystem falls?

B). Aquatic Ecosystem: As the name suggests, these include the ecosystems found within water bodies. They are the most common types of ecosystem found on the Earth as water covers around 75% of the Earth's surface. It is divided into two groups –

i). Freshwater – Freshwater constitutes only about 3% of a total 75%. Some examples of natural ecosystems that fall within this category are lakes, rivers, ponds, streams, wetlands, etc.Rivers and streams originating from mountains carry essential nutrients which are then deposited in lakes and ponds. Freshwater is also the habitat for a variety of plants, animals, and microbes.

ii).. Marine Ecosystem – This is one of the most diverse forms of ecosystems. It consists of coral reefs, kelp forests, mangroves, salt marshes, rocky shores, deep sea, the open ocean, and so on. Marine ecosystems depend on physical factors like high salt content, availability of light, temperature, tides, geology, and geography. For this reason, some areas, such as mangroves, and salt marshes, are full of life, while the presence of life in areas such as the abyssal plain at the bottom of the sea is scarce.

2. Artificial ecosystem: Artificial ecosystems are human-made structures where biotic and abiotic components are made to interact with each other for survival. It is not self-sustaining and can perish without human help. Examples of artificial ecosystems include aquariums, agriculture fields, zoos, etc. and the two broad categories are: i). Cropland ecosystem and ii). Fish farm ecosystem. What are the physical local conditions, which shape the aquatic ecosystems?
Self-Assessment Exercises 2

1. What are the three basic categories of freshwater environments?

2.What are the variety of organisms that live in oceanic ecosystems?

1.5 Subdivisions of Modern Ecology

Two major subdivisions of modern ecology are:
i)Ecosystem ecology - which views ecosystems as large units, and
ii). Population ecology - which attempts to explain ecosystem behavior from the properties of individual units.
In actuality, the two strategies are frequently combined. Ecosystem and community architecture, dispersal patterns, and population structures are highlighted in descriptive ecology descriptions of

the sorts and nature of organisms and their surroundings. Functional ecology describes how ecosystems function, including how populations react to environmental change and how matter and energy circulate within them. Ecosystems can be roughly categorised as natural and man-made. Terrestrial and aquatic ecosystems are subcategories of natural ecosystems, which are those that exist in nature. Aquatic encompasses ponds, rivers, streams, lakes, estuaries, oceans, mangroves, swamps, and bays, among other things, whereas terrestrial includes hot desert, grassland, tropical and temperate rainforest, and so on. These two ecosystems, however, are open, self-regulating systems that allow for unrestricted inputs and outputs from other systems. Artificial ecosystems are straightforward, man-made, unstable, and open to human manipulation. Typically, it is created by removing a section of grassland or forest to create a crop field or other agricultural area. 2 Ecosystem Structure and Function The biotic (consisting of living things) and abiotic (containing of elements that are not alive) components make up an ecosystem. According to some sources, the following are considered to be non-living constituents: habitat, gases, sun radiation, temperature, moisture, and inorganic and organic nutrients. You can further divide living things into producers, consumers, and decomposers. Basic inorganic and organic elements of the environment or habitat of the organism are considered abiotic components. Carbon dioxide, water, nitrogen, and calcium phosphate are the inorganic elements that make up an ecosystem, and they are all involved in the matter cycle (biogeochemical cycles). Proteins, carbohydrates, lipids, and amino acids are the organic components of an ecosystem. They are all produced by the biota (flora and fauna) of an ecosystem and enter the ecosystem as waste products, decomposing bodies, etc. Abiotic elements of ecosystems include temperature, light soil, and other aspects of the climate or "microclimate."

1.5.1 Functions of an Ecosystem

Ecosystem function is the ability of natural processes and elements to directly or indirectly meet human demands for commodities and services. Ecological processes and ecosystem structures are subsets of ecosystem functions. The natural processes that make up the entire ecological sub-system, of which each function is a part, produce each function. Natural processes, on the other hand, are brought about by intricate interactions between biotic (living things) and abiotic (chemical and physical) elements of ecosystems, which are fueled by the universal forces of matter and energy. There are four primary groups of ecosystem functions

(1) regulatory functions,
(2) habitat functions,
(3) production functions and
(4) information functions.

This grouping concerns all ecosystems, not only for forests. The following are the general characterization of ecosystem functions are:

(1) Regulatory functions: The ability of natural and semi-natural ecosystems to control vital ecological processes and life support systems via bio-geochemical cycles and other biospheric processes is represented by this category of functions. In addition to preserving the ecosystem's (and the biosphere's) health, these regulatory activities offer a wide range of services that are advantageous to people both directly and indirectly (i.e., clean air, water and soil, and biological control services).

(2) Habitat functions: natural ecosystems provide refuge and a reproduction habitat to wild plants and animals and thereby contribute to the (in situ) conservation of biological and genetic diversity and the evolutionary process.

(3) Production functions: Energy, carbon dioxide, water, and nutrients are transformed by autotrophs through photosynthesis and nutrient intake into a wide range of carbohydrate structures,

which are subsequently utilised by secondary producers to produce an even wider range of living biomass. Numerous ecosystem products for human use, including food and raw materials, energy sources, and genetic material, are produced by the wide variety of carbohydrate structures.

(4) Information functions: Natural ecosystems support human health by 3 offering opportunities for introspection, spiritual enrichment, cognitive development, recreation, and aesthetic experience. Since the majority of human evolution occurred in the context of an undomesticated habitat, natural ecosystems contribute to the maintenance of human health. An ecosystem's constituents are: The four basic elements of an ecosystem are producers, consumers, decomposers, and abiotic elements like ponds. If any of these four elements is missing, the ecosystem is classified as being incomplete, such as a cave or an ocean depth. Productivity in the Environment: There are three types of productivity: primary productivity, secondary productivity, and net productivity. Ecosystem productivity is the rate at which solar energy is fixed by the vegetation within the ecosystem. Primary productivity, also known as gross primary productivity (GPP) and net primary productivity, is the rate at which radiant energy is stored by producers' photosynthetic and chemosynthetic activity (NPP). The unit of measurement is either weight (g/m2/yr) or energy (kcal/m2). Energy storage rates at the consumer level are referred to as secondary productivity. In order to administer contemporary industrialised societies in ways that are compatible with environmental preservation and improvement, an understanding of ecology is a necessity. Applied Ecology is the area of ecology that deals with foreseeing how technology and development will affect ecosystems and giving recommendations so that these actions will have as little negative influence as possible—or even beneficial—on ecosystems. The approach is multidisciplinary.

1.5.2 Ecological Concepts

There are some important concepts commonly used in the study of ecology which enable one to understand the subject matter. Some of these ecological concepts include.

(1) Environment: The environment include all the factors external and internal, living and non-living factors which affect an organism

(2) Biosphere or ecosphere: The biosphere or ecosphere is the zone of the earth occupied by living organisms. It is a layer of life which exists on the earth surface. The biosphere is a narrow zone where complex biological and chemical activities occur. It can be found on land soil, water and air. It provides habitat for organisms like animals, plants and micro organisms.

(3) Lithosphere: The earth's solid core is known as the lithosphere. It is the earth's crust's outermost layer or zone. It makes up 30% of the earth's surface and is composed of rocks and minerals. The lithosphere, which makes up the topmost layer of the landmass and serves as the foundation for all human habitation, is composed of loose rock components including gravel, sand, and soils.

(4) Hydrosphere: The liquid or aquatic portion of the earth or the biosphere is known as the hydrosphere. Approximately 70% of the earth's crust is covered with it. It can store water in solid (ice), liquid (water), and gaseous forms (water vapour). Lakes, pools, springs, the ocean or sea, ponds, oases, rivers, and streams are examples of hydrospheres.

(5) Atmosphere: The atmosphere is the gaseous portion of the earth. It is a layer of gases surrounding fhe earth. Over 99% of the atmosphere lies within 30 km of the earth surface. It contains 78% nitrogen, 21% oxygen , 0.03% carbon dioxide and 0.97 rare or inert gases.

(6) Habitat: A space or home inside an ecosystem where an organism naturally resides is referred to as a habitat. A biotic community's home is also referred to as a habitat. Or to put it another way, a habitat is any environment that a creature inhabits. For instance, fish live in water as their environment. The different types of habitats include terrestrial habitats, which include savanna forests and deserts, as well as aquatic habitats, which include rivers, lakes, ponds, streams, lagoons, seas, and oceans. Similar species frequently interact and coexist in groups. Every habitat is

impacted by biotic and abiotic environmental variables. Habitats may be terrestrial e.g, Tropical rain forest / grassland/ savanna/ desert any suitable example , or aquatic e.g ocean/ lake pond arboreal trunks/ leaf surface/ or any suitable example

(7). Biotic Community or biome: Any naturally occurring group of various creatures coexisting and interesting in the same environment is referred to as a biotic community. The greatest group of living things is called a biome; examples include rain forests and Guinea savanna.

(8). Ecological niche: An ecological niche is a distinct area of a habitat that a particular species or organism occupies. Every organism is adapted to a particular environment and has a certain function within that community, such as feeding on other species or acting as their food source, obtaining nutrients from its habitat or returning those nutrients to it, or acting as either a producer or a consumer. For any specific organism, the totality of all these functions is referred to as its ecological niche. For instance, on the same plant, a caterpillar and an aphid inhabit different places, or ecological niches. While the aphid lives on the young stem and takes sap from it, the caterpillar primarily dwells on the leaves and eats on them. Despite sharing a habitat, each organism has a separate living space and food supply.

(9). Population: Population is defined as the total number of organisms belonging to the same species that are present in a certain location and period. For instance, the population of tilapia fish in a pond is equal to the total number of tilapia fish present in that habitat.

(10). Ecosystem: It is a natural system made up of both living and non-living components that work together to create a stable system. An ecosystem is a collection of living things that coexists with their inorganic surrounds. A habitat's ecosystem is made up of both living and non-living components, to put it another way.

(11). Community: This describes a collection of organisms that live in a certain location and can adapt to its conditions. They may continue to live successfully and create new offspring because they are interdependent, i.e., they depend on one another.

(12). Climax Community: When an ecological succession has reached a stable or unchanging community, the climax community is established. The community and the environment are in balance. The level of vegetative development peaks. The same species of creatures, plants, or organisms recur year.

Self-Assessment Exercise 3

1. What is an ecological niche?

2. What is a Biotic Community?

1.6 Summary

You have learned about the meaning of ecosystems ecology and functioning as the combined study of components of ecosystems and their interactions. Ecosystems have specific structural components (the organisms and the physical environment) interacting among themselves (through the processes of energy flow and cycling of materials) to accomplish the goal of the continuance of life.. You have also studied the classifications of ecosystems into natural and artificial. The different categories of ecosystems, namely terrestrial and freshwater and their various components have been highlighted.

1.7References/Further Readings/Web Sources

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1.8 Possible Answers to Self-Assessment Exercises

Answers to SAEs 1

1. Ecosystem ecology is the combined study of components of ecosystems and their interactions.
2. Ecology can be approached from the viewpoints of (1) the environment and the demands it places on the organisms in it or (2) organisms and how they adapt to their environmental conditions.

Answers to SAEs 2

1. Lentic, Lotic and Wetlands
2. These organisms include the corals, the brown algae, echinoderms, cephalopods, sharks, and dinoflagellates.

Answers to SAEs 3

1. Ecological niche refers to the specific portion of a habitat which is occupied by a particular species or organism.
2. A biotic community or biome is any naturally occurring group of different organisms living together and interesting in the same environment.

Unit 2: Functioning Ecosystem

Unit Structure

1.1 Introduction

You will learn the basic concepts and operations of a functional ecosystem in this unit. You will understand the concept of food chain and food web, and recognise that food relationship exists among living things, and that chemical energy (in the form of carbohydrates, fats, proteins) and nutrients are transferred among producers, consumers and decomposers. The energy tropic levels, pyramid of energy/number and the nature of energy flow in the ecosystem will also be highlighted.

2.2 Intended Learning Outcomes (ILOs)

By the end of the unit, learners should be able to:

- Have a knowledge of some ecosystem concepts
- Understand the concept of food chain and food web.
- Define the terms autrotrophy and heterotrophy,
- Recognise that food relationship exists among living things,
- Recognise that chemical energy (in the form of carbohydrates, fats, proteins) and nutrients are transferred among producers, consumers and decomposers,
- State that trophic level refers to the parts of food chain,
- Correctly define (or describe) food chains and pyramid of energy/number,
- Describe the nature of energy transfer or flow in the ecosystem,

2.3 Functioning Ecosystem

Ecosystem is made up of inter independent communities of species and their interaction with their physical environment. A single ecosystem may cover thousands of hectares or just a few. They include major natural systems such as grasslands, mangroves, coral reefs, wetlands, tropical forests and agricultural lands. Our major focus in this unit is on how the ecosystem functions and so other details regarding ecosystem shall be discussed in the next unit.

Figure 1. Functioning ecosystem. Source www.myschoollibrary.com

The following concepts would give us clear understanding of a functioning ecosystem.

1. Autotrophy: Autotrophy simply refers to the process whereby certain organisms (e.g green plants) use sunlight or chemicals to manufacture their food from inorganic substances through a process called photosynthesis.
2. Heterotrophy: When an organism, such as an animal, cannot produce food on their own and must rely either directly or indirectly on plants for nutrition, this is referred to as heterotropy. consumers, decomposers, heterotrophs, and autotrophs. Green plants and some bacteria are examples of autotrophs—organisms that produce their own food through the process of

photosynthesis using either sunlight or chemicals. In other words, autotrophs are organisms that can make their own food, which is why they are referred to as producers.

3. Producer

A producer is a type of green plant, also known as an autotroph, that uses CO2, water, basic inorganic elements, or radiant energy from the sun to capture and transform it into chemical energy, which is then used to create organic molecules via photosynthesis. Every food chain's origin or starting point is represented by it. Food is provided by autotrophs to the other species in the area. Grass, trees, and bushes are examples of terrestrial autotrophs, while phytoplankton, water hyacinths, and seaweeds are examples of aquatic autotrophs.

4. Heterotrophs

Heterotrophs are organisms, primarily animals, that rely directly or indirectly on plants for nourishment. This is why they are also known as consumers. Herbivores, also known as primary consumers, are animals that eat only green plants (producers), while carnivores, sometimes known as secondary consumers, are creatures that eat the main consumers. Tertiary consumers are animals that eat the secondary consumers. All animals, carnivorous plants, fungi, the majority of protists, and some bacteria are heterotrophs.

5. Consumer

This organism obtained all of its food, nutrients, and energy either directly or indirectly from plants. It is an organism, in other words, that relies on other creatures for food, energy, and nutrition. Customers are all heterotrophs without chlorophyll. They are either other animals (such as cats, hyenas, lions, and leopards) that eat herbivores and thus obtain energy indirectly from the producers, or they are animals that directly consume plants for nutrients, food, and energy (such as cows and sheep). These animals are known as herbivores or primary consumers. Carnivores or secondary consumers are what these are. Heterotrophs that consume other organisms are called consumers. They comprise all holozoic creatures, including parasites, decomposers, omnivores, herbivores, and carnivores. In a terrestrial ecosystem, consumers or heterotrophs include things like caterpillars, cows, dogs, lions, toads, hawks, lizards, and humans, whereas aquatic heterotrophs include things like water fleas, tadpoles, insect larvae, and fishes.

What are holozoic organisms?

Self-Assessment Exercise 1

1. What is the meaning of heterotrophy?

2. What are heterotophs?

2.4 The Concept of Food Chain and Food Web

The principal producers in an ecosystem are green plants, which harvest solar energy that strikes their leaves and transform it into food energy. A portion of the accumulated energy in these plants is really transformed into the bodies of the other species that eat them when they are consumed by them. These consumers can be broken down into several levels. The primary consumers, the herbivores, eat the green plants directly and provide the principal carnivores with food (secondary consumers). These might then become food for secondary carnivores or, in some situations, advance to other phases of nutritional dependence. Parasites and various types of saprophytes may also devour the tissues of the different plants and animals in the ecosystem after the creatures have died. A food chain is made up of the creatures (plants and animals) from each of these levels that may be feeding on one another. It defines a one-line eating relationship between species within an

ecosystem, to put it simply. Examples of food chain in terrestial habitat are:
i. Guinea grass – grasshopper – toad – snake – hawk
(Producer) (primary consumer) (secondary (tertiary consumer) Consumer)

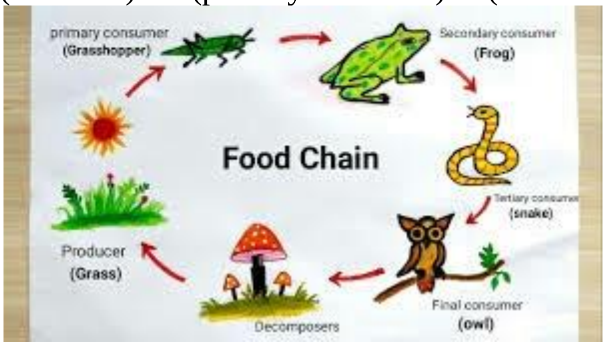

Figure 2. Diagram of Food Chain: Source:www.myschoollibrary.com

ii. Grass – antelope – lion
(Producer) (primary consumer) (secondary consumer)

Every food chain typically starts with a producer (green plant), which is then consumed by a herbivore (primary consumer), which is then consumed by a carnivore (like a toad), which is then consumed by a snake, which is then consumed by a larger carnivore like a hawk. An illustration of an aquatic food chain is:

Diatoms - mosquito larvae- Tilapia fish- whales.
(Producer) (primary consumer) (secondary consumer) (tertiary consumer).

Food energy is transported linearly from one creature to another throughout the process that takes place in a food chain. Despite the fact that most food chains start with producers, the hyphens indicate the direction in which the food is being transmitted. There aren't many exceptions that begin with dead animals or plants. For instance, Humus, an earthworm, a domesticated bird, a man, etc. A food web is a complex network of interconnected chains, also known as food chains, that connects organisms living in the same environment. Food webs contain two or more food chains, which means that there are more species in them than in food chains. In nature, the interaction in feeding are more complicated because a single plant could be fed upon by more than one or two organisms. When a consumer feeds on different types of plants or animals in a food web, it has a better chance of survival in its ecosystem. A given kind of organism rarely feeds exclusively on another form of organism in the natural world. Each creature typically feeds on two or more different kinds before being fed on by a variety of other types of organisms. Diagrammatic representations of the relationship show multiple branching lines rather than a single straight line. It's known as a food web (Figure. 3.). It is actually a network of interrelated food chains that transport materials and energy across an ecosystem.

i. Guinea grass – grasshopper – toad – lizard – hawk
(1st trophic level) (2nd trophic level) (3rd trophic) (4th trophic) (5th trophic)
respectively. These are the top five feeding or trophic levels. In other words, energy is transported across five linkages, from producers (such Guinea grass) to end users (e.g Hawks). The first trophic level is occupied by guinea grass, the second by grasshoppers, the third by toads, the fourth by lizards, and the fifth by hawks. Here is yet another illustration of trophic level.

ii. Grass - goat - man
(1st trophic level) (2nd trophic level) (3rd trophic level)

In the above food chain, there are only three trophic or feeding levels.

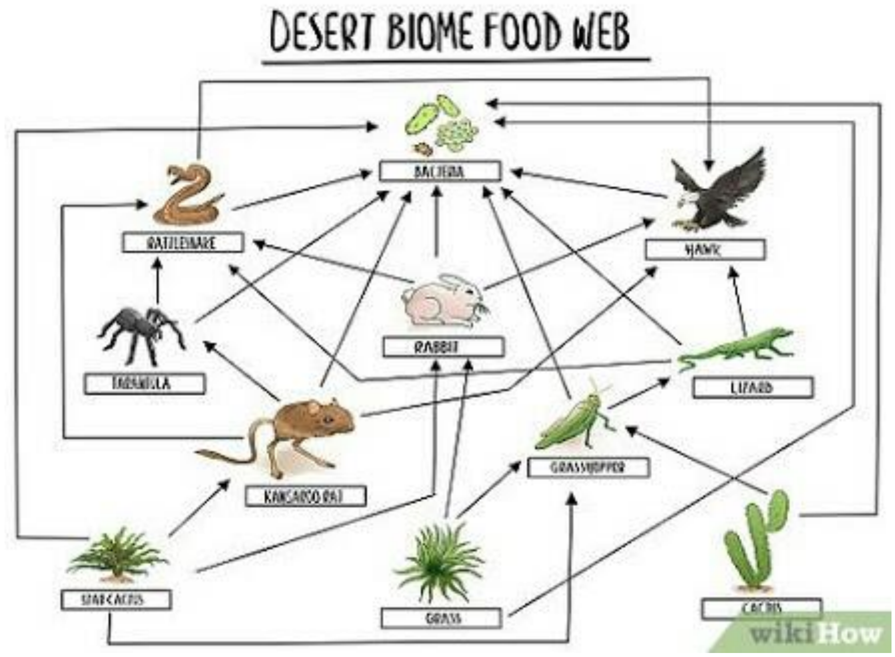

Figure 3. Diagram Of Food Web: Source: wikihow.com

Self-Assessment Exercise 2

1. What is the initial stage of energy transfer in an ecosystem?
2. What is a food web?

2.5 Pyramid of Number and Pyramid of Energy

The term "pyramid of number" describes how the number of distinct creatures at each trophic level in a food chain gradually declines from the first to the lowest trophic level. In a diagrammatic representation of the food chain called a pyramid, producers are at the base and carnivores are at the top. There are a proportionately large number of creatures at various trophic levels in a food chain or food web. Typically, as one moves up the trophic levels, there are less and fewer creatures present. For example:

Grasses – Grasshoppers – Lizards -Hawks

The number of grasses consumed by grasshoppers exceeds the number of grasshoppers, the number of lizards consumed by grasshoppers exceeds the number of lizards, and the number of hawks consumed by lizards exceeds the number of hawks. This justification reveals that the number of creatures declines steadily from the first to the last trophic level. The term "pyramid of number" refers to the diagrammatic portrayal of this gradual decline in the population of creatures along the food chain.

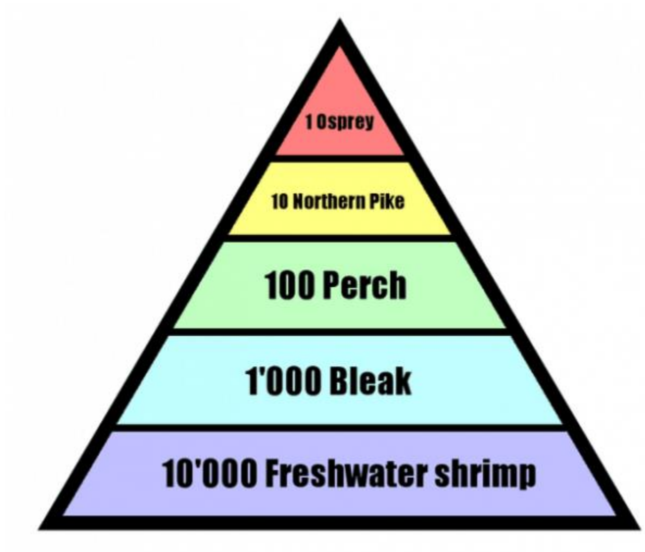

Figure 4.Pyramid of Number: Source: www.earthclipse.com

The energy content of living things at various trophic levels of a food chain is referred to as the pyramid of energy. In a food chain or web, the pyramid of energy depicts the gradual decline in energy from the first trophic level to the last trophic level. The producers at the top trophic level hold the most of the energy, much like the pyramid of numbers. While the secondary or tertiary consumers have the least energy, the primary consumers have less energy. The producers, like grasses, create the base of the pyramid, just like the pyramid of numbers, while the tertiary consumers, like hawks, form the summit. As a result, energy decreases from the pyramid's base to its summit.

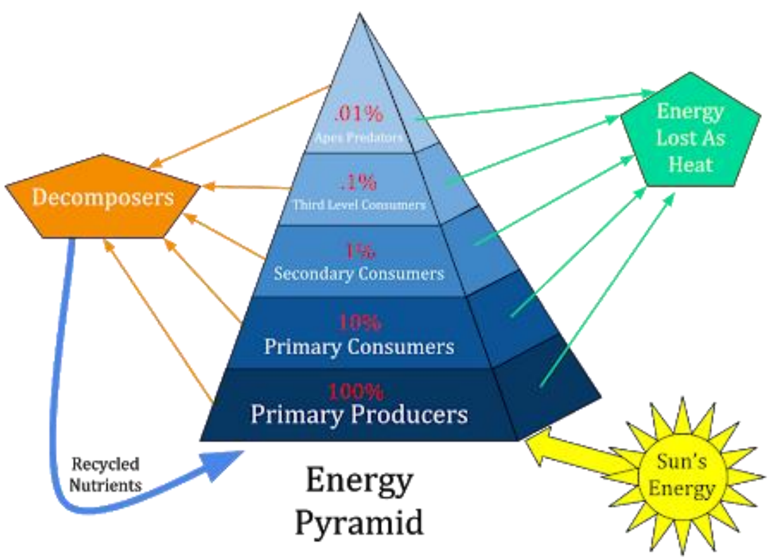

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Figure 5. Pyramid of Energy: Source: www.en.wikipedia.com

The Principles of ecosystem operation

i. Food chain starts with photosynthesis (producers) and ends with decay.

ii. Shorter food chains are made more efficient than larger food chains in terms of waste of energy.

iii. Large population are characterised by more steps in food chain. This means that useful energy decreases so that little of it will be made available to the tertiary consumers.

Self-Assessment Exercise 3

1. What is the main difference between Pyramid and pyramid of number? 2. Outline the Principles of ecosystem operation

2.6 Summary

You have learned that an ecosystem is a large group of living things that coexist with the physical elements of the environment (abiotic variables) in a given area. The non-living aspects of the ecosystem, such as light energy and inorganic nutrients, as well as the live elements, such as producers and consumers, make up the ecosystem. Additionally, you have learnt about the many ecosystems, both natural and man-made. You already know that the phrase "food chain" refers to a single feeding link between species within an ecosystem. We have a food chain when consumers consume numerous species and are then consumed by multiple species. The term "trophic level" refers to each feeding level, with plant producers constituting the first trophic level or the foundation of natural ecosystems. We have a pyramid of biomass and a pyramid of numbers because the feeding connection between trophic levels can be depicted as pyramids. There are times when the pyramids are upside down.

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2.8 Possible Answers to Self Assessment Exercises

Answers to SAE 1

1. What is the meaning of heterotrophy? Heterotrophy refers to the process or situation where certain organisms such as animals cannot manufacture their own food but depends directly or indirectly on plants for their food.

2. What are heterotophs? Heterotrophs are organisms, mainly animals, which cannot manufacture their own food but depend directly or indirectly on plants for their food, hence they are called consumers.

Answers to SAE 2

1. It starts when green plants, the primary producers in an ecosystem capture energy from sunlight that fall on their leaves and convert it to food energy.

2. Food web is defined as a complex feeding relationship among organisms in the same environment with two or more interrelated chains-called food chains.

Answers to SAE 3

1. Pyramid of number refers to the number of individual organisms at each trophic level which decreases progressively from the first to the last trophic level in a food chain. Pyramid is a diagrammatic representation of food chain in which producers form the base and the carnivores form the apex.

2. The Principles of ecosystem operation are:

i. Food chain starts with photosynthesis (producers) and ends with decay.

ii. Shorter food chains are made more efficient than larger food chains in terms of waste of energy.

iii. Large population are characterised by more steps in food chain. This means that useful energy decreases so that little of it will be made available to the tertiary consumers.

Unit 3: Productivity of Ecosystems

Unit Structure

3.1 Introduction

Energy is needed by all living things for metabolic processes and sustaining themselves. Through the producers, who are able to create organic materials from sunlight, this energy enters the environment. In this lesson, we'll talk about how solar energy is captured by living things and how it moves up the energy spectrum from producers to consumers. At each step, the effectiveness of this energy transfer will be examined.

3.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you should be able to:

- Understand the term primary productivity and recognize its significance to the ecosystem
- Differentiate between gross primary productivity and net primary productivity
- Understand the manner of energy flow in the ecosystem
- Understand the efficiency of energy flow from one trophic level to the next
- Recognise the pyramid of energy

3.3 Productivity in Ecosystems

Did you realise that Earth's days are getting longer? It's a fact, so don't be shocked. Earth's day used to last around six hours when it was founded nearly 4.5 billion years ago. The moon's gravitational attraction caused the Earth's rotation to slow down over 4.5 billion years, and it still does so at a rate of 1.7 miliseconds per year. What would happen to our world, its environment, and its productivity if a day were to shorten to six hours today? We must comprehend the operation and productivity of our environment in order to comprehend that. Productivity in ecosystem can be defined as the rate at which the biomass increases per unit area. It can be measured in units of biomass per unit volume per unit area, i.e., gm–2 yr–1 or (kcal m–2) yr–1. Dry matter or dry mass can be used to define biomass. The ecosystem has a strong influence on productivity. Each ecosystem has a unique distribution of producers, consumers, and decomposers, which has a significant impact on production. The food web is typically represented as a pyramid shape by the ecological productivity. Additionally, ecological productivity is just as important as primary and secondary productivity. Productivity can be studied at two different levels:

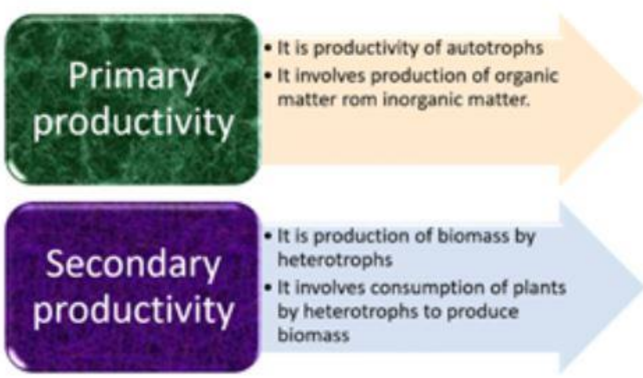

Figure 1: Types of Productivity

3.3.1 Primary Productivity in Ecosystem

1. It is carried out by autotrophs or producers.
2. Primary productivity can be defined as the amount of solar energy converted to chemical energy by an ecosystem’s producers for a given area during a certain time period.
3. Producers produce biomass by performing photosynthesis.
4. Some primary producers can be chemosynthetic as well, i.e., they produce biomass by chemosynthesis. E.g., Purple sulfur bacteria.
5. Primary productivity can be divided into two types as below:

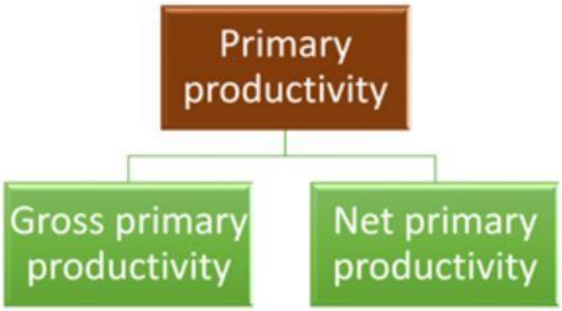

Fig. 2. Types of Primary Productivity

Gross primary productivity (GPP) is the term used to describe how much solar energy is used to produce biomass during the photosynthesis process (GPP). It is the pace at which organic stuff is produced. A small portion of GPP is transferred to the consumers and some is used by the plant itself. The internal metabolism, cellular respiration, or development and repair processes of plants cause the majority of the GPP to be lost. Respiratory loss is the term used to describe the GPP lost (R). Net primary productivity (NPP) is the amount of biomass that remains after respiratory loss for consumers or heterotrophs. The plants store this biomass. In order to produce food, fibre, wood, and increasingly biofuels, humans heavily influence net primary production, which is the foundation of ecological food chains. This can be described as:

NPP = GPP – R

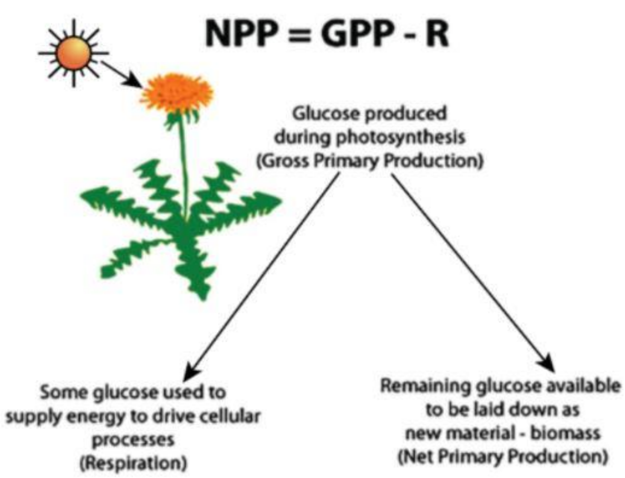

Figure 3. Depiction of GPP, NPP, and R

In terrestrial environments, tropical forests exhibit the highest primary productivity, whereas deserts exhibit the lowest primary output. Approximately 170 billion tonnes of net primary productivity are produced annually in the entire biosphere, compared to the ocean's only 55 billion tonnes of biomass, according to estimates. There is a positive association between primary productivity and solar radiation, and the amount of solar energy has a significant impact on the primary productivity of a natural environment. Primary production diminishes noticeably as we approach towards the poles because the amount of solar energy received at the Earth's surface reduces as we move from the equator to the poles. E.P. Odum asserts that there are three degrees of productivity in the world:

1. Shallow water areas, moist forests (tropical and temperate), alluvial plains, and regions of intensive farming represent the regions of high ecological productivity. 2. Arctic snow-covered wastelands, deserts, and deep ocean areas represent the regions of low ecological productivity. 3. Grasslands, shallow lakes, and farmlands represent regions of intermediate ecological productivity. What are the three levels of productivity as outlined by Odum?

3.3.2 Secondary Productivity in Ecosystem

The rate of biomass generation by consumers or herbivores is known as secondary productivity. organisms that can take energy from biomass produced as a result of primary productivity but cannot manufacture their own food. The important thing to note here is that, unlike primary productivity, different trophic levels, such as herbivores, carnivores, omnivores, etc., exist at the level of secondary productivity. Only 10% of the biomass that each trophic level consumes is converted into energy; the remainder is discharged as faeces and is available for utilisation by lower trophic levels or by decomposers. The energy that is ingested is used for a variety of metabolic functions, including growth and reproduction. The entire secondary production is a representation of trophic level energy flow. Secondary productivity is basically the amount of energy stored in the tissues of consumers of each trophic level.

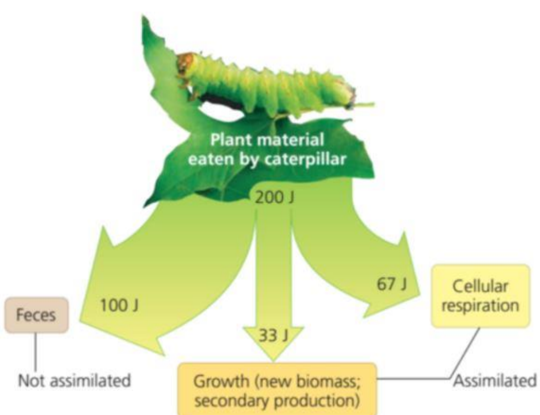

Figure 4. Secondary Productivity and Energy Flow

In terrestrial ecosystems, productivity is highest in Swamps, marshes, tropical rain forests (most productive), while lowest in the desert. In contrast, in aquatic ecosystems, productivity is highest in the Estuaries, lowest in the open ocean.

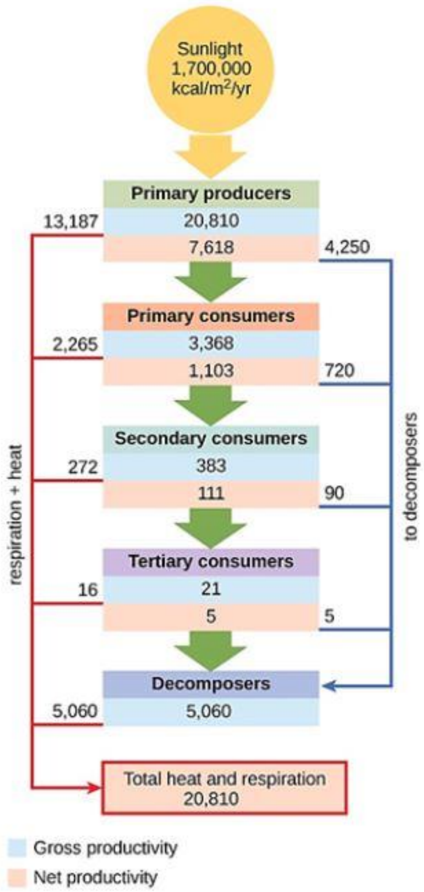

Figure 5: Productivity and Energy Flow Through the Different Trophic Level

Self-Assessment Exercise 1

1. What is the primary source of energy in an ecosystem?
2. When are all the ecosystems equally productive?

3.4 Energy Flow

Energy is the core of life and is defined as the capacity to perform tasks. Ecological systems and life could not exist without energy flows. All living activities utilise energy that is produced from solar radiant energy. The rules of thermodynamics define how energy behaves: (i) Energy may be transformed from one type into another but is never created or destroyed, and (ii) no process involving an energy transformation will spontaneously occur unless there is a degradation of the energy from a concentrated form into a dispersed form, etc.

The sun's radiance energy leaves the body and moves through space in waves. However, only a small portion of solar radiation, which is needed to power the biotic elements of the ecosystem, reaches the planet. The fate of radiant energy that reaches the earth's atmosphere is depicted in Figure 5. The image makes it evident that the majority of the radiation is lost in space as a result of scattering, absorption, and reflection processes. Its energy is significantly changed as light travels through vegetation, water, and clouds.

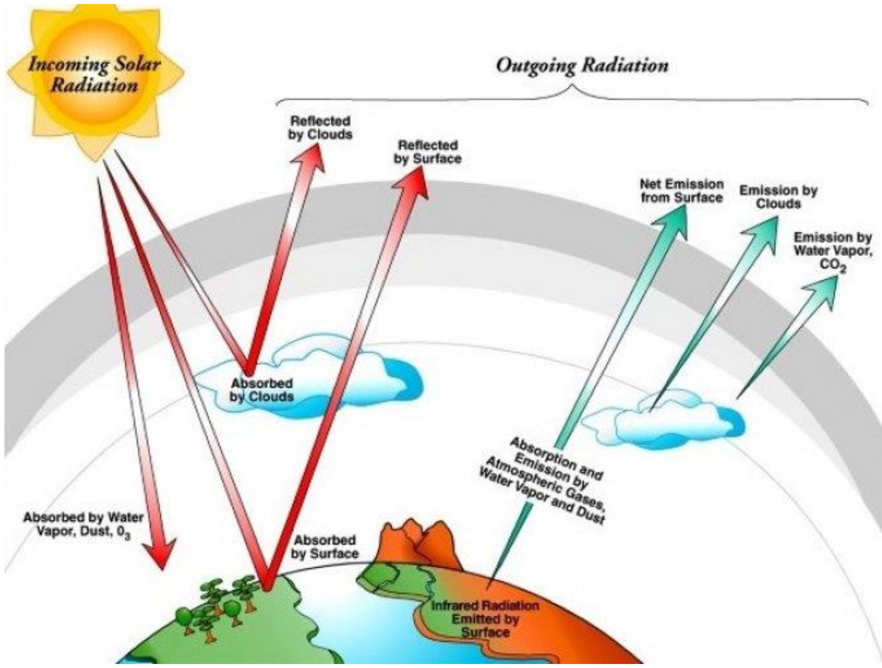

Figure 5. Radiant energy reaching earths surface.

Source: https://www.energy.gov/science/doe-explainsatmospheric-radiation

The average daily solar energy intake to an ecosystem's autotrophic layer ranges from 100 to 800 to 300 to 400 g cal per cm2 (or 3000 to 4000 kcal per m2 in the temperate zone).

Seasonal variations in the total radiation flow within the ecosystem's many strata, along with variations in the surface characteristics of the earth, regulate the distribution and behaviour of species.

Plants and other living things change and/or absorb the energy that reaches the earth's surface. By transforming light energy into chemical energy during photosynthesis, it is used by green plants to provide food for other living things. In 1942, Lindeman conducted the first study of these energy exchanges in the food chain. He claimed that by understanding two properties of each trophic level—the degree of energy storage and the effectiveness of energy transfer—all the processes of an ecosystem could be explained in terms of energy. Odum's simplified representation of the process of energy flow in an ecosystem is illustrated in Figure 2.3, where the trophic levels are represented by the "boxes" and the energy flow into and out of each level is displayed by the "pipes." This simple model shows that the energy transfer from producers to herbivores and then to carnivores is significantly reduced at each subsequent trophic level. **IN -TEXT QUESTION (ITQ)**: How does the radiant energy reach the Earth? Energy is transferred from the sun to Earth via electromagnetic waves, or radiation. Most of the energy that passes through the upper atmosphere and reaches Earth's surface is in two forms, visible and infrared light. The majority of this light is in the visible spectrum.

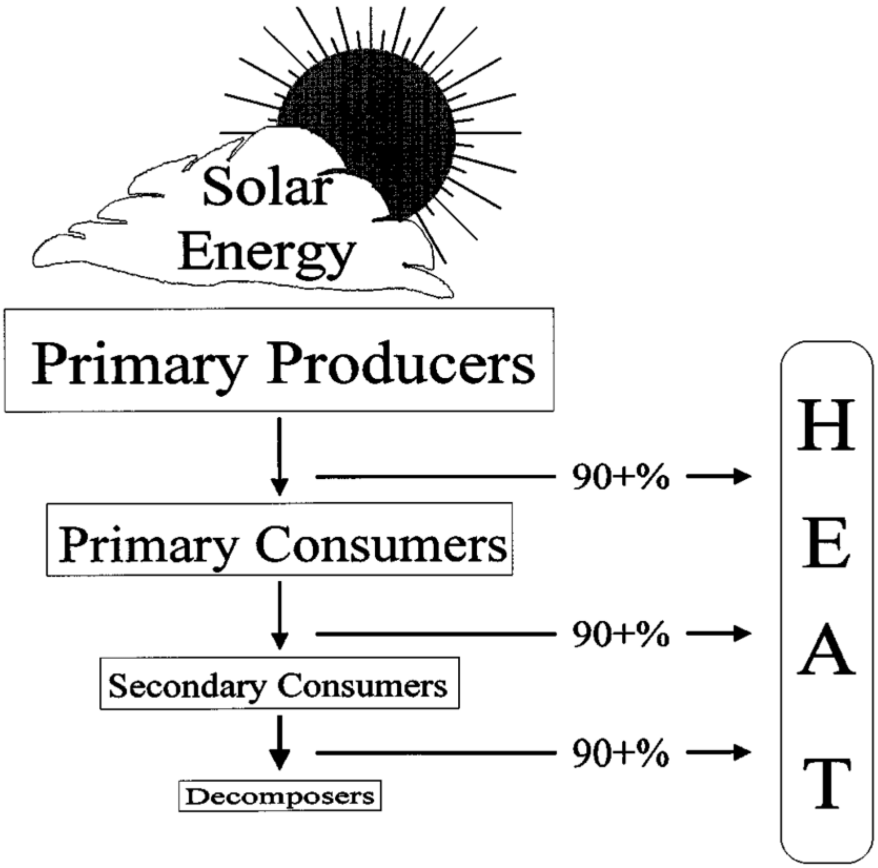

Figure 6. Energy flow in a food chain
Source: https://www.energy.gov/science/doe-explainsatmospheric-radiation
Self-Assessment Exercise 2

1. What is trophic level?

2.What are the stages of energy flow in an ecosystem?.

3.5 Concepts of Productivity

By comparing the quantity of goods and services produced (output) with the quantity of inputs required to generate those goods and services, productivity is a measure of economic performance. Productivity in ecology refers to the pace at which biomass is formed within the ecosystem, as explained in the previous section. It also goes by the name "photosynthesis-generated energy" and is made up of the ideas listed below:

a. Standing crop,
b. Materials removed, and
c. Production rate.

a. Standing Crop:

This is the amount of creatures that are present in the area at any one time. It can be expressed in terms of the quantity of people, the biomass of the creatures, the energy content, or in other appropriate measures. The concentration of people in the different populations of the ecosystem can be found by measuring the standing crop.

b. Materials Removed:

The second concept of productivity is the materials removed from the area per unit time. It includes the yield to man, organisms removed from the ecosystem by migration, and the material withdrawn as organic deposit.
c. Production Rate:
The third concept of productivity is the production rate, at which the growth processes are going forward within the area. The amount of material formed by each link in the food chain per unit of time per unit area or volume is the production rate.

3.5.1 Environmental Factors Affecting the Productivity in Ecosystem:

1. Solar radiation and temperature.
2. Moisture, i.e., leaf water potential, soil moisture, fluctuation of precipitation, and transpiration.
3. Mineral nutrition, i.e., uptake of minerals from the soil, rhizosphere effects, fire effects, salinity, heavy metals and nitrogen metabolism.
4. Biotic activities, i.e., grazing, above ground herbivores, below ground herbivores, predators and parasites and diseases of primary producers.
5. Impact of human populations, i.e., populations of different sorts, ionising radiations, such as atomic explosions, etc.
6. In aquatic systems, productivity is generally limited by light, which decreases with increasing water depth. In deep oceans nutrients often become limiting for productivity. Nitrogen is most important nutrient limiting productivity in marine ecosystems.

3.5.2 Productivity of the Major Ecosystems

The size of primary productivity is dependent on the capacity of producers for photosynthetic activity as well as the current environmental factors, such as solar radiation, ambient temperature, and soil moisture. In tropical environments, primary productivity may continue year-round if sufficient soil moisture is available. While in temperate regions, the cold environment and a brief snow-free growing season of the year limit primary productivity.
Upon which factors does the largeness of primary productivity depends?

Table 12.1. Geographical area, mean plant biomass and net productivity in major world ecosystems

Major world ecosystems	*Geographical area 10^6 km^2*	*Mean plant biomass ($t\ ha^{-1}$)*	*Mean net primary productivity ($t\ ha^{-1}\ year^{-1}$)*
1. Tropical rain forest	17	440	20
2. Tropical deciduous forest	8	360	15
3. Temperate deciduous forest	7	300	12
4. Temperate coniferous forest	12	200	8
5. Savanna	15	40	9
6. Temperate grassland	9	20	5
7. Desert shrub	18	10	0.7
t = ton = 1000 kg ; ha = 10,000 m^2			

Self-Assessment Exercise 3

1. What is the primary source of energy in an ecosystem?
2. When are all the ecosystems equally productive?

3.6 Summary

We have learnt about ecosystem productivity in this unit. Primary productivity is a term used to describe the amount of organic matter or energy produced by plants from sunlight (solar energy) in a given area during a given period of time, and Gross primary productivity refers to the total organic matter(energy) produced by the photosynthetic organism (plant or algae)while net primary productivity excludes the energy expended by the metabolic activities of the organism in for example respiration. We have also learned that the energy acquired by the producers is transferred from one trophic level to the next along the food chain and the length of food chain is limited to 3 or rarely 4 levels because too much energy is lost at each transfer point.

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3.8 Possible Answers to Self Assessment Exercises

Answers to SAE 1

1. What is the primary source of energy in an ecosystem?

Sun is the primary source of energy in an ecosystem. The producers such as plants, cyanobacteria and algae use sunlight to prepare their food. This marks the beginning of energy flow through the food chain.

2. When are all the ecosystems equally productive?

All the ecosystems are equally productive under drought conditions. According to researches, under drought conditions, the tropical forests can use water as efficiently as deserts

Answers to SAE 2

1.The feeding level from producers to consumers is called a trophic level. Energy flows only one way through various trophic levels.

2. Energy flow can be described through food chains as the transfer of energy from one organism to the next, beginning with the autotrophs and moving up the chain as animals are consumed by one another. Another way to display this type of chain or simply to display the trophic levels is through food/energy pyramids.

Answers to SAE 3

1. Sun is the primary source of energy in an ecosystem. The producers such as plants, cyanobacteria and algae use sunlight to prepare their food. This marks the beginning of energy flow through the food chain.

2. All the ecosystems are equally productive under drought conditions. According to researches, under drought conditions, the tropical forests can use water as efficiently as deserts.

Unit 4: The Cycling of Nutrients in Ecosystems

Unit structure

4.1Introduction

Element interactions between animals and reservoirs in the liquid or gas (oxygen, water, carbon, and nitrogen) or solid (phosphorus) phases are essential to the survival of species throughout their life cycles within ecosystems. It starts when they are absorbed into the bodies of organisms from the atmosphere or from worn rock. Since the elements are immutable under earthly natural conditions, when molecules move from one trophic level to another, they continue to circulate. Since they function in a closed system, they can be recycled repeatedly. Some of these elements will be examined in this unit along with their recycling processes.

4.2 Intended Learning Outcomes (ILOs)

By the end of this unit you should be able to:

- Know the major nutrients in ecosystems that are cycled and recycled by living organisms.
- Understand how the nutrient cycles include the living biosphere and the nonliving lithosphere, atmosphere and hydrosphere.
- Know the process of recycling of water and some of the important nutrients within the ecosystem.
- Explain the processes of Ammonification, Nitrification, NitrogenFixation and Dentrification.
- Understand how the phosphorus cycle differs from other nutrientcycles
- Know how the various nutrient cycles interact.
- Understand the importance of the nutrient cycles to organismswithin an ecosystem.

4.3 Nutrient Flows and Cycles

One of the most crucial processes that takes place in an ecosystem is nutrient cycling. The nutrient cycle explains how nutrients are used, transported, and recycled in the environment. In order for organisms to exist, valuable elements like nitrogen, phosphorus, hydrogen, oxygen, and carbon must be recycled. Both living and nonliving elements are included in the nutrient cycles, which also incorporate biological, geological, and chemical processes. These nutrient circuits are referred to as biogeochemical cycles for this reason. Global cycles and local cycles are the two basic subtypes of biogeochemical cycles. Abiotic ecosystems including the atmosphere, water, and soil recycle elements like carbon, nitrogen, oxygen, and hydrogen. These elements' cycles are of a global scale because the atmosphere serves as their primary abiotic source environment. Before being absorbed by living things, these elements may travel over long distances. The primary abiotic habitat for the recycling of elements like calcium, potassium, and phosphorus is soil. As a result, they usually travel across a small area. What is Nutrient cycling?

Self-Assessment Exercise 1

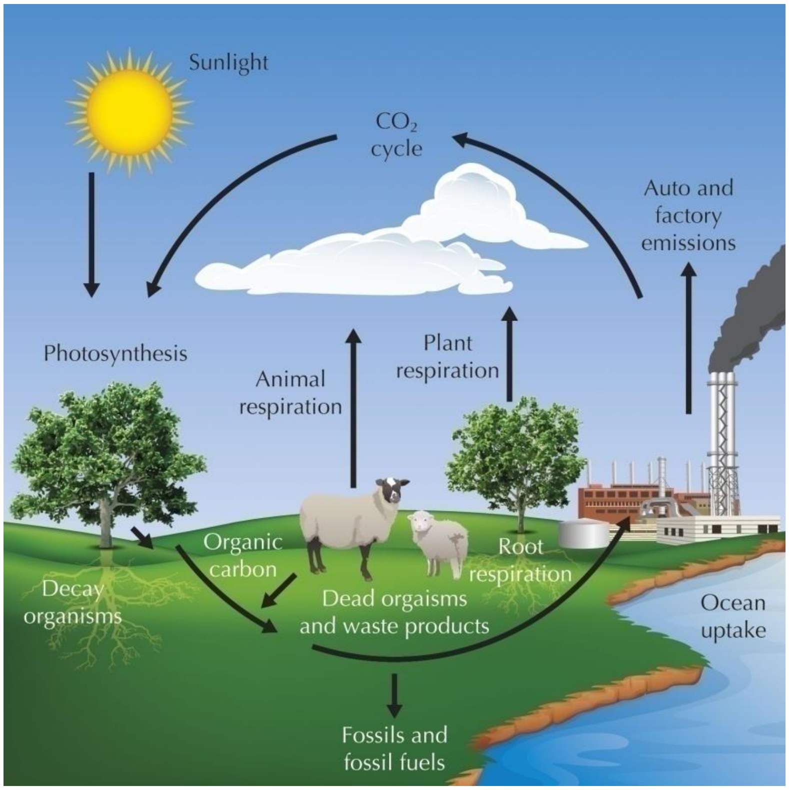
1. What does the organic compartment of the nutrient cycles consists of?
2. What are the three functional groups of the nutrient cycle compartment?

4.3.1 The Carbon Cycle

Since carbon is the primary component of all living things, it is necessary for all life. It acts as the main building block for all organic polymers, such as lipids, proteins, and carbohydrates. Global climates are influenced by the circulation of carbon molecules in the atmosphere, such as carbon dioxide (CO2) and methane (CH4). The processes of photosynthesis and respiration are principally responsible for the movement of carbon among living and nonliving ecosystem components. CO2 is a gas that is used by plants and other photosynthetic organisms to create biological components. Through respiration, organisms such as plants, animals, and decomposers (bacteria and fungi) return CO2 to the atmosphere. The rapid carbon cycle is the flow of carbon through biotic elements of the environment. The time it takes for carbon to move through the biotic elements of the cycle is significantly shorter than the time it takes it to go through the abiotic elements. For carbon to flow through abiotic components like rocks, soil, and oceans, it can take up to 200 million years. The sluggish carbon cycle is the name given to this carbon cycle.

4.3.2 Steps of the Carbon Cycle

Photosynthetic organisms (plants, cyanobacteria, etc.) take CO2 from the atmosphere and use it to produce organic molecules and increase biological mass. Animals eat photosynthetic organisms to obtain the carbon that the producers have stored. All living things breathe, returning CO2 to the environment. Dead and decaying organic matter is broken down by decomposers, who also produce CO2. Burning organic material releases some CO2 back into the atmosphere (forest fires). Erosion, volcanic eruptions, or the burning of fossil fuels can release CO2 that has been trapped in rock or fossil fuels back into the atmosphere.



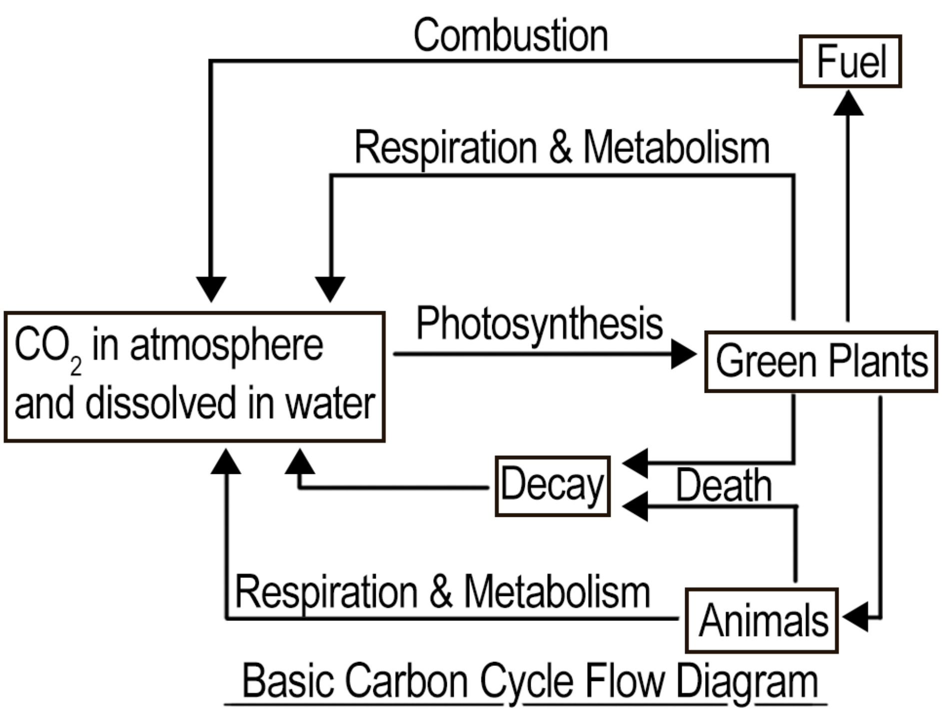


Figure 1. The Carbon Cycle

4.4 The Nitrogen Cycle

As with carbon, biological molecules cannot exist without nitrogen. Amino acids and nucleic acids are a few of these compounds. Although there is a lot of nitrogen (N_2) in the atmosphere, most living things can't use it to make chemical compounds. Prior to being turned to ammonia (NH_3), atmospheric nitrogen must first be fixed by certain bacteria. Nitrogen cycle steps: In aquatic and soil habitats, nitrogen-fixing microorganisms transform atmospheric nitrogen (N_2) into ammonia (NH_3). These organisms create the biological compounds necessary for their survival using nitrogen. Nitrifying bacteria are then responsible for converting NH_3 to nitrite and nitrate. Through the roots of the plant, ammonium (NH_4-) and nitrate are absorbed to provide plants with nitrogen from the soil. Organic chemicals are created using nitrate and ammonium.
Animals consume plants or other animals to obtain nitrogen in its organic form. Decomposers break down solid waste and dead or decaying stuff to release NH_3 into the soil. NH_3 is converted to nitrite and nitrate by nitrifying bacteria. Nitrite and nitrate are converted to N_2 by denitrifying bacteria, which then releases N_2 back into the atmosphere.

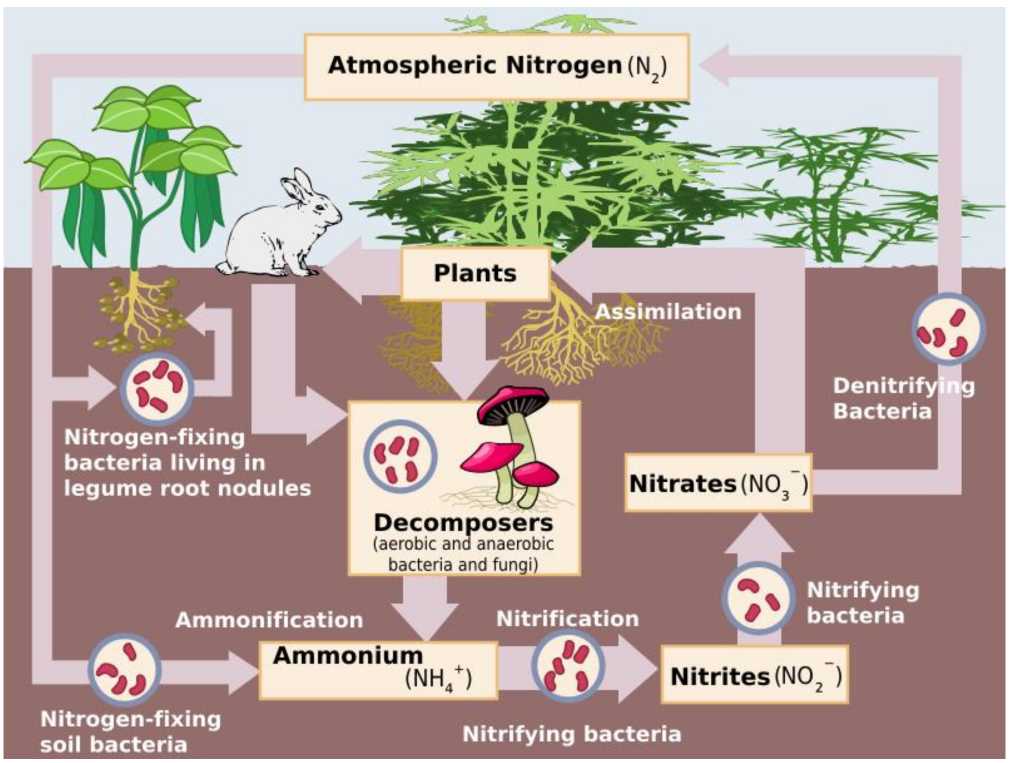


Figure 2. Nitrogen cycle. Source

4.4.1 Nitrogen Fixation

Dinitrogen gas has a strong triple bond holding its two nitrogen atoms together, making N_2 a very inert substance. Because of this, although being relatively common in the environment, only a few specialised organisms can directly utilise N_2. All of these microbes that fix nitrogen have the capacity to break down N_2 into NH_3 gas, which they can subsequently use as food. More crucially, the majority of autotrophic plants and microorganisms that are unable to fix N_2 on their own can now indirectly access the NH_3. The majority of ecosystems rely on biological nitrogen fixation to supply the nitrogen that supports their primary productivity. In reality, N2 fixation is ultimately responsible for nearly all of the organic nitrogen in the biomass of animals and ecosystems across the biosphere because nitrogen is not a significant component of rocks and soil minerals. The only other substantial sources of fixed nitrogen for ecosystems are plant uptake of NO and NO2 gases and atmospheric deposition of nitrate and ammonium in precipitation and dust fall. However, in comparison to biological N2 fixation, these sources are typically insignificant.

The Rhizobium bacteria, which are found in specialised nodules on the roots of leguminous plants like peas and beans, are the most well-known N2-fixing microorganisms. Some non-legumes, like alders, coexist with N2-fixing bacteria in a beneficial symbiosis. Most lichens, a mutualistic relationship between an alga and a fungus, share this trait. In soil or water, many additional N2-fixing microorganisms, including cyanobacteria, live in the open (blue-green bacteria).

Non-biological nitrogen fixation also happens, for example, during a lightning strike when atmospheric N2 and O2 combine under extremely hot and pressured conditions. N2 can also be fixed by humans. For instance, the production of NH3 nitrogen fertiliser involves mixing N2 with hydrogen gas (H2, which is created from the fossil fuel CH4) in the presence of iron catalysts. Additionally, when N2 and O2 combine at high pressure and temperature in car internal combustion engines, NO gas is created. Vehicle exhaust releases a lot of NO into the atmosphere, which contributes to air pollution. Currently, fertiliser production accounts for around 83% of the 120 million tonnes of anthropogenic N2 fixation every year. This is a crucial part of the current nitrogen cycle that is comparable in importance to non-human N2fixation on a global scale (about 170 million tonnes per year). The majority of Fabaceae species, including these soybeans, form a mutualistic relationship with Rhizobium bacteria. In nodules on the roots, the Rhizobium convert nitrogen gas (N2) into ammonia (NH3), which the plant can utilise as a fertiliser.

4.4.2 Ammonification, Nitrification and Denitrification

The organically bound nitrogen in an organism must be changed into inorganic forms when it dies in order for its fixed nitrogen to be recycled. Ammonification, the first step in this process, involves converting the organic nitrogen in dead biomass into ammonia, which then picks up a hydrogen ion (H+) to create ammonium (NH4+). As a result, ammonification is a part of the intricate degradation process that is unique to the nitrogen cycle. Numerous microbes perform ammonification. Many species of plants can benefit from the ammonium that is produced, especially those that thrive in situations with acidic soil. The majority of plants, however, are unable to efficiently absorb NH4+ and must instead rely on nitrate (NO3-) as their primary source of nitrogen nutrition. The creation of nitrate from ammonium is known as nitrification. The first process is the conversion of NH4+ to nitrite (NO2-), which is done by Nitrosomonas bacteria. Nitrobacter bacteria quickly convert the produced nitrite to nitrate by oxidation. Acidic soil or water prevents nitrification because Nitrosomonas and Nitrobacter are sensitive to acidity. This is why plants need to be able to utilise ammonium as a source of nitrogen in environments that are acidic. The graphic shows the most significant inorganic nitrogen changes that occur in soil and aquatic ecosystems. What is Nitrification? Nitrification is the process by which nitrate is synthesized from ammonium. Nitrate is transformed into one of the gases N2O or N2, which are then released into the atmosphere, during denitrification, which is another process carried out by a wide range of microbial species. Under anaerobic conditions, denitrification takes place, and its rate is highest when there is a high concentration of nitrate, such as on fertilised agricultural land that is briefly flooded. In some ways, denitrification can be seen as a process that balances off nitrogen fixation. The total amount of fixed nitrogen in the biosphere is actually not changing all that much over time since the rates of denitrification and nitrogen fixation are roughly equalised on a global scale.

Self-Assessment Exercise 2

1. what is ammonification?

2. How is atmospheric nitrogen converted to ammonia?

4.5 Water Cycle

4.5 The Water Cycle

The hydrosphere is the region of the planet where water is moved around and stored as liquid water in rivers, lakes, and seas, as well as underground (groundwater), in ice sheets and glaciers, and as water vapour in the atmosphere. Human cells contain more than 70% water, while the average human body contains roughly 60% water. 97.5 percent of the water reserves on Earth are salt water. More than 99 percent of the remaining water is either ice or groundwater. Lakes and rivers therefore contain less than 1% of freshwater. This small fraction is essential to many creatures, and its absence can harm ecosystems. Of course, humans have created technology to improve the availability of water, such as drilling wells to gather groundwater, collecting rainwater, and desalinating ocean water to produce potable water. Despite the fact that humans have been seeking drinkable water throughout history, there is still a significant problem with the availability of fresh water today. The various processes that occur during the cycling of water are illustrated in Figure 2 below. The processes include the following:

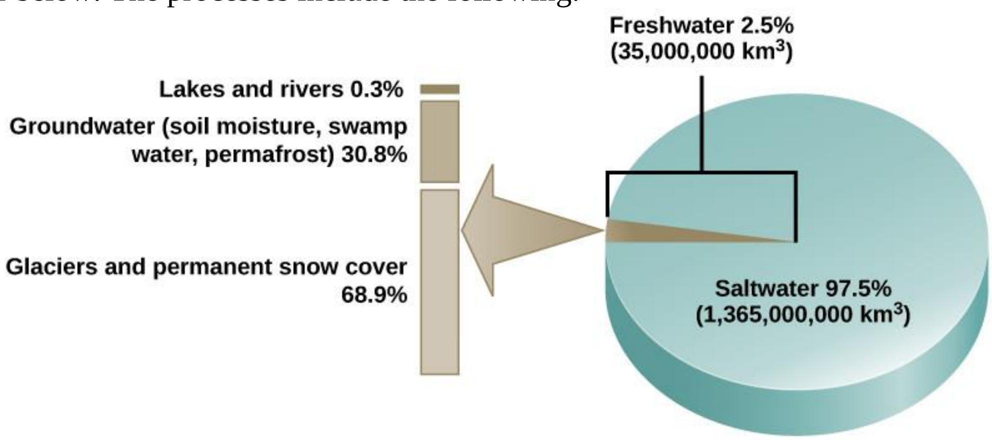


Figure 1. Sources of Water

Only 2.5 percent of water on Earth is fresh water, and less than 1 percent of fresh water is easily accessible to living things.

evaporation and sublimation

condensation and precipitation

subsurface water flow

surface runoff and snowmelt

stream flow

The Sun's energy, which heats the seas and other surface waters, drives the water cycle. Due to the evaporation of liquid surface water into water vapour and the sublimation of frozen water into water vapour, significant volumes of water are transferred into the atmosphere as water vapour. This water vapour eventually condenses into clouds of liquid or frozen droplets and produces precipitation (rain, snow, and hail), which brings water back to the Earth's surface. When rain falls on Earth, it may re-evaporate, run off the surface, or seep into the earth. Surface runoff, or the movement of freshwater over land from rain or melting ice, is the easiest to witness. Runoff can go from lakes and streams to the oceans. Rain usually comes into contact with vegetation before it reaches the soil surface in most natural terrestrial ecosystems. On plant surfaces, a large portion of the water evaporates right away. The remainder reaches the ground and starts to sink. Only after the earth is completely saturated with water during a severe downpour can surface runoff occur.

Plant roots can absorb water from the soil. Most of this water will be lost back to the atmosphere through a process known as transpiration, while some of it will be used by the plant for its own metabolism and some will end up in animals that eat the plants: Through the stomata (tiny microscopic apertures) of the leaves, water evaporates or transpires through the vascular system of plants. Evapotranspiration, a term coined by ecologists to describe the process of water being returned to the atmosphere, combines the terms transpiration and evaporation. When water in the soil is not absorbed by plants or evaporates, it can percolate into the bedrock and subsoil, where it becomes groundwater.

A large subterranean fresh water storage is groundwater. It can be found in the cracks in rocks or the spaces between the granules of soil, sand, and gravel. These pores and fissures allow for the sluggish movement of groundwater, which finally makes its way to a lake or stream where it rejoins the surface water. Many streams continue to flow even when they are not directly refilled by rainwater but rather by a steady inflow of groundwater from below. Deep within the bedrock, there is some groundwater that can stay there for centuries. The majority of groundwater aquifers, also known as reservoirs, are where wells take water for cultivation or drinking. These aquifers are frequently being used up more quickly than they are being refilled by water that percolates down from above. Minerals, such as phosphorus and sulphur, are frequently cycled from land to water by rain and surface runoff. The environmental effects of runoff will be discussed later as these cycles are described.

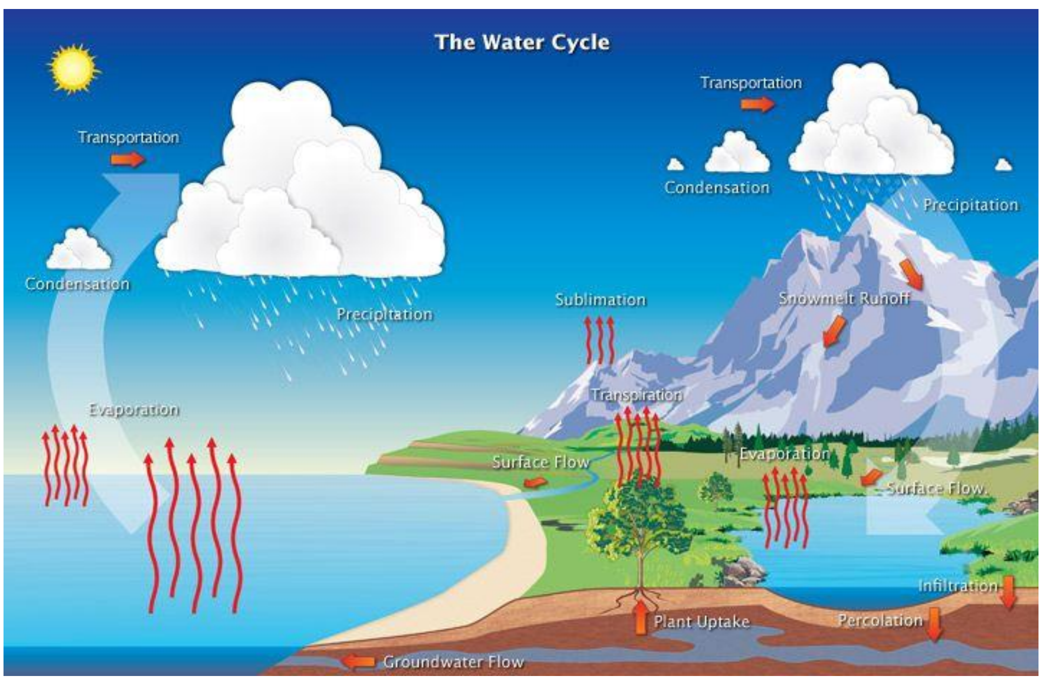


Figure 3. Water cycle

4.5.1 Oxygen Cycle

Oxygen is an element that is essential to biological organisms. The vast majority of atmospheric oxygen (O2) is derived from photosynthesis. Plants and other photosynthetic organisms use CO2, water, and light energy to produce glucose and O2. Glucose is used to synthesize organic molecules, while O2 is released into the atmosphere. Oxygen is removed from the atmosphere through decomposition processes and respiration in living organisms.

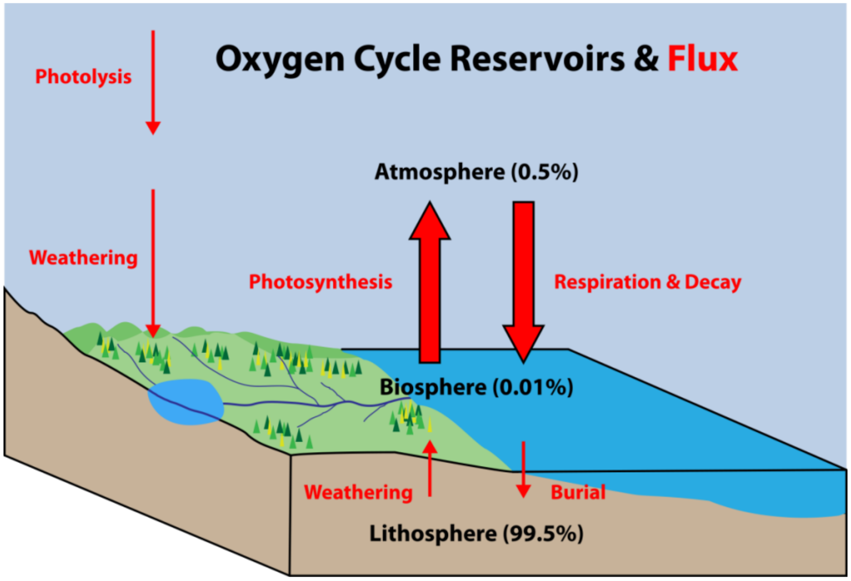


Figure 4. Oxygen cycle

4.5.2 Phosphorus Cycle

Biological substances include RNA, DNA, phospholipids, and adenosine triphosphate contain phosphorus (ATP). A highly energetic chemical called ATP is created during fermentation and cellular respiration. Phosphorus is primarily transported throughout the phosphorus cycle by soil, rocks, water, and living things. The phosphate ion is the form of phosphorus that is present organically (PO43-). Runoff from the weathering of phosphate-containing rocks adds phosphorus to soil and water. Plants take up PO43- from the soil, and people take it in when they eat plants and other animals. Decomposition causes phosphorus to be reintroduced to the soil. In aquatic situations, phosphates can also get caught in sediments. Over time, these phosphate-containing sediments produce new rocks.

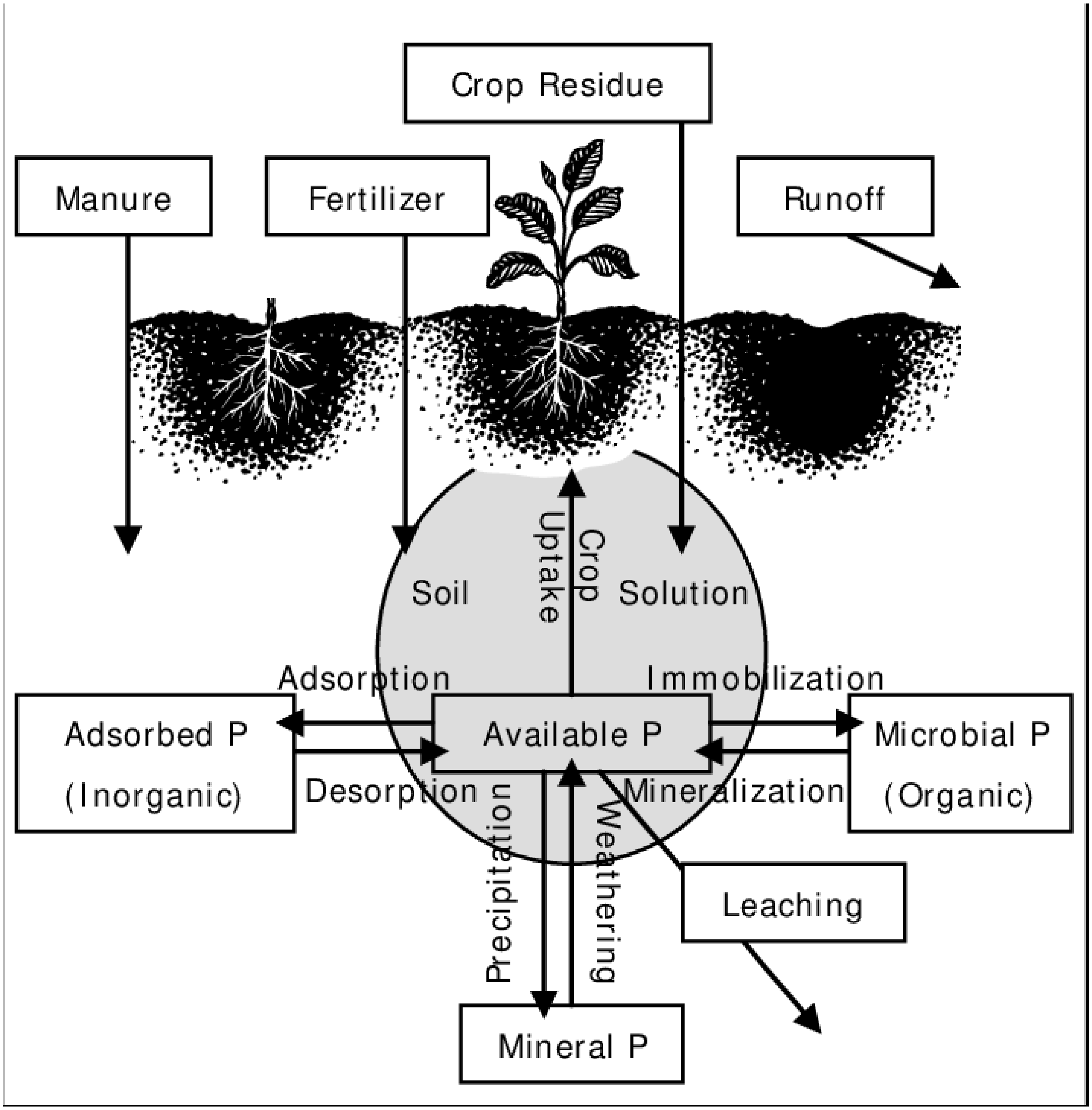


Figure 5. Phosphorus cycle

4.5.3 Pollution by Nutrients

The healthy metabolism of living things and the proper operation of ecosystems depend on nutrients. The idea behind the usage of fertiliser in agriculture is that, frequently, increasing the availability of specific nutrients would raise the productivity of both wild and domesticated plants. There are, however, instances where an abundance of nutrients has seriously harmed the environment. These are typically the most plentiful nutrients in fertiliser because the supply of readily available forms of nitrogen, especially NO3- and NH4+, is frequently a limiting factor to agricultural output. However, the usage of agricultural fertiliser may lead to NO3- concentrations in drinking water that are too high to be safe for people, particularly for young children. Along with NO3- and NH4+ from precipitation and soil water, plants may also absorb gaseous NO and N2O from the atmosphere and use them as nutrients. However, gaseous NO and N2O are air pollutants if they are present in large quantities, particularly in sunny situations where they are implicated in the photochemical synthesis of harmful ozone. Acid rain may also be a result of high NO_3^- and NH_4^+ concentrations in snow and rain.

There are further instances of how too many nutrients can harm the environment. For instance, because carbon makes up almost half of plant biomass, CO_2 is one of the most crucial nutrients for plants. The atmospheric quantity of this important nutrient, however, is only about 0.04%. However, the concentration of CO_2 in the atmosphere has increased by about 45% during the past two centuries and it continues to amplify. This well-documented change is contributing to global warming, an important environmental problem. Eutrophication, or an excessive productivity of waterbodies, is another environmental problem related to an excessive supply of nutrients. It is most often caused by an excess of PO_4^{3-}, usually because of sewage dumping or runoff from fertilized agricultural land. Highly eutrophic lakes are degraded ecologically and may no longer be useful as a source of drinking water or for recreation.

Clearly, these examples show that there is a fine balance between chemicals serving as beneficial nutrients, or as damaging pollutants.

Self-Assessment Exercise 3

1. As oxygen is an element that is essential to biological organisms, where does the vast majority of atmospheric oxygen (O_2) comes from?

2. I what form is phosphorus is found organically ?

4.6 Summary

Nutrients are chemicals that are essential for the metabolism of organisms and ecosystems. If they are insufficient in quantity, then ecological productivity is less than it potentially could be. Nutrients can also be present in excess, in which case environmental damage may be caused by toxicity and other problems. Nutrients routinely cycle among inorganic and organic forms within ecosystems. Key aspects of nutrient cycles are illustrated by the carbon, nitrogen, phosphorus, and sulphur cycles.

4.7 References/Further Reading/Web Sources

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4.8 Possible Answers to Self Assessment Exercises

Answers to SAE 1

1. The organic compartment of the nutrient cycle consists of nutrients present within living and dead organic matter.
2. The compartment can be divided into three functional groups namely: (a) living biomass of autotrophs such as plants, algae, and autotrophic bacteria, (b) living heterotrophs including herbivores, carnivores, omnivores, and detritivores, and (c) and all forms of dead organic matter.

Answers to SAE 2

1. Ammonification, in which the organic nitrogen of dead biomass is transformed to ammonia, which acquires a hydrogen ion (H+) to form ammonium (NH4+).
2. Atmospheric nitrogen (N2) is converted to ammonia (NH3) by nitrogen-fixing bacteria in aquatic and soil environments.

Answers to SAE 3

1. The vast majority of atmospheric oxygen (O2) is derived from photosynthesis.
2. Phosphorus is found organically in the form of the phosphate ion (PO43-).

Unit 5: Interactions Within Ecosystems

Unit Structure

5.1 Introduction

When we took a tour through population ecology, we mostly looked at populations of individual species in isolation. In reality, though, populations of one species are rarely—if ever!—isolated from populations of other species. In most cases, many species share a habitat, and the interactions between them play a major role in regulating population growth and abundance. This is what we shall study in this unit. Together, the populations of all the different species that live together in an area make up what's called an ecological community.

5.2 Intended Learning Outcomes (ILOs)

By the end of this unit you should be able to:

- State the significance of the community in ecology, and list types of community interactions.
- Define predation, and explain how it affects population growth and evolution.
- Describe competition, and outline how it can lead to extinction or specialization of species.
- Define symbiosis, and identify major types of symbiotic relationships.

5.3. Ecological communities

The biotic element of an ecosystem is known as a community in ecology. It is made up of communities of several species that coexist and communicate in the same space. Species interactions in communities are significant biotic factors in natural selection, just like abiotic elements like climate or water depth. The interconnections influence how the interacting species evolve. Predation, competition, and symbiosis are three main categories of community interactions.

1. Predation

Predation is a situation in which individuals from one species—the predator—consume individuals from another species (the prey). In Figure 1, the lions and cape buffalo serve as classic illustrations of predators and prey. In addition to the lions, this statue also features another predator. Can you locate it?" The Cape Buffalo is the other predator. It eats prey animals like the lion does, in this instance grass species. In food chains and webs, predator-prey interactions are responsible for the majority of energy transfers.

Figure 1: An adult male lion and a lion cub feed on the carcass of a South African cape buffalo.

2. Types of Predators

The lions in Figure 1 are true predators. The predator kills its prey in real predation. True predators like lions will take enormous prey, dissect it, and chew it before devouring it. The smaller prey is caught and swallowed whole by other genuine predators. Snakes, for instance, can consume mice entire. Because they don't kill their victims, some predators aren't actually predators. They graze on their prey instead. When grazing, a predator usually consumes only a portion of its prey. Deer, for instance, graze on plants but rarely harm them. It is also possible to "graze" on animals. For instance, female mosquitoes can spread disease but only consume minute amounts of animal blood without causing harm.

3. Predation and Populations

The size of prey populations is regulated in part by true predators. This is particularly valid when a predator only feeds on one species. In general, the balance of both species' populations is maintained via the predator-prey interaction. In Figure 2, this is displayed. Every shift in one species' population size is followed by an equivalent shift in the other species' population size. Predator-prey populations often continue to fluctuate in this manner so long as there is no outside interference..

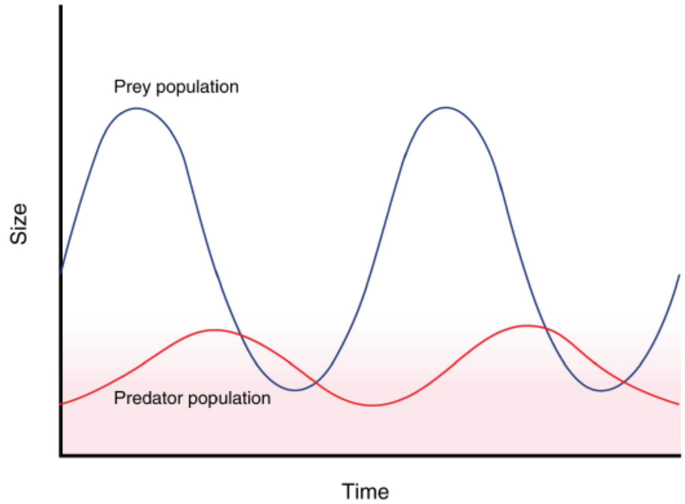

Figure 2. As the prey population increases, the predator population starts to rise. When there are more predators, the prey population begins to diminish, which, in turn, results in a decline in the predator population. This pattern keeps coming back. Between changes in one population and changes in the other population, there is usually a small lag. Because they are so vital to their community, some predator species are referred to as keystone species. The population of a keystone species is drastically impacted by the introduction or eradication of that species. This in turn has an i Both prey and predators have predation adaptations. The predator's adaptations aid in catching prey. They benefit from adaptations that assist prey avoid them. Camouflage, or disguise, is a typical adaptation in both predator and prey species. To become invisible in the background is one technique to use camouflage.mpact on the populations of numerous other species in the neighbourhood. For instance, certain species of sea stars are important components of coral reef communities. The only natural predators of mussels and sea urchins are the sea stars. A coral reef community would be destroyed if sea stars were eliminated because the populations of mussels and sea urchins would explode and drive out the majority of other species. In order to control pests, people occasionally purposefully bring predators into an area. The term for this is biological pest control. A species of insect known as a scale bug was among the first pests managed in this manner. Inadvertently, the scale insect was brought from Australia to California in the late 1800s. It was destroying the citrus trees in California and had no natural predators there. The scale insect was then imported into California along with its natural predator from Australia, a kind of beetle. The insect was entirely under the predator's control within a short period of time. Unfortunately, this is not always the case with biological pest control. Pest populations frequently recover after a decline.

4. Adaptations to Predation

Both predators and prey have adaptations to predation. Predator adaptations help them capture prey. Prey adaptations help them avoid predators. A common adaptation in both predator and prey species is camouflage, or disguise. One way of using camouflage is to blend in with the background. Several examples are shown in Figure 3 below:

Figure 3: Can you see the crab in the photo on the left? It is camouflaged with algae. The preying mantis in the middle photo looks just like the dead leaves in the background. The stripes on the zebras in the right photo blend the animals together, making it hard to see where one zebra ends and another begins.

Taking on the appearance of a different, more dangerous species is another method of camouflaging. Mimicry is the act of copying another animal's look. A mimicking example can be shown in Figure 4. The moth in the illustration has markings on its wings that resemble owl eyes. The moth only shows the patterns when a predator is close by. The moth has time to flee when the predator is startled by this. The opposite of camouflage-like adaptations can be found in some prey species. They have conspicuous features that warn potential predators to stay away, such as vivid colours or other easily apparent characteristics. For instance, birds have learnt to avoid eating some of the most vibrant butterflies since they are hazardous to them. By being so colorful, the butterflies are more likely to be noticed—and avoided—by their predators.

Figure 4. The moth on the left mimics the owl on the right. This "disguise" helps protect the moth from predators.

5. Predation, Natural Selection, and Co-evolution

Natural selection is the process by which predation adaptations develop. It is more suitable for a prey creature to evade a predator than it is for a member of the same species to be consumed by it. The organism may produce more offspring and lasts longer. As a result, characteristics that enabled the prey organism to elude the predator gradually increase in frequency in the population of prey. The evolution of comparable qualities in the predator species follows the evolution of traits in the prey species. We refer to this as co-evolution. Each species plays a significant role in the natural selection of the other species during co-evolution. Predator-prey co-evolution is illustrated by rough-skinned newts and common garter snakes, both shown in Figure 5. Through natural selection, newts evolved the ability to produce a strong toxin. In response, garter snakes evolved the ability to resist the toxin, so they could still safely prey upon newts. The capacity to create larger quantities of poison then evolved in newts. Garter snakes then developed a tolerance to the greater doses. Simply put, the interaction between predators and prey sparked an evolutionary "arms race," which resulted in exceptionally high toxin levels in newts.

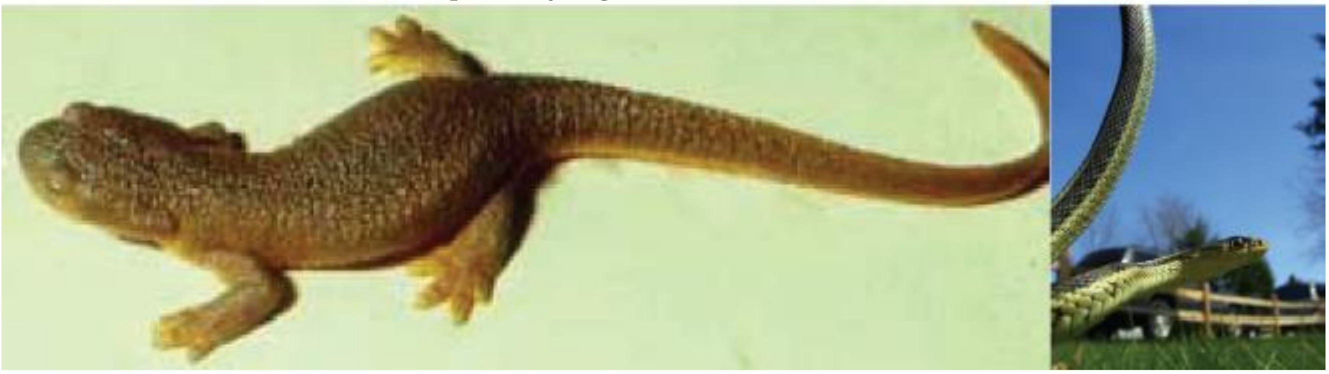

Figure 5: The rough-skinned newt on the left is highly toxic to other organisms. Common garter snakes, like the one on the right, have evolved resistance to the toxin.

What is biological pest control?

Self-Assessment Exercise 1

1. What is co-evolution?

2. What is true predation?

5.4 Competition

A relationship between creatures that compete for the same scarce resources is called competition. Food, nesting grounds, or territory are some examples of the resources. Intraspecific and interspecific competition are two separate types of competition.

• Intraspecific competition:Members of the same species compete against one another. For instance, in the same region, two male birds of the same species can compete for mates. Natural selection requires intraspecific competition as a necessary component. It eventually causes a species to adapt over time.

• Interspecific competition: Members of various species compete against one another interspecifically. Two predator species might compete for the same prey, for instance. In communities of interacting species, interspecific rivalry occurs.

1. Interspecific Competition and Extinction

When multiple species' populations rely on the same resources, there could not be enough of those resources to go around. One species may receive fewer of the essential resources if it has a disadvantage, such as more predators. As a result, members of that species will have a lower chance of surviving and a higher mortality rate than members of other species. The species may eventually become extinct in the area since there will be fewer offspring born. Competition between species has frequently resulted in the extinction of species in nature. When humans introduced new species into regions where they had no predators, many more extinctions have place. For example, rabbits were introduced into Australia in the mid-1800s for sport hunting. Rabbits had no predators in Australia and quickly spread throughout the continent. Many species of Australian mammals could not successfully compete with rabbits and went extinct.

2. Interspecific Competition and Specialization

The emergence of characteristics that distinctly distinguish competing species is another effect of interspecific rivalry. Competing species can grow more specialised through natural selection. As a result, they may coexist without having to fight over the same resources. The anolis lizard is one illustration. In tropical rainforests, a variety of anolis species can be found that feed on insects. Specializations emerged as a result of competition between several species. To hunt for insects under leaf litter on the forest floor, several anolis have developed specialised traits. Others developed specialised traits to eat insects on tree branches. This made it possible for the many anolis species to coexist together. What causes evolution of specialization in species?

Self-Assessment Exercise 2

1. What is competition?

2. What is the difference betwenn **Intraspecific competition Interspecific competition?**

5.5 Symbiotic Relationships

A close relationship between two species, in which at least one species gains, is referred to as symbiosis. The result of the relationship for the other species could be favourable, unfavourable, or neutral. Symbiotic relationships can be divided into three categories: parasitic, commensalist, and mutualistic.

1. Mutualism

A symbiotic relationship in which both species profit is called mutualism. Lichen is a nice illustration. A lichen is made up of an alga and a fungus, not one single organism. The fungus takes up minerals from rock or soil as well as water from the air. The water and minerals are used by the alga to produce nourishment for both the fungus and itself. Another illustration involves shrimp and goby fish. The fish and the virtually blind shrimp spend the majority of their time together. The goby and shrimp coexist in a tunnel that the shrimp maintains in the sand. The fish warns the shrimp that a predator is close by by touching the shrimp with its tail. Then, until the predator has left, both fish and shrimp withdraw to the burrow. Each gains from this mutualistic relationship: the shrimp gets a warning of approaching danger, and the fish gets a safe home and a place to lay its eggs.

Figure 6: The multicolored shrimp in the front and the green goby fish behind it have a mutualistic relationship. The shrimp shares its burrow with the fish, and the fish warns the shrimp when predators are near. Both species benefit from the relationship.

In mutualistic organisms, co-evolution is a frequent occurrence. Flowering plants and the species that pollinate them offer numerous examples. Flowers on plants have evolved characteristics that encourage pollination by specific species. In turn, pollinator species have developed characteristics that make it easier for them to collect pollen or nectar from particular types of flowers. For instance, hummingbirds and the plant with tube-shaped blooms in Figure 7 co-evolved. Long, narrow beaks were developed by the birds, enabling them to consume the nectar from the tubular blossoms.

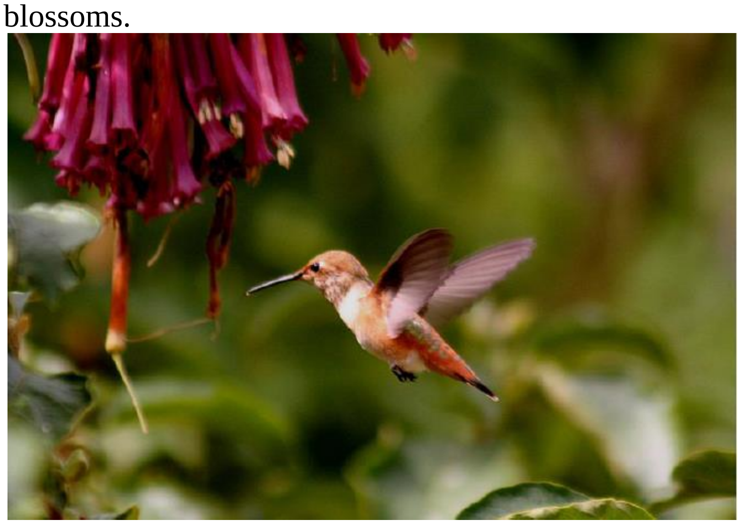

Figure 7. This hummingbird's long slender beak and the large tubular flowers of the plant are a good match, which resulted from a long period of co-evolution. Their relationship is an example of mutualism. The hummingbird uses nectar from the flowers for food and pollinates the flowers in the process.

2. Commensalism

A symbiotic relationship known as commensalism occurs when one species benefits while the other is unaffected. Commensalism is when one animal makes use of another for something than food. Hermit crabs use the shells of deceased snails as a form of refuge, and mites cling to larger flying insects to receive a "free ride." Some commensal interactions are explained by co-evolution. The human species and some of the bacterial species that reside inside of people are two examples. Many bacterial species have developed the capacity to dwell inside the human body without causing harm as a result of natural selection.

3. Parasitism

A parasitic relationship is one in which one species, the parasite, benefits and the other, the host, suffers. Some parasites reside on their host's exterior. Others have a home inside their host, arriving via a skin crack or by food or water. For instance, roundworms are intestine-parasitic parasites. The worms create enormous quantities of eggs, which are released into the environment through the host's excrement. By consuming the eggs in tainted food or water, other people can contract the disease. Typically, this only occurs in unsanitary areas. Some parasites kill their host ultimately. Most parasites don't, though. Successful parasitism, which does not result in the death of the host, is quite prevalent in nature. The majority of animal species exhibit parasitism at some point during their life cycles. Many different kinds of plants and fungi are parasitic at different stages. Most animals serve as hosts for one or more parasites, which is not surprising. Co-evolution between parasitic species is likely to occur. Both parasites and hosts develop strategies to circumvent each other's defences throughout time. For instance, numerous plants have developed poisons that kill parasitic fungus and bacteria that live on plants. Human malaria is caused by a small parasite that has developed a means of dodging the immune system. It hides out in the host's blood cells or liver where the immune system cannot find it.

Self-Assessment Exercise 3

1. What is parasitism?

2. What is a Lichen

5.6 Summary

You have studied an ecological community as consisting of all the populations of all the different species that live together in a particular area. Interactions between different species in a community are called interspecific interactions—inter- means "between."You have learned the significance of the community in ecology, types of community interactions and how predation affect population growth and evolution. The different types of associations of competition, symbiosis and predation have been explained.

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5.8 Possible Answers to Self Assessment Exercises

Answers to SAE 1

1. It is evolution of traits in the prey species that leads to evolution of corresponding traits in the predator species.
2. The condition on which the predator kills its prey

Answers to SAE 2

1. Competition is a relationship between organisms that strive for the same limited resources
2. Intraspecific competition occurs between members of the same species, while Interspecific competition occurs between members of different species.

Answers to SAE 3

1. Parasitism is a symbiotic relationship in which one species (the parasite) benefits while the other species (the host) is harmed.
2. A lichen is not a single organism but a fungus and an alga.

Unit 6: Patterns of Community Structure

6.1 Introduction

Even though a region's climate is consistent from year to year, ecosystems have a propensity to go from being extremely simple to complex through a process called as succession. Uninhabited open area or cut-down trees gradually fill with an increasing number of bigger and bigger plants. Vegetation encroaches from the margins of a pond and gradually fills it with itself, transforming it into vegetation-covered dry land. This unit under succession will study the gradual change of vegetation throughout time.

6.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you should be able to understand fully the;

- The meaning of succession
- Difference between primary succession and secondary succession
- Process of primary succession
- The influence of man on succession

6.3 Ecological Succession

Due to (1) changes in climatic and physiographic variables and (2) the actions of the species and communities themselves, the environment is constantly changing over time. These forces significantly alter the dominants of the current community, which is eventually replaced by a new community in the same location. Throughout this process, successive communities grow one after the other over the same region until the terminal last community once more stabilises for a while. It happens in a very defined order. The succession of communities is this orderly transition. Odum referred to this systematic process as ecological succession or ecosystem development. Succession is a systematic process of community growth that includes adjustments to species composition and community dynamics across time. It is generally directed and so predictable. Succession is ongoing and has a global scope. For instance, if a wooded area is cleaned and left unattended, the vegetation will gradually retake the space. The clearing will eventually vanish, returning the region to its natural state as woods. Succession is a logical evolution. Therefore, changes brought about by human activity such as clearing and replanting land cannot be referred to as succession. There are two types of succession: main and secondary. Despite the fact that the physical environment dictates the pattern, succession is regulated by the society. The completion of this process will bring the ecosystem to equilibrium. A climax community is the one that succeeds in achieving this goal. Some species multiply in an effort to reach this balance, while others decline in number. Sere refers to the order of changing communities in a region. As a result, each evolving community is referred to as a seral stage or seral community. Every community that we see around us today has gone through succession over the course of its history. Therefore, we may claim that ecological succession and evolution have both occurred at the same time. Also, the initiation of life on earth can be considered to be a result of this succession process. The examples of ecological succession are as follows:

a) Off the coast of Iceland sits the volcanic island of Surtsey. This island was created in 1963 as a result of the volcano's eruptions. The earth was largely rocking after the eruption. On the rock, mould and fungi began to develop. These started to decompose the rock and create soil. The little grasses then begin to establish themselves and grow. Smaller shrubs then start to sprout. As the larger plants started to emerge, the small burrowing critters crept in to disturb the soil. Where there was simply rock, trees started to sprout after a few years.

b) Tropical forests are examples of secondary succession in which forests were cleared for timber and agricultural needs. In these areas, the reestablishment took place at varying speeds, and it took several years for a community to be fully restored.

6.3.1 Process of Ecological Succession

Natural succession takes place across a number of phases and procedures. Succession starts with a change to the ecosystem that already exists, then as the area recovers, organism variety and density increase. Ecologists use the following terminology to describe environmental succession:

Initial Conditions (Equilibrium)

Disturbance

Colonization
Competition
Succession
Climax

Interactions between various plant species and biotic (or alive) and abiotic (or nonliving) environmental variables occur during these stages and processes. The stages of ecological succession show a complex process that is mainly reliant on chance. The direction of the wind, the weather, human activity, geological occurrences, animal movement, and the species makeup of the immediate area all affect when each cycle occurs and which species are engaged.

Initial Conditions (Equilibrium)

Before a big ecological change, the first conditions were present. This may be an equilibrium state in some ecosystems when species populations are steady and balanced. This equilibrium is significantly influenced by the output of primary producers, such as plants and algae. Due to apex predator extinction, habitat damage, or other ecological imbalances, the initial conditions may already be unstable.

Disturbance

Before a big ecological change, the first conditions were present. This may be an equilibrium state in some ecosystems when species populations are steady and balanced. This equilibrium is significantly influenced by the output of primary producers, such as plants and algae. Due to apex predator extinction, habitat damage, or other ecological imbalances, the initial conditions may already be unstable.

Colonization

Tiny organisms eventually restore themselves in the harmed ecosystem following the disturbance. Colonization is the process of microscopic organisms and small primary producers returning. The first species that repopulates the habitat needs to be able to withstand challenging circumstances.

Competition

New species can flourish when colonising organisms alter environmental factors, such as the composition of the soil. Resource rivalry grows as biodiversity, or the number of species in the area, increases. For instance, bushes and shrubs limit the amount of sunshine that smaller plants can receive. Shade-tolerant species eventually triumph over plants that demand more sunlight.

Succession

Succession is the process by which new species supplant established ones. Due to resource competition, the earliest organisms to occupy the area become less numerous or extinct, and larger plant species take over. This process might occur in stages if the founding ecosystem had a diversified population of herbaceous plants, shrubs, and trees. The process has fewer phases in habitats with fewer plant species, such as grasslands and some wetlands.

Climax

The last stage of ecological succession is the formation of a climax community. There is minimal resource competition and no further replacement of dominant plant species.

6.3.2 Causes and Characteristics of Ecological Succession

1). Some important causes may be defined as below:

i). Climatic Causes: these can be rainfall, temperature variations, humidity, gas composition, etc.

ii) Biotic Causes: the organisms in a community compete to thrive for existence. Some of them are lost in the process while some new ones are incorporated.

iii). External Causes: soil conditions are affected by the process of migration, invasion, and competition amongst various species.

2). Characteristics of Ecological Succession
Ecological succession has subsequent characteristics:
i). It results from the disparity in the physical atmosphere of the community.
ii). It is a systematic procedure of community development.
iii). It involves variations in species structure and it increases the diversity of species.
iv). Nutrient variation regulates the settlement of new communities.
v). Succession operates in a stabilized ecosystem.

6.3.3 Cyclic Succession

A pattern of vegetation change known as "cyclic succession" occurs when a small number of species gradually replace one another over time in the absence of widespread disturbance. The old Clementsian theories of a fixed species composition in the end-state climax community have been refuted by observations of cyclic replacement. A concept in community ecology, cyclic succession is one of several types of ecological succession. When used specifically, the phrase "cyclic succession" refers to processes that are not the result of extensive exogenous disturbances or significant long-term environmental physical changes. In instances of secondary succession, however, where frequent perturbations like bug outbreaks can 'reset' a whole population to a prior stage, broader cyclic patterns can also be seen. These examples are distinct from the traditional cyclic succession situations detailed below in that entire species groups are traded instead of a single species. Climate cycles can cause cyclic vegetation changes over geologic time spans by directly changing the physical environment.

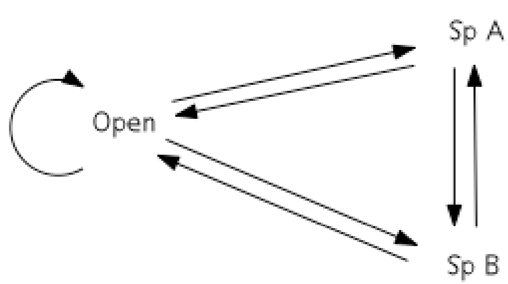

Figure 1. Graphic Model of Cyclic Succession
Self-Assessment Exercise 1

1. What are the Main Causes of Ecological Succession?
2. What is the Importance of Ecological Succession?

6.4. Types of Ecological Succession

1. Primary succession
When a new piece of land is produced or is first exposed, primary succession occurs. This may occur, for instance, when lava solidifies and forms new rocks or when a glacier recedes and reveals bare rocks. In the initial succession, organisms have to start over. First, lichens may cling to rocks, followed by a few small plants capable of surviving without much soil. The term "pioneer species" refers to these. More and larger plants start to colonise the region as a result of the decomposition of those plants, which gradually helps to create soil. Once sufficient soil has accumulated and

sufficient nutrients are accessible, a climax community, such as a forest, is created. In the event that the area is disturbed after this, secondary succession happens..

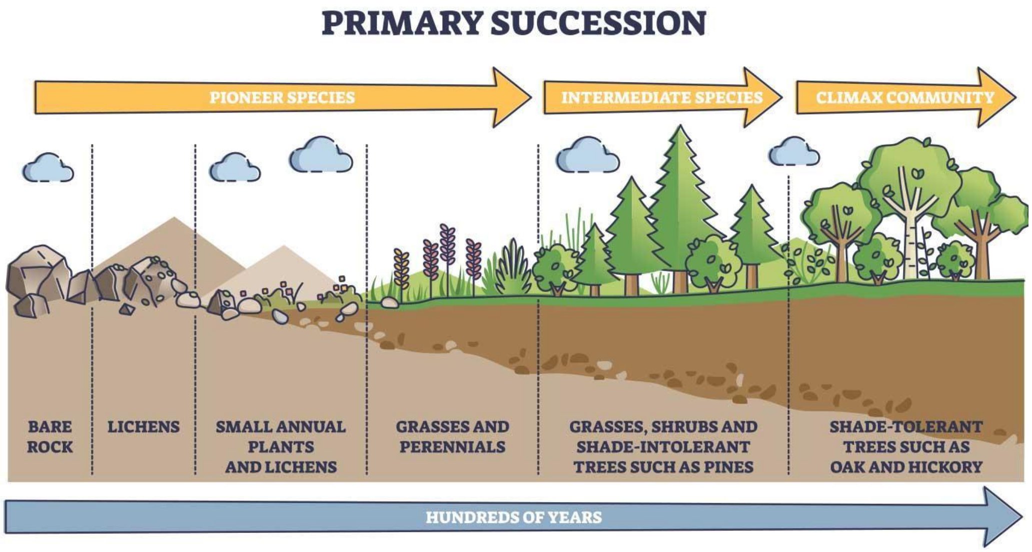

Figure 1. Primary succession begins when no plant life is present on the landscape, such as after a lava flow or glacial retreat. Over centuries, soil forms and deepens and successive communities of plants grow. Source:

2. Secondary succession

When a climax community or an intermediate community is affected by a disturbance, secondary succession occurs. The succession cycle is restarted, but not to the start because the soil and nutrients are still there. For instance, after a forest fire decimates all the mature trees in a particular terrain, grasses, shrubs, and various tree species may sprout up before the community that was there before the fire reappears.

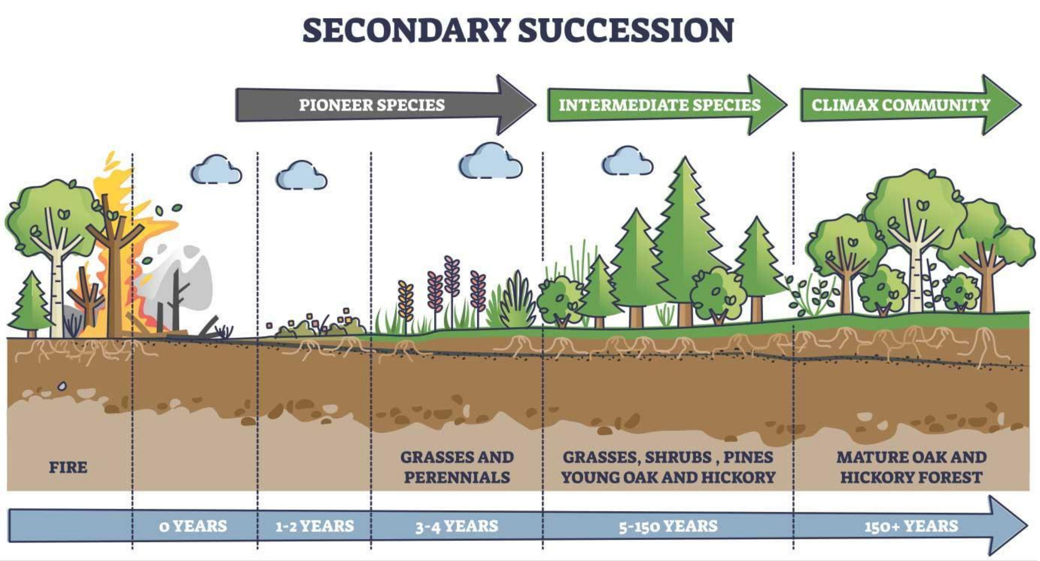

Figure 2. Secondary succession begins after a disturbance, like a fire. Crucially, some soil and nutrients remain present—fire, in fact, may help recycle those nutrients.

3. Seral Community

"A seral community is an intermediate stage of ecological succession advancing towards the climax community." A sere, or seral community, is defined as the evolution of an ecological community's growth phases from the pioneers to the climax. "A seral community is a transitional stage of ecological succession going in the direction of the climax community." The last stage of succession is defined as an ecological community's climax, where populations are stable and cohabit peacefully with one another and their environment. This community remains mostly intact until it is destroyed by a natural calamity or human intervention. The succeeding community takes the place of the seral community. It comprises of straightforward food chains and food webs. It demonstrates relatively little variability. There are fewer people overall, and there are also less nutrients. There are seven different types of seres:

Types of Seres	Explanation
Hydrosere	Succession in aquatic habitat.
Xerosere	Succession in dry habitat.
Lithosere	Succession on a bare rock surface.
Psammosere	Succession initiating on sandy areas.
Halosere	Succession starting in saline soil or water.
Senile	Succession of microorganism on dead matter.
Eosere	Development of vegetation in an era.

4. Climax Community

The "endpoint" of succession in the context of a specific climate and geography is a climax community. A climax community will stay put until a disturbance happens in that area. But in many ecosystems, disturbances happen frequently enough that a variety of community types might be seen on the landscape on a regular basis. an ecological setting where plant or animal populations are stable and coexist in harmony with one another and their surroundings. The last stage of succession is a climax community, which lasts until it is destroyed by an occurrence like a fire or human intervention. For instance, mature forests may be found close to grassy meadows with fewer, dispersed trees in a region like the western U.S. that is prone to wildfires. Thus, numerous plant and animal communities can flourish within a certain climatic and geographic niche—not just those adapted to the absence of disturbance found in climax communities—due to persistent disturbance and fluctuation in parameters like water and nutrient availability over the course of decades. What do we refer to succession in aquatic habitat?

1. What is primary succession?
2. What do you mean by halosere?

6.5 Community equilibrium and species diversity

In some situations, succession achieves a pinnacle, resulting in a steadfast society ruled by a select few notable species. It is believed that this equilibrium, known as the climax community, arises when the web of biotic interactions becomes so complex that no additional species can coexist. In other habitats, a variety of species coexist in communities that are constantly disturbed on a tiny scale; any species can take over as the dominant species. The consequences of unanticipated disruptions on the formation of community structure and composition are highlighted by this nonequilibrium dynamic. Within a square kilometre, certain tropical forests with a variety of species can support hundreds of tree species. The area created when a tree perishes and tumbles to the earth is available for sale. Similar to coral reefs, some of which support hundreds of fish species, the species that establishes a new disturbance area will prevail. The struggle for dominance reemerges after every minor disturbance.

Ones that are diverse are healthy communities. Long-term ecological research have demonstrated that communities with more species are able to rebound from perturbations more quickly than communities with fewer species. In the Midwest of the United States, grasslands with more species tend to have higher primary output. The community's ability to withstand drought is affected to a greater and greater extent with each additional species lost from these grasslands. Similar to this, more diversified plant communities exhibit stronger species composition stability during extreme drought than less diverse ecosystems do in Yellowstone National Park. Additionally, the more diversified communities in Africa's Serengeti grassland exhibit greater biomass stability over the course of the seasons and greater capacity for recovery following grazing. The link between species variety and community stability emphasises the need to keep biological communities as rich as possible. A rich interactive web of native species that have had time to adapt to one another is substantially different from a field of weeds comprising species that were only recently introduced to the community. Undisturbed communities with a variety of species have the resilience to maintain a healthy ecosystem, which is essential to life. Additionally, these groups are better equipped to deal with the consequences of alien species, which, even when unintentionally introduced, can cause significant ecological and economic damage in less stable societies. The tight web of interactions that make up natural biological communities sustains both biodiversity and community stability.

6.5.1 Ecological Stability

Ecosystem stability refers to an ecosystem's capacity to sustain equilibrium even after a stressor or disturbance has taken place. An ecosystem must have systems in place to assist it in returning to its initial state after a disruption for it to be deemed stable. OR The ability of an ecosystem to remain in the same state is what is meant by stability. The introduction or eradication of a species is one type of alteration that can have a profoundly negative impact on natural ecosystems. Equilibrium, which is a comparatively steady state that maintains population sizes within a reasonable range, is referred to as a healthy ecosystem (not too many of a certain species alive or dead). Ecosystem stability is often divided into two components: resistance and resilience.

1. Resistance: Resistance is the capacity of an ecosystem to maintain equilibrium in the face of perturbations. Or A community or ecosystem's capacity to sustain structure and/or function in the face of possible disturbance is known as resistance. (A minor change in a species' abundance brought on by a disturbance suggests better resistance than a bigger shift.) The absence of resistance to ecological change is typically researched, that is, when a system finally adapts to ecosystem change. These studies frequently demonstrate that when ecological redundancy is minimal and essential species' ecological roles cannot be substituted by other species within the ecosystem, change happens more swiftly. Recent human removal of important species, such as top predators, can drastically diminish redundancy and hence change an ecosystem's capacity to withstand ecological change, particularly in maritime environments. Example: I). Soils with a high level of organic matter and biodiversity are drought-resistant. Healthy, organically rich soils that have been nourished by agroecological fertilisers (green manures, compost, animal dung, etc.) are less likely to erode and better able to retain water. According to a wealth of scientific data,

organic matter has the single most crucial role in improving soils' drought resistance and ability to handle variable rainfall. Organic matter expands the soil's pore space, where water can be stored more easily. This allows the soil to store more water for a longer length of time and facilitates infiltration during heavy rains, allowing for the total capture of more water. Soil with more organic matter can grow crops with less water than soil with less organic matter. Additionally, organic matter increases the activity of worms, fungus, and microorganisms, which reduces soil density, prevents compaction, and improves the soil's capacity to hold water. These traits increase the ability of organic matter-rich soils to withstand drought and raise the water-use efficiency of the entire farm as well as the crop. II). Invasion Resistance: Increased survival and percentage cover of invasive species were found to be connected with declines in the diversity of native taxa in numerous marine habitats. This shows that, similar to terrestrial plant ecosystems, the integrity of the local species pool enhances invasion resistance. For instance, certain systems make better use of resources like available space. A decrease in the diversity of native taxa was associated with an increase in the survival and percent cover of invasive species in benthic (sea bottom) communities that were artificially built. Open space served as the invaders' only resource, and communities were insulated from invasion by more species by boosting temporal stability. High levels of functional redundancy are also anticipated to increase community resilience by providing insurance. Even though there are few research on the effects of biodiversity in marine ecosystems, the information that is currently available points to the possibility that marine systems may have invasion resistance mechanisms that are comparable to those found in terrestrial systems.

2. Resilience: Resilience is the ease with which an ecosystem recovers its equilibrium after being disturbed. Or The term "resilience" refers to the capacity to recover quickly after a setback. A resilient community or ecosystem can withstand major disruption and soon recover to its previous state. Or The ability of an ecosystem to bounce back from a disturbance or sustain ongoing stressors is referred to as ecological resilience. It is a gauge of how well an ecosystem can withstand disruption without degenerating into another state governed by a distinct set of mechanisms. Resilience refers to a dynamic system of disruption and recovery rather than a single ideal ecological condition. Thresholds are the boundaries of natural variability, and they are crossed when an ecosystem undergoes a disturbance or invasion and does not naturally return to its previous state before transitioning to a new, alternative one. Example: Cyclones, outbreaks of the crown-of-thorns starfish, freshwater intrusions, and a variety of human activities are among the dangers that frequently affect coral reefs and other tropical marine ecosystems. These occurrences frequently harm, stress, or even kill ecological elements. A resilient ecosystem will be able to completely recover from such disruptions and return to being as bio diverse and healthy as it was before the damage, given enough time. A resilient ecosystem might also be able to handle the strain brought on by these events with little to no deterioration. What influences resilience? Because so many different factors can have an impact on ecosystem resilience, it is difficult to comprehend and evaluate. The natural biology and ecology of an ecosystem's constituent species or habitats; the state of these individual components; the type, severity, and duration of the impacts; and the extent to which potential impacts have been eliminated or mitigated all affect an ecosystem's capacity to absorb or recover from impacts and its rate of recovery. Populations of species or habitats can frequently absorb or recover from effects if all of these qualities are present, allowing the ecosystem to continue to operate. However, if any limitations exist, the capacity of the ecosystem to absorb impacts without changing will be lower than optimal and recovery will take much longer, or even fail.

6.5.2 Human Influence on Succession

There is vegetation covering a sizable amount of the earth's surface that is no longer growing in a normal succession. Natural vegetation has been partially or entirely destroyed by human intervention for agricultural production. On arable land, where monocultures of crops are planted in place of the natural flora, farming methods are most obviously felt. Only a few months are spent growing these plants before they are harvested, the earth is turned, and a fresh crop is sown. The only wild plants that can withstand such methods are annual weeds that grow quickly and can blossom and set seed before the crop is collected. Grassland is a significant managed vegetation type. All of these practises preserve grassland and stop succession to scrub, including grazing by sheep, cattle, or other domestic animals, as well as annual hay-making and short-term turf mowing. Today, it is clear that human land management has a negative impact on succession prevention and diversion. Large tracts of natural vegetation have been removed, with the removal of tropical rainforest to provide grassland for cattle arguably being the most contentious. The environment in question is typically altered by such extensive clearing. Upon what does an ecosystem's ability to absorb or recover from impacts, and its rate of recovery, depend?

Self-Assessment Exercise 3

1. What is **Ecosystem stability?**
2. What is Ecosystem resilience?

6.6 Summary

In this unit, we have learnt that succession is a process of ecological change from simple to complex that occurs over time in a given area of an ecosystem. The different types of succession namely primary or secondary have been highlighted. While primary succession starts from a bare surface either of rock, sanddunes, volcanic eruption or open water, secondary succession takes place after a disturbanceon a community of organisms that had existed initially. You have also recognise that humans by their agricultural activities have disrupted the process of succession in many parts of the world.

6.7 References/Further Readings/Web Sources

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6.8 Possible Answers to Self Assessment Exercises

Answers to SAE 1

1. The main causes of ecological succession include the biotic, topographic, and climatic factors that can destroy the populations of an area. Wind, fire, soil erosion, and natural disasters include the climatic factors.
2. Ecological succession is important for the growth and development of an ecosystem. It initiates colonization of new areas and recolonization of the areas that had been destroyed due to certain biotic and climatic factors. Thus, the organisms can adapt to the changes and learn to survive in a changing environment.

Answers to SAE 2
1. Primary succession starts in a barren area, never having vegetation of any type where no living organism ever existed.
2. The plant succession that begins in salty or saline water is called halosere.

Answers to SAE 3
1. Ecosystem stability is the ability of an ecosystem to maintain a steady state (equilibrium)
2. Ecosystem resilience refers to the capacity of an ecosystem to recover from disturbance or withstand ongoing pressures.

Glossary
Ecology Abundance: The number of organisms in a population, combining “intensity“ (density within inhabited areas) and “prevalence“ (number and size of inhabited areas).

Adaptation:

1) Characteristics of organisms evolved as a consequence of natural selection;

2) Changes in the form or behavior of an organism during life as a response to environmental stimuli;

3) Changes in the excitability of a sense organ as a result of continuos stimulation. Allochoton: see biomass.

Biodiversity: (Gk. bios, life) Refers to aspects of variety in the living world; used to describe the number of species, the amount of genetic variation or the number of community types present in the area.

Biogeochemical Cycle: The movement of chemical elements between organisms and non-living compartments of the atmosphere, lithosphere and hydrosphere.

Biogeography: The study of the geographical distribution of organisms

Biomagnification: The increasing concentration of a compound in the tissues of organisms as the compound passes along a food chain, resulting from the accumulation of the compound at each trophic level prior to its consumption by organisms at the next trophic level, as seen with DDT.

Biomass (organic matter): Total dry weight of all organisms in a particular population, sample or area; Biome: Large, ecological unit composed of similar types of climax communities on a global scale, arising as a result of complex interactions of climate, other physical factors, and biotic factors (e.g., rainforest, tundra, grassland....)

Biosphere: The zone of air, land and water at the surface of the earth that is occupied by organisms. Biotic: Living; usually applied to the biological aspects of an organism's environment, i.e. the influence of other organisms (opposite of abiotic). Abiotic: Non-living; usually applied to the physical and chemical aspects of an organism's environment;

Biotope: Canopy: (Gk. canopion, net) The dense roof-forming vegetation, typically represented by the crowns of the trees; kelps, brown algae, can also form dense forest-like canopies.

Carrying Capacity (K): The maximum population size that can be supported indefinitely by a given environment

Climate: The accumulation of seasonal weather patterns in an area over a long period of time. Macroclimate: Global climatic patterns. Microclimate: The climate within a very small area or in a particular, often tightly defined habitat; e.g., temperature gradient a few mm above a leaf, or along a tree trunk, etc.).

Climax: The presumed endpoint of a successional sequence.

Climax Community: Is largely determined by the climate and soil of the region; such a community has reached a steady state in a successional series (see there).

Climax Mosaic: A once established climax community can't be considered stationary but rather follows a pattern of micro-successional events caused by death and birth cycles of every organism living within.

Coexistance: The living together of two species (or organisms) in the same habitat, such as that neither tends to be eliminated by the other.

Community: The species that occur together in space and time; (see diversity and isotherms).

C. Stability: The tendency of a community to return to its original state after a disturbance (competition, temporarily changing environment, etc.)

Resiliance: The speed at which a community returns to its former state after it has been disturbed. Resistance: The ability of a community to avoid displacement from its present state by a disturbance. C. Competition: Interaction between members of the same population or of two or more populations to obtain a resource that both require and which is available in limited supply, hence, limiting overall fitnes

Cycle: Biogeochemical cycles on a global and local scale.

Carbon C.: The global flow of carbon atoms from plants through animals to the atmosphere, soil, water and back to plants.

End of Module Questions

1 What do you understand by the term ecology?
2 What are the two main branches of ecology? Explain each.
3 Mention and explain the various concepts of ecology.
4 Compare and contrast key aspects of the cycling of carbon, nitrogen, phosphorus, and sulphur.
5 If soil becomes acidic, the process of nitrification may no longer occur. What are consequences of this change for the nutrition of plants?
6 What are the basic aspects of a nutrient cycle? In your answer, describe the roles of compartments and fluxes.
7 How is soil formed from a parent material? Include the influences of physical and biological processes in your answer.
8 What are the major kinds of soil? How do they differ?
9 What are the key chemical transformations in the nitrogen cycle, and which ones are affected by human influences?

Module 2: Population Dynamics

Module Structure

In this module we will discuss about the population ecology, demography. regulation and dynamics with the following units:

Unit 1: Population Ecology
Unit 2: Population Patterns and Measurements

Unit 3 Population Growth
Unit 4: Population Regulation
Unit 5: Human Population Growth

Module 2: Population Dynamics

Unit 1: Population Ecology

Unit Structure

1.1 Population ecology

A population is a collection of interdependent species-specific creatures that includes individuals at all life stages, from pre-reproductive juveniles to reproductive adults. Most populations are made up of a mix of young and old people. You may determine the demographic makeup of a population by counting the number of people in each age group or stage. Population size, also known as population, and population density, which refers to how closely those individuals are clustered together, are two factors that distinguish populations in addition to demographic structure. The boundaries of a population's geographic range are determined by the physical conditions that the population can withstand, such as temperature or aridity, as well as by the encroachment of competing populations. Population ecologists often first consider the dynamics of population size change over time, of whether the population is growing in size, shrinking, or remaining static over time.

1.2 Intended Learning Outcomes (ILOs)

By the end of this unit you shall be able to:

Describe the characteristics of populations

Explain the Population characteristics of size, density, natality and mortality

Describe life tables and survivorship curve, types of survivorship curve and age distributions and pyramid

Describe population growth and fluctuations

1.3 Characteristics of Population

Some of the most important characteristics of population are as follows:
1. Population density 2. Natality 3. Mortality 4. Population growth 5. Age distribution of population 6. Population fluctuations.

1.3.1 Population Size and Density

The number of people in a population is the most basic demographic variable. The number of people living inside a geographical area that has been arbitrary assigned as the population size. Ecologists typically estimate population size by counting individuals within a small sample area and extrapolating that sample to the larger population because, despite the simplicity of the concept, it is nearly impossible to locate all individuals during a census (a full count of every individual). Despite the difficulties in determining population size, it is a crucial aspect of a population that has a big impact on how that population behaves overall. Based on their size, populations behave differently. Smaller populations are more vulnerable to extinction. Fewer people mate in these populations because it can be difficult for individuals to locate compatible partners; those who do run the risk of inbreeding. People in tiny populations are also more vulnerable to unplanned fatalities. Events like fires, floods, and diseases have a higher likelihood of wiping out the entire population. Large populations have their own set of issues. Large populations exhibit typical behaviour when they get close to the carrying capacity, or maximum sustainable population size. Greater resource competition, changes in the predator-prey interaction, and decreased fecundity are all symptoms of populations that are getting close to their carrying capacity. If the population expands too much, it can start to exceed the environment's carrying capacity and deteriorate the existing habitat. The size of any population in relation to some unit of space is referred to as population density. For example, 500 teak trees per hectare, 40 lions per 100 km2, and 5 million diatoms per cubic metre of water are some examples of how it is described in terms of the number of people or biomass per unit area or volume. The population density fluctuates across time and space and is rarely constant.
Population size can be measured by several methods:
(i) Abundance: Absolute number of individuals in population.
(ii) Numerical Density: Number of individuals per unit area or volume. It is expressed when the size of individuals in the population is relatively uniform, as in mammals, insects and birds.
(iii) Biomass Density: Biomass density is expressed in terms of wet weight, dry weight, volume, and carbon and nitrogen weight per unit area or volume.
Population density can be expressed in two ways:
(i) Crude Population Density: When the density is expressed with reference to total area at a particular time.
(ii) Ecological Density: when the density is stated in terms of the total area of the species's habitat. Because individual distribution patterns in nature vary, it is crucial to understand the relationship between ecological density and crude density. For example, individuals of some species, such as *Cassia tora* and *Oplismenus burmanni*, are found to be more crowded in areas with shade than in other areas of the same area. Therefore, the ecological densities would be estimated separately for the shaded and open areas, while the population density determined for the entire area would be crude density.
Population density can be calculated by the following equation:
$D = n/a/t$
Where D is population density; n is the number of individuals; a is area and t is unit time. Density of human population can be obtained by dividing the total number of persons in the area by the total land area of the region. Density of population of a country can be obtained by dividing the total number of persons living in the given region by total land area of that region. Average

population density in developing countries is more as compared to those in developed countries. Population density is affected by a number of environmental factors, such as geographical factors, mortality, natality, emigration and immigration and socio-economic factors.

1.3.2. Natality

Natality refers to the rate of reproduction or birth per unit time. It is an expression of the production of new individuals in the population by birth, hatching, germination or fission.

Natality is calculated by the following formula:

Birth rate or Natality (B) = Number of births per unit time/Average population.

Potential natality is the greatest number of births that a person can produce under perfect environmental conditions. It is also known as maximum natality, absolute natality, or biotic potential. Each organism has a unique natality. The population density and environmental conditions will determine this. It is a common rule that the birth rate will be low if the population density is typically low. This is true because there are few opportunities for males and females to mate. A low birth rate may also be caused by malnutrition, crowdedness-related medical or psychological issues, or extremely high population density. When the ecological and genetic conditions for the species are optimum, the highest or absolute natality is seen. In comparison to absolute natality, the actual number of births under the current environmental conditions is substantially lower. It is also known as realised natality or ecological natality. Population is not constant and may change with time as well as with population density.

1.3.3. Mortality:

Mortality refers to the number of deaths in population per unit time.

Mortality rate = D/t where D is the number of deaths in the time t.

Mortality can be expressed in the following two ways:

(i) Minimum or Specific or Potential Mortality: The actual number of births under the current environmental conditions is significantly less than absolute natality. It is sometimes referred to as ecological natality or realised natality. Population fluctuates throughout time and can vary depending on population density.

(ii) Ecological or Realized Mortality: It speaks about a population's demise due to current environmental circumstances. It is never continuous since it changes depending on the surrounding circumstances. The egg, larva, seedling, and old age have the highest mortality rates. Numerous elements, including density, competition, illness, predation, and environment, have an impact on mortality. The correlation between birth rates and death rates varies between species. The population is constant when the rate of natality is equal to the rate of mortality. A birth death ratio (Births/death x 100) is called vital index. For a population, the survival of individuals is more important than the death. One key element affecting the mortality rate is the ratio of births to the carrying capacity of the habitat. When there are more offspring than the habitat can support, the excess must either perish or move elsewhere. Mortality is best represented as survival or life expectancy because the number of survivors is more significant than the number of dying people. The average number of years that a population's members have left to live is referred to as the life expectancy. What is the meaning of vital index in population studies?

Self-Assessment Exercises 1

1. What is the difference between c**rude population density and ecological density?**
2. What is a **minimum or specific mortality?**

1.4 Life Tables and Survivorship Curve:

Regarding birth rates, average life spans, and mortality rates, the species vary. A life table that provides crucial statistics of mortality and life expectancy for people in various age groups in the population can be created when enough information about a species is available. The subscript index x, which is typically some convenient portion of the species life span, such as years or stage of development, is used in such tables to signify age. The life table is set up on the basis of an initial cohort or group of 100, 1000, 10,000 10, 00, 00 individuals and the number of living in the beginning of each successive age interval is symbolized as Ix. Plotting these data gives a survivorship curve for a species. The number of dying individuals within each age group is denoted as dx. The rate of mortality during each age interval (qx) is commonly expressed as the percentage of the number at the beginning of the interval.

qx = dx/lx x 100

Survival rate is the difference between the mortality rate and 100 per cent (i.e., 100 — qx) and is denoted by 5x. Life expectancy (ex), thus, is the mean time between any specified age and the time of death of all individuals in the age group.

1.4.1 Types of Survivorship Curve:

Plotting the number of survivors against time would result in a survivorship curve that looked like a right angle if it could be assumed that every member of an initial population has the same potential for survival (environmental variables are temporarily ignored). There are three common forms of survivorship curves, each of which depicts a different characteristic of survival in a particular population. (Fig. 1.).

Type I. Humans and most primates have a Type I survivorship curve. In a Type I curve, organisms tend not to die when they are young or middle-aged but, instead, die when they become elderly. Species with Type I curves usually have small numbers of offspring and provide lots of parental care to make sure those offspring survive.

Type II. Many bird species have a Type II survivorship curve. In a Type II curve, organisms die more or less equally at each age interval. Organisms with this type of survivorship curve may also have relatively few offspring and provide significant parental care.

Type III. Trees, marine invertebrates, and most fish have a Type III survivorship curve. In a Type III curve, very few organisms survive their younger years. However, the lucky ones that make it through youth are likely to have pretty long lives after that. Species with this type of curve usually have lots of offspring at once—such as a tree releasing thousands of seeds—but don't provide much care for the offspring.

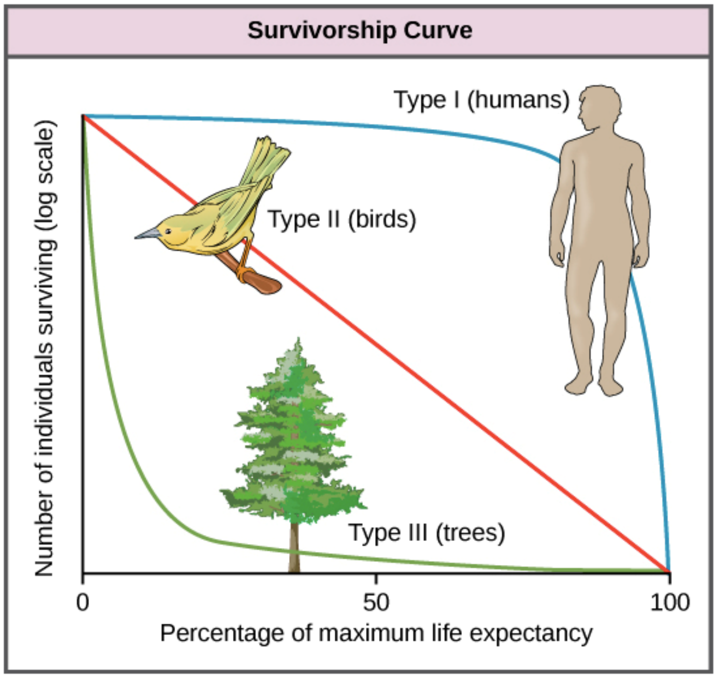

Figure 1. Showing the different types of survivorship curve
Source: https://www.khanacademy.org/science/biology/ecology/population-ecology/a/life-tables-survivorship-age-sex-structure

1.4.2 Population Growth:

One of the dynamic characteristics of a species' population is its expansion. The population grows in a recognisable way. A curve that shows the trend in the rise of population size in a particular time may be generated by plotting the population's number of individuals on the y-axis and the times on the x-axis. The population growth curve is the name of this curve. There are two types of growth curves:

(i) Sigmoid Curve: When a small number of organisms are introduced to an area, the population growth is initially very slow (positive acceleration phase or lag phase), then it accelerates quickly (logarithmic phase), and finally slows down (negative acceleration phase) until an equilibrium is reached Lund where the population size varies depending on environmental variability. The term "saturation level" or "carrying capacity" refers to the point beyond which no significant increase is possible. There is no population growth in the final phase since the number of new creatures is practically equal to the number of individuals who are dying. One obtains a sigmoid or 5-shaped growth curve in this method. (Fig. 2).

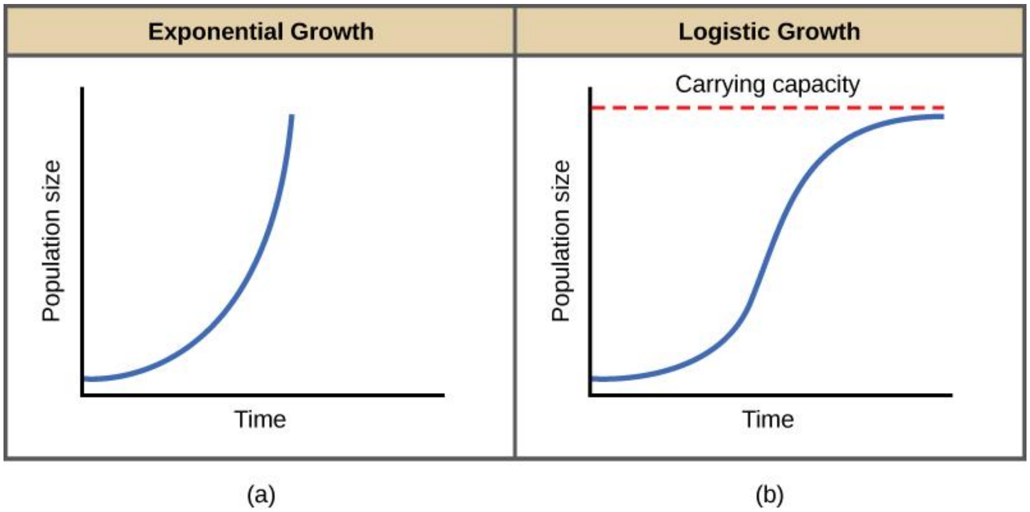

Figure 2. S-shaped and J-shaped population growth curves
Source: https://www.jobilize.com/biology2/course/19-2-population-growth-and-regulation-by-openstax?page=2
When resources are unlimited, populations exhibit (a) exponential growth, shown in a J-shaped curve. When resources are limited, populations exhibit (b) logistic growth. In logistic growth, population expansion decreases as resources become scarce, and it levels off when the carrying capacity of the environment is reached. The logistic growth curve is S-shaped.

(ii) J-Shaped Curve:
J-shaped growth curves are the second variety. Because it takes some time for the population to acclimate to the new environment, there isn't a rise in population size during this initial period. The population starts growing quickly as soon as it settles into the new surroundings. This population growth will continue until there is an abundance of food in the habitat. After some time, as the population grows, the habitat's food supply becomes scarce, which finally leads to a decline in the population. Because of this, the growth curve will be J-shaped rather than S-shaped. (Fig. 2). What is the consequence of type III survivorship growth curve?

Self-Assessment Exercises 2

1. Which organisms have a type I survivorship curve? 2. What creates populations exponential growth pattern?

1.5. Age Distribution:
Another crucial aspect of a population that affects natality and mortality is its age distribution. The likelihood of dying increases with age since it is more likely to do so in the early and late stages of life. Similar to this, natality is only possible in specific age groups, such as the middle age groups in higher animals. A population's people can be categorised into pre-reproductive, reproductive, and post-reproductive categories, in accordance with Bodenheimer (1958). Pre-reproductive group members are young, reproductive group members are mature, and post-reproductive group members are elderly. Age distribution may be uniform or irregular. It is intimately correlated with the population growth rate. Populations can be described as maturing, constant, or declining depending on the ratio of the three age groups. In other words, a population's

reproductive status is determined by the distribution of different age groups within it. A population that is rapidly growing has a high proportion of young people, a population that is stable has an even distribution of people in the reproductive age range, and a population that is declining has a high proportion of older people.

1.5.1 Age-sex structure

How can we determine whether a population will increase or decrease using the birth and death rates from a life table? We need a "snapshot" of the population as it is right now in order to accomplish this successfully. Consider two populations of bears, one made up primarily of females in their reproductive years and the other primarily of male bears who have passed their reproductive years. These populations will probably take different routes even if they have the same size and share the same life table—that is, they have the same rates of reproduction and survival at a given age. The first population is expected to expand because it contains a large number of bears that are in an ideal environment for giving birth to cubs. Due to the large number of bears that are nearing death and are no longer capable of reproducing, the second population is expected to decline. Therefore, while considering future population increase, who is already present in a population has a significant impact! A population pyramid is a common way to represent data regarding the age-sex composition of a population. Males are on the left axis and females are on the right, while the x-axis displays the percentage of the population in each category. Age groups are displayed on the y-axis from birth to old age.

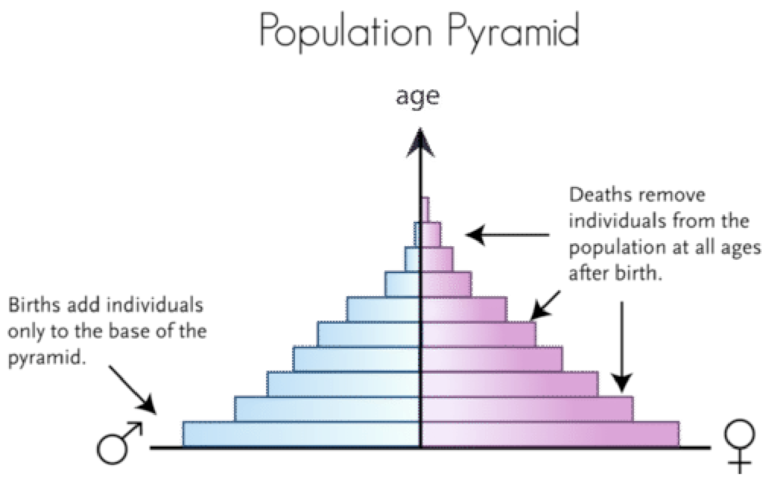

Figure 3. Population pyramid

Source: https://www.khanacademy.org/science/biology/ecology/population-ecology/a/life-tables-survivorship-age-sex-structure

It's common to see population pyramids used to represent human populations. In fact, there are specific shapes of pyramids that tend to be associated with growing, stable, and shrinking human populations, as shown below.

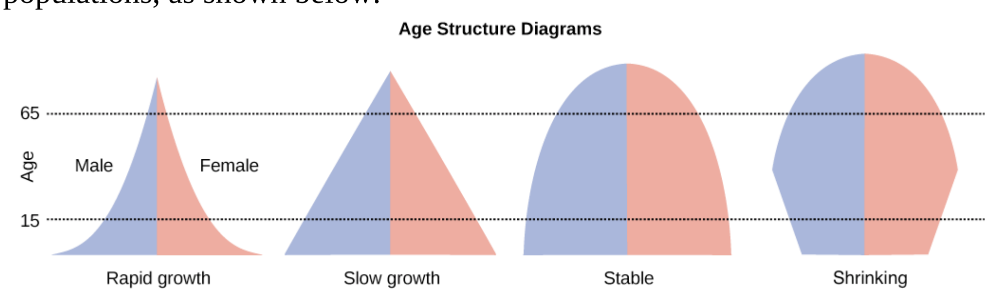

Figure 4. Age structure diagrams

Source: https://www.khanacademy.org/science/biology/ecology/population-ecology/a/life-tables-survivorship-age-sex-structure

Age structure diagrams in nations with high population increase have a sharp pyramid shape. In other words, they have a sizable proportion of younger people, many of whom are or soon will be of reproductive age. This pattern frequently occurs in nations with less developed economies, when access to resources such as healthcare and other resources has an impact on lifespan.

Slow-growing areas still feature pyramid-shaped age-sex systems, even more economically developed nations like the United States. In contrast to countries with high economic growth, the pyramid is not as acute, hence there are more elderly individuals than young, reproductive-age people. Other industrialised nations, like Italy, are experiencing little population increase. These populations' age distributions resemble a dome or a silo, with a higher proportion of middle-aged and elderly people than in the slow-growing example.

Finally, population sizes are actually declining in certain developed nations. For Japan, this is the situation. These nations often have a population pyramid that narrows toward the base, reflecting the fact that young people make up a relatively tiny portion of the population. These human examples' fundamental ideas apply to several communities in nature. A population is more likely to expand if there are significant proportions of young and fertile people. A population is expected to decline if a significant portion of the population is past the reproductive age.

1.5.2. Population Fluctuations

The size and density of natural population show a changing pattern over a period of time. This is called population fluctuation. There are three types of variations in the pattern of population change:

(i) Non-fluctuating: When the population remains static over the years, it is said to be non-fluctuating.

(ii) Cyclic: The cyclic variations may be (i) seasonal, and (ii) annual. Sometimes seasonal changes occur in the population and there are additions to the population at the time of maximum reproduction and losses under adverse climatic conditions. Common examples of seasonal variations are met in mosquitoes and houseflies which are abundant in particular season and so also the weeds in the field during the rainy season. When the population of a species shows regular ups and downs over the years, it is called annual cyclic variation. It appears in the form of a sigmoid curve with regular drops in population after peaks.

(iii) Irruptive: When the change in population density does not occur at regular intervals or in response to any obvious environmental factor, it is said to be irruptive fluctuation. In this there is a sudden exponential or logarithmic increase in population density in short time followed by equally quick drop in population density due to deaths, and final return to normal level or even below that level. What is population fluctuations?

.

Self-Assessment Exercises 1

1. What are the three types of variations in the pattern of population change?
2. What do we need to use the birth and death rates from a life table to predict if a population will grow or shrink?

1.6 Summary

Quantifying the number of people in each age group or stage, which reveals the demographic makeup of the population, has been the main focus of this unit. Population size, also known as population, and population density, which refers to how closely those individuals are clustered together, are two factors that distinguish populations in addition to demographic structure. The boundaries of a population's geographic range are determined by the physical conditions that the population can withstand, such as temperature or aridity, as well as by the encroachment of competing populations.

1.7 References/Further Readings/Web Sources

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1.8 Possible Answers to Self-Assessment Exercises

Answers to SAE 1

1. Crude population density is when the density is expressed with reference to total area at a particular time, whilwe ecological density is expressed with reference to total area of habitat available to the species.

2. Minimum or Specific or Potential Mortality represents the minimum of theoretical loss of individuals under ideal or non-limiting condition.

Answers to SAE 2

1. Humans and most primates have a Type I survivorship curve
2. When resources are unlimited, populations exhibit (a) exponential growth, shown as a J-shaped curve.

Answers to SAE 3

1. There are three types of variations in the pattern of population change:

(i) Non-fluctuating:

ii) Cyclic:

(iii) Irruptive:

2. To do this effectively, we need a "snapshot" of the population in its present state.

1. There are three types of variations in the pattern of population change:

(i) Non-fluctuating:

ii) Cyclic:

(iii) Irruptive:

2. To do this effectively, we need a "snapshot" of the population in its present state.

Unit 2: Population Patterns and Measurements

Unit Structure

2.1 Introduction

2.1 Introduction

Population biology is a field of study that explores populations and how they interact with their environment. Scientists observe all factors influencing a population within an ecosystem when gathering data about specific populations of interest.

1.2 Intended Learning Outcomes (ILOs)

By the end of this section, you will be able to:

- Describe how ecologists measure population size
- Describe three different patterns of population distribution
- Use life tables to calculate mortality rates
- Describe the three types of survivorship curves and relate them to specific populations

2.3 Population Biology

Populations are living things. The environment's seasonal and yearly fluctuations, natural catastrophes like forest fires and volcanic eruptions, and competition for resources among and within species are only a few of the many factors that affect their size and composition. Demography is the statistical study of populations; it uses a variety of mathematical techniques to define populations and track their evolution. Actually, many of these techniques were created to research human populations. For instance, life insurance firms initially created life tables, which describe the average life expectancy of people within a population, to determine insurance rates. In reality, while the name "demographics" is occasionally taken to refer to the study of human populations, same method can be used to examine all living groups.

Counting every person present is the most precise approach to estimate the population number. However, this approach is typically not practical from a logistical or financial standpoint, particularly when studying vast areas. As a result, when studying populations, scientists typically choose a representative sample from each habitat and use it to draw conclusions about the population as a whole. Most often, the characteristics of the organism being investigated are taken into account when choosing the sampling techniques to utilise to gauge population size and density. A quadrat can be used to measure the movement of small, slowly moving creatures or static species like plants. A quadrat is a square made of wood, plastic, or metal that is placed on the ground at random and used to count the number of people who are present inside its borders. This method requires placing the square at random spots across the habitat a sufficient number of times to generate an accurate assessment. The population size and density can be estimated using this counting technique. The type of organisms and the characteristics of their dispersion determine the quantity and size of quadrat samples. Mark and recapture is a common strategy for smaller mobile species like mammals. With this technique, a sample of caught animals is marked in some way before being released to rejoin the rest of the population. A new sample is then taken, and scientists count how many of the marked animals are present. Since they will have mixed with more unmarked individuals, this strategy believes that the greater the population, the lower the

percentage of marked organisms that will be recovered. The population size (N) can be calculated using the following equation, for instance, if 80 field mice are caught, marked, and released into the forest, followed by a second trapping in which 100 field mice are caught and 20 of them are marked:
number marked first catch × total number second catch   number marked second catch   = N
number marked first catch × total number second catch number marked second catch = N
Using our example, the population size would be 400.
80 × 100 20 = 400 80 × 100 20 = 400
These results give us an estimate of 400 total individuals in the original population. The true number usually will be a bit different from this because of chance errors and possible bias caused by the sampling methods. What is the most accurate way to determine population size?

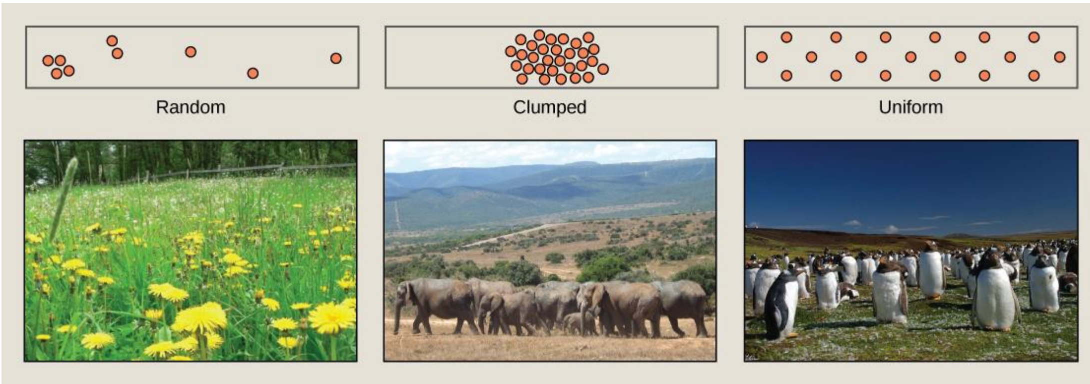
Self-Assessment Exercise 1

1. What is mark and recapture technique for the study of mobile organisms?

2. What is demography in population studies?

2.4 Species Distribution

In addition to counting the number of individuals in a population, you may learn more about it by examining how they are distributed across its range. The distribution of individuals within a habitat at a specific moment is referred to as a species distribution pattern; broad kinds of patterns are used to characterise them. Within a population, individuals may be randomly distributed, grouped, or similarly spaced apart (more or less). These are referred to, respectively, as random, clumped, and uniform distribution patterns. Different distributions represent crucial facets of the species' biology and have an impact on the mathematical techniques used to calculate population estimates. Dandelion and other plants that have wind-dispersed seeds that grow wherever they chance to fall in favourable circumstances are an example of random distribution. A clumped distribution can be seen in plants that drop their seeds directly to the ground, such oak trees, as well as in socially grouping animals (schools of fish or herds of elephants). Plants that emit compounds that stop neighbouring persons from growing show uniform dispersion (such as the release of toxic chemicals by sage plants). It can also be observed in animal species that are territorial, like penguins, which maintain a specific region for nesting. Each individual's territorial defence mechanisms result in a predictable pattern of distribution of similar-sized territories and the inhabitants therein. Consequently, the distribution of individuals within a population offers more insight into how they interact with one another than does a straightforward assessment of density. When compared to social species that congregate in groups, solitary species with a random distribution may experience comparable difficulties in locating mates as lower density species do.
IN-TEXT QUESTION (ITQ): What is the significance of species distribution pattern? Different distributions reflect important aspects of the biology of the species and also affect the mathematical methods required to estimate thier population sizes.



(a) (b) (c)

Figure 1. Species may have a random, clumped, or uniform distribution. Plants such as (a) dandelions with wind-dispersed seeds tend to be randomly distributed. Animals such as (b) elephants that travel in groups exhibit a clumped distribution. Territorial birds such as (c) penguins tend to have a uniform distribution.

Self-Assessment Exercise 1

1. What is species distribution pattern?
2. What are the three types of species distribution?

2.5 Life Tables

Life tables include crucial details about an organism's life cycle and the average lifespan of people at various ages. They are based on actuarial data that the insurance sector uses to calculate the average lifespan of people. The likelihood of each age group dying before their next birthday, the percentage of survivors dying at each age interval (mortality rate), and life expectancy at each interval are all possible inclusions in life tables. An example of a life table is shown in Table 1 from a study of Dall mountain sheep, a species native to northwestern North America. Notice that the population is divided into age intervals (column A). The mortality rate (per 1000) shown in column D is based on the number of individuals dying during the age interval (column B), divided by the number of individuals surviving at the beginning of the interval (Column C) multiplied by 1000.

mortality rate = number of individuals dying number of individuals surviving × 1000
mortality rate = number of individuals dying number of individuals surviving × 1000

For example, between ages three and four, 12 individuals die out of the 776 that were remaining from the original 1000 sheep. This number is then multiplied by 1000 to give the mortality rate per thousand.

mortality rate = 12 776 × 1000 ≈ 15.5 mortality rate = 12 776 × 1000 ≈ 15.5

As can be seen from the mortality rate data (column D), a high death rate occurred when the sheep were between six months and a year old, and then increased even more from 8 to 12 years old, after which there were few survivors. The data indicate that if a sheep in this population were to survive to age one, it could be expected to live another 7.7 years on average, as shown by the life-expectancy numbers in column E.

The amount of people who survive from one age group to the next is determined by life tables. Cohort life tables track a single cohort—a collection of people who were all born at the same time—until they pass away. Key presumptions for this demographic evaluation method include:
Each age group's population sample reflects its share in the overall population.

Since age-specific mortality rates were unchanged over that time, succeeding cohorts would have a similar birth and death pattern. Here's the best bit and the reason we bother to gather all the age-specific survivorship and fecundity information: if the assumptions (1 and 2 above) are met, then the sum of the product of survivorship and fecundity at each age gives a population growth parameter called R0 (pronounced R-nought), defined as the net reproductive rate. When R0 exceeds 1, the population is producing more offspring than it is losing from deaths. In other words, the population is growing. Is the population above growing, shrinking, or stable?
At what age is fecundity maximized? Survivorship? Because of life history trade-offs, patterns of age-specific survival are predictive of the general life history of a population. While a life table shows the survivorship in a numerical form, assessing pattern from columns of data is difficult. Instead, ecologists create survivorship curves by plotting lx versus time.

Table 1. Life Table of Dall Mountain Sheep

A	B	C	D	E
Age interval (years)	Number dying in age interval out of 1000 born	Number surviving at beginning of age interval out of 1000 born	Mortality rate per 1000 alive at beginning of age interval	Life expectancy or mean lifetime remaining to those attaining age interval
0–0.5	54	1000	54.0	7.06
0.5–1	145	946	153.3	—
1–2	12	801	15.0	7.7
2–3	13	789	16.5	6.8
3–4	12	776	15.5	5.9
4–5	30	764	39.3	5.0
5–6	46	734	62.7	4.2
6–7	48	688	69.8	3.4
7–8	69	640	107.8	2.6
8–9	132	571	231.2	1.9
9–10	187	439	426.0	1.3
10–11	156	252	619.0	0.9
11–12	90	96	937.5	0.6
12–13	3	6	500.0	1.2
13–14	3	3	1000	0.7

This life table of Ovis dalli shows the number of deaths, number of survivors, mortality rate, and life expectancy at each age interval for Dall mountain sheep.
Source: https://www.khanacademy.org/science/biology/ecology/population-ecology/a/life-tables-survivorship-age-sex-structure

2.5.1 Life history traits and their evolution

A population's members go through the stages of birth, development, adulthood, maturation, and decline into reproductive senescence. The way energy is distributed among these various aspects of an organism's survival is referred to as its life history, and this energy distribution results in traits that have an impact on survival and reproductive output, including size at birth, age at maturity, size at maturity, number and size of offspring (fecundity), reproductive value, lifespan, and senescence, which we will define as the decline in fecundity with age. Life history theory

explains how evolution optimises these reproductive and survival traits in various populations, influencing factors like how big and quickly people grow up, when they reach sexual maturity, how many children they have each time they conceive, how frequently they conceive, and when they die.
Reproduction and survival are "optimised," not "maximised," as you may have noticed. This is because, in most cases, while evolution improves one of these features, such as parent survival, it also tends to reduce another element of reproduction, such as the number of offspring produced annually. This optimization results in a life-history trade-off, which is represented as a conflict between reproduction and survival. (see figure below).

An organism's energy allocation split between survival and reproductive output is likely what leads to a life-history trade-off, which is represented as a negative relationship between survival and reproduction. Energy is viewed as the limiting component in trade-offs between survival and reproduction since organisms have a finite amount of energy and must use some of it to maintain their existence. Because of this, certain creatures, like the short-lived Chinook salmon, only reproduce once, whereas others, like Atlantic cod and humans, do so frequently. The rate of population increase and the carrying capacity of the environment can be related to selection for life history trade-offs between reproduction and survival. Recall that r is the intrinsic rate of natural increase of a population, and K is the environmental carrying capacity:
Life history traits that maximize growth rate (live fast, die young) are said to be r-selected, and include traits like having very large numbers of offspring, relatively small body size, early sexual maturity, broad dispersal of offspring, limited parental care, and short life-span. Species with r-selected life history traits include insects, bacteria, many types of plants, and some small mammals such as rodents. These species tend to exploit ecological niches where they are not limited by carrying capacity, in part because while they produce many many offspring, each individual offspring has a low chance of survival. Their population sizes can change dramatically over short periods of time.
K-selected life history traits include traits that are essentially the opposite of r-selected traits: relatively few offspring, relatively large body size, late sexual maturity, offspring that require a

great deal of parental care, and longer life span. These traits are selected for in organisms living at densities close to the environmental carrying capacity. Large organisms including many large mammals, several species of reptiles, and some species of birds are examples of species exhibiting K-selected life history features. These species' populations tend to be steady and close to their carrying capacity in the absence of a natural disaster, pandemic of a disease, or other catastrophic event. Regardless of whether a species has more r-selected or K-selected traits, individuals can have different likelihood of successful reproductive at different stages of their lives.
What are the meaning of r and l selected traits?

Self-Assessment Exercise 3

1. What is **net reproductive rate?**
2. Cohort life tables follow one group of individuals born at the same time, called a cohort, until the death of all individuals., what was the key assumptions of the technique?

2.6 Summary

You now know that the distribution, or dispersion, of the individuals that make up a population can be used to define that population. Individuals may be dispersed uniformly, randomly, or in clusters. You have also learned that in the life histories of organisms, individuals in a population go through a cycle of maturation into adulthood, decline into reproductive senescence, and birth, growth, and development. Life tables are useful in understanding the life history of an organism and the average lifespan of its members at various ages.

2.7 References/Further Readings/Web Sources

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2.8 Possible Answers to Self-Assessment Exercises

Answers to SAE 1

1. The mark and recapture method involves marking a sample of captured animals in some way and releasing them back into the environment to mix with the rest of the population; then, a new sample is captured and scientists determine how many of the marked animals are in the new sample.
2. Demography is the statistical study of populations where a set of mathematical tools designed to describe populations and investigate how they change.

Answers to SAE 2

1. A species distribution pattern is the distribution of individuals within a habitat at a particular point in time
2. Species may have a random, clumped, or uniform distribution.

Answers to SAE 3

1. the sum of the product of survivorship and fecundity at each age gives a population growth parameter called R0 (pronounced R-nought), when the following assumptions (The population sample of each age class is proportional to its numbers in the populationAge-specific mortality rates remain constant during the time period, meaning that subsequent cohorts will exhibit similar pattern of birth and death.) are met.
2. There are two assumptions of the technique:

i).The population sample of each age class is proportional to its numbers in the population
ii).Age-specific mortality rates remain constant during the time period, meaning that subsequent cohorts will exhibit similar pattern of birth and death.

Unit 3 Population Growth

Unit Structure

3.1 Introduction
3.2 Intended Learning Outcomes (ILOs)
3.3 Population Growth
3.4 Logistic Growth
3.5 Role of Intraspecific Competition
3.6 Summary
3.7 References/Further Readings/Web Sources
3.8 Possible Answers to Self-Assessment Exercises

3.1 Introduction

The most basic approach to population growth is to begin with the assumption that every individual produces two offspring in its lifetime, then dies, which would double the population size each generation. However, populations with unlimited natural resources grow very rapidly, which represents an exponential growth, and then population growth decreases as resources become depleted, indicating a logistic growth.

3.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you shall be able to:

- Define population growth, exponential growth, logistic growth, and carrying capacity.
- Compare and distinguish between exponential and logistic population growth equations and interpret the resulting growth curves.
- Compare and contrast models of population growth in the presence and absence of carrying capacity (K).
- Analyze graphs to determine if regulation is influenced by density.

3.3 Population Growth

The simplest method for analysing population growth is to start with the supposition that each person has two children during their lifetime before passing away, which would result in a population size that doubles every generation. If a bacteria had limitless resources, it would reproduce in an optimal way by doubling its number every generation. The two most basic models of population growth describe the rate of change in population size over time using deterministic equations (equations that do not take into account random events). Exponential growth, the first of these models, describes hypothetical populations that grow in size without any upper bound. The second model, logistic growth, places restrictions on the rate of reproduction that get tighter as the population gets bigger. Both models can be compared, although no one fully captures natural populations. Thomas Malthus, an English theologian, had a significant influence on Charles Darwin's theory of natural selection. In a book that was released in 1798, Malthus claimed that people grow exponentially when given unlimited access to natural resources, and logistically as those resources are used up. Bacteria provide the best example of exponential development in living things. Prokaryotes like bacteria mostly reproduce by binary fission. Many bacterial species require roughly an hour to complete this division. After just one hour, 1000 bacteria will have doubled to 2000 if they are placed in a big flask with a plentiful supply of nutrients (so the nutrients won't fast decrease). Each of the 2000 germs will divide after another hour, creating 4000 bacteria. There ought to be 8000 bacteria in the flask after the third hour. The key idea behind exponential growth is that the population size grows at an ever-increasing pace as a result of the growth rate, or the number of organisms added with each reproductive generation. The population would have grown from 1000 to more than 16 billion bacteria after 24 of these cycles. When the population size, N, is plotted over time, a J-shaped growth curve is produced. The bacteria-in-a-flask illustration does not accurately depict the actual world, where resources are frequently scarce. However, a species may exhibit exponential growth for a while when it is brought into a new habitat that it finds acceptable. Since there will be some bacteria that die in the flask during the experiment and are unable to reproduce, the growth rate is reduced from the maximum pace at which there is no mortality. A population's growth rate is primarily calculated by deducting the birth rate, B, from the death rate, D, (number of organisms that perish during a period) (number organisms that are born during an interval). The growth rate can be expressed in a simple equation that combines the birth and death rates into a single factor: r. This is shown in the following formula:

Population growth = rNPopulation growth = rN

The value of r can be positive, meaning the population is increasing in size (the rate of change is positive); or negative, meaning the population is decreasing in size; or zero, in which case the population size is unchanging, a condition known as zero population growth.

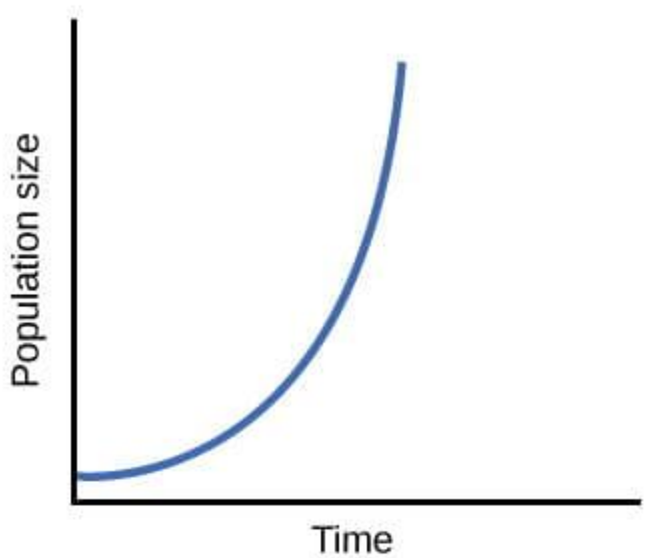

Figure 1. When resources are unlimited, populations exhibit exponential growth, resulting in a J-shaped curve. Source: https://www.khanacademy.org/science/biology/ecology/population-ecology/a/life-tables-survivorship-age-sex-structure

The population growth rate in this graphic is constant since the number of births and deaths at each time point remains constant across time. For this population of size N, the intrinsic rate of natural increase, or constant known as r, is the product of the population's birth rate (b) and death rate (d). The population size times the growth rate yields the change in population size over time, and this formula for exponential growth aids in our understanding of the growth pattern through time. Despite the fact that the value of r remains constant over time, the population in this model doesn't increase linearly since every person born in a given generation reproduces. As a result, the population quickly multiplies. In the natural world, a population expanding at this astronomical rate would swiftly deplete all habitat and resources. Natural populations have size constraints imposed by the environment, contrary to the exponential growth equation paradigm.

$$\frac{dN}{dt} = rN$$

How can a growth rate of a population be determined?
Self-Assessment Exercise 1

1. How would you express the growth rate in a simple equation that combines the birth and death rates into a single factor: *r*.?
2. What does the two simplest models of population growth use to describe the rate of change in the size of a population over time?

3.4 Logistic Growth

Extended exponential growth is possible only when infinite natural resources are available; this is not the case in the real world. In his depiction of the "fight for existence," Charles Darwin acknowledged this fact, stating that individuals will compete (with members of their own or other species) for scarce resources. The successful ones have a higher chance of surviving and passing on their qualities to the following generation at a faster pace (natural selection). The logistic growth model was created by population ecologists to simulate the reality of scarce resources.

Carrying Capacity and the Logistic Model

In the actual world, when resources are scarce, exponential growth cannot last forever. When there are few people and lots of resources available, exponential growth may occur; however, as the population grows, the resources become scarce and the growth rate slows. The growth rate will eventually level out or plateau (Figure 1a). The carrying capacity, abbreviated K, refers to the population size that is determined by the highest population density that a specific environment can support. In actual populations, a growing population frequently exceeds its carrying capacity, and as a result, the population size declines back to the carrying limit or lower as the death rate rises beyond the birth rate. Instead of existing exactly at the carrying capacity, most populations typically oscillate about it. The carrying capacity is included in the method for calculating logistic growth as a moderating factor in the growth rate. The number of people who can be added to a population at one time is denoted by the expression "K - N," and the portion of the carrying

capacity that is still available for expansion is denoted by "K - N" divided by "K." This constraint prevents the exponential growth model from producing the logistic growth equation:
Population growth = rN [K−NK]Population growth = rN [K−NK]
Notice that when N is almost zero the quantity in brackets is almost equal to 1 (or K/K) and growth is close to exponential. When the population size is equal to the carrying capacity, or N = K, the quantity in brackets is equal to zero and growth is equal to zero. A graph of this equation (logistic growth) yields the S-shaped curve (Figure 1b). Compared to exponential growth, it is a more accurate representation of population expansion. An S-shaped curve is divided into three halves. In the beginning, growth is exponential due to the low population and abundant resources. The growth rate then slows as resources start to become scarce. When the environment's carrying capacity is reached, the growth rate levels off and the population barely changes over time.

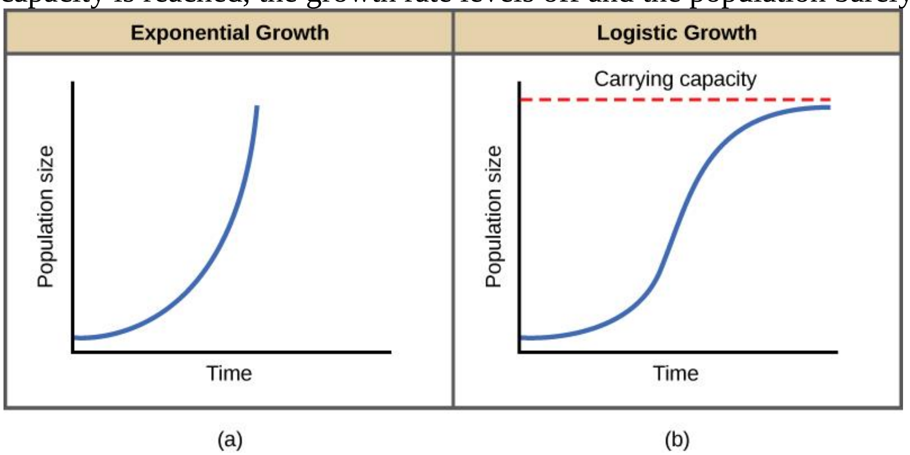

Figure 1. When resources are unlimited, populations exhibit (a) exponential growth, shown in a J-shaped curve. When resources are limited, populations exhibit (b) logistic growth. In logistic growth, population expansion decreases as resources become scarce, and it levels off when the carrying capacity of the environment is reached. The logistic growth curve is S-shaped.
Why is the formula used to calculate logistic growth adds the carrying capacity?

Self-Assessment Exercise 2

1. When is an extended exponential growth is possible?
2. What is the carrying capacity (or K) of a population referred to?

3.5 Role of Intraspecific Competition

According to the logistic model, each member of a population will have equal access to resources and a similar probability of surviving. The key resources for plants are water, sunlight, nutrients, and space to flourish; whereas for animals, the key resources are food, water, shelter, nesting space, and mates. In the actual world, phenotypic variation among populations results in certain members of the population being more adapted to their surroundings than others. Intraspecific competition is the word used to describe the resource competition that results among population members of the same species. Since resources are abundant and everyone can get what they need, populations that are far below their carrying capacity may not be affected by intraspecific competition. However, as population size increases, this competition intensifies. In addition, the accumulation of waste products can reduce carrying capacity in an environment. Examples of Logistic Growth: Yeast, a microscopic fungus used to make bread and alcoholic beverages, exhibits the classical S-shaped curve when grown in a test tube. Its growth levels off as the population depletes the nutrients that are necessary for its growth. In the real world, however, there are variations to this idealized curve. Examples in wild populations include sheep and harbor seals. In both examples, the population size exceeds the carrying capacity for short periods of time and then falls below the carrying capacity afterwards. This fluctuation in population size continues to occur as the population oscillates around its carrying capacity. Still, even with this oscillation, the logistic model is confirmed. What is the resulting competition for resources among population members of the same species called?

Self-Assessment Exercises 3

1. What can cause the deceleration of an exponential population growth? 2. What is the example of **Logistic Growth in wild populations**

3.6 Summary

Population growth is the term used to describe changes in population size over time, which can be either positive or negative based on the ratio of births to deaths. The population of the globe will increase very slowly or possibly stop growing if there are numerous deaths. Depending on particular environmental factors, two different patterns of population expansion may manifest: In a perfect, limitless environment, an exponential growth pattern (J curve) manifests itself. When environmental pressures slow the rate of growth, a logistic growth pattern (S curve) develops.

3.7References/Further Readings/Web Sources

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3.8 Possible Answers to Self-Assessment Exercises

Answers to SAE 1

1. This is shown in the following formula:

Population growth = rNPopulation growth = rN

Where the value of r can be positive, meaning the population is increasing in size (the rate of change is positive); or negative, meaning the population is decreasing in size; or zero, in which case the population size is unchanging, a condition known as zero population growth.

2. The two simplest models of population growth use deterministic equations (equations that do not account for random events) to describe the rate of change in the size of a population over time.

Answers to SAE 2

1. Extended exponential growth is possible only when infinite natural resources are available and this is not the case in the real world.

2. The carrying capacity, or K is the population size, which is determined by the maximum population size that a particular environment can sustain,.

Answers to SAE 3

1. As exponential growth occur in environments where there are few individuals and plentiful resources depletion of resources due to increased population numbers will slow down growth rate

2. Examples in wild populations include in sheep where the population size exceeds the carrying capacity for short periods of time and then falls below the carrying capacity afterwards.

Unit 4:Population Regulation

Unit Structure

4.1 Introduction

These population characteristics are often displayed in a life table. Population ecologists make use of a variety of methods to model population dynamics. An accurate model should be able to describe the changes occurring in a population and predict future changes.

4.2 Intended Learning Objectives

By the end of this section, you will be able to:

Explain how population size is regulated by factors that are dependent or independent of population density

Compare and contrast density-dependent growth regulation and density-independent growth regulation giving examples

Explain density-independent regulation and Interaction with density-dependent factors

Describe the demographic-based population models

4.3 Regulation of Population Size

Population size can vary depending on both biological and non-biological variables. Interspecific interactions including predation, competition, parasitism, and mutualism as well as disease are examples of biological variables. Environmental parameters include temperature, precipitation, disturbance, pollution, salinity, and pH are examples of non-biological influences. All of these factors have the ability to alter population growth, but only biological factors—with the exception of mutualism—can "regulate" a population by driving it to its carrying capacity, or equilibrium density. Mutualisms do not control population size among biological factors since they encourage population growth through advantageous interactions with other species. Different biological mechanisms that control population growth have an impact on dense vs sparse populations, such as competition and predation. For instance, communicable disease doesn’t spread quickly in a sparsely packed population, but in a dense population, like humans living in a college residence

hall, disease can spread quickly through contact between individuals. Density plays a key role in population regulation in the following ways:
Territoriality: Maintaining a territory will enable an individual to capture enough food to reproduce, where space is a limiting resource.
Disease: Transmission rate often depends on population density
Predation: Predators may concentrate on the most abundant prey
Toxic Wastes: Metabolic by-products accumulate as populations grow
Identifying evidence of density regulation requires a field or lab experiment that manipulates density and quantifies the response in population growth. Often an (easier to measure) proxy of population growth, like survival or reproductive output, stands in as a quick metric of the births and deaths that will impact population growth. The characteristic negative correlation in the image below is evidence of density-dependent population regulation: higher densities yield lower survival. What are non-biological factors of the environment?

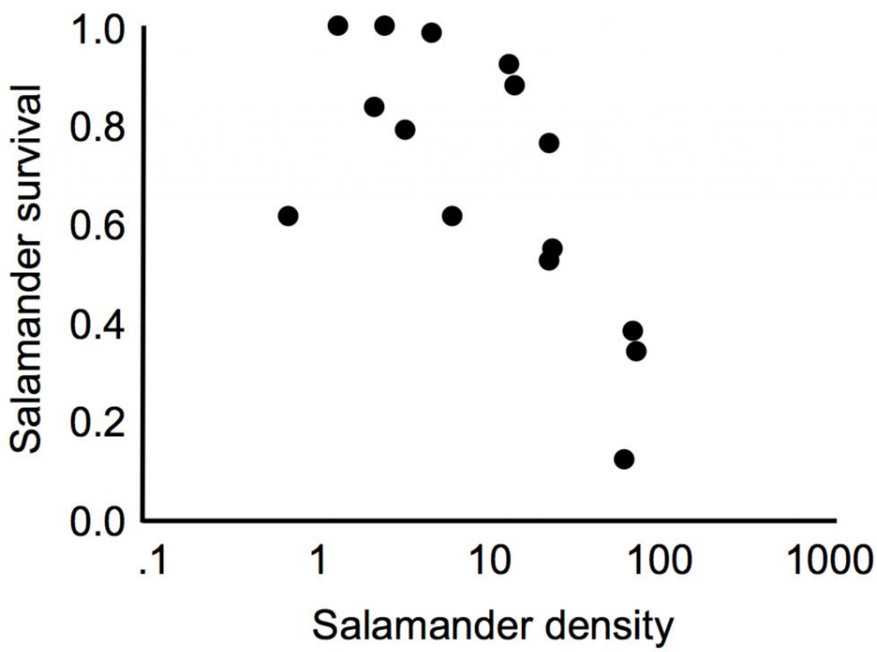

Figure 1. Manipulated salamander (Ambystoma laterale) larval density in the field
Source: https://openstax.org/books/concepts-biology/pages/19-introduction
Self-Assessment Exercises 1

> 1. Mention any five biological factors that can influence population size.
>
> 2. What is the advantage of maintaining territoriality by organisms?

4.4 Density Dependent and Density in-dependant Factors

Despite being useful and applicable in many natural populations, the logistic model of population growth is a simplification of actual population dynamics. The model makes the assumption that the environment's carrying capacity remains constant, which is false. Every year, the carrying capacity changes. In many regions, the carrying capacity during the winter is substantially lower than it is during the summer, for instance, some summers are hot and dry while others are chilly and damp. Natural occurrences like earthquakes, volcanoes, and fires can also change the ecosystem and, as a result, the carrying capacity. Furthermore, groups typically do not coexist in isolation. With other species, they coexist in the same environment and compete for the same resources (interspecific competition). These elements are crucial for comprehending how a certain population will expand. Numerous mechanisms exist to control population growth. These are divided into two categories: density-dependent factors, which impact growth rate and mortality depending on population density, and density-independent factors, which affect mortality regardless of population density. Understanding both categories is important for wildlife biologists in particular since it allows them to manage populations and avoid extinction or overpopulation.

4.4.1 Density-dependent Regulation

Predation, intra- and interspecific competition, and parasites are some biological aspects of density-dependent variables. Typically, a population's death rate increases with population density. For instance, the species' reproductive rates will often be lower during intra- and interspecific competition, slowing the rate of population expansion. Additionally, because the predator has a harder time locating its food supply, low prey density raises the mortality rate of the prey. Additionally, illness transmission rates increase with population density, which has an impact on death rates. In a field study including populations of wild donkeys at two locations in Australia, density-dependent regulation was investigated. A population control programme lowered the population on one site, but had no effect on the population at the other. In comparison to the low-density plot, the high-density plot was twice as dense. While donkey density increased in the low-density plot from 1986 to 1987, it decreased in the high-density plot. Death rates, not birth rates, were the main factor in the two populations' divergent growth rates. The number of children each mother gave birth to was shown to be unaffected by density, according to the researchers. The main reason for the disparity in growth rates between the two populations was the high rate of infant mortality brought on by maternal malnutrition in the dense population. Figure 2. shows the difference in age-specific mortalities in the two populations.

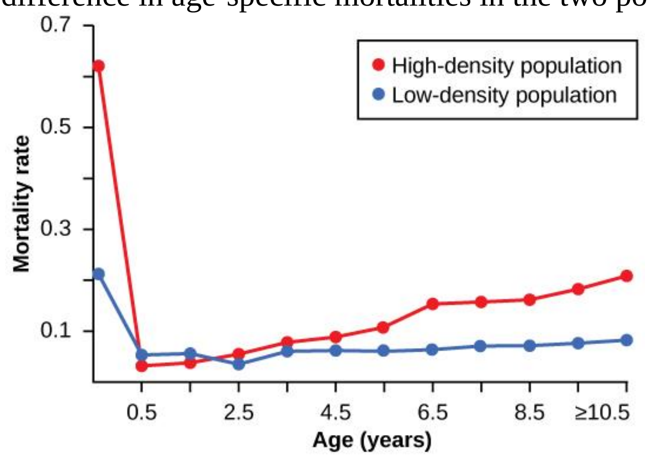

Figure 2. This graph shows the age-specific mortality rates for wild donkeys from high- and low-density populations. The juvenile mortality is much higher in the high-density population because of maternal malnutrition caused by a shortage of high-quality food.

4.4.2 Density-Independent Regulation and Interaction with Density-dependent Factors

Regardless of population density, a number of causes that are primarily physical in nature cause death in a community. These elements include the climate, calamities caused by nature, and pollution. No matter how many deer happen to be around, a single deer will perish in a forest fire. Whether there is a large or low population density, its odds of survival are the same. The chilly winter weather is no different. Population control in the actual world is extremely complex, and independent and dependent factors may interact. A dense population will be able to recover differently than a sparse population if it experiences mortality due to a density-independent cause. For instance, if there are more deer left after a particularly difficult winter, the population of deer will recover more quickly. Why is it said that the logistic model of population growth is a useful model, but is a simplification of real-world population dynamics?

Self-Assessment Exercise 2

1. How can population growth be regulated?

2. List any three factors that are typically physical in nature cause mortality of a population regardless of its density.

4.5 Demographic-Based Population Models

Population ecologists have proposed that some traits may evolve in species and result in specific environmental adaptations. The type of population expansion that their species experiences is influenced by these adaptations. Just like anatomy or behaviour, life history traits like birth rates, age at first reproduction, number of children, and even death rates change with time, resulting in adaptations that have an impact on population expansion. K-selected species are on one end of a continuum of life-history "strategy," and r-selected species are on the other, according to population ecologists. Species chosen by K are adapted to predictable, steady surroundings. K-selected species' populations often coexist at or near their carrying capacity. These species often produce fewer, but larger, offspring, and provide substantial resources to each child. Population ecologists have proposed that some traits may evolve in species and result in specific environmental adaptations. The type of population expansion that their species experiences is influenced by these adaptations. Just like anatomy or behaviour, life history traits like birth rates, age at first reproduction, number of children, and even death rates change with time, resulting in adaptations that have an impact on population expansion. K-selected species are on one end of a continuum of life-history "strategy," and r-selected species are on the other, according to population ecologists. Species chosen by K are adapted to predictable, steady surroundings. K-selected species' populations often coexist at or near their carrying capacity. These species often produce fewer, but larger, offspring, and provide substantial resources to each child.

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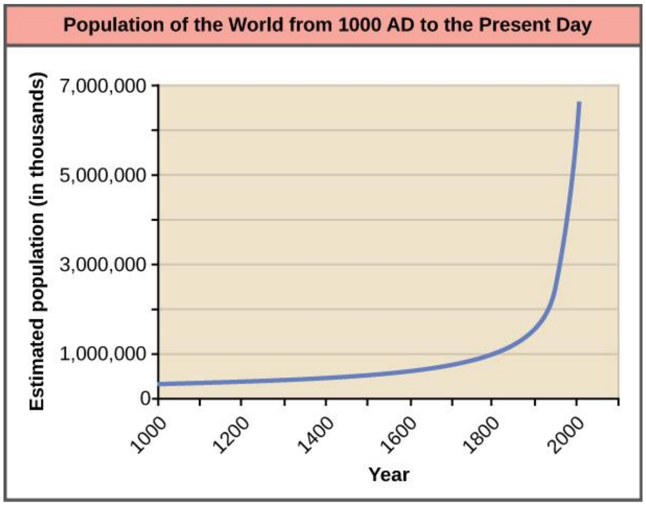

Figure 4 Human population growth since 1000 AD is exponential.

The time it takes to add a certain number of persons to the population is getting shorter as a result of exponential growth rate. Figure 4 demonstrates that while it took 123 years between 1804 and 1930 to add 1 billion people, it only took 24 years between 1975 and 1999 to add 2 billion. In the ensuing decades, this growth rate's acceleration is probably going to start to slow down. Despite this, the population will continue to grow and the risk of overpopulation persists, in part because the harm done to ecosystems and biodiversity is reducing the planet's ability to support human population growth.

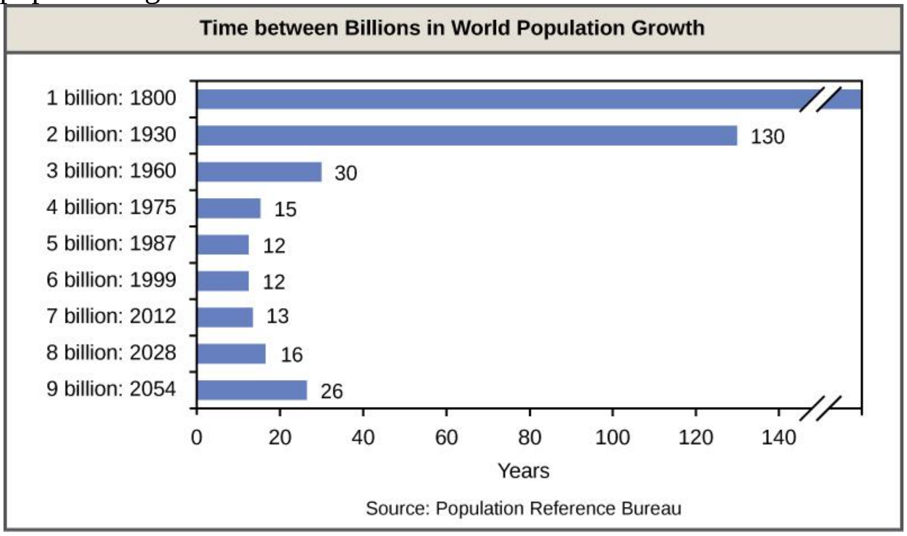

Figure 5. The time between the addition of each billion human beings to Earth decreases over time. (credit: modification of

Self-Assessment Exercise 3

1. How has population ecologists described a continuum of life-history "strategies"? 2.What is the strategy of K-selected species?

4.6 Summary

Populations are regulated by a variety of density-dependent and density-independent factors. Species are divided into two categories based on a variety of features of their life history patterns: r-selected species, which have large numbers of offspring, and K-selected species, which have few offspring. The r– and K-selection theory has fallen out of use; however, many of its key features are still used in newer, demographically-based models of population dynamics.

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4.8 Possible Answers to SAEs

Answers to SAE 1

1. Biological factors include interspecific interactions like predation, competition, parasitism, and mutualism, as well as disease.

2. Maintaining a territory will enable an individual to capture enough food to reproduce, where space is a limiting resource.

Answers to SAE 2

1 Population growth is regulated in a variety of ways: These are grouped into density-dependent factors, in which the density of the population affects growth rate and mortality, and density-independent factors, which cause mortality in a population regardless of population density.

2. Many factors that are typically physical in nature cause mortality of a population regardless of its density. These factors include weather, natural disasters, and pollution.

Answers to SAE 3

1. Population ecologists have described a continuum of life-history "strategies" with K-selected species on one end and r-selected species on the other.

2. K-selected species are adapted to stable, predictable environments.

Unit 5: Human Population Growth

Unit Structure

5.1 Introduction
5.2 Intended Learning Outcomes (ILOs)
5.3 Overcoming Density-Dependent Regulation
5.4 Age Structure, Population Growth, and Economic Development
5.5 Long-Term Consequences of Exponential Human Population Growth
5.6 Summary

5.1 Introduction

Concepts of animal population dynamics can be applied to human population growth. Humans are not unique in their ability to alter their environment. Humans, however, have the ability to alter their environment to increase its carrying capacity sometimes to the detriment of other species Earth's human population is growing rapidly, to the extent that some worry about the ability of the earth's environment to sustain this population, as long-term exponential growth carries the potential risks of famine, disease, and large-scale death.

5.2 Intended Learning Outcomes (ILOs)

By the end of this section, you will be able to:

- Explain how to overcome density dependent regulation
- Relate population growth and age structure to the level of economic development in different countries
- Explain how humans have expanded the carrying capacity of their habitat
- Describe the long-term consequences of exponential human population growth

5.3 Overcoming Density-Dependent Regulation

Humans are the only species that can change their surroundings in so many different ways. Because it resets the carrying capacity and gets beyond density-dependent growth regulation, this ability is what drives the increase in the human population. This skill has a lot to do with communication, society, and human intelligence. To expand their food supplies, humans have developed agriculture, tamed animals, and built shelters to protect themselves from the weather. Language is also used by people to pass on this technology to future generations, enabling them to build on earlier achievements. Migration and public health are other elements in the increase of the human population. The region that humans have colonised has grown since our ancestors left Africa and spread to almost every continent with habitable terrain. In affluent nations, the potential of infectious diseases to constrain human population growth has lessened thanks to public health, sanitation, and the use of medicines and vaccinations. Between 30 and 60 percent of the inhabitants in Europe died from diseases like the bubonic plague in the fourteenth century, which also caused a global population decline of up to 100 million people. The increase of the human population is still being impacted by infectious disease. For instance, life expectancy in sub-Saharan Africa began to drop after 1985, primarily as a result of HIV/AIDS mortality, after increasing from 1950 to 1990. According to estimates for 2005, HIV/AIDS reduced life expectancy by 7 years.
Lower birth rates are a result of declining life expectancy, which is a sign of rising mortality rates. The reduction in mortality brought on by the development of industrial age technologies, the urbanisation that supported those technologies, and especially the exploitation of the energy in fossil fuels has been the fundamental reason for the acceleration of the growth rate for humans over the past 200 years. Because of agriculture's use of machinery, herbicides, and fertilisers, as well as the taking of wild populations, fossil fuels have significantly increased the resources that can support the growing human population. What is the key ideas of density-dependent regulation?
Self-Assessment Exercise 1

1. What factors regulates population growth?

2. How can humans overcome density-dependent factors?

5.4 Age Structure, Population Growth, and Economic Development

Population dynamics heavily depends on the age composition of a population. A population's age distribution is referred to as its age structure. Age structure can be incorporated into models to improve population growth forecasting and to link that growth to a region's economic success. Age structure diagrams in nations with rapid growth have a pyramidal shape, indicating a majority of younger people, many of whom are of reproductive age (Figure 1). This tendency is most frequently seen in developing nations with large birth rates and subpar living circumstances, where people are less likely to live to old age. The age structure of regions with moderate growth, including industrialised nations like the United States, still has a pyramidal structure, but there are a lot fewer people who are young and of reproductive age and a lot more people who are older. Other industrialised nations, like Italy, are experiencing little population increase. These populations' age distribution is more conical, with an even higher proportion of middle-aged and older people. Figure 2 depicts the real growth rates in various nations, with the largest rates typically occurring in the less economically developed nations of Asia and Africa.

How can the age structure of population affect economic development?

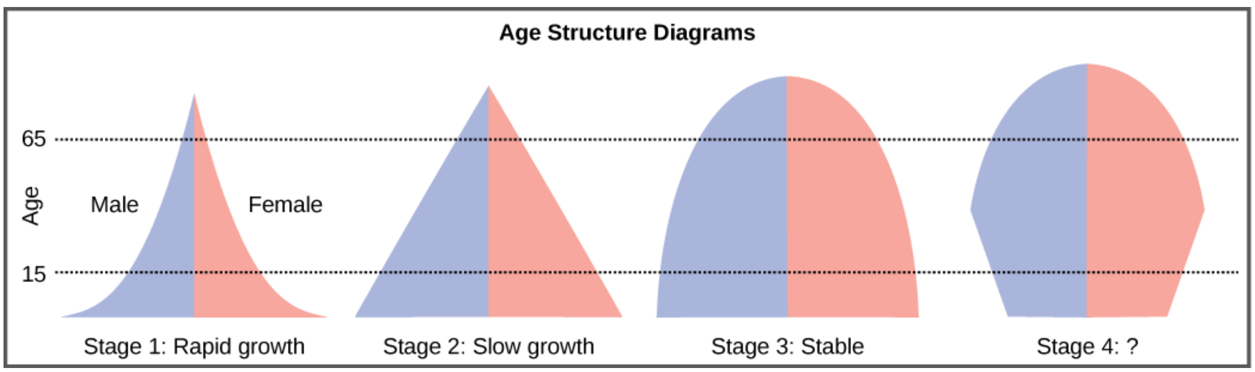

Figure 1. Typical age structure diagrams are shown.
Source: https://bio.libretexts.org/@api/deki/files/2192/Figure_45_05_03.png?revision=1

The rapid growth diagram constricts to a point, showing that the population shrinks quickly as people get older. According to the slow growth model, the population gets smaller as people get older. The top of stable population graphs is rounded, indicating that the proportion of people in each age group steadily declines and then rises as the population ages.Age structure diagrams for rapidly growing, slow growing and stable populations are shown in stages 1 through 3. What type of population change do you think stage 4 represents?

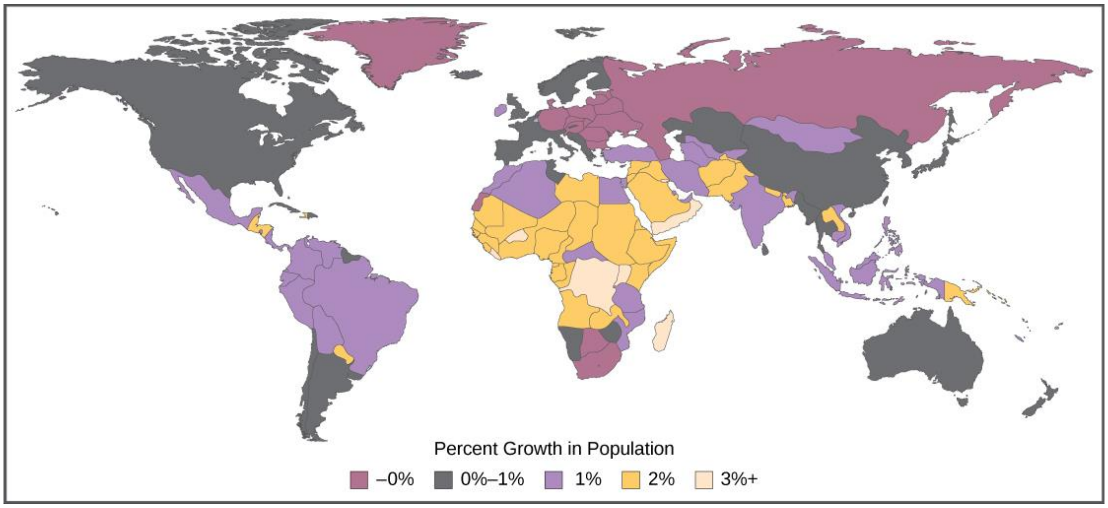

Figure 2. The percent growth rate of population in different countries is shown. Notice that the highest growth is occurring in less economically developed countries in Africa and Asia.
Source: https://bio.libretexts.org/@api/deki/files/2192/Figure_45_05_03.png?revision=1

Self-Assessment Exercise 2

1. How do population growth and age structure relate to the level of economic development in different countries?
2. What do age structures have to do with population growth?

5.5 Long-Term Consequences of Exponential Human Population Growth

Numerous ominous forecasts regarding the world's population growth and the ensuing "population explosion" have been made. The battle to feed the whole human race has been won, according to biologist Dr. Paul R. Ehrlich's 1968 book The Population Bomb. Despite whatever crash programmes implemented today, hundreds of millions of people would starve to death in the 1970s. Nothing can currently stop a significant rise in the global death rate. Although many sceptics think this claim is overstated, unfettered human population increase cannot go on forever because of the laws of exponential population growth. Numerous ominous forecasts regarding the world's population growth and the ensuing "population explosion" have been made. The battle to feed the whole human race has been won, according to biologist Dr. Paul R. Ehrlich's 1968 book The Population Bomb. Despite whatever crash programmes implemented today, hundreds of millions of people would starve to death in the 1970s. Nothing can currently stop a significant rise in the global death rate. Although many sceptics think this claim is overstated, unfettered human population increase cannot go on forever because of the laws of exponential population growth. Inequalities in access to food and other resources will keep growing as more food must be produced to support our growing population. By the year 2100, the world population, according to the UN, might be anywhere between 6 billion (a drop) and 16 billion. It is impossible to predict if the rate of population growth will slow down to the degree where a potential crisis may be avoided. The alteration and degradation of the natural environment are additional effects of population increase. Many nations have made an effort to minimise greenhouse gas emissions in an effort to lessen the effects of human activity on climate change. A global climate change treaty is still difficult, though, and many developing nations attempting to better their economic standing may be less reluctant to consent to such conditions if doing so will slow down their own economic progress. Furthermore, in certain industrialised nations, particularly the United States, the contribution of human activity to climate change has emerged as a contentious sociopolitical issue. In order to preserve the carrying capacity for the human species, we must be able to control the rate of population growth and safeguard the environment. What are some consequences of the increases in human population growth?

Self-Assessment Exercise 3

1. What are the consequences of exponential population growth of any population? 2. What is the biggest problem with exponential population growth?

5.6 Summary

he world's human population is growing at an exponential rate. Humans have increased the world's carrying capacity through migration, agriculture, medical advances, and communication. The age structure of a population allows us to predict population growth. Unchecked human population growth could have dire long-term effects on our environment.

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5.8 Possible Answers to SAEs

Answers to SAE 1

1. Population growth rate is affected by birth rates, death rates, immigration, and emigration. If a population is given unlimited amounts of food, moisture, and oxygen, and other environmental factors, it will show exponential growth.

2. Overcoming Density-Dependent Regulation, Humans can construct shelter to protect them from the elements and have developed agriculture and domesticated animals to increase their food supplies.

Answers to SAE 2

1. Age structure data allow the rate of growth (or decline) to be associated with a population's level of economic development. For example, the population of a country with rapid growth has a triangle-shaped age structure with a greater proportion of younger individuals who are at or close to reproductive age.9 Jun 2022

2. Countries with lower median age tend to have higher population growth rates. Lower-income countries tend to have a lower median age. This is because they have a 'younger' population overall: high fertility rates across these countries mean they have larger populations of young children and adolescents.

Answers to SAE 3

1. A consequence of exponential human population growth is the time that it takes to add a particular number of humans to the Earth is becoming shorter. Figure 2 shows that 123 years were

necessary to add 1 billion humans in 1930, but it only took 24 years to add two billion people between 1975 and 1999.

2. Exponential growth in a finite world is at the crux of many environmental issues including: climate change, biodiversity loss, and deforestation. Human population growth is an excellent example of how exponential growth can negatively affect our environmental systems.

Glossary

age structure: Proportion of population members at specific age ranges
age-specific: The age of the individual is important for statistical purposes.
clutch size: The number of offspring one female produces in one reproductive cycle.
cohort: Group of all individuals sharing a statistical factor (such as age or developmental stage)
density-dependent factors: Depending on the local density of the population
density-independent factors: Not linked to the local density of the population
discrete developmental stages: Non-overlapping and structurally distinct growth stages.
ecosystem: A natural system including the interaction of all living and non-living elements.
extinction: No longer existing.
extrapolating: Estimating an unknown value by assuming that a known value can translate (without distortion) to the scale of the unknown value.
growth rate: The rate of change of population size over time.
inbreeding: Breeding of closely related individuals, often with negative genetic consequences.
incubated: Provided with a heat source during embryonic development.
life tables: Specific format of statistical summary of demographic parameters.
migration: Populations moving from one geographic location to another.
objectively: To study without bias and by measurable and repeatable metrics.
offspring: The individual produced from the reproduction of its parents.
one-child policy: China's policy to limit population growth by limiting urban couples to have only one child or face the penalty of a fine
parameter: A value in an equation that does not vary. These values can change between different equations of similar form.
predator-prey relationships: How populations of predators are interacting with populations of prey.
predation: The act of killing another living organism for food.
physiological: The parts and functions of living organisms.
reproductive organs: Specialized collection of cells used to exchange gametes between sexually reproducing organisms.
rates: A mathematical term for the number of things or events happening in a given amount of time.
rearing: To invest energy in the growth and development of offspring after they are born.
subjectively designated geographic range: A parcel of land, the size of which is chosen without using standardized criteria. Picked at the discretion of the researcher.
sustainable: System able to be maintained itself indefinitely without supplement.
sexual maturation: An individual reaching a stage of development where it is able to sexually reproduce.
stress hormone: Chemical compounds synthesized in the body to chemically communicate a stress reaction to various systems within that organism.

statistic: A number acting as a description for more numbers.
theoretical: A rational, rather than practical, description of natural phenomena. Often using mathematical, conceptual, or mechanical models to study the underlying functional framework of nature.

End of Module Questions

What are examples of population demographics?

What are the three main areas of population demography?

What is population demography in ecology?

What are the types of population regulation?

Why is population regulation important?

What is the main factor of population regulation?

What factors regulates population growth?

Why is population dynamics important?

What are the major components of population dynamics?

What are the three main factors affecting population dynamics?

Module 3: Biological Communities

Module Structure

In this module we will discuss about the biological communities and ineractionswith the following units:

Unit 1: Ecological Communities
Unit 2: Community Organization and Functioning
Unit 3: Biogeography
Unit 4: World Biomes
Unit 5: Marine and Freshwater Biomes

Unit 1 Ecological Communities

1.1 Introduction

In this unit, you learn about community ecology, also known as synecology, which examines interactions between species in groups over a wide range of temporal and spatial scales, including distribution, population dynamics, structure, abundance, and demography.

1.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you will be able to:

- Define a Community Ecology
- Differentiate between community vs. ecosystem
- Describe the properties of a community
- Explain the types and importance of communities
- Describe the characteristics of communities

1.3 Community Ecology

Synecology, another name for community ecology, is the study of how species interact with one another throughout a wide variety of temporal and spatial scales, including distribution, population dynamics, structure, abundance, and demography. In biology, the term "community" describes the collection of coexisting, interacting organisms, whether they are of the same species or not. Members of a community tend to influence each other's abundance, distribution, adaption, and existence as a result of their interactions. Community function and community structure are two of its key characteristics. Community function is related to energy flow, community resilience, and community resistance while community structure is related to biotic composition.

Communities share similar traits aside from these qualities. These include ecological successions, ecotone-edge effect, spatial organisation, species interactions, and periodicity. A community can be as little as an assemblage found in a pond or a tree or as large as a biome, which is an enormous regional or worldwide biotic association. The word "community" has long been used to refer to a collection of people who may or may not live in the same place. A community in this sense would be one whose members, regardless of where they are located, share similar hobbies, languages, customs, manners, laws, or cultures. A modern community, for instance, is one that is constructed on a holistic, healthier, and eco-friendly design with the aim of coexisting peacefully with environment and other living forms. A community in biology is a collection of interacting organisms, regardless of whether they belong to the same species or not. Through symbiotic relationships, such as mutualism, parasitism, commensalism, or competitiveness, they interact with one another. The affiliation of a group (or groups) of species that co-habit a geographic area for a specific period of time is referred to as a community in ecology. To be precise, an ecological community refers to the assemblage of living organisms having symbiotic relationships among themselves, and thus functioning, at least to some degree, as an ecological unit.

1.3.1 Community vs. Ecosystem

Ecosystem and ecological community are two distinct but related ideas. While a community refers to a collection of species interacting and coexisting in a certain area, an ecosystem is a more comprehensive idea. An ecosystem is made up of both living beings and the surrounding physical environment, which together performs as a single entity. Therefore, an ecosystem would consist of both biotic and abiotic elements that are interconnected, particularly in terms of energy and biogeochemical cycling. The abiotic elements may not be included in the definition of an ecological community, but they nevertheless have an impact on the community's structure, pattern, abundance, and stability. In light of everything, numerous communities would make up an ecosystem in a specific environment. For a more detailed comparison between community and ecosystem, see the table below.

Table 1: Difference Between Community and Ecosystem

Community	Ecosystem
Comprised of biotic factors interacting and living together in a habitat	Comprised of biotic factors (living things) and abiotic factors (non-living things) in a particular environment
Basic biotic components are producers (e.g. plants), consumers (e.g. animals), and decomposers (e.g. bacteria)	Basic biotic components are producers, consumers, and decomposers whereas abiotic components are climatic factors (e.g. sunlight, humidity, temperature, atmosphere, etc.), edaphic factors (soil type, the geology of the land, etc.), and social factors (e.g. land use, water resources, etc.)
Community examples: Grassland communities Bird communities	Ecosystem examples: Forest ecosystem, comprised of various ecological communities co-inhabiting and interacting with one another as well as with their environment

Deciduous forest communities	Taiga ecosystem Stillwater ecosystem

1.3.2 Properties of Community

Identifying a biological community can be challenging since assemblages of organisms may occasionally overlap. However, they have unique qualities, such as community structure and function. The biotic composition of the community has to do with community structure. It includes the variety and quantity of species as well as the trophic interactions that were developed by a community's inhabitants. Additionally, resistance, resilience, and energy flow all contribute to community function. The movement of energy across different trophic levels in a food chain is an example of how energy flows in a community. Resistance and resilience are two crucial qualities. Because both biotic and abiotic changes can affect assemblages of organisms, stability requires that these changes be resisted. A stable community is one that can withstand these changes or at the very least bounce back from them. Resilience is the ability to recover from a perturbation or disturbance, whereas resistance is the act of ignoring the effects of the perturbation or disturbance. However, determining or measuring the equilibrium state might be challenging. Finding the point of stability can occasionally require years of study. What is a stable community in ecology?

Self-Assessment Exercise 1

1. What are the major properties of a community?

2. What is the meaning of Community structure?

1.4 Types and Importance of Communities

The size of communities can vary and overlap. Communities might be categorised as major or minor in this way. Larger geographic areas are covered by major communities, which appear to be independent of nearby settlements. Minor communities tend to be more or less reliant on nearby assemblages and are comparatively smaller. As a result, a significant community may be made up of smaller villages. Additionally, a community can be categorised as either open or closed. An open community is one where the creatures, especially the plants, are dispersed and new invasions are therefore feasible. The creatures are grouped together in a tight community. As a result, the area is no longer open to any new habitation by any organism. Communities are crucial because they enable interaction between species. For a variety of reasons, including nourishment, species interact with one another within a community. Animals, for example, are unable to produce their own food and must thus rely on plants and other living things for sustenance. On the other hand, plants can create their own through photosynthesis. However, one of the main sources of carbon dioxide for them comes from animals. As a waste product of mammalian metabolism, this gas is produced. It is required by plants as a chemical reactant during photosynthesis. They give off oxygen in exchange, which the animals breathe in to meet their metabolic needs. In addition to food, community members might also offer a safe haven. A tree, for instance, can be a habitat for various organisms, such as epiphytes, lichens, insects, and arachnids. What is the most important reason for species interaction in a community?

Self-Assessment Exercise 2

1. What is the striking difference between an open and closed community?

2. Why is it that some communities are considered as major in the ecosystem?

1.5 Characteristics of Community

Apart from the distinctive properties, communities share common features that can be useful for their identification. Some of the major characteristics of a community are as follows: i) Species diversity, ii). Species interactions iii). Spatial structure, iv). Periodicity, v). Ecotone and the edge effect, and vi). Ecological successions.

i). Species diversity

For a variety of reasons, including nourishment, species interact with one another within a community. Animals, for example, are unable to produce their own food and must thus rely on plants and other living things for sustenance. On the other hand, plants can create their own through photosynthesis. However, one of the main sources of carbon dioxide for them comes from animals. As a waste product of mammalian metabolism, this gas is produced. It is required by plants as a chemical reactant during photosynthesis. They give off oxygen in exchange, which the animals breathe in to meet their metabolic needs. In addition to food, community members might also offer a safe haven. The principal producers in a community are frequently the foundation species. Due to their ability to transform light energy into chemical energy, they supply the majority of the community's energy. They can store energy in biological substances like carbohydrates. They may act as a food source for other creatures, such as the consumers, as a result of this ability. As decomposers break down decaying or dead organic materials, consumers (and producers) provide nutrients for them. There is often a dominating population in a community that exerts more influence than the others. Ecological dominants are the name given to this dominant species. In a community, plants are frequently the dominating ecological species. As a result, they are frequently utilised as the foundation for community names, such as oak forest community, grass community, etc. Keystone species are yet another unique category of species. Because its eradication could cause the colony to disintegrate, this species is regarded as a key. Maintaining biodiversity and preserving the community's structure depend on keystone species. The banded tetra fish, which in nature contributes a significant amount of phosphorus to the population, is an illustration of a keystone species. As a result, eliminating this fish species could result in the extinction of its community.

ii). Species interactions

As a result, they are frequently utilised as the foundation for community names, such as oak forest community, grass community, etc. Keystone species are yet another unique category of species. Because its eradication could cause the colony to disintegrate, this species is regarded as a key. Maintaining biodiversity and preserving the community's structure depend on keystone species. The banded tetra fish, which in nature contributes a significant amount of phosphorus to the population, is an illustration of a keystone species. As a result, eliminating this fish species could result in the extinction of its community.

iii). Spatial structure

As a result, they are frequently utilised as the foundation for community names, such as oak forest community, grass community, etc. Keystone species are yet another unique category of species. Because its eradication could cause the colony to disintegrate, this species is regarded as a key.

Maintaining biodiversity and preserving the community's structure depend on keystone species. The banded tetra fish, which in nature contributes a significant amount of phosphorus to the population, is an illustration of a keystone species. As a result, eliminating this fish species could result in the extinction of its community.

iv). Ecotone

An ecotone can be used to identify adjacent settlements. The dividing line between two communities is an ecotone. Because it is frequently in a state of transition, it is more likely to be denser and wealthier than the two surrounding municipalities. Edge species are those that are constrained near the ecotone. Streams that cross through meadows and estuaries where rivers meet the sea are two examples of ecotones.

v). Periodicity

Periodicity can be used to forecast biological activity in a population because they are frequently rhythmic. As an illustration, some creatures (diurnal) are active during the day whereas others are active at night (nocturnal). Circadian rhythms have an impact on a wide variety of living things in a community.

vi). Community dynamics

Communities may be impacted by a disturbance (such as a volcanic eruption, fire, earthquake, etc.). For instance, a community that was formerly stable might not be able to return to balance following a shock. The original community might be replaced by a new one when this occurs. The term for this is ecological succession.

vii). Ecological succession

Ecological succession is the long-term, directional change that occurs in a region's communities. Primary succession and secondary succession are the two forms. A community colonises a newly developed land in primary succession. After the disruption, a new community succeeds the original one in secondary succession. The pioneer plants, such grasses and perennials, are frequently where the pattern begins. After some time, taller plant species (such pines and shrubs) begin to grow. The term "intermediary species" is used to describe them. Eventually, more developed plant species develop (e.g. oak and hickory). The assembly is referred to as the peak community after stability is attained (again). We maintain equilibrium until the next perturbation. What are the two types of ecological succession?

Self-Assessment Exercise 3

1. List the major characteristics of a community

2. What is an ecological succession?

1.6 Summary

Community ecology is the study of how communities, which are assemblages of interacting populations of the species residing in a specific area or habitat, are organised and function. Identifying a biological community can be challenging since assemblages of organisms may occasionally overlap. However, they possess unique qualities, i.e. community structure and community function. This was the basis of unit 1 of this module.

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1.8 Possible Answers to Self Assessment Exercises

Answers to SAE 1

1. **The t**wo of its major properties are community structure and community function.

2. Community structure pertains to the biotic composition of the community.

Answers to SAE 2

1. An open community is a community wherein the organisms, particularly plants, are distantly placed and therefore new invasion is possible. A closed community is one in which the organisms are closely placed. Thus, it is closed for any organism to further inhabit the area

2. Major communities span larger geographic areas and apparently independent over neighboring communities.

Answers to SAE 3

1. The major characteristics of a community are as follows: i) Species diversity, ii). Species interactions iii). Spatial structure, iv). Periodicity, v). Ecotone and the edge effect, and vi). Ecological successions.

2. Ecological succession refers to the directional and progressive change of communities in a given area over time.

Unit 2: **Community Organization and Functioning**

Unit structure

2.1Introduction

Communities are populations of many species of organisms living together in the same habitat or environment. The habitats vary from terrestrial to aquatic and so, influence the types of communities living in them. We shall learn in this unit what make up communities, the types and how they are structured.

2.2 Learning Outcomes

By the end of this unit, you should able to;

- Explain the meaning of community organization
- Understand the influence of co-evolution on communities
- Describe the pyramid structure of communities
- Explain the role played by biotic and abiotic factors oncommunities.
- Determine what influence the species richness of a community.
- Describe community keystone species and types

2.3 Community Organization

Community ecology is the study of how communities, which are assemblages of interacting populations of the species residing in a specific area or habitat, are organised and function. Species populations come together to form biological communities as a result of their interactions. These communities provide as excellent examples of what is meant by the word "biodiversity" due to the large number of interacting species and the complexity of their relationships. Communities develop structures as a result of species interaction, leading to the development of food chains, food webs, guilds, and other interacting webs. These connections alter over the course of evolution as species coevolve together and adapt to one another. Below are descriptions of the general organisation of biological communities, the structure of interspecific interactions, and the impacts that the coevolutionary process has on the biological community.

Community ecologists investigate how structures and organisms interact. Ecological niche features, species richness, and species composition are described by structure. Species engage in a variety of interactions with one another and their surroundings, such as battling for limited resources or cooperating to catch game. Communities heavily rely on population dynamics.

The food chain's constituent species can be seen producing and transferring energy using the energy pyramid. The broad base of the pyramid is made up of heterotrophic providers of sunlight-derived useable food energy.

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The food chain's constituent species can be seen producing and transferring energy using the energy pyramid. The broad base of the pyramid is made up of heterotrophic providers of sunlight-derived useable food energy.

A trophic pyramid is a basic interactional structure shared by all biological populations. Food energy is transferred from one trophic level to the next along the food chain, which is represented by the trophic pyramid (see below Food chains and food webs). Autotrophic species, or the primary producers of the environment, make up the pyramid's base. They don't get their nourishment and energy from eating other living things. Instead, they use photosynthesis (photoautotrophs) or, less

frequently, oxidation (chemoautotrophs) to convert inorganic materials into organic ones. All other organisms in the ecosystem are consumers known as heterotrophs, and they all rely on the producers of food and energy, either directly or indirectly. As organisms use energy for metabolic operations like keeping warm and digesting food, energy at each trophic level within all biological communities is lost as heat (by as much as 80 to 90 percent). The amount of energy available to an organism decreases with its position on the trophic pyramid; plants have more energy available than herbivores and detritivores (primary consumers), which have less energy than carnivores that feed on them (secondary consumers) and those that eat other carnivores (tertiary consumers).
The coevolutionary process is defined as the interaction and evolution of species in reaction to one another. One of the main mechanisms by which biological communities are organised is through coevolutionary processes, which refer to these reciprocal evolutionary changes in interacting species. Local populations of interacting species adapt to one another through coevolution, occasionally even creating new species in the process. Researchers must distinguish between features that have coevolved and those that were previously present in ancestors before the interspecific interaction started in order to comprehend how coevolution influences interactions within communities. Hummingbirds, for instance, use their wings and beak to access the nectar found inside flowers. A hummingbird with a long bill may have coevolved with a particular species of flower, but coevolution did not give rise to the hummingbird's wings. Birds had wings before hummingbirds appeared on the scene. Therefore, it is important to investigate both the evolutionary ecology and the history (phylogeny) of the interacting species. The tree shows when each species within a lineage first appeared as well as when each novel characteristic first appeared. The ecological studies can then demonstrate how each of those characteristics has been used and shaped by various ecological contexts. What does a community structure describe?

Self-Assessment Exercise 1

1. What is the relationship between energy and position of species on the trophic level?

2. What is the coevolutionary process?

2.4 The Pyramid Structure of Communities

A hummingbird with a long bill may have coevolved with a particular species of flower, but coevolution did not give rise to the hummingbird's wings. Birds had wings before hummingbirds appeared on the scene. Therefore, it is important to investigate both the evolutionary ecology and the history (phylogeny) of the interacting species. The tree shows when each species within a lineage first appeared as well as when each novel characteristic first appeared. The ecological studies can then demonstrate how each of those characteristics has been used and shaped by various ecological contexts. The biological communities that surround hydrothermal vents on the ocean floor are the most bizarre of all. These vents are the result of both volcanic activity and continental plate movement, which causes seabed cracks. Hydrogen sulphide accumulates in the water that seeps into the fractures, which then rises back to the ocean floor after being cooked by magma deep in the Earth's mantle. The heated, sulfur-rich water surrounding these fractures supports a thriving community of sulfur-oxidizing bacteria (chemoautotrophs). Reduced sulphur serves as the bacteria's energy source when fixing carbon dioxide. These deep-sea ecosystems, unlike any other known biological communities on Earth, rely on geothermal energy instead of solar energy since the energy they use to function is derived from chemosynthesis rather than photosynthesis. While some of the nearby species eat the sulphur bacteria, other species have developed long-lasting, mutually beneficial interactions (mutualistic symbioses) with sulphur bacteria. These organisms ingest the chemoautotrophic bacteria and receive all of their sustenance from them. Since the 1980s, when biological research of these vents began, about 200 new species have been described, and there are many more that remain undescribed—that is, not formally described and given scientific names. This is because the biological communities surrounding these vents are so different from those in the rest of the ocean. There are at least 75 new genera, 15 new families, one new order, one new class, and even one new phylum among the described species.

Each trophic pyramid is made up of a number of interconnected feeding interactions known as food chains because all species have specialised diets. The majority of food chains have three or four trophic levels. Plant, herbivore, carnivore, and top predator are examples of usual sequences. Another sequence is plant, herbivore, parasite of the herbivore, and parasite of the parasite. However, many herbivores, detritivores, carnivores, and parasites consume more than one species, and many animal species consume various diets at various times throughout their lives. Many species also consume both plants and animals, feeding at many trophic levels. As a result, food chains merge to form incredibly intricate food webs. Even a simplified food web can show a complicated network of trophic relationships.

Self-Assessment Exercise 2

1. Are the organisms that make up the base level of the pyramid in terrestrial and freshwater the same ?
2. What are the most unusual biological communities in the ecosystem?

2.5 Keystone Species

However, even a fully developed food web can only offer a cursory and static glimpse of the organisation of biological communities. Not all interspecies connections are equally crucial to population dynamics, evolutionary change, and community structure. Strong and weak relationships between species occur in food webs, and the strength of these interactions affects how communities are structured. Some species, known as keystone species, have an unreasonably significant impact on the communities in which they are found. By regulating populations of species that would otherwise dominate the community or by providing essential resources for a variety of species, they aid in maintaining local diversity within a community. A crucial species in the rocky marine intertidal communities off the northwest coast of North America is the starfish *Pisaster ochraceus*. This starfish predator, which feeds on the California mussel *Mytilus californianus*, is in large part responsible for preserving the local biodiversity of species in some populations. When the starfish were experimentally removed, the mussel populations quickly grew and completely covered the rocky intertidal shoreline, making it impossible for other species to establish themselves. As a result, the interaction between Pisaster and Mytilus promotes the communities' structure and species diversity. However, the starfish has little overall impact on the community's organisation in other Pisaster-affected areas. As a result, a species may not be a keystone species in all communities. Figs and a few other plants play a keystone species role in some tropical American forest communities, although they do it significantly differently from the starfish Pisaster. Many birds and mammals rely extensively on this small collection of plant species during the seasons of the year when other food resources are sparse since figs yield fruit all year long in some of these forest communities. Many species would vanish from the community without figs.

2.5.1 Guilds and Interaction Webs

The majority of communities are made up of guilds, which are collections of species that use the same resources in similar ways. The word "guild" underlines how similar these organisations are to guilds of craftsmen who use comparable methods to practise their trade. Different insect species that gather nectar in similar ways might form guilds, as can different bird species that use equivalent insect-foraging strategies or different plant species that have developed similar floral designs that draw in the same pollinators.

Guilds frequently consist of collections of closely related species that shared an ancestor. Due to their common ancestry, they use resources in comparable ways. As a result, a guild within a community may consist of numerous species belonging to the same genus. Unrelated species making up a guild is a less frequent but not unheard-of event.

It is not surprising that guild members frequently compete for the resources they share because they participate in similar activities, especially when those resources are limited. The rivalry between the guilds serves as a reminder that other forms of contact than food webs are essential to the community's structure. In addition to competing for resources, species interact with one another in a variety of ways. Numerous animals work together to get food or fend off predators. These and other nontrophic relationships between species are as important as food chains and food webs in shaping the organization of biological communities

2.5.2 Types of Communities

Biological communities are named according to their locations onland or water. Three major communities can therefore be identified as follows.

i. Terrestrial communities

The main terrestrial communities of creatures are mostly shaped by the climate, especially the temperature and rainfall, which are in turn determined by the planet's geography. Terrestrial communities are referred to as biomes, and they can be identified by their distinctive climates and general look. Every biome, which is distinguished from other types of biomes primarily by the general characteristics of the flora, has a similar structure and appearance throughout the world. There are other ways to categorise biomes, one of which will be used later in this lesson.

ii. Ocean communities

The oceans cover around three-quarters (3/4) of the earth's surface. The world's oceans are extremely rich in nutrients and biomass, especially in warm coastal areas and the planktonic layer of the surface zone. Oceanic photosynthetic productivity is thought to account for about 40% of the global total. Although marine environments are home to members of nearly every phylum, an estimated 90% of all extant species are terrestrial. Habitats in brackish water typically lie between freshwater and marine environments.

iii. Freshwater communities

Only a small portion of the water on Earth is preserved as freshwater in ponds, rivers, and lakes. Although they are smaller in scope than marine or terrestrial ecosystems, freshwater habitats are distinct from both. Running water makes up around 0.3% of the earth's surface, whereas inland lakes cover about 1.8%. Swamps and marshes serve as transitional habitats and connect all freshwater habitats to terrestrial ones. There are three zones where organisms can be found in lakes and ponds. The shallow shoreline area is known as the littoral zone. Plankton and other organisms that live in open water are found in the limnetic zone, which is the well-lit surface water that is located far from the shore. The region below the maximum effective light penetration is known as the profundal zone. Some communities however take their names from physical features for example, rock pools, lakes and sand dunes. Specialized communities do also occur e.g. the mammalian gut communities. Where do we find Brackish water habitat?

Self-Assessment Exercise 3

> 1. What are the three major types of biological communities?
>
> 2.What are the nontrophic relationships between species are as important as food chains and food webs in shaping the organization of biological communities?

2.6 Summary

In this unit we have learnt that;

- A community is a grouping of populations of many species that livein the same place, an environment or habitat.
- Many different organisms interact to determine the structure of the community.
- Interactions between organisms within a community have arisenout of their evolutionary history under what is termed co-evolution.
- The major types of communities are terrestrial, ocean or marineand freshwater. Specialized communities can also occuregmammalian gut communities.
- Community structures are determined by biotic and abiotc factors.

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2.8 Possible Answers to Self-Assessment Exercises

Answers to SAEs 1

1. The higher the organism is on the trophic pyramid, the less energy is available to it
2. It is the reciprocal evolutionary changes that evolve when pairs or group of species in interact with one another

Answers to SAEs 2

1. They are not the same. They vary from community to community, in terrestrial communities, multicellular plants generally form the base of the pyramid, whereas in freshwater lakes a combination of multicellular plants and single-celled algae constitute the first trophic level.

2. The most unusual biological communities of all are those surrounding hydrothermal vents on the ocean floor. These vents result from volcanic activity and the movement of continental plates that create cracks in the seafloor.

Answers to SAEs 3

1. The three major types of biological communities are:
i. Terrestrial communities ii. Ocean communities iii. Freshwater communities
2. Species cooperative interaction to search for food or avoid predators

Unit 3: Biogeography

Unit Structure

3.1 Introduction

You will learn about biogeography, as the study of the geographic distribution of living things and the abiotic factors that affect their distribution. The abiotic factors that affect the global distribution of plant and animal species, those that can impact aquatic and terrestrial environments will be highlighted.

3.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you will be to:
•Define biogeography?
• Give examples of abiotic factors that affect the global distribution of plant and animal species?
• Explain how abiotic factors can impact aquatic and terrestrial environments?
• Describe the effects of abiotic factors on net primary productivity

3.3 Introduction to Biogeography

The study of biogeography examines how living entities are distributed geographically and how abiotic causes may have an impact on that distribution. Latitude and elevation play a major role in the variation of abiotic elements like temperature and rainfall. The make-up of plant and animal communities changes as these abiotic elements do. For instance, you would see progressive changes in plant communities if you started your tour in the equator and walked north. You would observe broad-leaved evergreen trees in tropical wet forests at the start of your journey, which are typical of plant communities found close to the equator. These broad-leaved evergreens would eventually give place to seasonally dry woodlands with scattered trees as you travelled north. Additionally, you would start to notice fluctuations in humidity and temperature. These forests would transition into deserts, which are characterised by little precipitation, around roughly 30 degrees north. As you travel further north, you will see that deserts give way to grasslands or prairies. Grasslands eventually give way to deciduous temperate woods. The subarctic, or the region south of the Arctic Circle, is where these deciduous forests give place to the boreal forests. At the greatest northern latitudes, you would eventually arrive at the Arctic tundra. This journey north highlights the types of creatures that have adapted to environmental conditions linked with habitats found at various latitudes, as well as slow changes in climate. However, abiotic elements like jet streams, the Gulf Stream, and ocean currents contribute to the existence of various ecologies at the same latitude. The changes in the vegetation you would witness if you climbed a mountain would be similar to those you would experience as you moved to higher latitudes. Biogeographic ecologists look at patterns of species distribution. No species can be found everywhere; the Venus flytrap, for instance, is confined to a narrow region in North and South Carolina. A species that is endemic is one that can only be found naturally in a small, defined area of land. Others are generalists, inhabiting a wide range of habitats; the raccoon, for instance, is indigenous to most of North and Central America. Early studies of biogeography were closely related to the development of evolutionary thinking in the seventeenth century because species distribution patterns are based on biotic and abiotic elements and their influences over the extremely long periods of time required for species evolution. In areas that have been physically separated from one another by geographic barriers for millions of years, some of the most distinctive assemblages of plants and animals can be found. Australia, for instance, is thought to have between 600,000 and 700,000 plant and animal species, according to biologists. The majority of species of live plants and mammals are indigenous to Australia and cannot be found anywhere else.

3.3.1 Types of Biogeography

There are three main fields of biogeography: 1) historical, 2) ecological, and 3) conservation biogeography. Each addresses the distribution of species from a different perspective. The main focus of historical biogeography is the evolutionary distribution of animals. Phylogenic distributions across time are examined in studies of historical biogeography. The study of the variables influencing the global distribution of plant and animal species is referred to as ecological biogeography. Climate, habitat, and primary productivity are some examples of ecological parameters that are frequently investigated (the rate at which the plants in a particular ecosystem produce the net chemical energy). Additionally, ecological biogeography is distinct from historical biogeography in that it focuses on the transient distribution of different organisms rather than their long-term changes during evolutionary epochs. By presenting policymakers with data on prospective conservation biology concerns, conservation biogeography aims to manage the current amount of biodiversity globally.

3.3.2 Biogeography and Evolution

By comparing similar species that have modest changes that resulted from adaptations to their separate environments, biogeography shows that evolution has occurred. The continents of the Earth have drifted away, collided, and separated over time, leading in the emergence of new climates and habitats. Members of the same species that had been geographically separated diverge as they acclimated to these conditions, eventually leading to the development of different species. Understanding how adaptations happened in the past in response to shifting surroundings is crucial because it allows us to apply that knowledge to the present and the future. How does biogeography support evolution?

Self-Assessment Exercise 1

1. What are the 3 main field of biogeography?

2. What is the concern of a biogeography study?

3.4 Energy Sources in the Atmosphere

Green plants, algae, cyanobacteria, and photosynthetic protists all absorb solar energy. These microbes transform solar energy into the chemical energy that all living things require to function. Light availability has the potential to have a significant impact on how photosynthesizers evolve adaptations. For instance, when the trees in the canopy above them in the late spring entirely leaf out, the plants in the understory of a temperate forest are shadowed. It should come as no surprise that understory plants have evolved to effectively collect available light. One example of this adaptation is the spring ephemeral plants' quick growth, like the spring beauty. Early in the season, before the trees in the canopy begin to develop leaves, these spring blooms complete a large portion of their growth and complete their life cycle (reproduce). Because sunlight is absorbed by water, plants, suspended particles, and resident microbes, it may not be as abundant in aquatic ecosystems. There is a region at the bottom of a lake, pond, or ocean where light cannot penetrate. Since photosynthesis cannot occur there, a variety of adaptations have developed that allow living creatures to exist in the absence of light. For instance, think of the broad, floating leaves of a water lily; water lilies cannot thrive without light. Aquatic plants also have photosynthetic tissue close to the water's surface. Because there isn't enough light for photosynthesis in places like hydrothermal vents, certain bacteria get energy from inorganic compounds. Another crucial element of energy or photosynthesis in aquatic settings is the availability of nutrients. When an organism dies in the open ocean, many of them fall to the bottom; if there is no ocean upwelling, the energy contained in that living organism is then trapped for some time. When prevailing winds blow along surface waters close to a shoreline, ocean upwelling—the rise of deep ocean waters—occurs. Water from the ocean's bottom rises to replace ocean waters that are pushed offshore by the wind. As a result, the nutrients that once existed in dead species are now accessible to other living things.

Changes in air temperature trigger the recycling of nutrients in freshwater systems. In the spring and fall turnovers, the nutrients at the bottom of lakes are recycled twice a year. A periodic process called the spring and fall turnover recycles nutrients and oxygen from a freshwater ecosystem's bottom to the surface of a body of water. The development of a thermocline—a layer of water with a temperature significantly different from the layers around it—is what leads to these turnovers. In many northern places, lakes have frozen surfaces in the winter. The water near the lake's bottom, at 4 to 5 °C (39.2 to 41 °F), is even warmer than the water just beneath the ice. Since water becomes more thick at 4 °C, the deepest water is also the densest. The oxygen content of the deepest water is low because the oxygen that is used up by the decomposition of organic material at the lake's bottom cannot be supplied by oxygen diffusion into the water because of the surface ice cover.

3.4.1 Temperature

The density and state of water, as well as the physiology of living creatures, are all impacted by temperature. Due to metabolic limitations, only a small number of living things can survive at temperatures below 0 °C (32 °F). As a result, temperature has a significant impact on living things. Additionally, it is uncommon for living things to endure temperatures higher than 45 °C (113 °F); this is a result of their evolutionary adaptation to normal temperatures. Enzyme efficiency is limited to a small, precise temperature range; at higher temperatures, enzyme breakdown can take place. As a result, organisms either need to keep their internal temperature constant or live in environments that allow them to maintain a body temperature that supports metabolism. Some species have evolved to allow their bodies to withstand large temperature swings, as shown in reptilian torpor or hibernation. Similar to this, some bacteria are able to survive in hot environments like geysers. These bacteria are an example of an extremophile, an organism that can survive under harsh conditions. The dispersal of living organisms can be restricted by temperature. Animals may respond to temperature changes by adapting, such as migrating, in order to survive. Those creatures have adapted to moving from one place to another, including many that live in climates with seasonal cold. Finding food, a mate, and temperature issues are all resolved by migration. The Arctic Tern (Sterna paradisaea), for example, travels 40,000 km (24,000 mi) round trip annually between its feeding grounds in the southern hemisphere and its nesting grounds in the Arctic Ocean. Danaus plexippus, or the monarch butterfly, spends the warmer months of the year in the eastern United States and the winters in Mexico and the southern United States. There are some animal species that migrate. To find food, reindeer (Rangifer tarandus) travel roughly 5,000 kilometres (3,100 mi) annually. Because they are unable to migrate, the distribution of amphibians and reptiles is more constrained. Not all creatures that have the ability to migrate do so because it is dangerous and requires a lot of energy. To survive in harsh climates, certain creatures estivate or hibernate. Animals may endure cold climates by hibernating, and they can endure the harsh circumstances of a hot, dry climate by estivating. When an animal estivates or hibernates, they reach a state of torpor, in which their metabolic rate is dramatically slowed. The animal can then postpone till its environment is more conducive to its survival. A substance akin to antifreeze is present in the cells of several amphibians, including the wood frog (Rana sylvatica), which maintains the integrity of the cells and prevents them from bursting.

3.4.2 Water

All living organisms need water since it is essential for cellular functions. Terrestrial species have developed several adaptations to retain water since they lose water to the environment by simple diffusion.

• Freshwater species are surrounded by water and are always at risk of having water rush into their cells due to osmosis.

• Plants have a number of fascinating structures on their leaves, such as leaf hairs and a waxy cuticle, that serve to minimise the rate of water loss by transpiration. Organisms that live in freshwater habitats have developed a variety of adaptations to keep the concentration of solutes in their bodies within acceptable ranges. The discharge of diluted urine is one example of an adaptation.

• Marine organisms are at risk of losing water to the environment due to osmosis because the water around them has a higher solute content than the organism. For these creatures to hold onto water and release solutes into the environment, morphological and physiological changes are necessary. For instance, Amblyrhynchus cristatus marine iguanas sneeze up salty water vapour to keep solute concentrations within safe limits while they swim in the ocean and consume marine vegetation. What is the form of energy required by all living things to build their tissue?

Self-Assessment Exercise 2

1. In environments such as hydrothermal vents, where there is no light for photosynthesis how does bacteria obtain energy?

2. What is the adaptation of Marine organisms are surrounded by water with a higher solute concentration than the organism that are in danger of losing water to the environment because of osmosis

3.5 Inorganic Nutrients, Soil and other Factors

Nitrogen and phosphorus are two examples of inorganic nutrients that are crucial to the distribution and quantity of living beings. When water enters a plant through its roots, it pulls these inorganic nutrients from the soil. Soil structure (the size of the soil's particles), soil pH, and soil nutrient concentration all have a big impact on where plants grow. Animals eat food that contains inorganic nutrients. As a result, the distribution of the food that animals eat is tied to it. Animals may follow the source of their food as it moves across the environment.

Other Aquatic Factors

A few abiotic elements, like oxygen, play a role in both terrestrial and aquatic ecosystems. Animals living on land get their oxygen from the air they breathe. However, as there are fewer oxygen molecules in the air at very high altitudes, oxygen supply can be a problem for creatures living there. The amount of dissolved oxygen in aquatic systems depends on the temperature and flow rate of the water. Compared to warmer water, colder water has more dissolved oxygen. Abiotic elements that can have a significant impact on aquatic environments include salinity, current, and tide.

Other Terrestrial Factors

The rate of evaporation and transpiration are both influenced by wind, which makes it a significant abiotic component. Because soil, water, or other abiotic elements can all be moved by wind in addition to the organisms that make up an ecosystem, wind's physical force is equally significant. Another terrestrial element that has the potential to significantly affect terrestrial ecosystems is fire. Some creatures are adapted to fire, and as a result, a stage of their life cycle necessitates the intense heat produced by fire. One coniferous tree that needs heat from fire for its seed cones to open is the jack pine. Fire minimises competition by reducing undergrowth and fertilising the soil by releasing nitrogen into it through the burning of pine needles.

Abiotic Factors Influencing Plant Growth

Temperature and moisture have a significant impact on the amount of organic matter that is available for use as food and plant production (primary productivity) (net primary productivity). The amount of organic matter that is accessible as food is estimated by net primary productivity, which is determined as the total amount of carbon fixed annually less the amount that is oxidised during cellular respiration. In terrestrial ecosystems, the aboveground biomass per unit area, which is the total mass of living plants, excluding roots, is used to assess net primary productivity. This indicates that a significant portion of plant biomass that is underground is excluded from this measurement. Net primary productivity is a crucial factor to take into account when comparing biomes. High aboveground biomass is seen in biomes that are very productive.

The abiotic elements of the environment are directly related to annual biomass output. The conditions for photosynthesis, plant development, and the resulting net primary productivity are optimal in environments with the greatest amounts of biomass. These regions have a warm, humid environment. The highest quantity of carbon dioxide (CO2) may enter the plant, resulting in high biomass production, when photosynthesis can occur at a high rate, enzymes can function most effectively, and stomata can remain open without the risk of excessive transpiration. The above-ground biomass creates a variety of crucial resources for other living creatures, such as food and habitat. Conversely, dry and cold environments have lower photosynthetic rates and therefore less biomass. The animal communities living there will also be affected by the decrease in available food. What is the relationship between annual biomass production and the abiotic components of the environment?

Self-Assessment Exercise 3

1. What are the three soil components that play important role in the distribution of plants?

2. What is the significance of the statement that animals obtaining inorganic nutrients from the food they consume?

3.6 Summary

Biogeography, **the study of the geographic distribution of plants, animals, and other forms of life**. It is concerned not only with habitation patterns but also with the factors responsible for variations in distribution. The different types of biogeography, namely historical, ecological and conservation, and the various abiotic factors affecting biogeography were explained.

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3.8 Possible Answers to Self-Assessment Exercises

Answers to SAEs 1

1. There are three main fields of biogeography: **1) historical, 2) ecological, and 3) conservation biogeography**. Each addresses the distribution of species from a different perspective.

2. Biogeography is concerned with **the causes of geographical distribution of species and biological entities at high hierarchical levels, and with their dynamics through evolutionary time**

Answers to SAEs 2

1. In environments such as hydrothermal vents, some bacteria extract energy from inorganic chemicals because there is no light for photosynthesis.

2. These organisms have morphological and physiological adaptations to retain water and release solutes into the environment.

Answers to SAEs 3

1. The three soil components that play important role in the distribution of plants are:

i). soil structure (particle size of soil components),

ii). soil pH, and

iii). oil nutrient content.

2. Because animal distributions are related to the distribution of what they eat.

Unit 4: World Biomes

Unit Structure

4.1 Introduction

Numerous ecologists have attempted to categorise the primary terrestrial plant types that exist around the planet. The term "biome" currently refers to these various vegetation kinds across the planet. There are other acknowledged aquatic biomes. Additionally, as we previously learned, creatures interact with their environs and one another to move matter and energy. Examples of these interactions abound in biomes. A primary form of terrestrial (or aquatic) community referred to as a biome is dispersed in accordance with the climate, which defines the dominating flora. The vegetation in turn affects the kinds of animals that can live there. There are many different sorts of biomes, and this unit and subsequent ones will explore them all.

4.2 Intended Learning Outcomes

By the end of this unit you should be able to:

- Define accurately what biomes are?
- Determine the major factors that influence the distribution of terrestrial biomes
- Determine the major factors that influence the distribution of aquatic biomes
- Have knowledge of the characteristics of the terrestrial and aquatic biomes

4.3 The Meaning of a Biome

Climate- and geography-defined regions called "biomes" have ecologically similar communities of plants, animals, and soil organisms. Temperature and precipitation, two abiotic elements, served as the basis for R. H. Whittaker's classification of biomes. Whittaker's classification schemes call for the understanding of the following key terminologies: Physiognomy: The external qualities, apparent traits, and appearance of a species; The primary population of the plant normally present in a certain habitat serves as the basis for formation; Biome-Type: Based on physiognomy, biome-type is the collection of various convergent biomes and the development of various continents; Formation Type: A cluster of several convergent formations defines a formation type. Whittaker used the term "formation" to describe solely plant species, whereas the term "biome" include both plants and animals. Intertidal levels, climatic moisture gradient, temperature gradient defined by latitude, and temperature gradient defined by altitude are the parameters utilised by Whittaker for his classification.

There are many different kinds of biomes; the precise number of biomes in the world is yet unknown and is constantly changing. The biomes cover a wide range of habitats, such as deserts,

various forest kinds, polar regions, national parks, bird sanctuaries, zoos, aquatic life, and much more. The biomes are divided into major groupings based on the predominate flora and are distinguished by organism adaptations. This classification is based on some commonalities and is intended to be more straightforward. What is Physiognomy?
Self-Assessment Exercise 1

> 1.What are biomes?
>
> 2. What is Whittaker's classification of biomes based on the major population of the plant typically found in a given environment referred?

4.4 Types of Biomes

1. Tropical Wet Forest
Tropic rainforests are another name for tropical wet woods. The equatorial regions are home to this biome. Plants with large leaves that shed throughout the year define the vegetation. The forests in this biome are "evergreen" all year round, unlike deciduous forests, which experience seasonal leaf loss due to changes in temperature and sunlight. Compared to other terrestrial biomes, the temperature and sunshine profiles of tropical wet forests are highly constant, with temperatures ranging from 20 °C to 34 °C (68 °F to 93 °F). The absence of seasonal temperature change in the tropical wet forest is evident when comparing the annual temperature variance of tropical wet forests with that of other forest biomes. Instead of the seasonal (spring, summer, and fall) growth seen in other biomes, this absence of seasonality results in year-round plant growth. Tropical ecosystems do not experience long and short days throughout the year like other ecosystems do. Instead, a consistent amount of sunlight (11–12 hours each day) produces more solar radiation and extends the time during which plants can grow. With some monthly variance, the annual rainfall in tropical wet woods ranges from 125 to 660 cm (50-200 in). The amount of sunlight and the temperature are rather constant, but the amount of rain each year varies greatly. Tropical wet forests experience both wet months with up to 30 cm (11–12 in) of precipitation and dry months with less than 10 cm (3.5 in) of precipitation. A tropical wet forest's driest month, meanwhile, still exceeds the yearly rainfall of certain other biomes, such deserts. Because the yearly temperatures and precipitation amounts in these regions are favourable for plant growth, tropical wet forests have high net primary production. As a result, the tropical wet forest's abundant biomass creates plant communities with extremely high species diversities. More tree species are found in tropical wet forests than in any other biome; in South America, a single hectare (2.5 acres) of these forests is home to between 100 and 300 different species of trees. Comparing the distinct horizontal layers found in the tropical wet forest biome can help visualise this. On the forest \sfloor is a sparse layer of plants and decaying plant matter. Above that is an understory of short shrubby foliage. Above this understory, a layer of trees grows, and on top of them is a closed upper canopy, which is the topmost layer of branches and leaves in the sky. Through its dense upper canopy, a few more trees appear. Within the tropical wet forests, these layers offer a diversity of plants, fungus, animals, and other species complex and diverse ecosystems. For instance, plants known as epiphytes grow on other plants without often doing any harm to them. All biomes of tropical wet forests contain epiphytes. The variety of flora and intricate structure of the tropical wet forests provide food and shelter for many different species of animals. Some organisms have evolved to lead an arboreal lifestyle, living several metres above the earth.

2. Savannas

Africa, South America, and northern Australia are all home to savannas, which are grasslands with sporadic trees. Savannas are hot, tropical regions with average temperatures of 24 to 29 °C (75 to 84 °F) and 10 to 40 cm of yearly rainfall (3.9–15.7 in). Because of the lengthy dry season in savannas, forest trees there do not develop as well as they do in tropical wet forests (or other forest biomes). As a result, there aren't many trees in the grasses and forbs (herbaceous flowering plants) that make up the savanna. Plants have evolved highly developed root systems that enable them to quickly re-sprout because fire is a significant source of disturbance in this biome.

3. Subtropical Deserts

Between 15 and 30 degrees north and south latitude, subtropical deserts can be found, and they are centred on the Tropics of Cancer and Capricorn. In some years, evaporation in this biome exceeds precipitation due to its extreme aridity. Subtropical hot deserts can reach nightly lows of 0 °C (32 °F) and midday soil surface temperatures above 60 °C (140 °F). Cold deserts can experience highs of up to 25 °C and lows of -30 °C (-22 °F). Low annual precipitation of less than 30 cm (12 in), limited monthly variation, and unpredictable rainfall are characteristics of subtropical deserts. In some subtropical deserts in central Australia, the annual rainfall might be as low as 2 cm (0.8 in). (“the Outback”) and northern Africa.

This biome's low and erratic precipitation is directly tied to its flora and poor animal diversity. In contrast to perennial plants that survive from year to year, annual plants commonly grow swiftly and multiply when water does occur before dying in very arid deserts. Numerous other plants in these regions exhibit a variety of water-saving adaptations, including deep roots, less leaves, and stems that may store water. Desert seed plants can generate seeds that can remain dormant for a long time in between rainfall. Animals living in the desert have evolved to burrow and act nocturnally.

4. Chaparral

California, the Mediterranean Sea, and the southern Australian coast are all home to the chaparral, often known as scrub woodland. This biome experiences an average annual rainfall of 65 to 75 cm (25.6-29.5 in), with the most of it falling during the winter. The summers are extremely dry, and many chaparral vegetation become dormant. Figure 35.16 depicts the chaparral vegetation, which is dominated by shrubs and adapted to recurrent fires. Some plants even produce seeds that only sprout following a high fire. After a fire, the ashes that remain are full of nitrogen-rich nutrients that feed the soil and encourage plant regrowth.

5. Temperate Grasslands

Temperate grasslands are also known as steppes in Eurasia and are spread to central North America where they are also known as prairies. Warm summers and chilly winters characterise the annual temperature variations in temperate grasslands. For plants, the annual temperature variance results in distinct growing seasons. When temperatures are warm enough to support plant growth and there is plenty of water available, which happens in the spring, summer, and fall, plant growth is conceivable. Low temperatures and ice storage throughout the winter prevent plants from having access to water, which is necessary for their growth.

Precipitation every year varies from 25 cm to 75 cm (9.8–29.5 in). In temperate grasslands, there aren't many trees outside those that grow alongside rivers or streams due to the area's relatively lower annual precipitation levels. While certain prairies support colonies of grazing animals, grasses often make up the majority of the vegetation. Because of the abundance of these grasses' roots and rhizomes (underground stems), the soils are fertile and the flora is highly dense. When plants die and decompose, their roots and rhizomes work as anchors in the earth and replace the organic matter (humus) in the soil.

In temperate grasslands, fires—which are primarily sparked by lightning—are a common natural disturbance. In temperate grasslands, flora gradually changes to scrub and dense forests when fire is inhibited. Often, the restoration or management of temperate grasslands requires the use of controlled burns to suppress the growth of trees and maintain the grasses.

6. Temperate Forests

The most prevalent biome in eastern North America, Western Europe, Eastern Asia, Chile, and New Zealand is temperate woods. Nearly everything in the mid-latitudes is this biome. Every year, the temperature falls below freezing and ranges from -30 °C to 30 °C (-22 °F to 86 °F). These temperatures indicate that the spring, summer, and early fall are the specific growing seasons for temperate woods. Throughout the year, precipitation is generally consistent and ranges from 75 cm to 150 cm (29.5–59 in). Deciduous trees predominate as the primary plant in this biome due to the moderate yearly rainfall and temperatures. Every fall, deciduous trees shed their leaves, and they are bare in the winter. Thus, during the dormant winter season, there is no photosynthesis in deciduous trees. Each spring, when the temperature rises, fresh leaves begin to emerge. The net primary production of temperate forests is lower than that of tropical wet forests as a result of the dormant period. Additionally, compared to tropical wet forest biomes, temperate forests have a lower species variety of trees. The trees in temperate forests leaf out and shade a large portion of the ground, yet this biome is less densely forested than tropical wet forests since the trees in temperate forests don't get as tall. The organic and inorganic nutrients are abundant in the soils of temperate woods. This is because the forest floors have a heavy covering of leaf litter. As this leaf litter decays, nutrients are returned to the soil. The leaf litter also protects soil from erosion, insulates the ground, and provides habitats for invertebrates (such as the pill bug or roly-poly, *Armadillidium vulgare*) and their predators, such as the red-backed salamander (*Plethodon cinereus*).

7. Boreal Forests

The majority of Canada, Alaska, Russia, and northern Europe are covered in the boreal forest, sometimes referred to as taiga or coniferous forest, which is located south of the Arctic Circle. The seasons in this biome are short, cool, and rainy with cold, dry winters. The yearly precipitation ranges from 15.7 to 100 cm (40 to 40 inches), and it typically falls as snow. Because of the frigid temperatures, there is less evaporation. In the boreal forest, cold-tolerant cone-bearing plants predominate due to the lengthy and harsh winters. These are coniferous trees that are evergreen and have needle-shaped leaves all year long, such as pine, spruce, and fir. Because a needle-like leaf requires less energy from the sun to warm than a broad leaf does, evergreen trees can photosynthesize earlier in the spring than deciduous trees. This helps evergreen trees, which in the boreal forest grow more quickly than deciduous ones. Additionally, the soils in areas with boreal forests are frequently acidic and have little nitrogen availability. Deciduous trees must generate a fresh crop of leaves, which are nitrogen-rich structures, every year. As a result, retaining nitrogen-rich needles on coniferous trees may give them a competitive edge over broad-leafed deciduous trees. Boreal forests' net primary productivity is lower than that of temperate and tropical wet forests. Because these slow-growing tree species live long lives and amass standing biomass over time, boreal forests have substantial aboveground biomass. The diversity of plant species is lower than it is in temperate and tropical wet forests. The distinct components of the layered forest structure found in tropical wet forests are absent from boreal forests. A boreal forest typically only has two layers: the tree layer and the ground layer. Fewer nutrients are given to the soil to support plant growth when pine needles are lost because they disintegrate more slowly than wide leaves.

8. Arctic Tundra

All over the Arctic regions of the northern hemisphere, the Arctic tundra is found to the north of the subarctic boreal forest. The average summer temperature ranges from 3 °C to 12 °C (37 °F-52 °F), and the average winter temperature is -34 °C (-34 °F). The growing season for plants in the arctic tundra is just 10 to 12 weeks long. However, there are nearly 24 hours of daylight during this period, and plant development is quick. The Arctic tundra has very little yearly fluctuation in precipitation and very little annual precipitation. Additionally, due to the freezing temperatures, there is not as much evaporation as in boreal forests. In the Arctic tundra, plants typically grow close to the ground. There is limited aboveground biomass, little net primary productivity, and negligible species diversity. Permafrost, a state of perpetually frozen earth, may persist in the Arctic tundra. Permafrost prevents roots from growing deeply into the soil and slows organic matter breakdown, which prevents the release of nutrients from organic matter. The Arctic tundra's ground might become entirely covered with lichens or plants throughout the growth season.

Where is the Arctic tundra located? hemisphere.

Self-Assessment Exercise 2

1. Where is Tropical Wet Forest located?
2. What is the structure of a boreal forest?

4.5 Abiotic Factors Influencing Aquatic Biomes

Aquatic biomes are influenced by a number of abiotic elements, much like terrestrial biomes are. Water, the aquatic medium, differs from air in terms of its physical and chemical characteristics. Water absorbs light on its own even if the water in a pond or other body of water is completely clean (there are no suspended particles). There will ultimately come a depth into a deep body of water where the sun cannot shine. While some abiotic and biotic elements (such as fog, dust, or insect swarms) in a terrestrial ecosystem may block light, they are often transient elements of the environment. The groups of organisms present in freshwater and marine habitats both depend heavily on light in aquatic biomes. The most important abiotic element in freshwater systems is stratification caused by changes in density, which is connected to the energy characteristics of light. In addition to having a substantial impact on local climate and weather patterns, the thermal properties of water (rates of heating and cooling) are important for the operation of marine systems. Large-scale physical water movements like currents, which are less significant in most freshwater lakes, have an impact on marine systems as well.

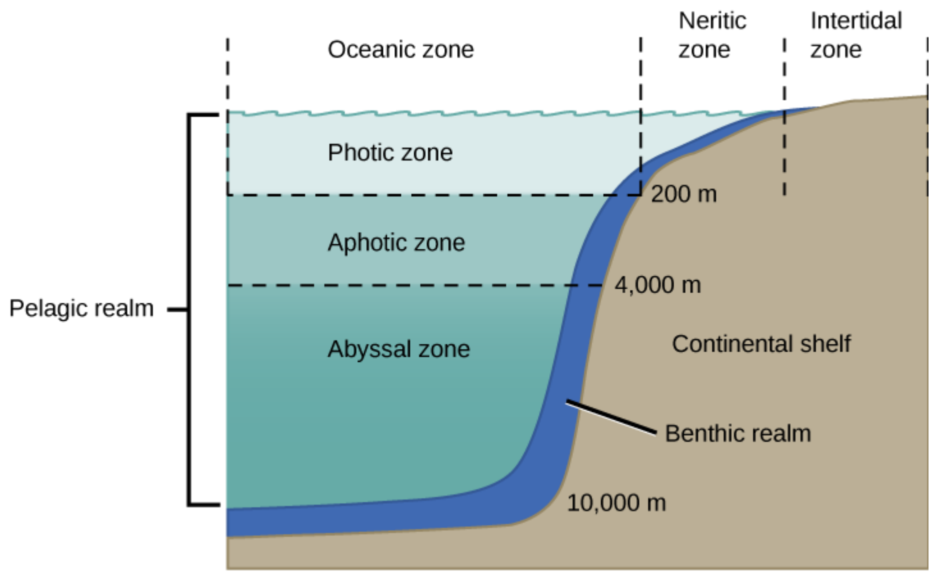

Figure 1. The ocean is divided into different zones based on water depth and distance from the shoreline.
Source: https://openoregon.pressbooks.pub/envirobiology/chapter/3-4-aquatic-biomes/

There are various zones and locations that make up the ocean. The pelagic domain refers to all of the ocean's open water (or zone). From the seashore to the deepest portions of the ocean floor, the benthic realm (or zone) covers the whole surface of the water. The photic zone, or area of the water where light can enter, is located within the pelagic realm (approximately 200 m or 650 ft). The aphotic zone is the region below 200 metres in depth where light cannot reach. Since most of the ocean is aphotic, photosynthesis cannot occur there. The Mariana Trench, in the western Pacific Ocean, contains the deepest portion of the ocean, known as the Challenger Deep, which is 11,000 metres (approximately 6.8 miles) deep. The average depth of the ocean is 4267 metres (14,000 feet), which gives some perspective on how deep this trench is. Freshwater lakes also fall under the purview of these regions and zones. Is the thermal properties of water (rates of heating and cooling) of any significance to the function of marine systems?
Self-Assessment Exercise 3

1. What is the most critical abiotic factor in freshwater systems?

2. What is the pelagic realm in the ocean?

4.6 Summary

You have learned about the biome as an **area classified according to the species that live in that location**. Temperature range, soil type, and the amount of light and water are unique to a particular place and form the niches for specific species allowing scientists to define the biome.

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4.8 Possible Answers to Self-Assessment Exercises

Answers to SAEs 1

1. Biomes are climatically and geographically defined areas of ecologically similar appearance in characteristic of communities of plants, animals and soil organisms.
2. Formations

Answers to SAEs 2

1. This biome is found in equatorial regions.
2. The structure of a boreal forest is often only a tree layer and a ground layer

Answers to SAEs 3

1. In freshwater systems, stratification due to differences in density is perhaps the most critical abiotic factor and is related to the energy aspects of light.
2. All of the ocean's open water is referred to the Pelagic realm

Unit 5: Marine and Freshwater Biomes

Unit Structure

5.1 Introduction

Marine and Freshwater Biology is the study of the organisms including microbes, plants and animals in aquatic ecosystems, as well as the chemical and physical processes in the sediments of these systems and the relationships between them. Aquatic biomes are distinguished by the **availability of sunlight and the concentration of dissolved oxygen and nutrients in the water**. The photic zone extends to a maximum depth of 200 meters, while the aphotic zone is deeper than 200 meters. Aquatic biomes in the ocean are called marine biomes.

5.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you should be able to:

- Know the meaning of marine, freshwater environments

- Outline the key aspects/characteristics of aquatic environments
- Describe the various types of aquatic biomes: la**kes and ponds, rivers and seas, oceans, estuaries, coral reefs, wetlands, mangroves, and intertidal zones**.
- Demonstrate the various elements of five different aquatic ecosystems
- Compare and contrast the characteristics of the ocean zones

5.3 Marine Biomes

The largest marine biome is the ocean. It is a continuous body of salt water with a rather homogeneous chemical make-up; it contains decomposed living materials and a weak solution of mineral salts. Another type of marine biome is coral reefs, which are found in the ocean. Estuaries, which are coastal regions where fresh and salt water mingle, make up a third distinct marine biome. Plants, animals, and other species are significantly influenced by the physical diversity of the ocean. Depending on how deep the light penetrates the ocean, it is divided into various zones. The ocean is divided into five distinct zones: the epipelagic (dawn zone), mesopelagic (twilight zone), bathypelagic (midnight zone), abyssopelagic (abyssal zone), and hadal zone (trenches). There is a unique collection of species in each zone that have adjusted to the biotic and abiotic conditions unique to that zone. The part of the ocean nearest to land is called the intertidal zone, which is the area between high and low tide. The majority of people typically picture this area of the ocean as a sandy beach. Although the intertidal zone occasionally resembles a sandy beach, it can also be rocky or muddy. Because of tides, the intertidal zone has a very changeable environment. At low tide, organisms are exposed to the air and sunshine; yet, they spend the most of their time underwater, especially at high tide. As a result, organisms that flourish in the intertidal zone have evolved to tolerate prolonged periods of dryness. The species found in the intertidal zone are evolved to endure damage from the pounding force of the waves since the beach there is frequently battered by waves as well. Shoreline crustaceans have hard exoskeletons that shield them from desiccation and wave damage. One example is the shore crab, Carcinus maenas. Few algae and plants manage to establish themselves in the continually shifting rocks, sand, or mud, which is another effect of the pounding waves. At the edge of the continental shelf, the neritic zone stretches from the intertidal zone to depths of around 200 m (or 650 feet). The neritic zone can support photosynthesis since light can reach this depth. The water is well-oxygenated, low in pressure, and constant in temperature. It also contains silt. Some of the marine life present in the neritic zone is supported by phytoplankton and floating Sargassum, a type of free-floating marine seaweed. The neritic zone is home to zooplankton, protists, small fish, and shrimp, which provide the foundation of the food chain for the majority of global fisheries. The oceanic zone is the expanse of open water located beyond the neritic zone. Thermal stratification occurs when warm and cold waters within the oceanic zone mix as a result of ocean currents. The foundation of the food chain for larger creatures like whales and dolphins is abundant plankton. This region of the marine biome is significantly less productive due to the scarcity of nutrients. In contrast to freshwater lakes, the open ocean lacks a mechanism for getting the organic nutrients back up to the top when photosynthetic organisms and the protists and animals that feed on them perish. Their carcasses fall to the bottom of the ocean, where they remain. Sea cucumbers (phylum Echinodermata) and other species that survive on the nutrients found in the dead bodies of animals in the photic zone make up the majority of the organisms in the aphotic zone. The benthic realm, which is the deepwater area beyond the continental shelf, lies beneath the pelagic zone. Sand, silt, and dead organisms make up the benthic realm's substratum. As water depth rises, temperature drops but stays above freezing. Because of the dead organisms that wash down from the ocean's upper layers, this area of the water is nutrient-rich. A variety of mushrooms, sponges, sea anemones, marine worms, sea stars, fish, and bacteria exist as a result of the high nutritional content. The abyssal zone, which is located at depths of at least 4000 m, is the deepest area of the ocean. The abyssal zone is extremely cold, under great pressure, has a high oxygen content, and has little in the way of nutrients. This zone is home to a wide range of invertebrates and fish, however due to the lack of light, there are no plants in the abyssal zone. The abyssal zone is where you may mostly find hydrothermal vents; chemosynthetic bacteria utilize the hydrogen sulfide and other minerals emitted from the vents. These chemosynthetic bacteria use the hydrogen sulfide as an energy source and serve as the base of the food chain found in the abyssal zone.

5.3.1 Coral Reefs

Marine invertebrates that live in warm, shallow waters in the ocean's photic zone build coral reefs, which are ridges of the ocean. They might be located 30 degrees north or south of the equator. A well-known reef system called the Great Barrier Reef is a few miles off Australia's northeastern coast. Other coral reef systems include atolls, which are elongated reef systems around a once-underwater landmass, and fringe islands, which are close to the surface of the ocean. Colonies of saltwater polyps make up the coral creatures (phylum Cnidaria), which secrete a calcium carbonate skeleton. The underwater reef is created by the gradual accumulation of these calcium-rich skeletons. A mutualistic interaction exists between corals and photosynthetic unicellular algae in shallower waters (at a depth of roughly 200 feet or 60 metres). Corals get most of the nutrients and energy they need from this interaction. Without this mutualism, huge corals would not be able to develop in the nutrient-poor environments where these corals reside. Some corals that live in deeper, colder waters don't have a mutualistic interaction with algae; instead, they catch animals with stinging cells on their tentacles to obtain energy and nutrients. Coral reefs are thought to be home to more than 4,000 different species of fish. These fish are able to eat coral and cryptofauna (invertebrates found within the calcium carbonate substrate of the coral reefs), or the seaweed and algae that are associated with the coral. Additionally, several fish species—including predators, herbivores, and planktivores—live within a coral reef's confines. Predators are carnivorous, or "flesh eaters," animal species that hunt. Planktivores eat plankton, whereas herbivores consume plant matter.

5.3.2 Estuaries: Where the Ocean Meets Fresh Water

Estuaries are types of biomes that exist where freshwater sources like rivers and the ocean converge. As a result, both fresh and salt water can be found nearby; combining them together produces diluted (brackish) saltwater. Many of the young offspring of crustaceans, mollusks, and fish begin their lives in estuaries, which are protected regions. Salinity has a significant impact on the creatures found in estuaries as well as their adaptations. Estuaries' salinity fluctuates and depends on how quickly their freshwater sources are flowing. High tides pour salt water into the estuary once or twice daily. The salt water movement is reversed when low tides occur on a regular basis. For the plants and animals that live in estuaries, the short-term and fast changes in salinity caused by the mixing of fresh water and salt water present a significant physiological challenge. Many kinds of estuary plants are halophytes, or salt-tolerant plants. Halophytic plants have developed to deal with salinity brought on by sea spray or saltwater on their roots. Some halophytes include filters in their roots that take the salt out of the water they receive. Other plants have the ability to supply their roots with oxygen. Animals with behavioural adaptations that require a lot of energy to function in this rapidly changing environment include mussels and clams (phylum Mollusca). Low salinity causes these species to stop feeding, seal their shells, and transition from gill-based aerobic respiration to gill-based anaerobic respiration (a process that does not require oxygen). These creatures emerge from their shells, start feeding, and resume aerobic respiration when high tide returns to the estuary because the water's salinity and oxygen level have increased. What are estuaries?

Self-Assessment Exercise 1

1. What are Halophytic plants?

2. What are the five zones of the ocean water

5.4 Freshwater Biomes

Lakes, ponds, rivers, and streams are examples of freshwater biomes, as are other bodies of standing water (flowing water). In addition, they contain wetlands, which will be covered later. Freshwater biomes supply the aquatic resources needed by humans for industry, sanitation, agriculture irrigation, and drinking water. The term "ecosystem services" refers to these numerous functions and advantages for humans. Due to their presence in terrestrial landscapes, lakes and ponds are associated with both biotic and abiotic variables affecting these terrestrial biomes.

5.4.1 Lakes and Ponds

From a few square metres to thousands of square kilometres, lakes and ponds can vary in size. An key abiotic factor influencing the living creatures in lakes and ponds is temperature. Thermal stratification of lakes and ponds happens in the summer when the sun warms the top layer of water without mixing it with deeper, colder water. Within the lake or pond's photic zone, light can enter. The foundation of the food web of lakes and ponds is made up of phytoplankton, which includes algae and cyanobacteria. These phytoplankton are eaten by zooplankton, such as rotifers and tiny crustaceans. Dead species that settle to the bottom of lakes and ponds are decomposed by bacteria in the aphotic zone. Important limiting nutrients in lakes and ponds are nitrogen and phosphorus. As a result, they play a role in determining the rate of phytoplankton development in ponds and lakes. A massive buildup of algae known as an algal bloom occurs when there is a significant inflow of nitrogen and phosphorus (from sewage and runoff from fertilised lawns and farms, for example). Algal blooms can grow to be so large that they block more light from entering the water. As a result, the lake or pond turns aphotic and cannot support photosynthesis by plants. The water loses a significant amount of oxygen when the algae decay and die. Dead zones that emerge from this are present all over the world and increase the likelihood that fish and other species that need oxygen will perish. Significant environmental issues are posed by phosphorus control and storm water runoff in freshwater and marine environments including Lake Erie and the Gulf of Mexico.

5.4.2 Rivers and Streams

Large volumes of water are continuously transported by rivers and streams from the headwaters, or source, to lakes and the ocean. The Nile River in Africa, the Amazon River in South America, and the Mississippi River in North America are among the greatest rivers.

The abiotic characteristics of rivers and streams change during their whole length. A location known as the source water is where streams start. The supply water is typically clean, nutrient-free, and cold. The channel, or river or stream's breadth, is narrower here than it is everywhere else throughout its length. As a result, the current here frequently moves more quickly than at any other location along the river or stream. The water is clean because the swiftly flowing water causes little silt to accumulate at the river's or stream's bottom. Because of the rapid current, phytoplankton cannot develop here, thus algae that are growing on rocks are mostly responsible for photosynthesis. Leaves and other organic matter that fall into rivers and streams from trees and other plants near the water can provide an extra source of energy. The organic matter and nutrients in the leaves are returned to the water when they disintegrate. Animals and plants have adjusted to this swift water. For instance, leeches (phylum Annelida) have elongated bodies and suckers on both ends. These suckers attach to the substrate, keeping the leech anchored in place. Freshwater trout species (phylum Chordata) are an important predator in these fast-moving rivers and streams. The width of the channel gradually increases and the current slows as the river or stream moves away from its source. More sedimentation is present in this slowly moving water as a result of the gradient's decline and the volume's increase as streams join together. Additionally, phytoplankton can float in still water. As a result, the water won't be as crystal clear as it is close to the source.

Moreover, the water is warmer. Burrowing into the muck are worms (phylum Annelida) and insects (phylum Arthropoda). Waterfowl, frogs, and fish are higher order predator vertebrates (phylum Chordata). Unlike the trout in the waters at the source, these predators may not be able to use vision as their primary sense to find food in these slow-moving, occasionally muddy waters. In contrast, they are more likely to employ chemical or gustatory clues to locate prey.

5.4.3 Wetlands

Wetlands are places where the soil is occasionally or continuously soaked with water. Because wetlands are shallow bodies of water and lakes have a range of depths, wetlands differ from lakes in this regard. Wetland plants with parts of their leaves, stalks, and flowers protruding above the water's surface are considered emergent vegetation. There are many different kinds of wetlands, including salt marshes, mudflats, bogs, and marshes. These three traits—hydrology (the substrate is saturated with water or covered by shallow water at some point during the growing season of each year), hydrophytic vegetation (the land at least occasionally supports primarily hydrophytes), and hydric soils—are what define these types as wetlands (the substrate is predominantly undrained). Water flows slowly and steadily in freshwater marshes and wetlands. Bogs grow in arid areas where there is little to no water flow. Bogs typically develop in places with a clay bottom and weak percolation. Water moves through soil or rock pores through a process known as percolation. Due to the lack of oxygen replacement during the decomposition of organic materials, the water in bogs is stagnant and oxygen-depleted. Decomposition slows down as the water's oxygen content decreases. As a result, organic acids and other acids accumulate and cause the pH of the water to decrease. Nitrogen becomes inaccessible to plants with a lower pH. As a key limiting resource, nitrogen presents a problem for plants as a result. Sundews, pitcher plants, and Venus flytraps are examples of swamp plants that catch insects and use the nitrogen from their bodies as food. Because the water in bogs contains little nitrogen and oxygen, bogs have low net primary production. What are rivers?

Self-Assessment Exercise 2

1. What is the difference between a wetland and a lake?

2. What are the 3 key defining characteristics of a wetland?

5.5 Continental Shelf

A continental shelf is the edge of a continental landmass and is a large, generally shallow undersea terrace of continental crust. Most continental shelves feature a topography known as ridge and swale, which is a gently rolling terrain. The geology of continental shelves is frequently comparable to that of the neighbouring exposed area of the continent. The normal depth of a continental shelf is between 100 and 200 metres (330–660 feet). It has a slight seaward slope, with an average slope of roughly 0.1°. It always comes to an abrupt end at its seaward edge, known as the shelf break. At a depth of around 4,000 to 5,000 metres, the continental slope, a much steeper zone, combines with a region of the ocean floor known as the continental rise (13,000 to 16,500 feet). Some continental margins, including those at Porcupine Bank, off the western coast of Ireland, and those off the Mediterranean coast of France, preserve a generally convex form to the seafloor rather than a strongly marked break in slope.

Continental shelves typically measure 65 kilometres wide (40 miles). The shelves are essentially a continuation of the continental landmass beneath the ocean's edges almost everywhere. As a result, they are broad and relatively flat offshore from plains yet narrow, rocky, and steep off mountainous shores. The shelf encircling the eastern coast of the United States is more than 120 km (75 miles) wide, but the shelf along the country's rocky west coast is only approximately 32 km (20 miles) wide. Off the coasts of northern Australia and Argentina, there are unusually extensive shelves. The largest continental shelf in the world stretches into the Arctic Ocean for a distance of 1,500 km (about 930 miles). Sand, silt, and silty mud are typically present as a layer on continental shelves. Their surfaces have some relief, with a mix of shallow depressions, valley-like troughs, and minor hills, ridges, and hills. In a few instances, undersea canyons with steep walls cut deeply through the shelf and the slope below.

About 8% of the earth's surface is made up of continental shelves. Since several of the continents' extensive continental shelves are located 130 metres or more below sea level on average, benthic algae and plants can photosynthesise in their shallower parts. Laminaria and other huge brown algae are seen in these spectacular kelp forests. Kelps are frequently found in locations with abundant nutrient supplies because of ocean currents and wave movement. Despite their great output, few animals feed on them, thus they enter the food chain as debris. Numerous animals from several phyla are supported in vast numbers by the continental shelf benthos. These animals include polychaete worms, nemertine worms, mollusks, sea squirts, sponges, sea spiders crustaceans and echinoderms along with a number of fish. What is the relative percentage of the continental shelf compared to that of the ocean?

Self-Assessment Exercise 3

1. What is the continental shelf? **2.** What are the 3 main sections of the continental shelf?

5.6 Summary

You have learned about the aquatic biome as **the largest of all the biomes, covering about 75 percent of Earth's surface**. This biome is usually divided into two categories: freshwater and marine. Typically, freshwater habitats are less than 1 percent salt.

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5.8 Possible Answers to Self-Assessment Exercises

Answers to SAEs 1

1. Halophytic plants are adapted to deal with the salinity resulting from saltwater on their roots or from sea spray

2. **The ocean water column is made up of five zones:** the sunlight zone (epipelagic), the twilight zone (mesopelagic), the midnight zone (bathypelagic), the abyssal zone (abyssopelagic) and the hadal zone (trenches)**.**

Answers to SAEs 2

1. Wetlands are different from lakes because wetlands are shallow bodies of water whereas lakes vary in depth.

2. Wetlands must have one or more of the following three attributes: 1) at least periodically, the land supports predominantly hydrophytes; 2) the substrate is predominantly undrained hydric soil; and 3) the substrate is saturated with water or covered by shallow water at some time during the growing season of each year.

Answers to SAEs 3

1. The **continental shelf** is a broad, relatively shallow submarine terrace of continental crust forming the edge of a continental landmass.

2. The **continental rise, continental slope, and continental shelf** are the three basic components that actually make the entire structure of continental margins. The continental slopes and the continental shelves are structural constituents of continents even though they are below the surface of sea.

Glossary

Background Extinction: Normal **extinction** of **species** that occurs as a result of changes in local environmental conditions. Also see **mass extinction**.

Backshore: Area behind the **shore**. This coastal feature is located between the beach **berm** and the **backshore slope**.

Backshore slope: Sloping bank **landward** of the **shore**. This coastal feature is composed of relatively non-mobile **sediments**.

Bacteria: Simple single celled **prokaryotic** organisms.

Base Level: The subterranean elevation below which a **stream** cannot vertically **erode sediment**. For many streams this hypothetical elevation is **sea-level**.

Basement Rock: Very old **granite** and **metamorphic rocks** found in **continental crust**. These rocks make up the continental **shield**.

Basic: Substance having a **pH** greater than 7.

Basic Solution: Any water solution that is **basic** (pH greater than 7) or has less hydrogen ions (H+) than hydroxide ions (OH-). Also see **acidic solution** and **neutral solution**.

Basin: A topographic **rock** structure whose shape is concave downwards.

Batholith: A large mass of subsurface **intrusive igneous rock** that has its origins from **mantle magma**.

Bay: A body of sheltered water found in a crescent shaped coastal configuration of land.

Bedrock: Rock at or near (beneath **soil** and **regolith**) the Earth's surface that is solid and relatively **unweathered**.

Benthos: The **plant** and **animal** organisms that live on the sea floor. Often divided into two categories: ***deep-sea benthos***, below 200 meters and the ***littoral benthos***, from 200 meters to the high-water **spring tide** level.

High pressure: system that develops over the western subtropical North Atlantic. Also called ***Azores High***.

Beta Particle: Electron emitted from the **nucleus** of a **radioactive isotope**. Also see **alpha particle** and **gamma rays**.

B Horizon: Soil horizon normally found below the **A horizon** and above the **C horizon**.

Biennial Plant: Plant species that completes its life in two growing seasons.

Big Bang: Theory that suggests that about 15 billion years ago all of the matter and energy in the **Universe** was concentrated into an area smaller than a atom.

Biodiversity: The **diversity** of different species (**species diversity**), genetic variability among individuals within each species (**genetic diversity**), and variety of ecosystems (**ecosystem diversity**). Abbreviation of biological diversity.

Biogeochemical Cycling: Cycling of a single **element, compound** or chemicals by various **abiotic** and **biotic** processes through the various stores found in the **biosphere**, **lithosphere**, **hydrosphere**, and **atmosphere**.

Biogeography: Field of **physical geography** that studies the spatial pattern of living organisms.

Biological Amplification: Increase in concentration of toxic fat-soluble chemicals in organisms at successively higher trophic levels of a **grazing food chain** or **food web** because of the consumption of organisms at lower **trophic levels**.

Biological Weathering: The disintegration of **rock** and **mineral** due to the chemical and/or physical agents of an organism.

Biomass: The weight of living tissues usually measured per unit area over a particular time interval. Can include the dead parts of organisms like bark, hair, and nails.

Biome: Largest recognizable assemblage of **animals** and **plants** on the Earth. The distribution of the biomes is controlled mainly by climate.

Bioregion: A unique region on the Earth that has distinct soils, landforms, watersheds, climates, native **plants**, and **animals**, and/or other particular natural characteristics.

Biosphere: Part of the Earth where life is found. The biosphere consists of all living things, plant and animal. This sphere is characterized by life in profusion, diversity, and clever complexity. Cycling of matter in this biosphere involves not only metabolic reactions in organisms, but also many **abiotic** chemical reactions. Also called **ecosphere**.

Biotic: (1) Referring to life. & (2) Influences caused by living **organisms**.

Biotic Potential: Maximum rate that a **population** of a given **species** can increase in size (number of individuals) when there are no limits on growth rate.

Biotite: Rock forming **mineral** of the **mica** group.

Bird: Group of warm blooded **vertebrate animals** whose body is covered with feathers.

Boreal Forest: High to mid-latitude **biome** dominated by **coniferous** forest. Predominant vegetation of this biome is various species of spruce, fir, pine, and cedars. Also called ***Taiga*.**

Bottomset Bed: Horizontal **deltaic** deposit of **alluvial sediment** composed of fine **silt** and **clay**.

Brackish: Environment that is influenced by **seawater** with a **salinity** less than 35 parts per thousand (usually caused by the presence of an inflow of **fresh water**).

End of Module Questions

1 What are the 3 main field of biogeography?

2 What is biogeography PDF?

3 What is biogeography easy words?

4 What are the components of biogeography?

5 What is the difference between terrestrial and aquatic?

6 What are the 7 aquatic biomes?

7 How are aquatic and terrestrial biomes similar?

8 What are the importance of terrestrial and aquatic biomes?

Module 4: Man and the Environment

Module Structure

In this module we will discuss about the link between man and the environment with the following units:

Unit 1: Relationship between Man and the Environment
Unit 2 Pollution, Types, Sources and Characteristics
Unit 3 Effects of Pollution on the Environment
Unit 4: Pollution: Effects, Prevention and Control
Unit 5: Humans, Environmental and Health

Unit 1: Relationship between Man and the Environment

Unit Structure

1.1 Introduction
1.2 Intended Learning Outcomes (ILOs)

1.3 Relationships Between Human Activity and the Environment

1.4 Use of Natural Resources
    1.4.1 Deforestation
    1.4.2 Energy resources
    1.4.3 Water resources
1.5 Production of waste and pollutants
    1.5.1 Technology and the Environment
    1.5.2 Agriculture and environment
    1.5.3 How we can protect and restore our environment
1.6 Summary
1.7 References/Further Readings/Web Sources
1.8 Possible Answers to Self-Assessment Exercises

1.1 Introduction

The relationships between human activity, values and use of natural resources will be highlighted. You will learn the processes of deforestation, energy resources and production of waste and pollutants in the environment. You will also study the impact of technology on the environment, and impact of agriculture on the environment. You will learn how we can protect and restore our environment

1.2 Intended Learning Outcomes (ILOs)

By the end of the unit, you shall be able to:

- Define and use correctly all of the key words printed in bold.
- Describe the relationships between human activities and the environment and explain the importance of creating a better environment.

- Describe the ways in which humans use natural resources and give examples of problems caused by over-exploitation.
- Give examples of positive and negative ways in which technology affects the environment.

1.3 Relationships Between Human Activity and the Environment

Our physical surroundings and the features of the neighbourhood where we reside make up our environment. It also refers to the larger natural world, including the land, the ocean, and the atmosphere. Since the beginning of time, humans have interacted with their environment. For instance, humans have impacted the ecosystem for centuries by clearing forests to make way for agricultural land. On the other hand, the environment also has a variety of effects on us. The way we alter our attire in reaction to cold or hot weather is a straightforward example. In this section, we'll discuss some of the ways that people affect their environment and the ways that our surroundings affect us—both favourably and unfavourably. People can survive and prosper when there are favourable physical conditions, such as a favourable climate, clean water that is readily available, fertile soil, etc. However, adverse situations that make it more difficult for people to exist include a very hot climate, a lack of water, and infertile soil. Major natural calamities like earthquakes, floods, and droughts that cause damage to homes, property, and agriculture also have an impact on us. These have the potential to displace residents, cause harm, fatalities, and the ruin of livelihoods. They can also harm water sources and pipes, contaminating the water supply and escalating the spread of diseases transmitted by water. You will learn more about the effects of floods and droughts in subsequent units.

Industrialization, which started in the UK in the 18th century and quickly extended to the rest of Europe and North America before reaching every corner of the globe, altered our connection with the environment. Because the technologies at the time could not significantly alter the environment, human activity had little impact before industrialization. People back then lived in agrarian cultures with hand tools and basic technologies that had little effect on the environment. Resource exploitation has increased as a result of industrialization. For instance, we now employ strong chainsaws to cut down trees and chemical fertilisers and insecticides made in factories to grow crops. The impact of humans on the environment has significantly increased as a result of these developments. Utilization of natural resources such as land, water, food, soils, minerals, plants, and animals is one of the key activities that has a direct impact on the environment.

creation of wastes from a variety of activities, including as mining, industry, and agriculture, as well as wastes from our own bodies. When does industrialisation began in the UK?

Self-Assessment Exercises 1

1. What bring about the change in the relationship between man with the environment? 2. Why is it that prior to industrialisation the impacts of human activity on the environment were not very significant?

1.4 Use of Natural Resources

Natural resources come in numerous forms, and we use them all on a regular basis. For our survival, we need food, water, and energy for a variety of activities, such as domestic cooking and large-scale industrial processes. The creation of all the things we use, including our clothing, vehicles, structures, tools, and other stuff, requires a variety of materials. Take a straightforward illustration. As you study this section, consider the resources that were utilised to create a notebook similar to the one you might be using right now. Wood, water, and energy were required as raw resources for the creation of the paper. To grow, the trees that provided the wood needed soil, water, and a place to be planted. Your notebook might contain ink, metal staples, or other parts created from different kinds of resources. We have a significant and expanding need for resources as a result of rising population and per-person consumption due to socioeconomic development. Particularly for non-renewable resources, the depletion of natural resources by extraction and exploitation is of concern. We use resources that are either renewable or non-renewable. The primary distinction between the two is the rate at which they may be restored to a useful state in comparison to the rate at which humans use them. Resources that are not renewable cannot be replenished naturally at the same pace as their consumption. They consist of minerals and fossil fuels made from decomposing plants and animals that have been around for millions of years, such as oil, coal, and gas.

Natural processes can regenerate renewable resources over brief periods of time or make them continuously available. Solar energy is one example of a renewable resource that is not altered or depleted by people. Some resources, like water, are affected when humans use them and can be overused or degraded to the point where they are no longer useful. Can you suggest some other renewable resources that are replenished naturally but need to be managed properly and not over-exploited? Wood, animals and plants. For example, trees are cut down to provide wood and they will regrow but they need time to regenerate.

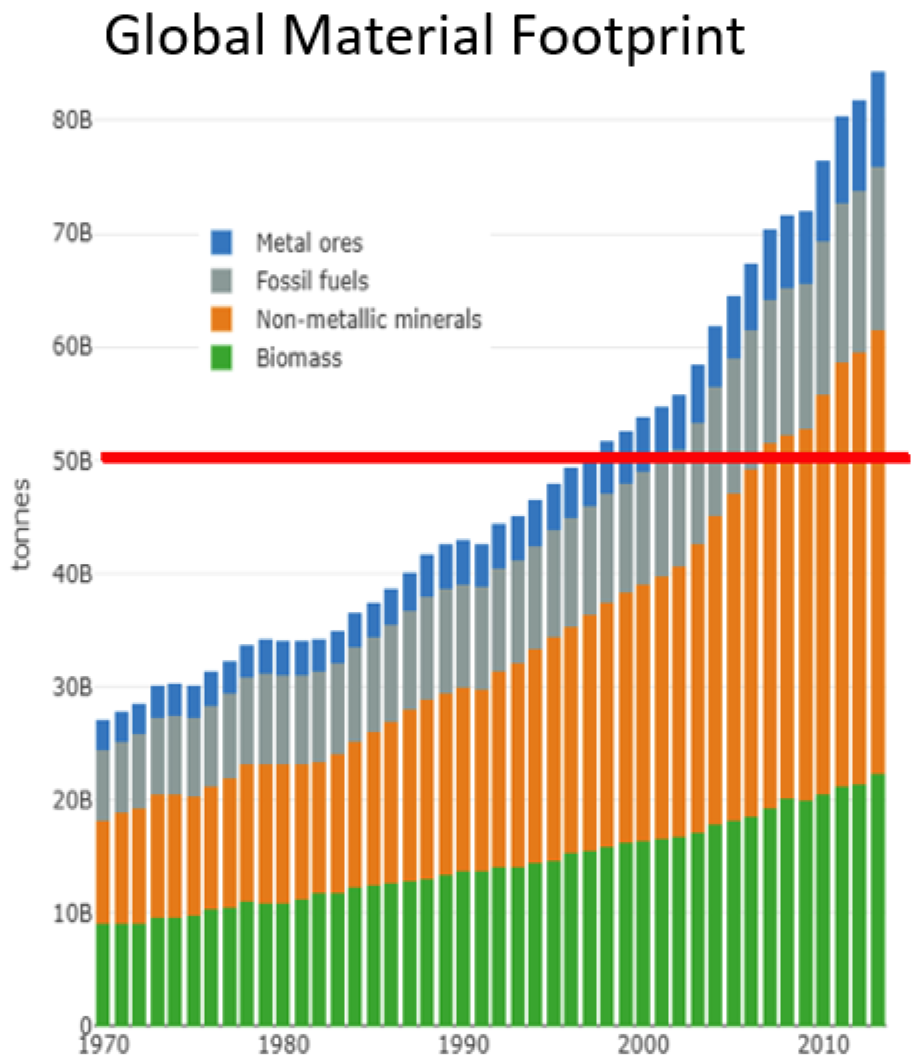

Figure 1. global material resource use in tonnes
Source: https://twitter.com/jasonhickel/status/1112285422091227137

Population growth and resource depletion both accelerated globally. Figure 1 displays the global tonnage of material resources used. Ecologists consider the red line to represent a generally sustainable level of consumption. About 20 years ago, we crossed that threshold, and since then, resource use has only increased. The diagram depicts the extraction of four different kinds of natural resources: metals, minerals, biomass, and fossil fuels. The term "biomass" refers to biological material made from living things like plants, animals, fish, timber, etc. From vehicles to computers, metals are employed in the production of a diverse range of products. Our homes, highways, and other structures are built using minerals via industrial processes. Both metals and minerals are extracted from mined rocks and put through numerous processing steps to get the precious resource. By enabling people to access new resources and to exploit more resources per person, technological advancements have enhanced the exploitation of natural resources (per person). For instance, the quantity of fish that can be caught by fisherman using traditional technology, such as tiny boats, is constrained. Large ships are used by modern industrial fishing fleets to traverse vast ocean areas at greater depths and catch a higher number of fish. Overfishing is the act of catching fish more quickly than they can reproduce, which can result from this.

1.4.1 Deforestation

Deforestation, which happens when forest areas are removed and the trees are not restored or given the chance to regenerate, is one issue specifically brought on by the overexploitation of natural resources. In Nigeria, the demand for fuel and building supplies has led to a gradual loss of forest area as land has been cleared for cultivation to support the country's rising population's food needs. The destruction of forests has a number of unfavourable effects. In addition to many various kinds of trees and other plants, forests are also home to a vast variety of species, from insects to birds and mammals. The biodiversity, or variety of living things, that results from the conversion of forests to agriculture is significantly reduced (all life forms). Humans depend on other living things to provide us with a number of need, making biodiversity important:

Food: We eat both plants and animals, including fish, goats, wheat, rice, and maize.

Medicines: New medicines are developed from various traditional medicines, which are made from plants and animals.

Ecological services: Living things, particularly plants and microorganisms, are crucial to the processes that preserve our way of life and the environment. These processes include the production of oxygen, the purification of water, the removal of trash, and the regulation of erosion.

Soil erosion is significantly exacerbated by deforestation. The underlying earth becomes visible once the trees and vegetation have been cleared away. The soil is more prone to be washed away by rain when there is no vegetation or tree roots to intercept the water and hold the soil together.

Water availability is significantly impacted by the loss of forests. Deep-rooted trees break up the soil's particles and enhance soil permeability, which makes it easier for rains to seep in and replenish groundwater. (Permeability is the term used to describe how easily water may pass through rock or soil.)

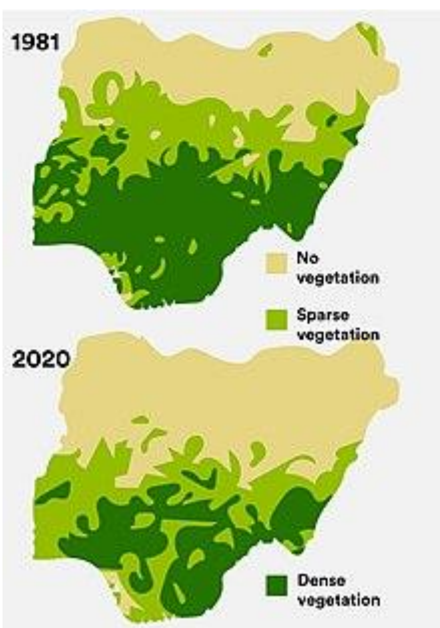

Figure 2. Deforestation in Nigeria 1981-2020

Source: https://en.wikipedia.org/wiki/Deforestation_in_Nigeria

Desertification, ecosystem loss, loss of biodiversity, land degradation, and soil erosion are only a few of the negative effects of deforestation on the environment. The environment's ability to sustain itself, the economy, and the safety of the populace are all threatened by deforestation. Education of society about sustainable resource usage, forest management, advanced technology, and alternate energy sources is one potential answer to deforestation. Leading sources of forest removal in the West African nation are listed as logging, agriculture, and the gathering of wood for fuel.

1.4.2 Energy Resources

When thinking about energy resources, the usage of renewable or non-renewable resources is crucial. The primary energy source for global industrialization has been fossil fuels, but since they are not renewable, their supply is ultimately limited and their use is not long-term sustainable. Furthermore, the primary contributor to climate change is the use of fossil fuels. (Full discussion of climate change is covered in following study sessions.) To replace fossil fuels, there are a number of renewable options. Although wood can be used as fuel again since trees grow, there are also drawbacks, such deforestation, as you have seen. Wind farms are utilising wind energy to produce electricity in many developing nations, but water is the most significant source of renewable energy. Numerous hydroelectric plants already exist in African nations, and more are planned. Hydroelectric power is renewable because it harnesses the power of moving water without consuming any water. Solar energy, which uses photovoltaic cells to transform the sun's energy into electricity, is another renewable energy source.

1.4.3 Water resources

Numerous hydroelectric plants already exist in African nations, and more are planned. Hydroelectric power is renewable because it harnesses the power of moving water without consuming any water. Solar energy, which uses photovoltaic cells to transform the sun's energy into electricity, is another renewable energy source. (FAO, 2012).

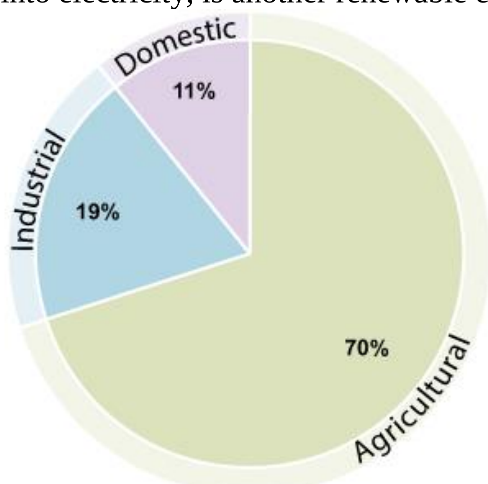

Figure 3. Global water withdrawal by sector. (Adapted from FAO, 2012)

In addition to being directly used by humans, water is crucial for the environment and to preserve biodiversity. Wildlife needs rivers, lakes, and wetlands as crucial habitats, and they always need a minimum level of water. When there is a shortage of water compared to the demand, this becomes an issue. Water is not a renewable resource indefinitely. Water demand is often much higher than the water supply can maintain in many regions of the world. Sustainable water supply refers to having sufficient quantities and quality of water to meet present and future demands on both the environment and human population. Water stress or scarcity are already widespread issues in many nations. These terms refer to the volume of water available relative to the use and demand for it, which is linked to the population served.

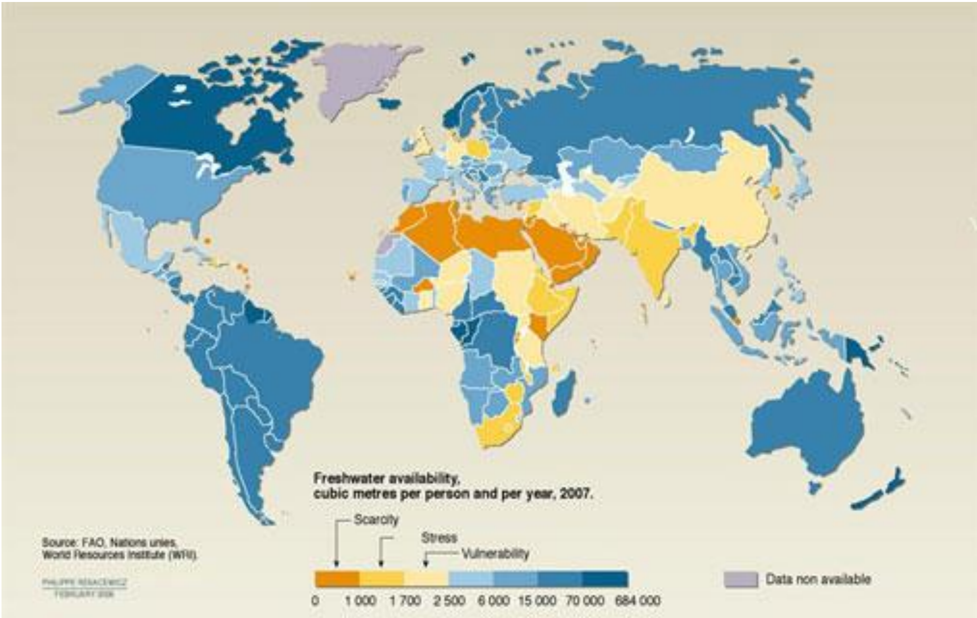

Figure 4. shows the availability of freshwater across the world.

Water-stressed nations are those with fewer than 1700 m3 of water per person per year for all uses (United Nations, 2014). Countries that have less than 1000 m3 of water per person annually are considered to be water scarce. However, these exact estimates should be used with caution because they obscure the root reasons of water scarcity and fail to account for differences between nations. Unsustainable usage of water resources results from rising water demand. Water supply is replenished by the water cycle. However, extracting too much water from rivers and groundwater for home, industrial, and agricultural use reduces the quantity of water that is available for both current and future use. Water withdrawals have tripled globally during the past 50 years as a result of population growth and rising per-person demand. While many regions with ample resources can support this use, in some nations future water shortages may occur unless demand is controlled. If the trend for increased consumption continues, what could be the result for African countries?
Self-Assessment Exercises 2

1. Is fish a renewable or non-renewable resource?

2. How are natural resources used globally?

1.5 Production of waste and pollutants

Production of waste indicates the consumption of materials and energy as well as the depletion of both renewable and non-renewable resources on Earth. Wastes will inevitably be produced as a result of our usage of natural resources. Our own bodily wastes rank as the most significant of these. Open defecation and poor sanitation have serious negative effects on both the general environment and human health. Pathogens (disease-causing agents) in water and food that have been polluted by diseased people's wastes are what cause waterborne diseases. It is extremely important to avoid this link between consumption of contaminated water and human waste. Wastes from industry, agriculture, and energy production can contaminate the air, water, and soil.

Pollution is the act of introducing pollutants into the environment that could harm people and other living things. For instance, the tanning process in the leather sector results in significant amounts of liquid wastes. These wastes include dangerous (toxic) compounds, such as some human carcinogens, and organic elements like fat from the hides (cancer-causing agents). Another illustration is the emission of so-called greenhouse gases like carbon dioxide, methane, and nitrous oxide that contribute to climate change caused by human activity.

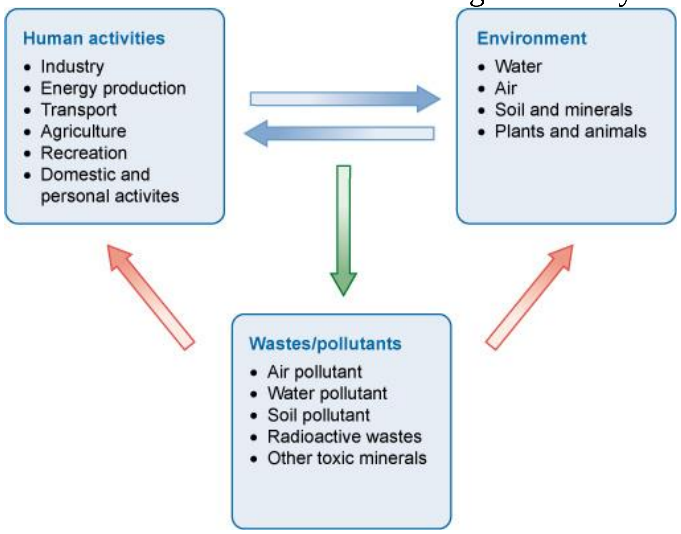

Figure 5.Summarises the interactions between 'human activities' and 'the environment'. The green arrow indicates the waste generated as a product of this interaction. The red arrows indicate the negative effect on both the environment and humans if the waste is not properly managed.

1.5.1 Technology and the Environment

Technologies have reshaped transportation, business, communications, and our personal and professional life. For those who can afford them, gadgets like mobile phones, laptops, televisions, microwave ovens, and refrigerators have raised living standards. Technology can also make our environment better. As an illustration, energy can be produced from renewable resources like wind and solar energy, which lessens our dependency on non-renewable energy sources like fossil fuels and also contributes to reducing the discharge of toxic gases into the atmosphere. The utilisation of cutting-edge environmentally friendly wastewater treatment facilities that can recover nutrients and waste water from waste, notably brewery waste that would otherwise be dumped into the environment, is another illustration of the advantages of technology. Technology of this kind can lessen the issue of water scarcity, stop surface water contamination, and save the environment. Although technology provides many benefits for both humans and the environment, it also has drawbacks, such as the creation of toxic waste from technical processes and the disposal of electronic devices once their useful life are over.

1.5.2 Agriculture and Environment

A significant portion of Nigeria's GDP, or roughly 24 percent in 2021, will come from agriculture as a source of revenue and a supply of vital food crops. Crop production had the biggest contribution, accounting for roughly 21% of the GDP. The second most important industry in Nigeria's economy after oil is agriculture, which accounts for a sizeable share of GDP. The agricultural industry in Nigeria employs over 70% of the labour force, making it essential to the bulk of people's livelihoods. But agriculture also significantly harms our ecosystem in other ways, such as through soil erosion, pollution, climate change, and the need of a lot of water for irrigation.

Poor agricultural techniques, particularly on land with a steep slope, are a major contributor to soil erosion in Nigeria because rainfall washes soil particles away downhill. In the next 20 years, the effects of soil degradation may cause a 40% decrease in world food supply unless immediate precautionary actions are taken. To lessen the impact, a paradigm change away from conventional farming production and toward technology-driven practise is still a viable option. In addition to being an issue for agriculture, this lost soil clogs up rivers and lakes with silt. A decrease in soil fertility due to soil erosion and biodiversity loss lowers agricultural output. The loss of soil down slopes can also be prevented by using good agricultural practises, such as the use of terraces and diversion ditches. Because it releases greenhouse gases into the atmosphere, agriculture also contributes to climate change. For instance, the addition of fertilisers to the soil releases nitrous oxide, while the production of livestock releases methane from the digestion of cattle and the breakdown of manure. Carbon dioxide is produced when burning trees to clear agricultural land and using fossil fuels to power agricultural machinery. You will study more about climate change and how greenhouse gases affect it in the next units to come.

1.5.3 Protecting and Restoring the Environment

The World Health Organization estimates that air pollution causes about 7 million deaths annually. This equates to around one death per eight worldwide. The world's biggest environmental health danger is air pollution. It's critical to comprehend the various environmental protection measures in order to lessen this risk. Reducing energy use is one method of environmental protection. We must thus consider what is happening in our planet and what we can do to alter it in order to protect, conserve, and restore our ecosystem. We need to consider how our actions affect the environment and how we might make modest changes in our lives that will have a large impact. We also need to look at the way we produce and consume energy, and find new ways to reduce our dependence on fossil fuels.

This lesson ends on a positive note. Humans can both negatively and favourably contribute to maintaining the environment. Among the methods is to lessen our ecological footprint. Lessening our ecological impact means putting less pressure on the environment. By making the best use of the "waste hierarchy," this can be accomplished. The hierarchy of measures to be performed to lessen waste production and enhance overall waste management processes and programmes is known as the waste hierarchy. The three R's of the trash hierarchy are: Reduce, Reuse, and Recycle. What problems do you think are caused by using large amounts of water for agriculture?

Self-Assessment Exercises 3

1. What is production of waste?
2. What is Waste Hierarchy?

1.6 Summary

Since the beginning of human history, humans and the environment have interacted, as you have studied in this lesson. Both favourably and badly, humans influence their surroundings, and the environment has a variety of effects on how people live. The utilisation of resources and the creation of trash are the two fundamental interactions between people and their environment. The Earth's natural resources are being extracted by humans in greater and greater quantities, which is leading to over-exploitation issues, such as overfishing and deforestation. Human activity generates a wide variety of garbage that might harm the environment.

1.7 References/Further Readings/Web Sources

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1.8 Possible Answers to Self-Assessment Exercises

Answers to SAE 1

1. Industrialisation
2. Because the technologies used then were not capable of modifying the environment on a large scale.

Answers to SAE 2

1. Fish are a renewable resource. However, if fishing is not managed properly and more fish are taken from the water than can be replaced naturally, the fishery will fail.

2. Natural resources are used **to make food, fuel and raw materials for the production of goods**. All of the food that people eat comes from plants or animals. Natural resources such as coal, natural gas and oil provide heat, light and power.

Answers to SAE 3

1. Waste production implies **the use of material and energy and the depletion of the Earth's renewable and non-renewable resources**
2. Waste Hierarchy is the order of priority of actions to be taken to reduce the amount of waste generated and to improve overall waste management processes and programs. The waste hierarchy consists of 3 R’s as follows: **Reduce, Reuse and Recycle.**

Unit 2 Pollution, Types, Sources and Characteristics

3.1 Introduction

The interactions between humans and their physical surroundings have been extensively studied, as multiple human activities influence the environment. The environment is a coupling of the biotic (living organisms and microorganisms) and the abiotic (hydrosphere, lithosphere, and atmosphere).

2.2. Intended Learning Outcomes (ILOs)

When you have studied this session, you should be able to:

- Explain the meaning of Pollution and use it correctly.
- Describe the main types of pollution.
- Explain the sources of pollution and the way pollutants reach the environment.
- Describe the main characteristics of water, air and soil pollution.

2.3 Pollution, Types, Sources and Characteristics

How can you know if water is contaminated if you hold up a glass in front of you? You would anticipate drinking water to be transparent, flavourless, and colourless (not turbid with suspended particulates). If none of these items were present, it might be contaminated. If you were gazing at river water, it probably wouldn't be as clear as drinking water in a glass, but if you saw that the water didn't appear dirty or smell terrible, you could infer that it wasn't polluted. Fish were swimming in the water, and animals were able to consume it without suffering any negative consequences. However, you may assume that pollution was the issue if the water was discoloured, had an awful odour, or you could see dead fish floating on the surface. The addition of any substance (solid, liquid, or gas) or any form of energy (such as heat, sound, or radioactivity) to the environment at a rate faster than it can be dispersed, diluted, decomposed, recycled, or stored in some harmless form is therefore known as pollution, also known as environmental pollution. The three main types of pollution are air pollution, water pollution, and land pollution, which are often categorised by environment. Particular pollutant kinds, like plastic, light, and noise pollution, are also of concern to contemporary civilization. Pollution of all kinds frequently has an adverse effect on the health and wellbeing of people as well as the environment and wildlife.

Although natural occurrences like forest fires and active volcanoes can result in environmental pollution, the word pollution typically suggests that the contaminants have an anthropogenic source—that is, a source produced by human activity. Ever since the first time that large groups of people gathered and stayed for a long time in one location, pollution has been a part of humankind. Indeed, the remains of ancient human communities, such as shell mounds and rubble piles, are often used to identify them. As long as there was enough room for each person or group, pollution was not a major issue. However, with the establishment of permanent settlements by great numbers of people, pollution became a problem, and it has remained one ever since.

Let's think about the potential human activity that led to the pollution. Consider a river that cuts across a piece of land near a town. The community uses the water for vegetable farming as well as drinking and other domestic purposes. Many locals utilise this water to irrigate tiny plots of land where they grow vegetables. To increase output, many farmers also use pesticides and fertilisers. Chemicals like nitrogen, potassium, and phosphorus, which are crucial plant nutrients, are used to make fertilisers. Pesticides are substances that kill pests but may be dangerous to other life forms, including people.

2.3.1 Types of Pollutants

The classification of pollutants is done from different points of view:

(i) Depending upon their existence in nature pollutants are of two types, namely quantitative and qualitative pollutants.

(a) Quantitative Pollutants: These are the compounds that naturally occur in the environment and become pollutants when human careless behaviour causes their concentration to rise. For instance, carbon dioxide is categorised as a quantitative pollutant if it is present in the atmosphere at a quantity that is higher than normal as a result of automobiles and industries and has observable consequences on people, animals, plants, or property.

(b) Qualitative Pollutant: These are those substances which do not normally occur in nature but are added by man, for example, insecticides.

(ii) Depending upon the form in which they persist after being released into the environment, the pollutants are categorized into two types, namely primary and secondary pollutants.

(a) Primary Pollutants: These are those which are emitted directly from the source and persist in the form in which they were added to the environment. Typical examples of pollutants included under this category are ash, smoke, fumes, dust, nitric oxide, sulphur dioxide, hydrocarbons etc.

(b) Secondary Pollutants: These are the pollutants that are created from primary pollutants through chemical reactions with atmospheric constituents. Examples include ozone, nitrogen dioxide, aldehydes, ketones, and sulphur trioxide. In the presence of sunlight, nitrogen oxides and hydrocarbons, two primary pollutants emitted by cars, combine to produce ozone and peroxyacyl nitrate (PAN), secondary pollutants that are much more hazardous than the original primary pollutants. Synergism is the term used to describe the phenomena of increased toxicity caused by chemical interactions between contaminants.

(iii) From the ecosystem point of view, i.e., according to their natural disposal, pollutants are of two types:

(a) Bio-degradable Pollutants: These are the contaminants that naturally disintegrate quickly. Domestic sewage and heat pollution are included in this category because they can quickly disintegrate through natural processes or through constructed systems like municipal treatment plants and other such systems.

(b) Non-degradable Pollutants: These are the compounds that, in the natural environment, either do not disintegrate or degrade very slowly. These include aluminium cans, DDT, long-chain phenolic compounds, mercury salts, and others. Such non-biodegradable contaminants migrate through the biogeochemical cycle and along food chains in the ecosystem, where they accumulate and are biologically amplified. For instance, DDT is absorbed by phytoplankton, which is consumed by fish, when it is washed from the ground and into streams. As a result, the initial amount of DDT, which was innocuous to phytoplankton, becomes extremely toxic to fish as it accumulates over time. As a result, enormous populations of fish die or become sterile, and the same is true for birds that eat these fish. This phenomenon is known as bio-magnification or biological magnification.

2.3.2 Physical nature of the pollutant

The four main types of pollutants are gas, liquid, solid, and energy. Liquid waste is typically where liquid pollutants originate. Human excreta (including faeces and urine), industrial wastewaters, and other types of waste from water-using activities are all considered liquid waste. Liquid waste is produced in factories by activities like washing products during production, cleaning things, and chemical mixing. Human waste from water-flushed toilets and other wastewater from homes and businesses are combined to form sewage. Pollution is frequently caused by sewage and human waste from overflowing septic tanks and latrines. Another form of liquid waste that might pollute is urban runoff. Many different kinds of garbage are washed from the land surface into lakes and rivers by rainwater. Quite a bit of organic stuff can be found in urban runoff. This could result from improper treatment of organic waste generated by homes and businesses or from open defecation. Anything made from living things, such as animal and human waste, decomposing plants, and food scraps, is considered to be organic matter.

Pollutants can also be solid. One of the most prevalent types of solid trash are plastic bags. Any solid material that is deemed to be unusable and discarded is referred to as solid waste. Different types of solid waste, such as paper, plastic, metal, chemicals in solid form, pieces of cloth or food, and animal remains, are produced by factories, enterprises, and families. Faecal matter often gets thrown out with solid trash, which makes things worse. The fourth type of pollution is widespread in urban areas. Noise pollution is energy in this sense. Unacceptable noise levels include those found in residential, commercial, and recreational settings. Noise annoys and bothers us, makes it difficult to have a conversation, and over time, can harm our hearing. Loud music coming from bars and music stores in an urban area is a well-known form of noise nuisance. While some people may enjoy the noise, many others find it to be upsetting since it keeps them from talking during the day and from resting at night. What is organic matter?

Self-Assessment Exercises 1

1. What are Bio-degradable Pollutants?

2. What is biomagnification?

2.4 Sources of Pollution

The area of human activity that generates the pollution can also be used to categorise it. There is an essential difference to be made regarding pollution sources before we look at the various industries. Pollution sources can be classified as point sources or non-point sources. Point sources are easily found, recognisable points or locations. A diesel truck that emits audible, dark exhaust gases from its tailpipe serves as an illustration. Another illustration is the discharge of liquid sewage into a river through a conduit. It is challenging to pinpoint the precise source of pollution from a non-point source, commonly referred to as "diffuse pollution." A good example is floodwater, which sweeps various kinds of waste from the land into a river, possibly including faeces. In this case, it is impossible to pinpoint a specific person, family, or place of business as the source of the water pollution.

2.4.1 Domestic sources

Toilets, latrines, and wastewater from kitchens and bathrooms are all examples of domestic sources of pollution. These wastes won't cause pollution if they are properly contained and kept from entering the environment. However, this is not always the case. Human excrement is obviously released into the environment through open defecation, where it can then wash into rivers and other surface waters. What types of organic waste are produced by a typical household?

2.4.2 Industry

The pollution brought on by industry is referred to as industrial pollution. The development of more industries and technology that accompanied the industrial revolution led to significant contamination of our planet's air, land, and water. This type of pollution is among the worst since the smoke that industry releases into the air plays a significant role in ozone depletion, animal and human health issues, and global warming. Additionally, the trash from these enterprises is dumped on land and in water, which has a negative impact on both the health of animals and plants. Many dangerous and unnatural compounds are released into the soil and water as a result of these industrial pollution, which ultimately cause the extinction of some plant and animal species. " *We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect." ~ Aldo Leopold.* Industrial pollution is any type of pollution that has its direct origins in industrial processes. Industries of some form are to blame for the majority of global pollution.

In reality, organisations working to combat environmental deterioration now place a high priority on the issue of industrial pollution. Countries that are experiencing the sudden and quick rise of these industries see it as a severe issue that has to be swiftly brought under control. Industrial pollution has many different guises. It degrades the quality of soil all across the world, contaminates several sources of drinking water, and releases undesired pollutants into the atmosphere.

2.4.3 Agriculture

In Nigeria, agricultural activities are growing and changing just like the industrial sector. More insecticides and fertilisers are being used in Nigerian agriculture. Pesticides have the potential to pollute lawn, water, and other vegetation. Pesticides can be poisonous to a variety of different organisms in addition to insects and weeds, such as birds, fish, helpful insects, and non-target plants. Phosphate and nitrate are components of fertiliser, and if they get into water bodies, they can promote excessive plant growth. Along with solid pollutants like crop residues, packing materials, and other wastes similar to those produced domestically, agriculture is also to blame for gaseous pollutants like methane produced by cattle. Animal excrement contributes to the creation of waste and potential contaminants.

2.4.4 Transport

Do you reside in a city or have you ever travelled to one nearby? If so, you are undoubtedly aware of the range of automobiles that travel on our highways. Some are light motor trucks, while others are compact cars. These cars vary not just in size but also in the types of fuel they use, including gasoline, diesel, and blended fuel (10% ethanol and gasoline). You can notice the black exhaust gas created by diesel engines if you look at the tailpipe of the car. Poorly maintained cars have more intense black paint, which can occasionally make the air hazy or smoky, irritate the eyes, and trigger coughing fits. Transport has a big impact on the environment since it consumes a lot of energy and burns the majority of the world's petroleum. This contributes significantly to global warming by emitting carbon dioxide and causing air pollution, which includes nitrous oxides and particles. The issue is exacerbated by the lack of a policy to remove outdated automobiles from the road.

Self-Assessment Exercises 2

1.Can you think of examples of point and non-point source pollution from earlier in this study session?
2. Why is it that the environmental effects of transport are significant?

2.5 Pathways of Pollution

As we previously stated, there is always a source and a beneficiary of pollution. The pollutant's passage from its source to the environment, the human body, or some other recipient is known as the pathway of pollution. Depending on the type of pollutant, the pathway between source and recipient might take on a variety of distinct shapes. Water, air, and soil are the main areas that are impacted by pollution. Humans typically come into contact with pollutants through the ingestion of tainted and polluted food and water, as well as through breathing dirty air. Many pollutants' severe side effects are lessened after they are discharged into the environment by one or more of the following procedures:

i). Dispersion – smoke disperses into the air and is no longer noticeable away from the source.

ii).Dilution – soluble pollutants are diluted in the water of a river or lake.

iii). Deposition – some suspended solids carried in a river settle (are deposited) on the river bed.

iv). Degradation – some substances break down (degrade) by natural processes into different, simpler substances that are not polluting.

In each case the effect is to reduce the concentration of the pollutant. Concentration is a measure of the amount of the substance in a known volume of water or air. The units used for water pollutants are usually milligrams per litre (mg/l, also written as mg l-1), although sometimes you may see ppm which stands for 'parts per million'. These processes do not apply to all pollutants. There are some persistent pollutants which remain intact when released into the environment because they do not break down by natural processes.

2.5.1 Sector of the Environment Affected by Pollution

Classifying pollution by the sector of the environment affected – water, air, soil and land – is probably the most commonly used method.

1 Water pollution

Surface water like rivers and lakes, soil moisture, groundwater in aquifers, and the oceans can all be impacted by water pollution. The activities of the water cycle connect all these many water reservoirs, as you are aware from Study Session 4. An example of how a polluted river could harm the marine ecosystem is when it empties into the ocean. The ocean's large amount of water can, however, spread and dilute the pollutant, limiting its harshest impacts to areas close to river mouths. Excess physical, chemical, or biological pollutants that alter the characteristics of the water and have the potential to harm living things constitute water pollution. Natural or unpolluted water is colourless, odourless, and transparent, as we just mentioned. One could say that hazy, bad-tasting, or odorous water are signs of water pollution. Some water pollutants, such as some chemicals, such as pesticides, and the majority of the microorganisms that cause waterborne infections, however, cannot be seen or tasted. Water contamination, then, affects more than simply how the water looks. Water that has been contaminated should not be utilised for irrigation, washing, bathing, or drinking. Depending on the type and concentration of the pollutant, drinking polluted water can have a variety of negative effects on the body. In Nigeria, most rivers and streams have large amounts of suspended particles that are transported by the current and give the water a brown appearance, especially during the rainy season. The majority of the solids are small soil particles that rain from the surrounding area has washed into the river, frequently after construction or agriculture. Large amounts of solids in the water can diminish light refraction, which can have an impact on plant growth.

Microorganisms that are detrimental to humans and other life forms are known as biological water pollutants. They are to blame for a wide range of waterborne illnesses. People or animals that have already been exposed to the microorganisms in question are the initial sources of these contaminants. Pollutants can enter surface and groundwater if human waste from diseased people is not properly controlled and treated. Bacteria, viruses, protozoa, and helminths are the main categories of biological contaminants (worms).

Depending on their source, chemical water contaminants can take on a wide variety of shapes. They include fertilisers known as plant nutrients (phosphorus and nitrogen compounds) that, as you read earlier, can wash from fields into rivers. These nutrients are typical surface water contaminants that are also created by the decomposition of human and animal waste.

Heavy metals, insecticides, and other persistent pollutants are also chemical pollutants. A class of hazardous chemical pollutants known as heavy metals is made up of compounds of persistent metals like mercury, cadmium, lead, and chromium. If absorbed through drinking or eating, heavy metals present in water at levels over what is considered safe can sicken and kill both animals and people.

POPs, or persistent organic pollutants, are poisonous to both people and animals. They include a variety of synthetic organic chemicals produced for use as industrial solvents and as pesticides, such as DDT, aldrin, and PCBs (polychlorinated biphenyls). In other nations, several of these persistent substances have been outlawed.

2 Air pollution

Both gases and solid particles can contribute to air pollution, which can occur at all spatial and temporal scales. It can have an impact on you at home, in your town, or in your city, and it can also effect the atmosphere globally. The burning of wood, charcoal, and other biomass fuel by homes, small enterprises like bakeries, manufacturing industries, and vehicles is one of the main causes of air pollution in Ethiopia's urban centres. The presence of excessive levels of chemical elements that can harm living things is referred to as air pollution. Nitrogen makes up 78% of the volume of clean air, followed by oxygen (21%), and trace gases (< 1%). Particulate materials (like black soot) and a variety of gaseous compounds, including carbon monoxide, carbon dioxide, nitrogen oxides, sulphur oxides, ozone, nitrates, sulphates, organic hydrocarbons, and many others, may be present in contaminated air. Many of these are also found in clean air as trace gases, but if they are present in excessive amounts, they turn into pollutants.

Black smoke emissions are a sign of severe pollution. Nevertheless, not all air pollution is audible or visible. Gases like carbon dioxide and monoxide are odourless and invisible. The dangers of carbon monoxide to people are great. It can be created when fuel is burned inefficiently (for instance, using a charcoal burner in a house with insufficient air supply), and if breathed in excessive amounts, it can be fatal. An major contaminant that contributes to climate change is carbon dioxide.

3 Soil and land pollution

Soil pollution, also called land contamination are linked to water pollution. Surface-level liquid wastes containing harmful substances or pathogenic microorganisms have the potential to slowly seep into the soil and contaminate groundwater, which could have an impact on nearby spring or well users. Open defecation, pit latrines, and leaky waste and chemical storage containers are a few potential causes. Soil pollution can be caused by solid waste. Solid waste that is gathered in one area or that is dispersed around is ugly and may smell unpleasant to you as you pass by. Food waste that will eventually decompose normally makes up the majority of household garbage. This emits an unpleasant odour and draws rats and insects, both of which help spread disease. A substance called leachate is created as the garbage breaks down and seeps into the soil. Leachate is a liquid pollutant that is extremely concentrated and may contain pathogenic microorganisms, hazardous chemicals, and high amounts of organic compounds. The issue is exacerbated by rainwater that falls on solid waste and washes through it. What is a leachete?

Self-Assessment Exercises 3

1. What are the three main sources of pollution? 2. Describe the pollution pathways

2.6 Summary

This lesson has taught you that environmental pollution is a byproduct of human development and activity and happens when physical, biological, and chemical agents are released into the environment in large enough numbers to have a negative impact on human health as well as the ecosystem. According to its physical characteristics, its source, its recipient, the sector it affects, or its effects, pollution can be categorised. An energy source, a liquid, a solid, or a gas can all be forms of pollution.

Pollution may arise from point sources, which are easily recognised, or from non-point sources, which are diffuse and difficult to identify. Household activities, manufacturing, agriculture, and transportation are the main causes of pollution. Once they have been released into the environment, the concentration of some pollutants is reduced by dispersion, dilution, deposition or degradation.

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2.8 Possible Answers to Self-Assessment Exercises

Answers to SAE 1

1. Bio-degradable Pollutants are the pollutants that are quickly degraded by natural means

2. Biomagnification refers to **the condition where the chemical concentration in an organism exceeds the concentration of its food when the major exposure route occurs from the organism's diet**.

Answers to SAE 2

1. The farmer washing his sack is an example of a point source because you could identify where he washed his sack. However, the pesticide washing from the field is an example of a non-point source. The pollutant would wash into the river at several places, and could possibly also have come from other fields. This is an example of how difficult it can sometimes be to accurately identify the source.

2. The environmental effects of transport are significant because transport is a major user of energy, and burns most of the world's petroleum causing **air pollution, including nitrous oxides and particulates**, and is a significant contributor to global warming through emission of carbon dioxide.

Answers to SAE 3

1. The three major types of pollution are **air pollution, water pollution, and land pollution**.

2. The pathway of pollution is the way the pollutant moves from the source, enters into the environment, and finally how it reaches the human body or other recipient. The pathway between source and recipient can take several different forms depending on the type of pollutant. Primary recipients for pollution are water, air, and soil. Pollutants usually reach humans through the consumption of contaminated and polluted water and food, and breathing polluted air.

Unit 3 Effects of Pollution on the Environment

Unit Structure

3.1 Introduction

This unit begins by describing the effect of water pollution on surface water ecosystems, such as lakes, rivers and streams. Pollution from human activities enters surface waters, either directly when wastes are dumped into lakes and rivers, or indirectly when wastes released on land or into the air are washed into surface waters. An ecosystem was defined in unit 1 as ‘all living organisms and their physical environment and the interactions between them’. Pollution can disturb and unbalance those interactions in a number of ways. This is what we shall be looking here.

3.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you should be able to:

- Explain the Effects of organic pollution
- Describe the effects of water pollution on aquatic ecosystems.
- Describe the effects of air pollution on the environment and on human health.
- Describe the effects of water pollution on human health.
- Describe some key principles that support pollution prevention and control.

3.3 Effects of organic pollution

Remember that organic matter is any substance derived from living organisms from the previous unit. Any contamination of water by organic matter is referred to as organic pollution. Where do organic contaminants come from? Domestic sewage, whether it is raw or treated, urban runoff, industrial (trade) effluents, and farm wastes are the sources of organic pollutants. The majority of organic compounds discharged into freshwaters come from sewage effluents. Examples include urban run-off and human and animal waste. For their survival, many aquatic (water-living) creatures rely on oxygen that has been dissolved in the water. Fish, amphibians (such as frogs and toads), and several invertebrate species, such as insect larvae, snails, and worms, are examples of aquatic animals. They are able to sustain their supply of oxygen in the water thanks to atmospheric oxygen in the air above them and oxygen produced by green aquatic plants during photosynthesis. Water that is moving quickly and turbulently will aerate (gain oxygen) faster than water that is motionless because the air-water interface is more active. Bacteria will consume organic pollutants like human and animal waste if they are released into a body of water. Proteins, lipids, and carbohydrates are complex organic compounds that bacteria break down into simpler chemicals, which are then further oxidised to form nitrates, sulphates, and carbonates. This process, known as biodegradation, utilises dissolved oxygen from the water and gives the bacteria energy. If there is little organic waste present and there is a lot of dissolved oxygen, the pollution will be eliminated by this natural breakdown process very fast. High quantities of organic pollution, on the other hand, can raise the bacterial population to the point where the water's oxygen content is completely depleted. It is known as deoxygenation. Complete deoxygenation can occur in lakes or slow-moving channels, but it is rare to occur in a river where the water is moving. Conditions that are anaerobic (oxygen-free) are ugly and smell bad. If they are unable to travel, fish and other aquatic species that depend on oxygen for survival may eventually perish. The reduction in fish populations and other aquatic animals not only disrupts the ecosystem but also results in a loss of food for local people and loss of jobs for local fishermen.

Figure 1. Dying fish due to oxygen starvation.
Source: https://www.open.edu/openlearncreate/mod/oucontent/view.php?id=79964&printable=1

3.3.1 Effects of Excess Nutrients on the Environment

Common pollutants produced by residential areas and agricultural run-off include phosphorus and nitrogen. They frequently come up while discussing fertiliser, human and animal waste, or both. Plants require the nutrients phosphorus and nitrogen in order to grow. If there are a lot of nutrients present, the water may get overgrown with plants. Algal blooms, which are characterised by a sharp rise in the number of tiny algae, can result from this. A water body is said to as eutrophic or eutrophicating if it has excessive levels of nutrients. The condition of eutrophication is widespread in Nigerian water bodies. The density of microscopic green algae prevents sunlight from accessing the water, killing and decomposing larger plants below the surface. The primary issue with eutrophication is that rapid algal blooms can disappear just as abruptly. Deoxygenation of the water might result from bacterial decomposition of the algae. Nitrate-rich water is unpleasant to drink and can be harmful to both people and animals. Additionally, some cyanobacteria species—also referred to as blue-green algae—that thrive in these environments create toxins that harm both humans and animals' livers, nerves, and skin. Larger plants like the invasive floating water hyacinth (*Eichhornia crassipes*), which can cover huge portions of lakes, develop more quickly as a result of eutrophication. When these plants die, they add to the problems of deoxygenation caused by decaying organic material.

3.3.2 Effects of Persistent Pollutants

Even though persistent pollutants like heavy metals and persistent organic pollutants are present in water at extremely low quantities, they eventually accumulate in organisms' tissues through a process known as bioaccumulation. There is no known biological function for these compounds in animals, nor is there a way to remove them from the body. The chemicals stay in the body and gradually build up if they are ingested or otherwise absorbed from the environment. Fish and shellfish in particular face difficulties since they obtain their food by filtering plankton from huge amounts of water. Fish will become polluted if the plankton are contaminated. Pollutant concentrations can rise to dangerous levels as they get more and more concentrated.

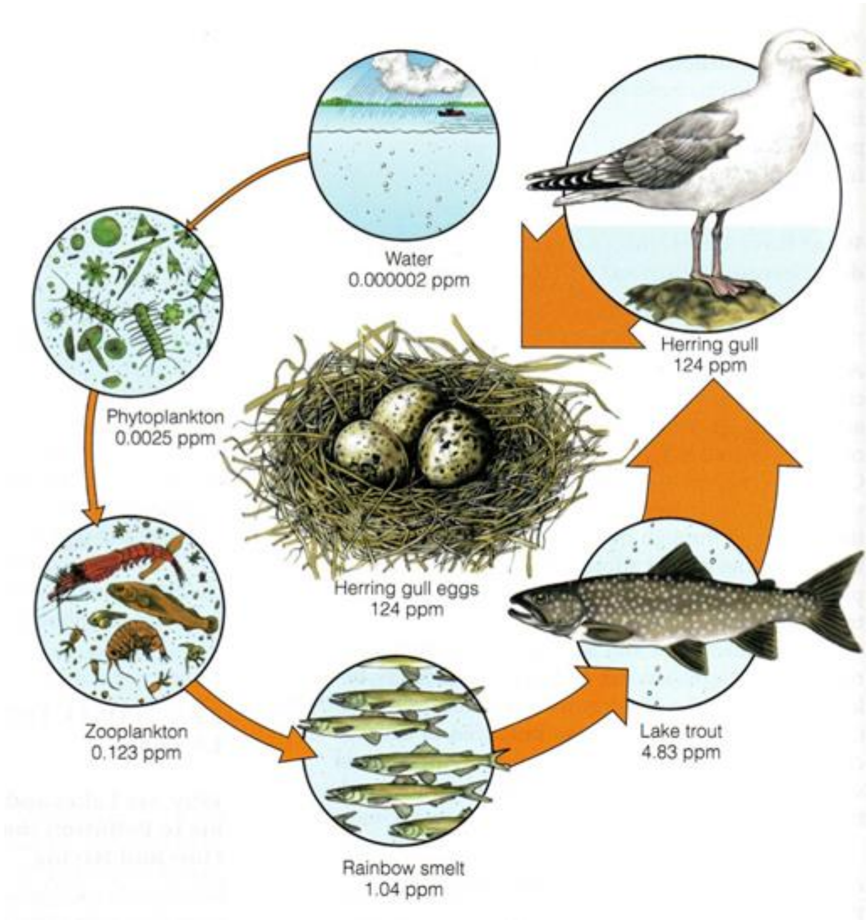

Figure 2. shows how levels of heavy metals, in this case mercury, increase through a food chain. A food chain is the sequence of who eats whom, or what.
Source: https://www.open.edu/openlearncreate/mod/oucontent/view.php?id=79964&printable=1

As seen in Figure 2 above, the quantity of mercury in the water is very low, but it rises in the bodies of phytoplankton (small aquatic plants), zooplankton (small aquatic creatures), fish that consume zooplankton, and lastly fish-eating birds. Additionally, the toxins can be transferred to eggs, harming avian reproduction. This progressive rise in concentrations along the food chain is referred to as biomagnification, a type of bioaccumulation. Humans and other terrestrial (land-dwelling) creatures are included in the aquatic food chain. A contaminant like mercury can accumulate to a point where it is hazardous enough to be harmful if swallowed. Pollutants will continue to bioaccumulate in plants and animals as long as the pollution continues.

3.3.3 Effects of air Pollution on the Environment

When there are enough toxins in the air to harm people, animals, and plants' health, it is considered air pollution. When gases into the atmosphere are released, such as nitrogen oxides, hydrogen sulphides, and sulphur oxides, they can dissolve in cloud water vapour and fall as rain. These contaminants produce acid rain by making the water more acidic (Figure 3). Acid rain, which often has a pH of less than 5, is very corrosive and harmful, especially to trees and structures (pH is a measure of acidity and alkalinity on a scale from 0 to 14. pH 7 is neutral; less than 7 is acid; more than 7 is alkaline). Why are persistent pollutants a major environmental problem?

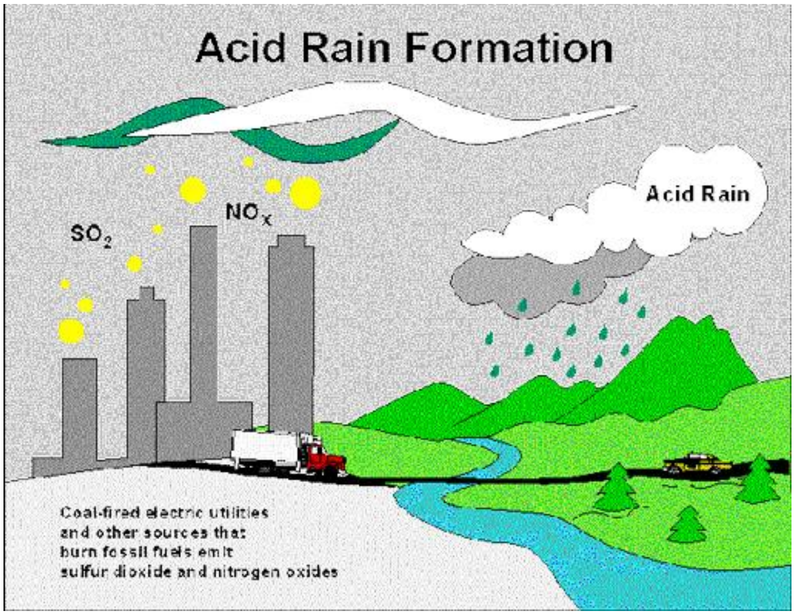

Figure 4. Acid rain formation **.**
Source: https://www.open.edu/openlearncreate/mod/oucontent/view.php?id=79964&printable=1

F*igure 5. Acid rain due to air pollution kills trees and destroys forests.*
Source: https://www.open.edu/openlearncreate/mod/oucontent/view.php?id=79964&printable=1

Self-Assessment Exercises 1

1. What are the origins of organic pollutants?
2. How does nutrient pollution affect the environment?

3.4 Effects of Pollution on Human Health

This section will mostly discuss the impacts of water pollution, but we also need to consider the effects of air pollution. Particulate matter in the form of dust and soot, as well as gases like carbon monoxide, sulphur dioxides, and nitrogen oxides, have detrimental effects on human health. Reduced lung function and illnesses of the respiratory system like asthma and bronchitis are brought on by severe air pollution. These days, acute respiratory infections are one of the most common reasons people visit outpatient clinics in hospitals and health centres. Although it is difficult to establish a direct causal connection, air pollution from household fires and car emissions is probably a contributing cause. The severe effects of water contamination on health are what we will discuss next.

3.4.1 Waterborne diseases

More than 2 billion people live in areas without access to drinkable water. The issue is particularly severe in underdeveloped rural areas, where a lack of infrastructure forces residents to rely on contaminated shallow wells and open springs. More than 1.2 million people die every year as a result of contaminated water. It is the most frequent cause of diarrhoea, a major risk factor for infectious diseases, and it makes malnutrition worse. In turn, diarrhoea is the second-leading cause of child death in the globe, killing an estimated 525,000 children under the age of five each year. Before the age of five, every child in Nigeria experiences diarrhoea on average five times. What might be the root of these paediatric illnesses? What more elements might have contributed to the spread of these diseases? Diarrhea is brought on by eating and drinking tainted food and water. Another important component in its transmission is poor hand hygiene. Numerous infections that are waterborne might manifest as diarrhoea (regular loose stools). They are brought on by biological contamination from diseased people's bodily wastes. Pathogenic organisms that cause waterborne illnesses, primarily diarrheal illnesses and parasitic worm infections, are present in faeces. Table 1 lists some instances of diarrheal and other watery illnesses along with their underlying causes.

Table 1. Examples of waterborne diseases.

Group	Disease	Causative agent
Bacteria	typhoid fever	Salmonella
	cholera	Vibrio cholerae
Viruses	viral gastroenteritis	rotavirus and others
	poliomyelitis	polio virus
	viral hepatitis	hepatitis A and E virus
Protozoa	cryptosporidiosis	Cryptosporidium
	giardiasis	Giardia
Parasitic worms	ascariasis	Ascaris lumbricoides
	schistosomiasis	Schistosoma

With one exception, every disease listed in Table 1 is brought on by either inadequate hand hygiene or swallowing microorganisms through contaminated food or drink. This type of infection is called faecal-oral transmission and occurs when bacteria from faeces enter a person's body through the mouth. The one exception is schistosomiasis, which is brought on by worms entering the skin when bathing or swimming in water tainted by an infected person's excrement.

3.4.2 Human Exposure to Pollution

Being exposed means not having any protection. In order for a pollutant or contamination to reach the human body, a number of conditions must be met. The collection of circumstances used to characterise exposure includes the existence of pollution, the medium in which the pollutant is present, and the human subject or host that will be harmed by the pollutant. The three major ways that pollutants enter the body are by eating, inhalation, and skin absorption. The term "dose" is frequently used to describe how much of a certain pollutant is consumed. The time and level of exposure will determine the dose. Organ dose explicitly refers to the quantity that enters the human organ where the pertinent effects may manifest, such as the lung.

Exposure can frequently happen simultaneously from numerous sources and via numerous paths. For instance, air pollution from vehicles and industry, drinking water, food, tobacco use, dusts, paints, and other products of industrial production as well as soil are all potential sources of lead exposure. Therefore, thorough understanding of the geographic distribution of the problematic pollutants, the temporal fluctuations in pollution levels, and the exposure processes is often required for valid exposure assessment. People are frequently exposed to several contaminants at once. These may be exposed to at various times and different places, such as the workplace and/or home. There are a lot of potential elements that could need to be looked at in their entirety. It may include a wide range of environmental pollutants, such as radioactive materials, dangerous chemicals, dusts, and particulates. It may also come from a variety of sources, such as the usage of pesticides, energy production, and industry. It may be emitted constantly or irregularly.

Self-Assessment Exercises 2

1. What are three main routes by which people are exposed to pollution
2.. What is exposure route?

3.5 Climate and Pollution

Climate change and air pollution are intimately related. The other factor lowering the quality of our planet is the climate. Climate change is mostly caused by natural factors, such as variations in the sun's rays, volcanic eruptions, changes in the Earth's orbit, and levels of carbon dioxide (CO2). Climate changes may also be brought on by the emissions of pollutants into the atmosphere. The term "climate forcers" is frequently used to describe these pollutants, which include greenhouse gases. The climate is warmed by ozone in the atmosphere, and it can be warmed or cooled by various PM constituents. The amount of sunlight that enters the atmosphere is impacted by pollutants such aerosols, methane, black carbon, and tropospheric ozone. As a result, the Earth's temperature is rising, which causes glaciers, icebergs, and ice to melt. Climate change will thus have an impact on the incidence and prevalence of both imported and residual illnesses. Climate and weather have a significant impact on the length, timing, and intensity of outbreaks and alter the distribution of infectious diseases around the world. Parasitic or viral infections spread by mosquitoes are very climate-sensitive because warming both shortens the incubation period for the pathogen and alters the geographic distribution of the vector. Similar to how climate change causes water to warm, this causes a high prevalence of waterborne illnesses. Recent population migration in Europe appears to be causing previously eradicated illnesses, such cholera, poliomyelitis, tick-borne encephalitis, and malaria, to reemerge. Natural weather disasters like storms, which appear to occur more frequently these days, are linked to the spread of epidemics.

The new illnesses that are harming public health are also linked to undernutrition and immune system imbalance. Since outbreaks of the disease were reported in Italy and France, the Chikungunya virus "took the aeroplane" from the Indian Ocean to the continent. Following flooding, there appears to have been an increase in cryptosporidiosis in the Czech Republic and the United Kingdom. As previously mentioned, aerosol compounds, despite their small size, have a significant impact on the climate. They are able to dissipate sunlight (the albedo phenomenon) by dispersing a quarter of the sun's rays back to space and have cooled the global temperature over the last 30 years.*What are the 3 main natural causes of climate change*? These have been caused by many natural factors, including changes in the sun, emissions from volcanoes, variations in Earth's orbit and levels of carbon dioxide (CO_2).

Self-Assessment Exercises 3

1. How does climate impact infectious diseases?
2. How can aerosols affect climate?

3.6 Summary

This unit has made it abundantly evident that organic and water pollution have a significant impact on aquatic ecosystems. Environmental and health effects of air pollution are also substantial. The unit has described some key principles that support pollution prevention and control, including the loss of vegetation, biological diversity, excessive levels of harmful chemicals in the ambient atmosphere and in food grains, rising risks of environmental accidents, and threats to life support systems as indicators of the decline in environmental quality as a result of pollution.

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3.8 Possible Answers to Self-Assessment Exercises

Answers to SAE 1

1, Organic pollutants originate from **domestic sewage (raw or treated), urban run-off, industrial (trade) effluents and farm wastes**. Sewage effluents is the greatest source of organic materials discharged to freshwaters.

2. Nutrient pollution **damages the environment and harms water quality** by creating algal blooms. Algal blooms consume large amounts of oxygen that fish, shellfish and other organisms need to survive. Algal blooms can make water cloudy, reduce the ability of aquatic life to find food, and clog the gills of fish.

Answers to SAE 2

1. The three main routes by which people are exposed to pollution are:
i. Ingestion
ii. Inhalation
iii. Skin contact

2. An exposure route is **the way a chemical enters an organism upon contact**. It is a point of contact/entry of a stressor from the environment into an ecological receptor (e.g., via ingestion, dermal absorption, or inhalation)

Answers to SAE 3

1. Climate and weather affect the duration, timing, and intensity of outbreaks strongly and change the map of infectious diseases in the globe.
2. They affect climate as they are able to dissipate sunlight (the albedo phenomenon) by dispersing a quarter of the sun's rays back to space and have cooled the global temperature over the last 30 years

Unit 4: Pollution: Effects, Prevention and Control

Unit Structure

4.1 Introduction

Appreciate the effect of pollution and human health, understand the links between environmental pollution and health and understand how to solve the environmental problems. The principles of pollution management through pollution prevention and pollution control will be explained.

4.2 Intended Learning Outcomes (ILOs)

By the end of this unit you will be able to:

- Appreciate the effect of Pollution and Human Health
- understand the links between environmental pollution and health
- Understand how to solve the environmental problems.
- Explain the principles of pollution management
- Describe the p**ollution prevention and Pollution control methods.**

4.3 Pollution and Human Health

Despite the significant efforts that have been made recently to clean up the environment, pollution still poses a serious threat to human health. The issues are obviously worse in the developing world, where a large number of people are exposed to traditional sources of pollution such industrial emissions, poor sanitation, insufficient waste management, contaminated water supplies, and indoor air pollution from biomass fuels. Environmental contamination does, however, still exist in wealthy nations, particularly in the lower sections of society. A wide variety of contemporary pollutants have also evolved in recent decades, including those linked to road traffic and the use of contemporary chemicals in food, the home, water treatment, and pest control. Effects on health are typically not instantaneous or immediately apparent because the majority of these pollutants are rarely present in excessively high quantities. Additionally, it was already said that just a small number of the environmental exposure issues that we face now include significant relative hazards. There are significant scientific problems in detecting minor effects against a background of exposure and human susceptibility variations, as well as measurement error. Even slight increases in relative risk can lead to significant public health concerns because a rising number of individuals are being exposed to environmental pollution (even if just as a result of population growth and urbanisation). There is a continual need for both attention and action due to the introduction of new sources of exposure and risk factors, some of which, like endocrine disruptors, have the potential to have lifetime effects on health. The need to acknowledge and treat the health concerns linked with environmental pollution becomes ever more pressing as human activity's effects and environmental health issues become more and more global in scope. Effective action, however, necessitates an awareness of the problem's scope as well as its root causes and underlying mechanisms since only then can an intervention be focused on the areas where it is most necessary and likely to have the biggest impact. What are the health consequences of air pollution on populations?

Self-Assessment Exercises 1

1. What is the consequence of the emergence of new sources of exposure and risk factors with the capacity to have lifelong implications for health? **2.** What are the traditional sources of pollution in developing world?

4.4 Links Between Environmental Pollution and Health

The presence of an agent in the environment that has the potential to harm the environment or human health can be simply, though rather broadly, characterised as environmental pollution. Pollutants can therefore take on various forms. In addition to chemicals, they also consist of living things, biological materials, and energy in all of its forms (e.g. noise, radiation, heat). Thus, there are virtually innumerable potential contaminants. For instance, there are currently about 30,000 chemicals in widespread use, and any one of them has the potential to release pollutants into the environment through usage or processing. Less than 1% of these have undergone a thorough evaluation of their toxicity and health hazards. There are genuinely too many biological contaminants to count. They encompass both dead and undead species, such as bacteria, as well as the enormous variety of endotoxins that can be released from the protoplasm of live things. Therefore, there is no shortage of possible health dangers associated with the environment. Understanding the nature and mechanisms of these dangers is mostly what is lacking.

4.4.1 The Source–Effect Chain

The relationship between pollution and health is intricate and variable. Pollutants must be present in concentrations that cause detectable symptoms in sensitive persons before they can have a negative impact on health. These people have to have been exposed to the pollutant, frequently over a lengthy period of time or repeatedly, for this to happen. Such exposures necessitate the simultaneous presence of contaminants and sensitive people in the same surroundings. In order for this to occur, the pollutants must not only be introduced into the environment but also spread therethrough in media accessed or used by people. Even for pollutants that are inherently toxic, health effects of environmental pollution are not always inevitable; instead, they depend on the coincidence of the processes of emission and dispersion that determine where and when the pollutant occurs in the environment, as well as the human behaviours that determine where and when they occupy those same locations.

Simply said, the entire process can be visualised as a source–to–effect causal chain. This shows that most pollutants are caused by people. They come from human activities like industry, energy usage and production, transportation, daily chores, waste management, agriculture, and leisure. Natural causes of pollution, however, might also be important in specific circumstances. These include heavy metals accumulating in soils and sediments derived from ore-bearing rocks, radon released through the decay of radioactive materials in the Earth's crust, arsenic released into ground waters from natural rock sources, and particulates and sulphur dioxides released by wildfires or volcanic activity. The atmosphere, surface waters, ground waters, and soil are just a few of the many environmental media through which these varied sources can release their waste. Since they are rarely directly measurable, estimates of emission by source and environmental medium are invariably simply approximations. Instead, most emissions inventories are the result of modelling, either based on input-output models or emission factors for various processes or source activities.

4.4.2 Solving the Environmental Problems

Rapid human population increase is to blame for all of the environmental issues that have so far been listed in this unit and the ones before it. The following difficulties are inescapable and clear results of the increase.

- an increasing need for energy
- a depletion of resources
- a growing level of pollution.

Environmental scientists have considered these problems not to be insurmountable. It will however require a combination of scientific investigation and public action to be brought to bear effectively for solutions to be achieved. Solving environmental problems may require the following suggested steps to be undertaken

- Assessment: The first stage in addressing any environmental problem is scientific analysis, through the gathering of information. With collected data and experimentation, models can be constructed to describe the situation and to make predictions about future course of events.

- Risk Analysis: Using the results of scientific analysis as a tool, it is possible to analyse what could be expected to happen if a particular course of action were followed. An environmental impact statement is often prepared at this point.
- Public Education: When a clear choice can be made among alternative courses of action, the public must be informed.
- Political Action: The public, through its elected officials, makes a choice, selecting a course of action and implementing it. To implement choices can be difficult when environmental problems transcend national boundaries.
- Follow –through: The result of any action taken should be carefully monitored to see whether the environmental problem is being solved and more basically to evaluate and improve the initial evaluation and modeling of the problems. It should be borne in mind that perhaps one of the ways of solving the world's environmental problems is the improvement of technology in the area of solar energy and wind energy to provide the driving force for the technological development of the future.
  What is environmental pollution?

Self-Assessment Exercises 2

1. What are the three rapid human population growth problems?
2. What is the Source–Effect Chain?

4.5 Principles of Pollution Management

There are two main approaches to pollution management:

1. **Pollution Prevention**: focuses on stopping pollution being produced in the first place, or reducing any waste generation at the source.

2. **Pollution control**: those measures taken to control pollution and wastes after they have been generated or produced.

4.5.1 Principles of Pollution Prevention

There are a number of principles of pollution prevention; we will briefly discuss some of them.

Principle of **waste optimisation**: The motto in this principle is 'Do not produce any waste; if this is not possible, reduce or minimise waste generation as much as possible'.

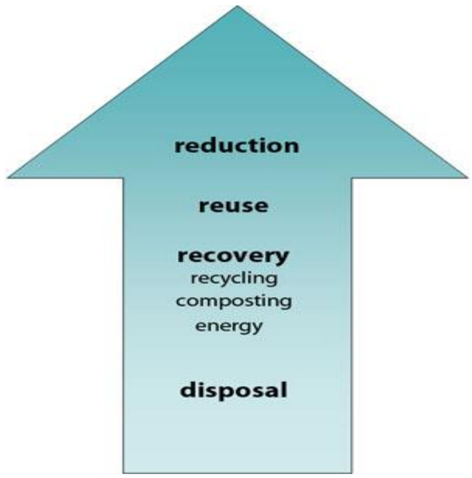

Figure 1. The waste hierarchy. Waste management options are listed in order of desirability from most desirable at the top to least desirable at the bottom.

There are three ‘Rs’ that are applied in waste optimisation: Reduce, Reuse and Recover. Figure 1. shows the hierarchy or the order in which the waste optimisation options should be used.

Reduction is the process of altering a process to prevent the creation of waste in the first place. Reusing something means using it more than once (for example you can reuse plastic bottles for collecting water). Recovery is the process of obtaining materials or energy through composting, recycling, and cremation. Using recycled metal to create new products out of used aluminium cans (also known as tin cans) is an illustration of recycling. We can turn organic waste into compost that can be used as fertiliser by composting it. We can recover the energy in waste items through incineration (burning). The concept of waste optimisation is applied in industries through cleaner production. Cleaner production implies appropriate environmental management, waste minimisation, replacement of toxic chemicals, process and product modification, and the application of the three ‘Rs’.

Polluter pays principle: According to this idea, those responsible for any harm to people or the environment are the individuals or organisations that create waste or pollution. They are liable for any damage's associated costs. The guiding concept serves as a practical means of enforcing duty and accountability. Making the polluter pay can be done by enforcing strict requirements for permits for pollution discharge and imposing high taxes on goods or waste management.

Principle of **‘Cradle to Grave’**: The production of any item or action by a person or organisation, as well as whatever pollution that item or activity may create during the course of its lifecycle, from the "cradle" to the "grave," are all covered by this principle. For instance, when making a plastic bottle, pollution may be created throughout the production process, in the lorries used to transport the bottles across the nation, and when the bottle is discarded. Consideration should be given to each of these factors.

Precautionary principle: The precautionary principle states that it is always necessary to avoid harming others, even when one is unsure of how their actions will affect other people or the environment. According to this theory, you take efforts to prevent environmental harm even if you are unsure that harm will occur. One example is the use of waste minimization.

Principle of **duty of care**: Any individual or organisation that generates waste, often known as a waste generator, has a civic and moral responsibility to manage their waste correctly. They have a responsibility to make sure it doesn't hurt the environment or other people.

Principle of discharge/emission permit: A waste generator has an obligation to obtain permission from the regulatory authority in order to discharge waste to surface water and to the atmosphere.

4.5.2 **Pollution Control**

It is not always possible to prevent pollution by various applicable concepts and procedures, and as a result, some pollution is created. If pollution is created, steps should be taken to reduce its impact on both humans and the environment. Some of the intervention choices in waste control include applying waste treatment prior to disposal, limiting waste contact with the public, and monitoring and analysing the impact of the trash on the nearby environment. What does the Principle of duty of care suggest?

Self-Assessment Exercises 3

1. What does the Polluter pays principle address?
2. What does the Principle of **'Cradle to Grave' implied?**

4.6 Summary

Despite the major efforts that have been made over recent years to clean up the environment, pollution remains a major problem and poses continuing risks to health. In this unit, we have on the effect of pollution on human health. You have also studied the links between environmental pollution and health ,and how to solve the environmental problems. The Principles of pollution management through pollution prevention and Pollution control was also explained.

4.7 Further Reading/Reference/Web Sources

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https://digitalcommons.mtech.edu/campus_lectures/60/
https://www.youtube.com/watch?v=6IKaUTYWtvg
https://www.youtube.com/watch?v=BzKs0FYSxmo
https://www.youtube.com/watch?v=C5tXyMiOVas
https://www.youtube.com/watch?v=K_nL8iPD83g

4.8 Possible Answers to Self-Assessment Exercises

Answers to SAE 1

1. The emergence of new sources of exposure and new risk factors, some of them—such as endocrine disruptors—with the capacity to have lifelong implications for health, means that there is a continuing need for both vigilance and action.

2. **The** traditional sources of pollution in developing world include: industrial emissions; poor sanitation; inadequate waste management; contaminated water supplies; and exposures to indoor air pollution from biomass fuels.

Answers to SAE 2

1. The three rapid human population growth problems are:

- an increasing need for energy
- a depletion of resources
- a growing level of pollution.

2. This effect tries to explain the link between pollution and health is both a complex and contingent process. For pollutants to have an effect on health, susceptible individuals must receive doses of the pollutant, or its decomposition products, sufficient to trigger detectable symptoms. For this to occur, these individuals must have been exposed to the pollutant, often over relatively long periods of time or on repeated occasions.

Answers to SAE 3

1. The principle is an economic tool to enforce accountability and responsibility

2. Principle of **'Cradle to Grave'** applies to the production of any object or to any activity by an individual or institution and all the pollution that object or activity might cause throughout its lifecycle

Unit 5: Humans, Environmental and Health

Unit Structure

5.1 Introduction
5.2 Intended Learning Outcomes (ILOs)
5.3 Human -Environmental Interactions
5.4 Coevolution and Coadaptation
5.5 Links between Ecosystem Services and Human Well-being
5.6 Summary
5.7 References/Further Readings/Web sources

5.8 Possible Answers to Self-Assessment Exercises

5.1 Introduction

In this unit, you will study the Human -Environmental-Health Interactions as interactions between the human social system and (the "rest" of) the ecosystem. You will learn about Coevolution and Coadaptation, although similar in process, are not the same; co-adaptation refers to the interactions between two units, whereas co-evolution refers to their evolutionary history. The links between ecosystem services and human well-being will be stressed.

5.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you shall be able to:

- Describe the human -environmental-health nexus as interactions between the human social system and the ecosystem.
- Explain the meanings of Coevolution and Coadaptation
- Explain the links between ecosystem services and human well-being.

5.3 Human -Environmental Interactions

The linkages between people and the overall ecological system are known as human environmental interaction. Both the environment and the human social systems are complex adaptive systems. They are complex because there are many components and connections between ecological units and human social systems. The ability to adapt is a result of the feedback systems that help with survival in constantly changing environments. The term "human environmental interactions" refers to interactions between the ecosystem and (the "rest" of) the human social system. Three different kinds of human-environment interactions exist: how people are dependent on the environment for things like food, water, lumber, and natural gas; The manner in which individuals modify the environment, either positively or badly, for as by drilling holes or constructing dams, to meet their own demands. Ecosystems and human social systems are both sophisticated adaptive systems. Complexity results from the large number of components and connections that both human social systems and ecosystems have. They are adaptive because they contain systems for feedback that help them survive in a setting that is continuously changing. Understanding certain traits of the human social system is crucial for analysing how people interact with their surroundings. The sort of society has a significant impact on how people behave, how they view nature, and how they affect ecosystems. Population size, social organisation, values, technology, money, education, knowledge, and many other factors are crucial aspects of human social systems. Values and knowledge, in particular, have a significant impact on how people "see life" and, as a result, how they behave. The available technology then places restrictions on the range of feasible activities. People alter the environment to serve their needs and gain from it (ecosystem services). For example, these ecosystem services include the provision of resources like water, lumber, food, electricity, information, land for farming, and many others. These ecosystem services are crucial for human well-being. Using these resources obviously has a significant impact on the environment. To create new ecosystems that seem to better meet their requirements, individuals frequently reorganise already-existing ones. The relationship between ecosystem services and elements of human well-being was examined as part of the Millennium Ecosystem Assessment (MA). Figure 1 shows the strength of relationships between categories of ecosystem services and frequently occurring aspects of human well-being. It also shows the extent to which socioeconomic considerations may be able to mitigate the relationship. (For instance, there is a high likelihood of mediation if a replacement for a deteriorated ecological service can be purchased.) Different ecosystems and geographical areas have varying levels of linkage strength and capacity for mediation. Various elements, such as other environmental factors, as well as economic, social, technological, and cultural factors, influence human well-being in addition to the impact of ecosystem services on it as shown above. Changes in human well-being also have an impact on ecosystems. Why are human social systems and ecosystems said to be complex adaptive systems?

Complex because ecosystems and human social systems have many parts and many connections between these parts.

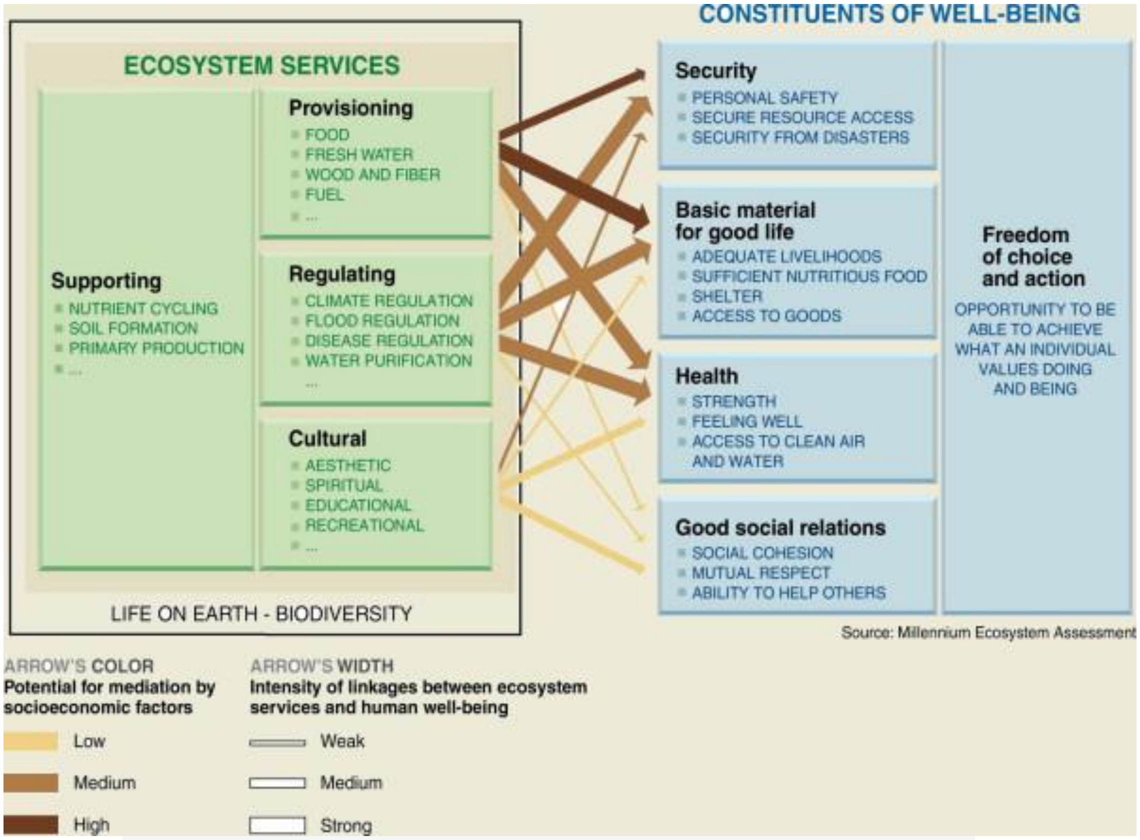

Figure 1. **Linkages between Ecosystem Services and Human Well-being.**
Source: https://learningforsustainability.net/mwa/dpsir/

Self-Assessment Exercises 3

1. A part from the influence of ecosystem services on human well-being depicted in Figure 1. What are the other factors that influences human well being?
2. What are the 3 types of human environment interaction?

5.4 Coevolution and Coadaptation

The never-ending process of mutual adjustment and change between human social systems and the environment is referred to as coevolution and coadaptation. Environmental implications are a result of human behaviour. The environment, however, also has an impact on human activity. Human social systems must change to fit their unique surroundings. Storms and earthquakes are examples of natural events that cause people to react. These natural phenomena may or may not be largely caused by human activity, but they nonetheless have an impact on human behaviour since humans must adapt to changing circumstances. To further comprehend this link, the Drivers-Pressures-State-Impact-Response (DPSIR) model was developed. With the help of the DPSIR model, you may examine and analyse the crucial interaction between social and environmental components. It is a widely accepted and favoured framework everywhere. A useful analytical framework for evaluating complicated natural resource challenges is the DPSIR model. It identifies the several causal networks that connect human activity to environmental deterioration. In order to clarify how human activity affects the state of the environment, the model separates several sorts of indicators. Human actions either exacerbate or lessen environmental pressure. It is primarily socio-economic and socio-cultural forces that propel human activity. For instance, it is helpful to be able to analyse the state of and influences on these ecosystems not just in the present but also across time since fresh water management considers continuously fluctuating complex aquatic ecosystems and their relationship to nearby populations. Why does the DPSIR model has to distinguishes several categories of indicators?

The following graphic explains the DPSIR process:

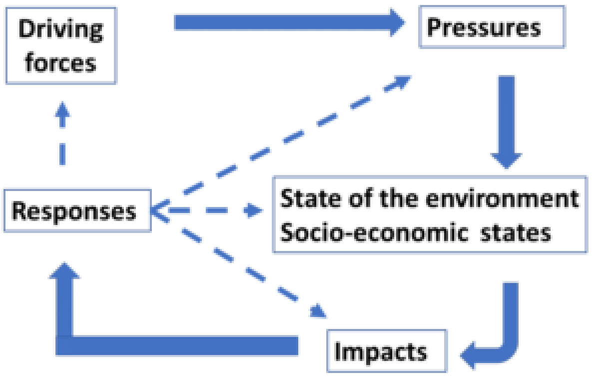

Figure 2. *A graphic outlining the DPSIR framework*
Source: https://learningforsustainability.net/mwa/dpsir/

Self-Assessment Exercises 3

1. What is the full meaning of DPSIR in sustainability ecology?
2. What does the terms coevolution and coadaptation implied?

5.5 Links Between Ecosystem Services and Human Well-being

Changes in the structure and function of ecosystems, as well as the subsequent flow of ecosystem services, have an impact on human well-being. When defined in terms of the ability of ecosystems to deliver a specific basket of services to users of those services, commonly used words like "ecosystem health" or "ecosystem integrity" gain much more focus. It is unclear if ecosystems can continue to supply the services required for a level of human well-being that is considered to be acceptable in light of evidence of growing human influences on ecosystems around the world. Numerous environmental services already suffer from human activities. Within a few decades, if current trends continue, mankind will have significantly changed almost all of Earth's surviving natural ecosystems. Typically, these changes will boost the supply of one service (such food or fibre) at the expense of others (for example, clean water and self-regulation of pests and diseases). The choices made by humans regarding how to use ecosystem services and how ecosystems are changed can either increase or decrease societal advantages. For instance, the conversion of wetlands and forests to croplands contributes to stable food supply but also damages biodiversity, pollutes streams, disrupts hydrology, reduces fish yields, and destroys picturesque areas. The long-term worth of the services lost to human civilization may be greater than the immediate economic gains from those transformational actions. Naturally, ecosystem alteration is done in order to reap current or future benefits, at least temporarily. Indeed, such transformation is necessary for the societies of today. One in every two jobs worldwide are in agriculture, forestry, and fishing, while industrial goods are outperformed in terms of their contribution to the global economy by crops, timber, and fish. How to comprehend and measure the costs, risks, and advantages associated with any scenario, both present and future, is the crucial question. The present and future well-being of people are greatly at risk. The intricate relationships between environmental services and human well-being are best illustrated by the mining industry in Papua New Guinea. Localized agricultural land, plantations, and coral reefs are lost as a result of mining, but the mining firms make up for this loss with financial payments. The money can also be used to obtain services that were not previously available, such as better housing, piped water supply systems, high-protein foods, western medicines, and other types of health care, with a significant improvement in well-being. This may not entirely replace the lost services, though. However, the loss of controlling and delivering services typically outlasts the financial benefit. There are also important social impacts (for example, social disintegration and loss of spiritual values connected to a ‘‘sense of place’’) that decrease well-being in important ways.

Ecosystem changes can affect people's well-being on a global, regional, sub-regional, national, and local level, frequently on several dimensions at once. For instance, fishing activities in the Caribbean Sea, which contribute significantly to the region's GDP and provide many people with employment and protein, can be studied at the scale of the fishing community, the nation, the subregion, the region, and the entire North Atlantic Ocean. All of these scales have institutions in place to control how the service is used, and when one of these institutions fails, it affects the tiers above and below it. Indigenous peoples are a unique example of the relationship between ecosystem services and wellness since they have existed within the setting of a specific ecosystem for many generations. Furthermore, when the ecosystem services they depend on deteriorate, individuals might not have many options for replacing them with services from other sources because their "feeling of place" plays such a large role in their worldview. Additionally, indigenous people are typically excluded from political decisions affecting the resources they have used and frequently preserved for decades. What are indigenous people? They are people who have lived within the context of a particular ecosystem for many generations, and represent a special case of ecosystem service-wellbeing linkage

Self-Assessment Exercises 3

1. What are the factors affecting human well being?

2. Changes to ecosystems, and thus to human well-being, can occur at several scales simultaneously. For example, fishing activities in a given locality, at what scale can it be analysed?

5.6 Summary

The linkages between people and the overall ecological system are known as human environmental interaction. Both the environment and the human social systems are complex adaptive systems. Three different kinds of human-environment interactions exist: People rely on the environment for things like food, water, wood, natural gas, etc. The manner in which people alter the environment, either positively or badly, by creating dams or drilling holes, to meet their own demands. The two inextricably linked emergent characteristics of the interdependent social system and ecology are: 1. Coevolution (changing together). 2. Coadaptation (fitting together) were described.

5.7 References/Further Readings/Web Sources

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https://www.youtube.com/watch?v=1gFxhYcStEg

https://www.youtube.com/watch?v=w391HkYO_bM

https://www.youtube.com/watch?v=r7UCAsBT5Yg

5.8 Possible Answers to Self-Assessment Exercises

Answers to SAE 1

1. Other factors the influences human well being-include other environmental factors as well as economic, social, technological, and cultural factors-influence human well-being

2. The 3 types of human environment interaction are:

The way people depend on the environment for food, water, timber, natural gas etc
The way people adapt the environment to fulfill their own needs
The way people modify the environment positively or negatively like drilling holes, building dams

Answers to SAE 2

1. Drivers-Pressures-State-Impact-Response
2. The terms coevolution and coadaptation describe the never-ending process of mutual adjustment and change between human social systems and the environment.

Answers to SAE 3

1. Human well-being is affected by changes in the composition and functioning of ecosystems and the resultant flow of ecosystem services.

2. It can be analyzed at the fishing community scale, the national scale, the subregional scale, the regional scale, and the scale of the entire continent

Glossary

Absorption: The passage of one substance into or through another.

Acid: A substance that has a pH of less than 7 (7 = neutral) which can lower the pH value of water or soils to be harmful to growth of crops.

Acute: Occurring over a short period of time; used to describe brief exposures and effects which appear promptly after exposure.

Acute Exposure: A single exposure to a toxic substance which may result in severe biological harm or death. Acute exposures are usually characterized as lasting no longer than a day, as compared to longer, continuing exposure over a period of time.

Air Quality Standards: The level of pollutants prescribed by regulations that are not to be exceeded during a given time in a defined area.

Ambient Temperature: Temperature of the surrounding air (or other medium).

Anaerobic: To function without air or oxygen.

Anhydrous: Free from water.

Aquifer: An underground rock formation composed of such materials as sand, soil, or gravel, that can store groundwater and supply

Area A: In accordance with Arizona Revised Statutes §49-541, the part of the greater Phoenix Metropolitan area where specific pollution control programs are in place for ozone, carbon monoxide, and particulate matter. Includes parts of Yavapai and Pinal County.

Back Pressure: A pressure that can cause water to backflow into the water supply when a user's water system is at a higher pressure than the public water system.

Bioaccumulation: The retention and concentration of a substance by an organism.

Bioassay: A test which determines the effect of a chemical on a living organism.

Bioconcentration: The accumulation of a chemical in tissues of an organism (such as fish) to levels that are greater than the level in the medium (such as water) in which the organism resides.

Biological Degradation: A process by which micro-organisms break down waste materials. Nutrient additives may be introduced into a contaminated area (such as groundwater or soil) for the specific purpose of encouraging biodegradation.

Cadmium: A highly toxic soft, malleable, bluish white metal that accumulates in the environment, found primarily in zinc ores.

Carbon monoxide: A colorless, odorless gas formed by incomplete combustion of carbon or a material relating to, containing or composed of carbon material.

Carcinogen: A substance or agent that may produce or increase the risk of cancer.

Characteristic: With respect to hazardous waste, one of the following four categories: ignitability, corrosivity, reactivity, and toxicity.

Chemical Compound: A distinct and pure substance formed by the union or two or more elements in definite proportion by weight.

Chlorinated Solvent: An organic solvent containing chlorine atoms. Chlorinated solvents are used in aerosol spray containers, highway paint, dry cleaning fluids and the electronics industry.
Chlorination: The application of chlorine to water, generally for the purpose of disinfection, but frequently for accomplishing other biological or chemical results (aiding coagulation and controlling tastes and odors).
Chlorofluorocarbons (CFC): A family of inert, nontoxic, and easily liquefied chemicals used in refrigeration, air conditioning, packaging, insulation, or as solvents and aerosol propellants.
Chronic: Occurring over a long period of time, either continuously or intermittently; used to describe ongoing exposures and effects that develop only after a long exposure.
Chronic Exposure: A continuous or repeated exposure to a hazardous substance over a long period of time.
Contamination: Any hazardous or regulated substance released into the environment.
Convection: Vertical transport of heat and moisture that can lead to an increase in cloud cover and precipitation. Commonly results in thunderstorm activity during the North American Monsoon.
Desalinization: Removal of salt from saline water to provide fresh water (also desalination).
Dichloro-Diphenyl-Trichloroethane (DDT): The first chlorinated hydrocarbon insecticide chemical name. It has a half-life of 15 years and can collect in fatty tissues of certain animals. EPA banned registration and interstate sale of DDT for virtually all but emergency uses in 1972.
Disinfectant: A chemical or physical process that kills pathogenic organisms in water, air, or on surfaces. Chlorine is often used to disinfect effluent, water supplies, wells, and swimming pools.
Dispersion: Dilution over time of a pollutant concentration from its point source due to spreading out of the pollutant.
Dissolved Oxygen (DO): The oxygen freely available in water, vital to fish and other aquatic life and for the prevention of odors. DO levels are considered a most important indicator of a water body's ability to support desirable aquatic life.
Domestic Water Source (DWS): The use of a surface water as a source of potable water.
Drain Water: Water that enters a drain or channel.
Drinking Water: Water safe enough to be consumed by humans or used with low risk of immediate or long-term harm. Also known as potable water.
Ecosystem: The interacting system of a biological community and its non-living environmental surroundings.
Effluent: Treated or untreated wastewater that flows out of a treatment plant, sewer, or industrial outfall. Generally refers to wastes discharged into surface waters.
Emission: Pollution discharged into the atmosphere from smokestacks, other vents, and surface areas of commercial or industrial facilities; from residential chimneys; and from motor vehicle, locomotive, or aircraft exhausts.
Environment: Includes the air, water and land, and the relationship that exists between them and all living things, including plants, man and other animals.
Environmental Assessment (EA): An environmental analysis prepared pursuant to the National Environmental Policy Act to determine whether a federal action would significantly affect the environment and thus require a more detailed environmental impact statement.
Environmental Sustainability: Maintenance of ecosystem components and functions for future generations.
Exposure Pathway: The route of contaminants from the source of contamination to potential contact with a medium (air, soil, surface water, or groundwater) that represents a potential threat

to human health or the environment. Determining whether exposure pathways exist is an essential step in conducting a risk assessment.
Extinction (of light): The loss of light due to scattering and absorption as it passes through the atmosphere.
Floodwater: The water that overflows because of a flood.
Groundwater: Water located beneath the ground surface in soil pore spaces and in the fractures of geologic formations. A formation of rock or soil is called an aquifer when it can yield a usable quantity of water.
Hardness (of water): The sum of the calcium and magnesium concentrations, expressed as calcium carbonate (CaCO3) in milligrams per liter. Excessive hardness results in excessive use of soaps and detergents and causes the deposition of scale in teapots, water heaters, etc.
Hazardous Air Pollutants (HAPs): Air pollutants which are not covered by ambient air quality standards but which, as defined in the Clean Air Act, may present a threat of adverse human health effects or adverse environmental effects. Such pollutants include asbestos, beryllium, mercury, benzene, coke oven emissions, radionuclides, and vinyl chloride.
Hazardous Substance: Any material that, because of its quantity, concentration, and physical or chemical characteristics, poses a significant present or potential hazard to human health and safety or to the environment.
Hazardous Waste (HW): By-products of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Hazardous waste possesses at least one of four characteristics -- ignitability, corrosivity, reactivity, or toxicity.
Hazardous Waste Operator Certification: The training process to meet guidelines produced and maintained by the Occupations Safety and Health Administration that regulates hazardous waste operations and emergency services.
Inorganic Compounds: Compounds that are considered to be of mineral as opposed to biological.

End of Module Questions

1. What are the three major consequences of population explosion?

2. What are the seven negative consequences of population growth?

3. Why is it unrealistic to expect exponential growth to continue forever?

4. Why can exponential growth not go on forever?

5. Why can't exponential growth go on indefinitely?

6. What is the weakness of the exponential growth model?

7. Why human population is increasing at an exponential rate?

7. What are the 4 main challenges of population growth?