Study Material

Compulsory Course (AECC): Environmental Studies

Unit 2: Ecosystem

Topics Covered:

- **Definition and properties of Ecosystem**
- **Structure and function of Ecosystem**
- **Energy flow in an Ecosystem**
- **Food chain, Food web**
- **Ecological Pyramids**
- **Biogeochemical cycles**
- **Ecological Succession**
- **Major Ecosystems**
- **Forest Ecosystem**
- **Grassland Ecosystem**
- **Desert Ecosystem**
- **Aquatic Ecosystem (pond, lake, river, stream, estuary and ocean)**

Ecology & Ecosystem:

The word *Ecology* was coined by German Zoologist *Earnest Haeckel* in 1869 from Greek Words: Oikos (Home) + Logos(study). So ecology is study of organisms in their natural home interacting with the biotic and abiotic components (Surroundings). The word *Ecosystem* was coined by British Ecologist *Arthur George Tansley* in the year 1935 in his article "The use and abuse of vegetational terms and concepts".

Definitions of Ecosystem:

- A. G. Tansley (1935): Ecosystem is a particular category of physical systems, consisting of organic and inorganic components in a relatively stable equilibrium, open and of various sizes and kinds.
- F.R. Fosberg (1963) has defined ecosystem as a functioning, interacting system composed of one or more living organisms and their effective environment, both physical and biological
- E. P. Odum (1971): Living organism and their non-living environment are inseparably interrelated and interact upon each other. Any unit that includes all of the organisms (community) in a given area interacting with physical environment (habitat) so that the flow of energy leads to clearly defined trophic structure, biotic diversity and material cycle within the system, is an ecological system or ecosystem.

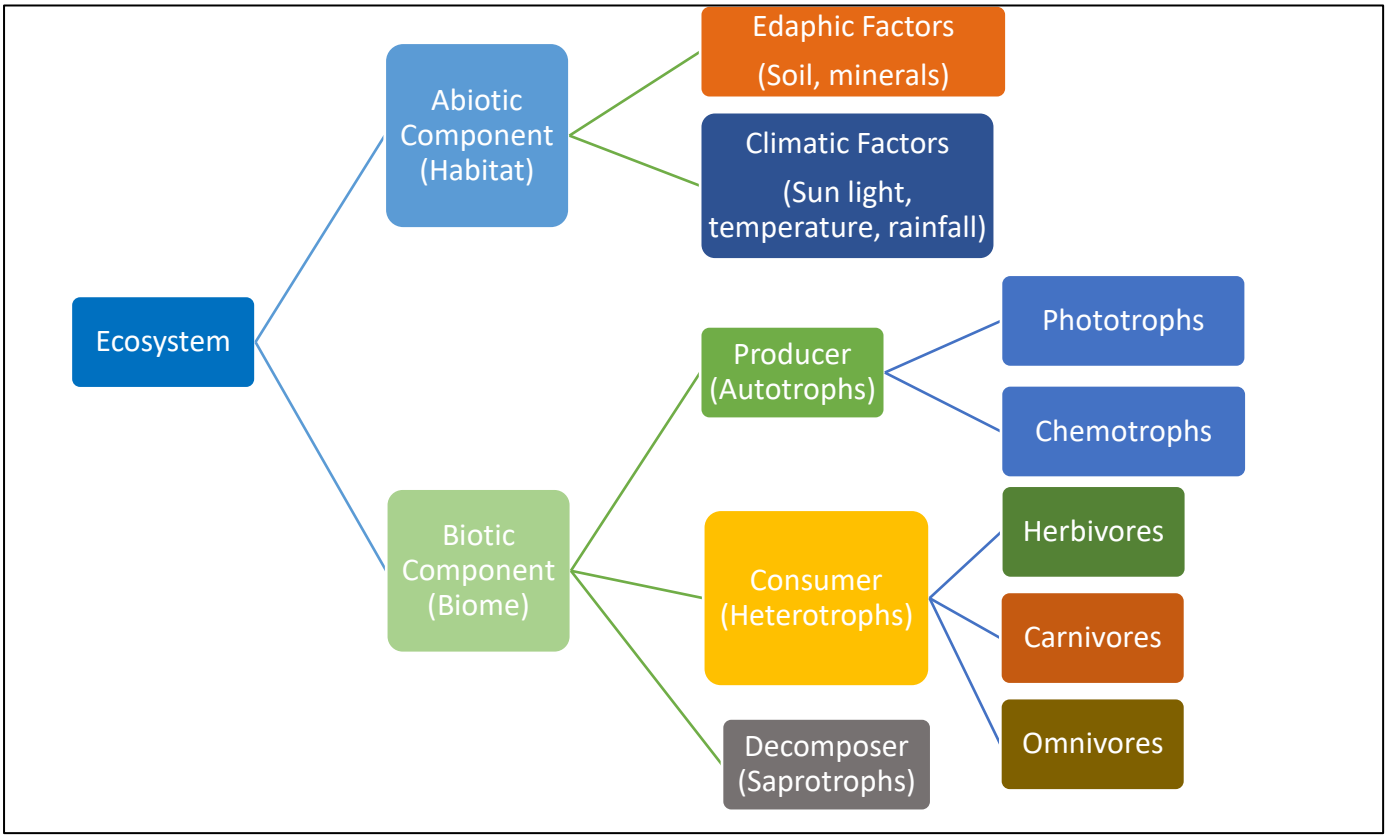
Properties of Ecosystems: The ecosystems are characterized by the following basic properties:

- Ecosystem of any given space-time unit represents the sum of all living organisms and physical environment.
- It is composed of three basic components viz. energy, biotic (biome) and abiotic (habitat) components.
- It occupies certain well-defined area on the earth-spaceship (spatial dimension).
- It is viewed in terms of time-unit (temporal dimension).
- There are complex sets of interactions between biotic and abiotc components (including energy component) on the one hand and between and among the organisms on the other hand.
- It is an open system which is characterised by continuous input and output of matter and energy.
- It tends to be in relatively stable equilibrium unless there is disturbance in one or more controlling factors (limiting factors).
- It is powered by energy of various sorts but the solar energy is the most significant.
- It is a functional unit wherein the biotic components (plants, animals including man and micro-organisms) and abiotic (physical environment) components (including energy component) are intimately related to each other through a series of large-scale cyclic mechanisms viz. energy flow, water cycle, bio-geo-chemical cycle, mineral cycle, sediment cycle etc.
- Ecosystem has its own productivity which is the process of building organic matter based on the availability and amount of energy passing through the ecosystem. The productivity refers to the rate of growth of organic matter in an aeral unit per time-unit.
- Ecosystem has scale dimension i.e. it varies in spatial coverage. It may be as small as a cowshed, a tree or even a part of a tree haying certain micro-organisms. The largest unit is the whole biosphere. Thus, the ecosystems may be divided into several orders on the basis of spatial dimension. It is clear that 'the ecosystem is a convenient scale at which to consider plants and animals and their interaction because it is more localised and thus more specific than the biosphere in its entirety, and it includes a sufficient wide range of individual organisms to make regional generalizations feasible and valuable' (C.C. Park, 1980).
- There are different sequences of ecosystem development. The sequence of ecosystem development in term of a particular suite of physical and chemical conditions is called as 'sere'. A 'sere' represents the development of a series of sequential successions starting from primary succession and culminating into the last succession in a sere as **'climax'** or 'climatic climax' which is the most stable situation of an ecosystem. Thus, the study of ecosystem development may help in environmental planning from ecological point of view.

Functions of Ecosystem:

- (1) Regulatory functions: this group of functions relates to the capacity of natural and semi-natural ecosystems to regulate essential ecological processes and life support systems through bio-geochemical cycles and other biospheric processes. In addition to maintaining the ecosystem (and biosphere health), these regulatory functions provide many services that have direct and indirect benefits to humans (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: Photosynthesis and nutrient uptake by autotrophs converts energy, carbon dioxide, water and nutrients into a wide variety of carbohydrate structures which are then used by secondary producers to create an even larger variety of living biomass. This broad diversity in carbohydrate structures provides many ecosystem goods for human consumption, ranging from food and raw materials to energy resources and genetic material.
- (4) Information functions: Since most of human evolution took place within the context of an undomesticated habitat, natural ecosystems contribute to the maintenance of human health by providing opportunities for reflection, spiritual enrichment, cognitive development, recreation and aesthetic experience.

Structure of Ecosystem:



Trophic Levels: In ecology, a trophic level pertains to a position in a food chain or ecological pyramid occupied by a group of organisms with similar feeding mode. The concept of trophic level is based

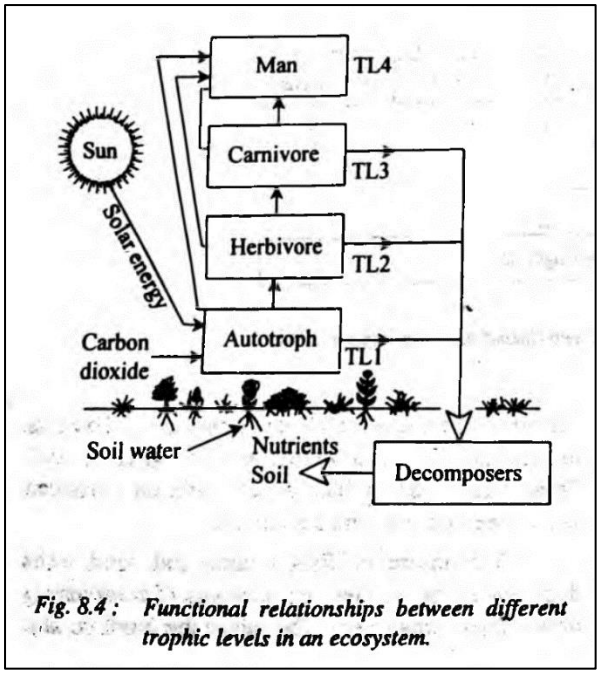


Fig. 8.4 : Functional relationships between different trophic levels in an ecosystem.

on the classic work of **R.L. Lindman (1942)** who pointed out that *"living organisms can be grouped into a series of more or less discrete trophic levels with each level depending on preceding one for its energy (food) supply"*.

On an average four trophic levels of a food chain are identified.

(1) **Trophic level 1:** The base of the food chain is formed by autotrophic primary producer organisms which include green plants. This base of the food chain is called trophic level 1 where green plants produce their food through the process of photosynthesis with the help of sunlight, water, carbon dioxide and inorganic salts and they consume the produced energy to build their tissues and bodies. The trophic level 1 is also the source of food for all other organisms of the food chain. All the green plants are the members of trophic level 1.

(2) **Trophic level 2:** The organisms, who do not produce their food themselves but depend on primary producers (of trophic level 1) for their food, are included in trophic level 2. These organisms are animals and are called primary consumers. They are basically grazers like sheep, cows, rabbits, goats, deers etc. These animals are also called herbivores. The trophic level where food energy is transferred from primary producers to primary consumers is called trophic level 2

(3) **Trophic level 3:** The animals, who depend on animals mainly herbivorous animals for their food, are included in this trophic level. These animals are called carnivores and secondary consumers because they depend on the primary consumer animals of herbivorous group of trophic level 2. Carnivores include (I) land animals-lions, hawks, beers, leopard, eagles etc (II) animals living in the soils-bacteria which decompose dead herbivorous animals; (III) aquatic animals-herring. The trophic level where energy is transferred from primary consumers to secondary consumers, is called trophic level 3.

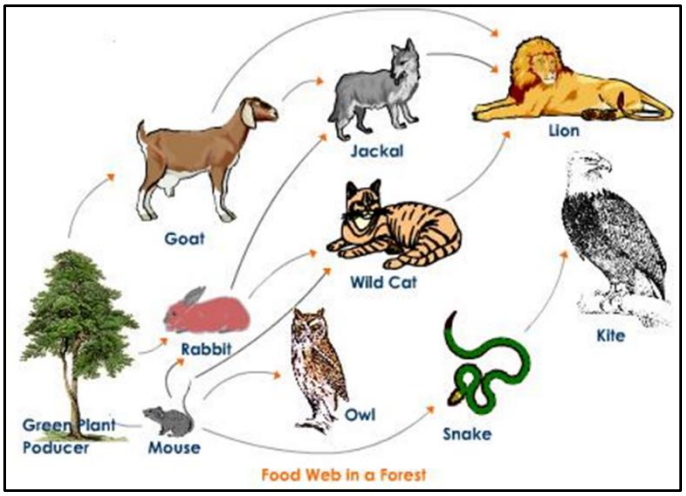
(4) **Trophic level 4:** Those animals are included in this trophic level which take their food either directly or indirectly from all the three lower trophic levels. Man is the most important member of this trophic level because he derives food and fuel from the green plants, commodities from second and third trophic levels. Such animals (as man) are called omnivores. Decomposers also derive their energy from all the trophic levels.

A **food chain** is in fact the sequence of energy transfer from the lower trophic levels to the upper or higher trophic levels.

Grass-≫insects-*frogs—>snake—>hawk—≫ leopard.

(i) **Grazing food chains:** which starts from the green plants that make food for herbivores and herbivores in turn for the carnivores. Ecosystems with such type of food chain are directly dependent on an influx of solar radiation.

(ii) **(ii) Detritus food chains:** It starts from the dead organic matter to the detrivore organisms which in turn make food for protozoan to carnivores etc. The detritus food chain (DFC) begins with dead organic matter. It is made up of decomposers which are heterotrophic organisms, mainly fungi and bacteria. They meet their energy and nutrient requirements by degrading dead organic matter or detritus. These are also known as saprotrophs (sapro: to decompose). *Decomposers secrete digestive enzymes that breakdown dead and waste materials into simple, inorganic materials, which are subsequently absorbed by them.*



Food Web in a Forest

When the feeding relationships in a natural ecosystem become more complicated, the food chain does not remain simple and linear rather it is also complicated by several inter-connected overlapping food chains. This happens when greater number of species feed on many kinds of prey. Such complicated food chain is called **food web**.

The nature of food chains and food webs depends on the richness or poorness of biodiversity of a natural ecosystem. The richer the biodiversity, the longer and more complicated the food chains and food webs. The ecosystem stability also depends on biodiversity and food chains and food webs. As the biodiversity increases, the food chains and food webs become longer and more complicated, so the ecosystem becomes more stable. A simpler food chain represents unstable ecosystem and poor biodiversity.

Significance of Food Chain & Food Web:

- Plays significant role in ecosystem as flow of energy and nutrient cycling take place through food chain and food webs.
- Food chain and food webs also help in the maintaining and regulating the population size of different animals thus maintain the ecological balance.
- Food chain shows a unique property of biological magnification of some chemicals. Pesticides for examples DDT or other chemical which are non-biodegradable in nature. Such chemicals are not decomposed or excrete out so their concentration keep on increasing at each successive trophic level. This phenomenon is known as biomagnification or biological magnification.
- Trophic structure: The producer and consumer are arranged in the ecosystem in a definite manner and their interaction along with population size are expressed together as trophic structure. Each food level is known as trophic level and the amount of living matter at each trophic level at a given time is known as standing crop or standing biomass.

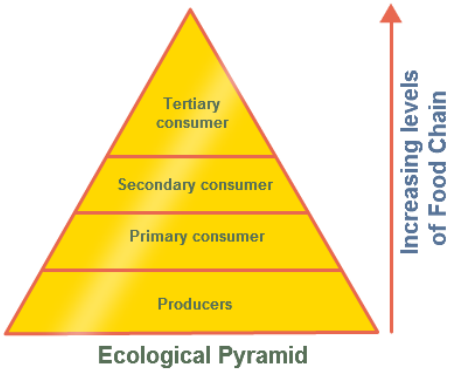
Difference between Food Chain & Food Web:

Food chain	Food Web
1. Food chain is defined as the phenomenon of transfer of energy through series of organisms falling on successive trophic levels.	1. Food web is an interconnection of food chains which shows relation between them.
2. In food chains, usually member of high trophic level feed upon a single type of organism of lower trophic level.	2. In food web members of higher trophic level feed upon many organisms of lower trophic level.
3. In food chains, separate and isolated food chains increase the instability of the ecosystem.	3. In food web, stability of the ecosystem increases by the presence of complex food webs.
4. It comprises of only one chain.	4. It comprises of many chains.
5. Removal of one group of organism disturbs the whole chain.	5. Removal of one group of organism not at all disturbs food web.

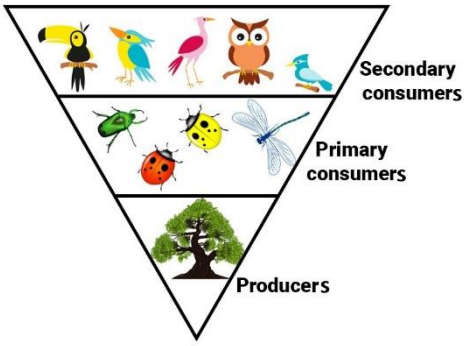
Ecological Pyramids: Ecological Pyramids: Ecological pyramids were first devised by British ecologist Charles Elton (1927). Ecological pyramids is graphical representation of trophic structure and function of an ecosystem, Starts with producers at the base and consumers at successive levels towards apex is called as an "Ecological Pyramid"

- Three types of ecological pyramids are there:
    - Pyramids of Numbers: Number of organisms at each trophic level at any point of time
    - Pyramids of Biomass: Total biomass at each trophic level at any point of time
    - Pyramid of Energy: Total energy used at each trophic level per unit area/unit time

1. Number Pyramids: Number pyramids include only the number of species and not their sizes (whether the organisms have larger bodies or smaller ones). C. Elton (1927) has pointed out that "the animals at the base of a food chain, are relatively abundant, whilst those at the end are relatively few in number, and there is a progressive decrease in between the two extremes". Thus, the pyramid of number means progressive decrease in the number of species with successive higher trophic levels.
Though the pyramids of number of species help in the comparative study of the diversity of the structure and food chains and food webs of different ecosystems (e.g. forest ecosystem, marine ecosystem) but these do not give any idea about the total biomass (total weight of living organisms) because pyramids of number consider only the number of organisms and not the size of the organisms.



Ecological Pyramid



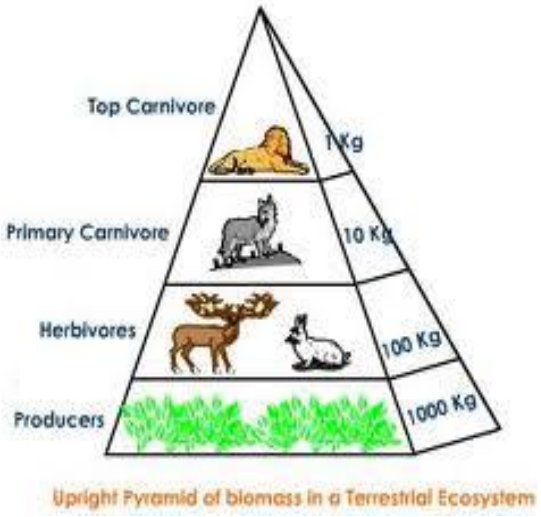
Inverted Pyramid of Numbers

2. Biomass Pyramid: Biomass refers to the mass of living organisms, including plants, animals, and microorganisms or, from a biochemical perspective, cellulose, lignin, sugars, fats, and proteins. Biomass is often reported as a mass per unit area (g m^{-2} or Mg ha^{-1}) and usually as dry weight (water removed by drying). It often expresses as *Standing Crop.* Pyramids of biomass include the biomass (total weight of organic matter) of each trophic level instead of number of species as is done in the case of pyramid of numbers. Thus, the total weight of whole organic matter (biomass) at each trophic level represents the standing crop at a single point in time. This enables the pyramid to assume its natural shape i.e. broad base and thin apex. Biomass pyramid does not give any idea of the rate of ecological/ecosystem production. The pyramid may be either Upright or Inverted. Forests account for 70–90% of terrestrial

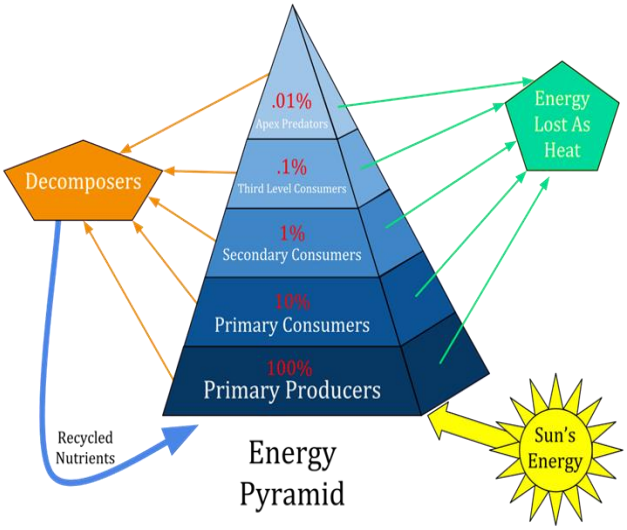
biomass, most of this biomass in trees. The distribution of terrestrial biomass among producers, consumers, and microbes is *c*. 0.90%, 0.001%, and 0.10%.

3. Energy Pyramid: C. Elton (1927) suggested to construct a pyramid of energy to have an idea of ecological productivity. The energy pyramid is constructed, thus, on the basis of total amount of energy used at each trophic level per unit area per unit time. The total amount of energy used is generally expressed in kilocalories (Kcal) per square metre per day or per year (Kcal/m2/year).

- Energy pyramids help in the comparative study of the productivities of different ecosystems.
- Amount of energy decreases at each trophic level.



Upright Pyramid of biomass in a Terrestrial Ecosystem



- It is always Upright and unidirectional
- Energy goes on reducing at each level.
- Loss is in the form of heat, respiration.

Reymond Lindeman gave ten per cent of energy transfer law or Lindeman's trophic efficiency rule in food chains. The 10 per cent energy is transferred from one trophic level to the next successive trophic level according to this rule. During energy transfer and respiration, the majority of the energy is lost

Energy flow: The energy flow (transfer of organic molecules) in the ecosystem is unidirectional and is noncyclic (is not available again for reuse). Energy flow in ecosystem follows two laws of thermodynamics:

- 1st Law: In any system of constant mass, energy can neither be created nor destroyed, it can be converted from one form to another, the energy inflow or input in a *system is* balanced by energy outflow or output.
- 2nd Law: When work is done, energy is dissipated and the work is done when one form of energy is transformed into another form.

Primary productivity is the rate of energy captured by producers that is the amount of new biomass of producers, per unit time and space.

- *Gross primary production (GPP)* is the total amount of energy produced by the autotrophs at trophic level one.
- *Net primary production (NPP)* represents the amount of energy or organic matter fixed or stored at trophic level one. Thus, net primary production excludes the amount of energy which is lost through respiration by the autographs.
- **Reymond Lindeman (1942**) has formulated the following **five principles** regarding the relationships between different trophic levels and **energy flow** in a natural ecosystem.

Principle I : As the distance between the organisms of a given trophic level and the initial source of energy (trophic level 1) increases, the probability of the organisms to depend exclusively on the preceding trophic level for energy decreases. In other words, the organisms at trophic levels 3 and 4 do not depend for their energy only on trophic levels 2 and 3 respectively rather they receive energy from more than one source (trophic level) which means that organisms at trophic level 3 and beyond tend to be 'generalists' rather than 'specialists' in terms of their feeding habit.

Principle II : The relative loss of energy due to respiration is progressively greater from higher trophic levels because the species at higher trophic levels being relatively larger in size have to move and work more for getting food and therefore more energy is lost due to respiration.

Principle III : Species at progressively higher trophic levels appear to be progressively more efficient in using their available food supply, because increased activity by predators increases their chances of encountering suitable prey species, and in general predators are less specific than their prey in food preferences'.

Principle IV : 'Higher trophic levels tend to be less discrete than the lower ones' because the organisms at progressively higher trophic levels receive energy from more than one source (trophic level) and are 'generalists' in their feeding habit and they are more efficient in using their available food supply.

Principle V : 'Food chains tend to be reasonably short. Four vertical links is a common maximum' because loss of energy is progressively higher for higher trophic levels and species at higher levels tend to be less discrete.

Biogeochemical Cycles: '*A biogeochemical cycle is the cycling of chemical element' through the earth's atmosphere, oceans and sediments as it is affected by the geological and biological cycles. It can be described as a series of compartments or storage reservoirs, and pathways between these reservoirs'* (D.B. Botkin and E.A. Keller, 1982). P.A. Furley and W.W. Newey (1983) have defined biogeochemical cycles as *'large scale cycles, involving inorganic substances which pass through a biotic phase and then return to an inorganic state*'.

The chemical elements or simply the materials or mineral nutrients (or simply nutrients) involved in the circulation within an ecosystem (the biosphere) and in the growth and maintenance of organisms are grouped into **three categories** e.g.

(i) Macro elements, which are required in large quantity by plants. These include **oxygen, carbon** and **hydrogen** which form the basic cell structures of the organisms and are the principal components of fats and carbohydrates in the organism,

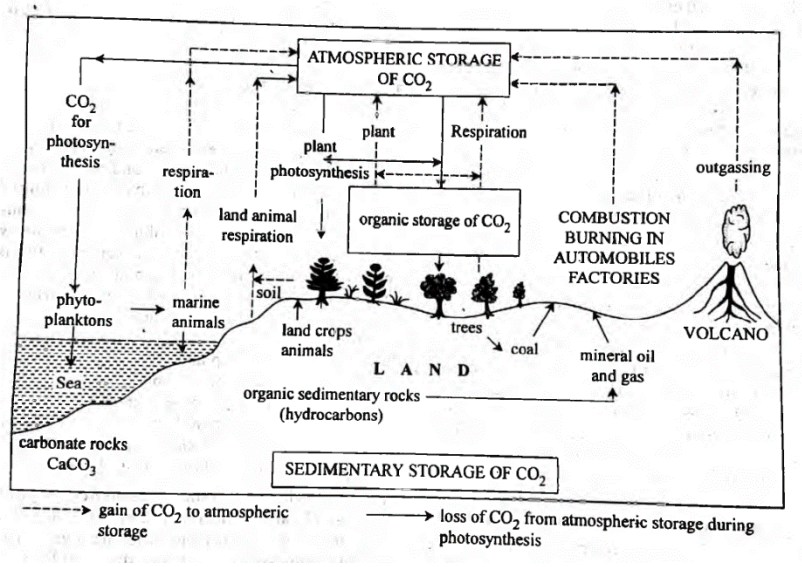
(ii) Minor elements, which are required by plants in relatively large amount. These elements include **nitrogen, phosphorous, potassium, calcium, magnesium and sulphur**. Nitrogen helps in the synthesis of proteins; phosphorous is responsible for the building of nucleic acids and cyptoplasm and the transfer of energy through cells of the organisms; sulphur helps in the formation of amino acids which form proteins; cell walls of the organisms are strengthened by calcium whereas chlorophyll is produced by magnesium.

(iii) Trace elements, which are required by plants in very small quantity. There are about 100 elements which are required by plants but the elements which are most required by plants are **iron, copper, manganese, zinc, boron, chlorine, molybdenum** etc.

Chemicals taken in by organisms are passed through the food chain and come back to the soil, air, and water through mechanisms such as respiration, excretion, and decomposition. As an element moves through this cycle, it often forms compounds with other elements as a result of metabolic processes in living tissues and of natural reactions in the atmosphere, hydrosphere, or lithosphere. ***Cyclic exchange of material between the living organisms and their non-living environment is called Biogeochemical Cycle.***

Nutrient cycles are of two types: (a) gaseous and (b) sedimentary. The reservoir for gaseous type of nutrient cycle (e.g., nitrogen, carbon cycle) exists in the atmosphere and for the sedimentary cycle (e.g., sulphur and phosphorus cycle), the reservoir is located in Earth's crust. Environmental factors, e.g., soil, moisture, pH, temperature, etc., regulate the rate of release of nutrients into the atmosphere. The function of the reservoir is to meet with the deficit which occurs due to imbalance in the rate of influx and efflux.

The elements (chemical or inorganic and organic) which are circulated in the biosphere belong to three main phases:
(i) **Atmospheric Phase** (hydrogen, oxygen, carbon, nitrogen),
(ii) **Sedimentary Phase** (potassium, calcium, magnesium, phosphorous, sulphur etc.), and
(iii) **Organic Phase** (organic matter including both plants and animals).

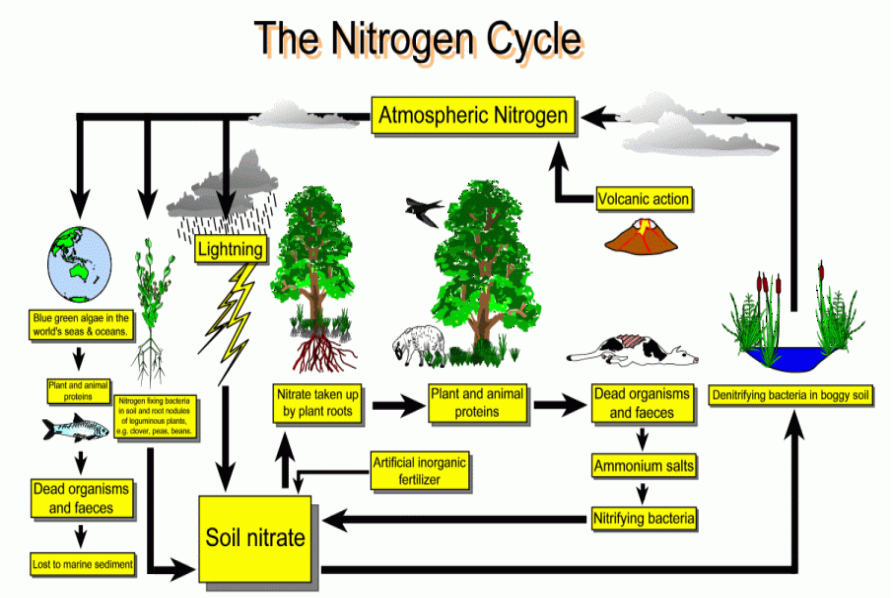


(1) Carbon Cycle: The carbon cycle involving the circulation of carbon within the biosphere includes two pathways or cycles e.g.
(i) gaseous cycle, which involves the movement of carbon as carbon dioxide (CO_2) which is found as free gas in the atmosphere and as a gas dissolved in the water of the land and of the seas and the oceans, and
(ii) non-gaseous or inorganic cycle involves the solid phase of carbon herein it resides in carbohydrate molecules (CH_20) in the organic matter, as hydrocarbon compounds in the rocks of the earth's crust (in coal etc.) and as mineral carbonate compounds such as calcium carbonate.
Carbon enters into the living world in the form of carbon dioxide through the process of photosynthesis as carbohydrates. These organic compounds (food) are then passed from the producers to the consumers (herbivores & carnivores). This carbon is finally returned to the surrounding medium by the process of respiration or decomposition of plants and animals by the decomposers. Carbon is also recycled during the burning of fossil fuels.

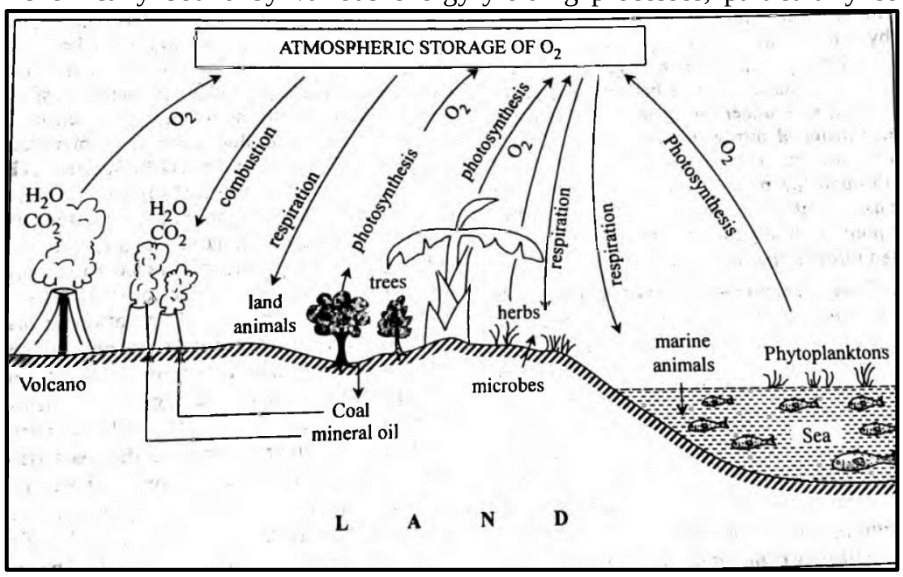
(2) Nitrogen cycle: Nitrogen is an essential component of protein and required by all living organisms including human beings. Our atmosphere contains nearly 79% of nitrogen but it cannot be used directly by the majority of living organisms. Broadly like carbon-di-oxide, nitrogen also cycles from gaseous phase to solid phase then back to gaseous phase through the activity of a wide variety of organisms. Cycling of nitrogen is vitally important for all living organisms. There are three main processes essential for nitrogen cycle:
(a)Nitrogen fixation: This process involves conversion of gaseous nitrogen into Ammonia, a form in which it can be used by plants. Atmospheric nitrogen can be fixed by the following three methods: -
(i)Atmospheric fixation: Lightening, combustion and volcanic activity help in the fixation of nitrogen.
(ii) Industrial fixation: At high temperature (400^oC) and high pressure (200 atm.), molecular nitrogen is broken into atomic nitrogen which then combines with hydrogen to form ammonia.
(iii) Bacterial fixation: There are two types of bacteria- (i) Symbiotic bacteria e.g. Rhizobium in the root nodules of leguminous plants. (ii) Free living or symbiotic e.g. 1. Nostoc 2. Azobacter 3. Cyanobacteria can combine atmospheric or dissolved nitrogen with hydrogen to form ammonia.
(b) Mineralization, nitrification and transfer of nitrogen from soils to plants and animals: Mineralization and nitrification are the processes of transformation of nitrogen in such forms in the soils that these can be easily taken up by plants. When organic nitrogenous compounds are transformed into an inorganic or mineral form (either ammonia or ammonium), the process is called mineralization or

ammonification whereas the process of the conversion of ammonium salts into nitrite and nitrate is called **nitrification.** Thus, plants take nitrogen in the form of nitrates from the soils through their roots.

(c) Denitrification: Conversion of nitrates back into gaseous nitrogen is called denitrification. Denitrifying bacteria live deep in soil near the water table as they like to live in oxygen free medium. Denitrification is reverse of nitrogen fixation.

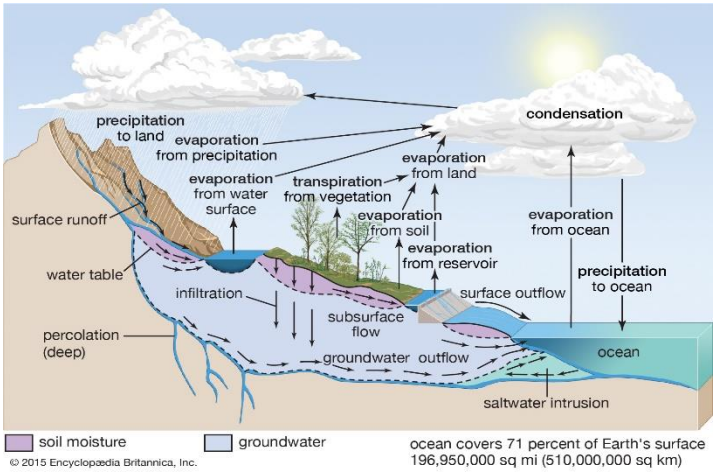


(3) Oxygen Cycle: The oxygen cycle involves the interchange of oxygen between the elemental form of gaseous O_2 in the atmosphere and chemically bound O in CO_2, H_2O, and organic matter. Elemental oxygen becomes chemically bound by various energy-yielding processes, particularly combustion and metabolic processes in organisms. It is released during photosynthesis. Thus, the oxygen cycle involves the input of oxygen to the atmospheric storage pool from the photosynthesis of marine and terrestrial autotrophic plants and from volcanic eruption and the loss of oxygen from the atmospheric storage pool through respiration of marine and terrestrial organisms and minerals oxidation, burning of wood, grasses and forest fires, combustion of fossil fuels (coal and petroleum).



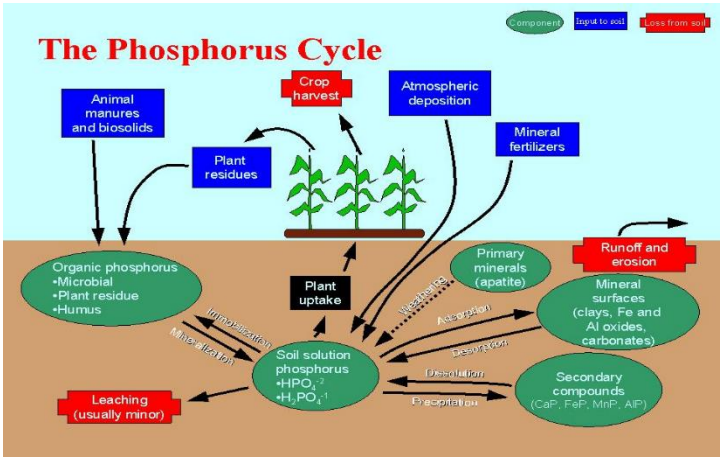
The residence time of oxygen in the atmosphere is much longer (2000 years, that is oxygen is recycled in 2000 years) than the residence time of Carbon (300 years, that is the carbon released by plants and animals through respiration is available again for them after 300 years).

(4) **Hydrological Cycle:** Water is essential for life. No organism can survive without water. Precipitation (rain, snow, slush dew etc.) is the only source of water on the earth. Water received from the atmosphere on the earth returns back to the atmosphere as water vapour resulting from direct evaporation and through evapotranspiration the continuous movement of water in the biosphere is called water cycle (hydrological cycle). Earth is a watery planet of the solar system, about 2/3rd of earth surface is covered with water. However, a very small fraction of this is available to animals and plants. Water is not evenly distributed throughout the surface of the earth. Almost 95 % of the total water on the earth is chemically bound to rocks and does not cycle. Out of the remaining 5%, nearly 97.3% is in the oceans and 2.1% exists as polar ice caps. Thus only 0.6% is present as fresh water in the form of atmospheric water vapours, ground and soil water.

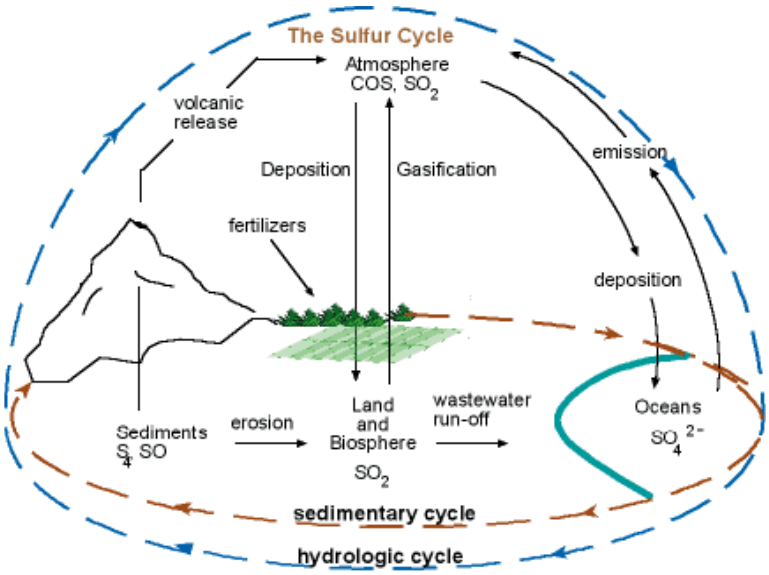


The driving forces for water cycle are 1) solar radiation 2) gravity. Evaporation and precipitation are two main processes involved in water cycle. These two processes alternate with each other Water from oceans, lakes, ponds, rivers and streams evaporates by sun's heat energy. Plants also transpire huge amounts of water through evaportranspiration. Water remains in the vapour state in air and forms clouds which drift with wind. Clouds meet with the cold air in the mountainous. On an average 84% of the water is lost from the surface of the through oceans by evaporation. While 77% is gained by it from precipitation. Water run-off from lands through rivers to oceans makes up 7% which balances the evaporation deficit of the ocean. On land, evaporation is 16% and precipitation is 23%.

(5) Phosphorus Cycle: Phosphorus is a major constituent of biological membranes, nucleic acids and cellular energy transfer systems. Many animals also need large quantities of this element to make shells, bones and teeth. The natural reservoir of phosphorus is rock, which contains phosphorus in the form of phosphates. When rocks are weathered, minute amounts of these phosphates dissolve in soil solution and are absorbed by the roots of the plants (Fig.). Herbivores and other animals obtain this element from plants and plant take phosphorous in the form of salt through root osmosis. The waste products and the dead organisms are decomposed by phosphate-solubilising bacteria releasing phosphorus back to soil again. Unlike carbon cycle, there is no respiratory release of phosphorus into atmosphere. The other two major and important differences between carbon and phosphorus cycle are firstly, atmospheric inputs of phosphorus through rainfall are much smaller than carbon inputs, and, secondly, gaseous exchanges of phosphorus between organism and environment are negligible. Phosphorous is such a chemical element (mineral)which has a very limited gaseous phase and has major sedimentary phase in the biogeochemical cycle. Phosphorous is temporarily present in the atmosphere in very small quantity in the form of dust and salt which are carried as salt spray from the sea or blown as dust from the areas of phosphate deposits and active mines.



Not all phosphorous present in the soils and rocks takes part in the cycle rather only 10 percent is involved in the cyclic pathways because phosphorous is relatively insoluble in water.



(6) Sulphur cycle: The sulphur cycle is relatively complex. It involves several gaseous species, poorly soluble minerals, and several species in solution. It is involved with the oxygen cycle in that sulphur combines with oxygen to form gaseous sulphur di oxide (SO_2) an atmospheric pollutant, and soluble sulphate ion, (SO_4^{2-}). Among the significant species involved in the sulphur cycle are gaseous hydrogen sulphide, H_2S; mineral sulphides, such as PbS; sulfuric acid, H_2SO_4, the main constituent of acid rain; and biologically bound sulphur in sulphur-containing proteins.

Ecological Succession: An orderly process of changes in the community structure and function with time mediated through modifications in the physical environment and ultimately culminating in a stabilized ecosystem Whole sequence of communities which are transitory are known as Seral Stages.

Environment is always kept on changing over a period of time due to (1) variations in climatic and physiographic factors, (2) the activities of the species of the communities themselves. These influences bring about marked changes in the dominants of the existing community, which is thus sooner or later replaced by another community at the same place. This process continues and successive communities develop one after another over the same area until the terminal final community again becomes more or less stable for a period of time. It occurs in a relatively definite sequence. This orderly change in communities is referred as succession. Odum called this orderly process as ecosystem development/ecological succession.

Succession is an orderly process of community development that involves changes in species structure and community processes with time and it is reasonably directional and therefore predictable. Succession is community controlled even though the physical environment determines the pattern.

- Ecological Succession starting from different Substrata or areas are named differently:
    - Hydrach / Hydrosere – starting from water or pond
    - Mesarch- Starting from adequate moist area
    - Xerach / Xerosere – Starting in dry area or areas with less moisture
- They Can also be of following types:
    - Lithosere- Starting on bare Rock
    - Psammosere- Starting on sand
    - Halosere- Starting on saline soil

Stages of Succession:

F.E. Clements (1916) has described five sequential phases in the successional development of vegetation community in a given habitat with available environmental conditions.

(i) **Phase of nudation** or the creation of bare area devoid of vegetation.

(ii) **Phase of migration** begins with the arrival of seeds into the newly created bare area.

(iii) **Phase of ecesis**, when the plant seeds are established in the newly created bare area and the seeds are germinated and plant growth continues.

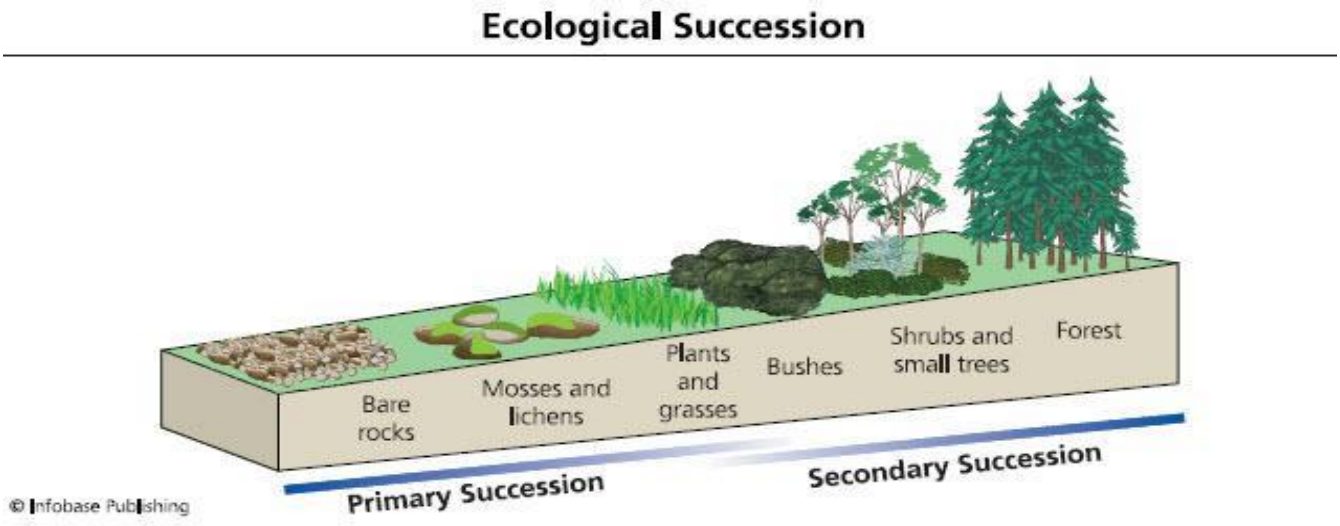
(iv) **Phase of reaction**, when there is competition between the established plants on the one hand and interactions between plants and the physical environment of the habitat on the other hand.

(v) **Phase of stabilization**, when there is equilibrium condition of populations of plant species in harmony with the environmental conditions of local and regional habitats.

Causes of succession: Succession is a series of complex processes, caused by (I) Initial/initiating cause: Both climatic as well as biotic. (II) Ecesis/continuing process ecesis, aggregation, competition reaction etc. (III) Stabilizing cause: Cause the stabilization of the community. Climate is the chief cause of stabilization and other factors are of secondary value.

Types of succession

• **Primary succession:** Starts from the primitive substratum where there was no previously any sort of living matter. The first group of organisms establishing there are known as the pioneers, primary community/primary colonizers. Very slow is the series of community changes that takes place in disturbed areas that have not been totally stripped their soil and vegetation.
• **Secondary succession:** Starts from previously built-up substrata with already existing living matter. Action of and external force, as a sudden change in climatic factors, biotic intervention, fire etc, causes the existing community to disappear. Thus area becomes devoid of living matter but its substratum, instead of primitive is built up. Such successions are comparatively more rapid.
• Autogenic succession: Community - result of its reaction with the environment, modified its own environment and thus causing its own replacement by new communities. This course of succession is autogenic succession.
• Allogenic succession: Replacement of the existing community is caused largely by any other external condition and not by the existing organisms.



• Autotrophic succession: Characterized by early and continued dominance of autotrophic organisms like green plants. Gradual increase in organic matter content supported by energy flow.
• Heterotrophic succession: Characterized by early dominance of heterotrophs, such as bacteria, actinomyces, fungi and animals. There is a progressive decline in the energy content.

- An **ecological community** is defined as a group of species that are commonly found together. Ecological communities may be animal or plant assemblages with similar habitat requirements and contain species which may influence each other or rely on similar processes in their environment.

- **Climax Community:** In scientific ecology, **climax community** or climatic **climax community** is a historic term for a **community** of plants, animals, and fungi which, through the process of ecological succession in the development of vegetation in an area over time, have reached a steady state.

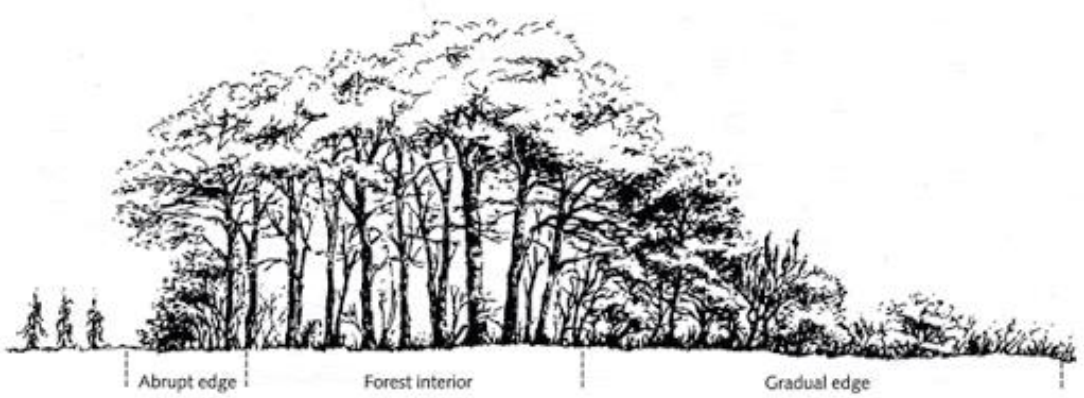
Ecological Niche: The concept of **'ecological niche'** was first introduced by J. Grinel in 1917 but it was developed by Charle s Elton in the year 1927.

- Ecological niche is a term for the position of a species within an ecosystem, describing both the range of conditions necessary for persistence of the species, and its ecological role in the ecosystem.

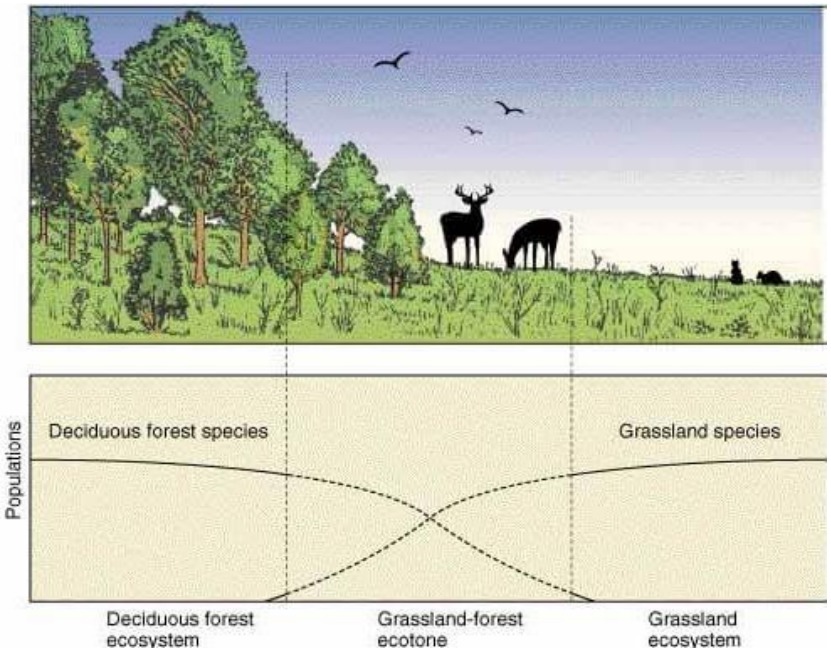
- Ecological niche subsumes all of the interactions between a species and the biotic and abiotic environment, and thus represents a very basic and fundamental ecological concept.

- The tentative definition presented above indicates that the concept of niche has two sides which are not so tightly related: one concerns the effects environment has on a species, the other the effects a species has on the environment

Edge Effect: In ecology, edge effects are changes in population or community structures that occur at the boundary of two or more habitats. Areas with small habitat fragments exhibit especially pronounced edge effects that may extend throughout the range.



Ecotone: An **ecotone** is a transition area between two ecosystems, where two communities meet and integrate. It may be narrow or wide, and it may be local (the zone between a field and forest) or regional (the transition between forest and grassland ecosystems). An ecotone may appear on the ground as a gradual blending of the two communities across a broad area, or it may manifest itself as a sharp boundary line.



Characteristics of Ecotone:

1. An ecotone can have a sharp vegetation transition, with a distinct line between two communities.

2.A change in physiognomy (physical appearance of a plant species) can be a key indicator.

3. A change of species can signal an ecotone.

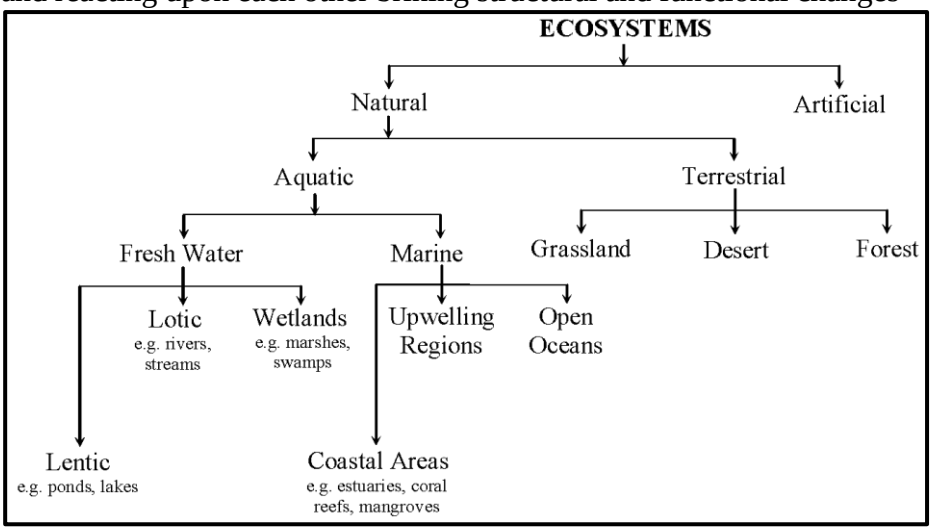
4. Ecotones are species rich regions

5. It is often associated with ***Ecocline***

Introduction to Major ecosystem: Earth is the giant ecosystem (biosphere) where abiotic and biotic components are constantly acting and reacting upon each other brining structural and functional changes in it.

An ecosystem represents the highest level of ecological integration which is energy based. This functional unit is capable of energy transformation, accumulation and circulation. Two major ecosystems are basically categorized in biosphere such as:

i) Natural ecosystem
ii) Artificial ecosystem



All types of natural ecosystems fall into one of two categories: **terrestrial** or **aquatic**.

(1) Terrestrial Ecosystems: The ecosystem which is found only on landforms is known as the terrestrial ecosystem. The main factor which differentiates the terrestrial ecosystems from the aquatic ecosystems is the relative shortage of water in the terrestrial ecosystems and as a result the importance that water attains in these ecosystems due to its limited availability. Another factor is the better availability of light in these ecosystems as the environment is a lot cleaner in land than it is in water. The main types of terrestrial ecosystems are the forest ecosystems, the desert ecosystems, the grassland ecosystems.

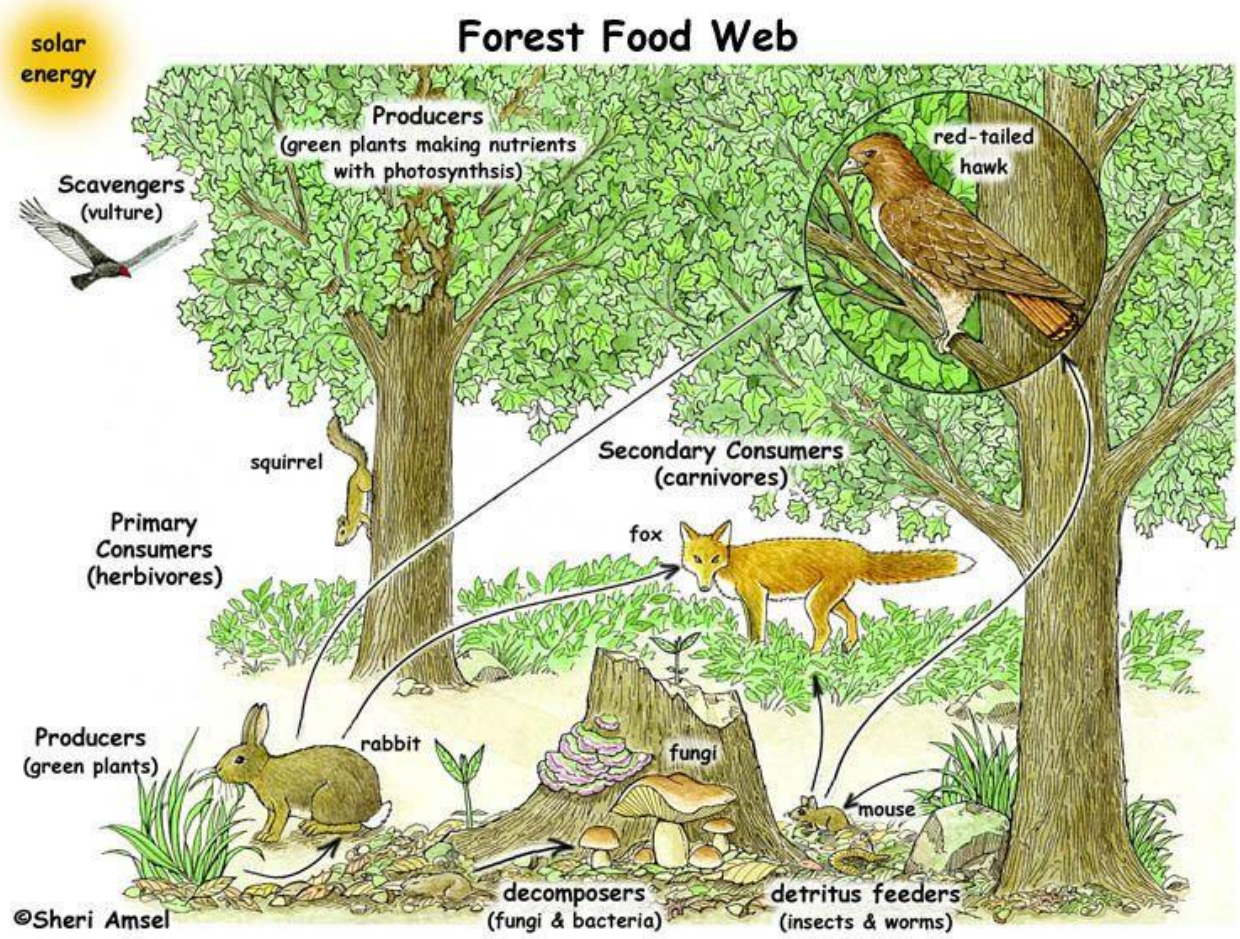
a) Forest Ecosystems: These ecosystems have an abundance of flora or plants and hence in these ecosystems a large number of organisms live in a small space. This means that these ecosystems have a high density of living organisms. These ecosystems are classified according to their climate type as tropical, temperate or boreal i.e; tropical evergreen forest, tropical deciduous forest, temperate evergreen forest, temperate deciduous forest and taiga. In the tropics, rainforest ecosystems contain more diverse flora and fauna than ecosystems in any other region on earth. In these warm, moisture-laden environments, trees grow tall and foliage is lush and dense, with species inhabiting the forest floor all the way up to the canopy. In temperate zones, forest ecosystems may be deciduous, coniferous or oftentimes a mixture of both, in which some trees shed their leaves each fall, while others remain evergreen year - round. In the far north, just south of the Arctic, boreal forests – also known as taiga – feature abundant coniferous trees.

A forest ecosystem is a functional unit or a system which comprises of soil, trees, insects, animals, birds, and man as its interacting units. A forest is a large and complex ecosystem and hence has greater species diversity and higher productivity. 31% of the total land area is covered by forest. Two main structural features of a forest ecosystem are:

1. **Species composition:** It refers to the identification and enumeration of the plant and animal species of a forest ecosystem.
2. **Stratification:** It refers to the vertical distribution of different species which occupy different levels in the forest ecosystem. Every organism occupies a place in an ecosystem on the basis of source of nutrition. For example, in a forest ecosystem, trees occupy the top level, shrubs occupy the second and the herbs and grasses occupy the bottom level.

Components of forest ecosystem:

- **Abiotic Components:** Sun is the source of energy. These are organic & inorganic substances present in the soil and atmosphere. In addition to minerals present in forest we find the dead organic debris, moreover light condition are different due to complex stratification in the plants.
- **Biotic Components:**
    1. *Producers:* These are mainly trees that show much species and greater degree of stratification. Besides trees there are also present shrubs, and ground vegetation.
    2. *Consumers:* Primary Consumers: These are herbivores that include animals feeding on tree leaves, ants, beetles, grass hoppers, etc., and large elephants, deers, squirrels, etc.
    3. *Secondary Consumers:* These are carnivores, like snakes, birds, lizards, fox, etc. feeding on herbivores.
    4. *Tertiary consumers:* These are top carnivores like lion tiger, etc. that eat carnivores of secondary level.
    5. *Decomposers:* These are wide variety of micro organisms including, fungi, bacteria. Epiphytes, lianas are also there.



b) Grassland Ecosystem: The Grassland Ecosystem covers about 10-15 percent of the Earth's surface. It is found where rainfall is about 15-75 cm per year not enough to support a forest, but more than that of true desert. Grassland ecosystems are often considered as transitional ecosystems. Typical grasslands are vegetation formations that are generally found in temperate climates.

These are known by different names in different region of the world like **steppes in Europe and Asia**, **pampas in South America**, **Veldt in South Africa** and **Downs in Australia**.

Components of Grassland Ecosystem:

- **Abiotic Components:** These are nutrients present in soil, and aerial environment, thus the elements like, phosphates, sulphates, water, carbon dioxide, present in soil and in air. Moreover some trace elements are also present.

- Biotic Components:

    - **Producers:** They are mainly grasses as species of Cynadon, Desmodium, besides them a few shrubs also contribute some primary production.

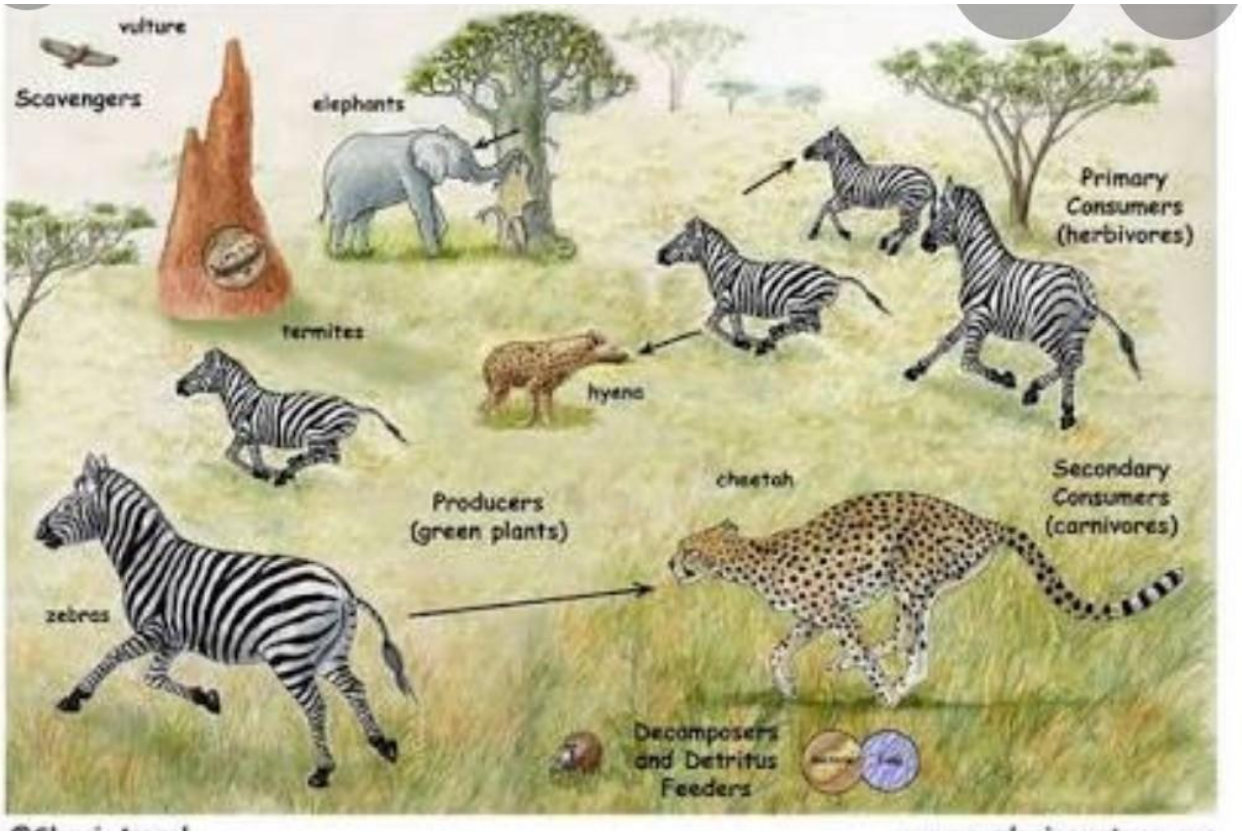
    - **Consumers:**

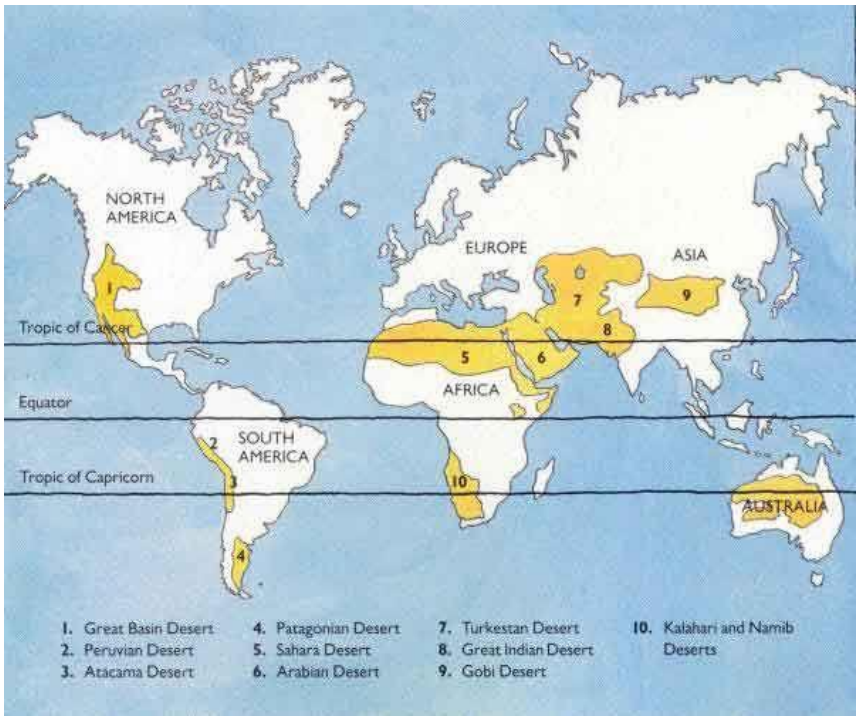
    - Primary Consumers: The herbivores feeding on grasses are grazing animals, as cows, goats, rabbit, etc. besides them there are some insects as termites, millipedes that feed on grasses.

    - Secondary Consumers: These are carnivores feeding on herbivores these include, animals like, fox, jackals, snakes, frogs, birds.

    - Tertiary Consumers: Some times hawks, vultures, feeding on secondary consumer, thus occupy tertiary consumers.

    - **Decomposers:** The microbes active in the decay of dead organic matter of different form are fungi and some bacteria

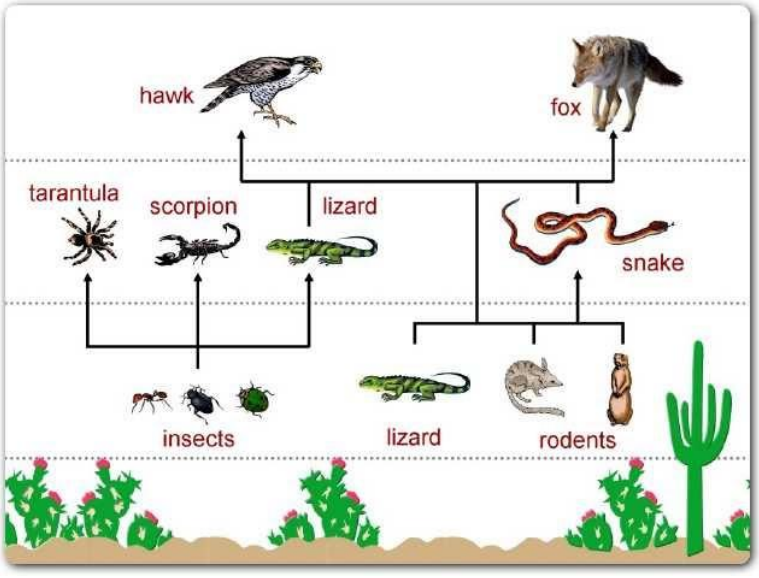




c) Desert Ecosystems: The common defining feature among desert ecosystems is low precipitation, generally less than 25 centimeters, or 10 inches, per year. Almost 17% of all the land on this planet is occupied by the desert ecosystems. The fauna and flora in these ecosystems are generally not much developed because of the high temperatures, intense sunlight and low availability of water. The main vegetation of such regions are the shrubs, bushes and a few grasses and trees. The stems and leaves of these plants are also developed in order to conserve as much water as possible. Camels, reptiles and some insects and birds are the living creatures which are found in such regions. Not all deserts are hot – desert ecosystems can exist from the tropics to the arctic, but regardless of latitude, deserts are often windy. Some deserts contain sand dunes, while others feature mostly rock.

Components of Dessert Ecosystem:

- **Abiotic Components:** There are nutrients present in soil, and aerial environment, thus the elements like, phosphates, sulphates, little amount of water, carbon dioxide, present in soil and in air. Moreover some trace elements are also present.



- Biotic Components:
    - **Producers:** The main vegetation of such regions are the shrubs, bushes and a few grasses and trees.
    - **Consumers:**
    - Primary Consumers: Camels, reptiles and some insects and birds are the living creatures which are found in such regions.
    - Secondary Consumers: These are carnivores feeding on herbivores these include, animals like, fox, jackals, snakes, frogs, birds.
    - Tertiary Consumers: Some times hawks, vultures, feeding on secondary consumer, thus occupy tertiary consumers.

- **Decomposers:** The microbes active in the decay of dead organic matter of different form are fungi and some bacteria

(2) Aquatic Ecosystem: An ecosystem which exists in a body of water is known as an aquatic ecosystem. The communities of living organisms which are dependent on each other and the aquatic surroundings of their environment for their survival exist in the aquatic ecosystems.
Components of Ecosystem: There are two main components of an ecosystem which are in constant communication with each other. They are the biotic components and the abiotic components.

Biotic Components The living components of an ecosystem are called the biotic components. Some of these factors include plants, animals, as well as fungi and bacteria. These biotic components can be further classified, based on the energy requirement source. Producers, consumers, and decomposers are the three broad categories of biotic components.

• Producers are the plants in the ecosystem, which can generate their own energy requirement through photosynthesis, in the presence of sunlight and chlorophyll. All other living beings are dependent on plants for their energy requirement of food as well as oxygen. In aquatic ecosystem algae, phytoplankton perform as producer.

• Consumers include the herbivores, carnivores, and omnivores. The herbivores are the living organisms that feed on plants. Carnivores eat other living organisms. Omnivores are animals that can eat both plant and animal tissue. Small fish/ insects, large fish, birds/human act as primary, secondary and tertiary consumers respectively.

• Decomposers are the fungi and bacteria present in the water, which are the saprophytes. They feed on the decaying organic matter and convert this matter into nitrogen and carbon dioxide. The saprophytes play a vital role in recycling the nutrients so that the producers i.e. plants can use them once again.

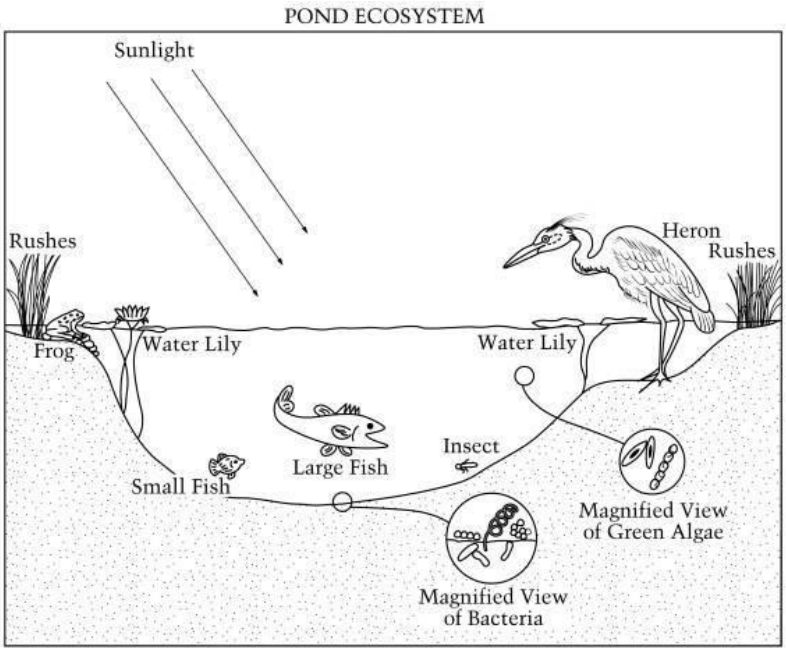
Abiotic Components: Abiotic components are the physical and/or the chemical factors that act on the living organisms at any part of their life. These are also called as the ecological factors. The physical and chemical factors are characteristic of the environment. Light, air, soil, and nutrients etc. form the abiotic components of an ecosystem. The abiotic factors vary from ecosystem to ecosystem. In an aquatic ecosystem, the abiotic factors may include water pH, sunlight, turbidity, water depth, salinity, available nutrients and dissolved oxygen.

The aquatic ecosystems are mainly of two types:

- Freshwater ecosystems
- Marine ecosystems

a) Fresh Water Ecosystem: The freshwater ecosystems are very small in magnitude as compared to the marine ecosystems as these covers only 0.8% of the earth's surface and only account for 0.009% of the total water present on earth. There are three basic kinds of freshwater ecosystems and these are Lentic, Lotic, and Wetlands. The lentic ecosystems are slow-moving or still water like ponds or lakes. Lotic ecosystems are fast-moving water like rivers. The wetlands are those systems where soil remains saturated for a long period of time. Many different species of reptiles, amphibians, and around 41% of the world's fish species live in these ecosystems. The faster moving waters contain more dissolved oxygen than the slow moving waters and hence support greater biodiversity.

i) Pond ecosystem: The pond is the simplest aquatic ecosystem to observe. There are differences in a pond that is temporary and has water only in the monsoon, and a larger tank or lake that is an aquatic ecosystem throughout the year. Most ponds become dry after the rains are over and are covered by

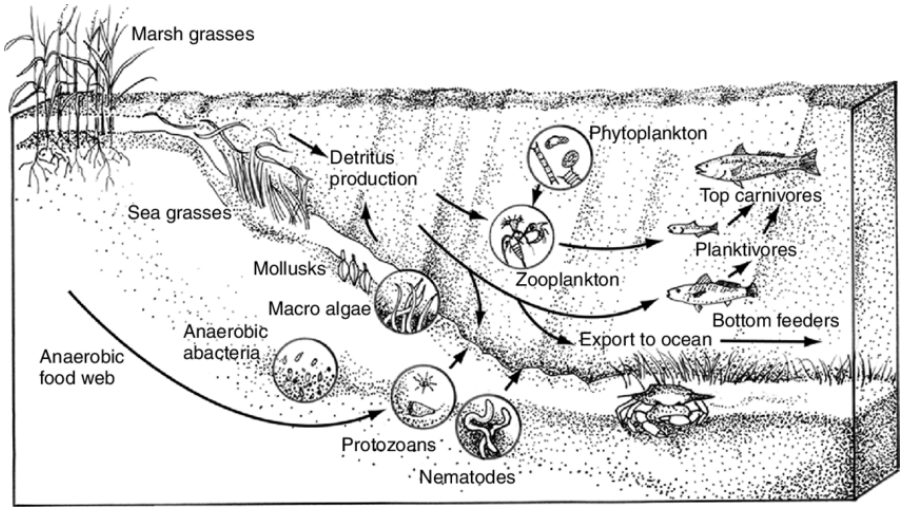


terrestrial plants for the rest of the year. When a pond begins to fill during the rains, its life forms such as the algae and microscopic animals, aquatic insects, snails, and worms come out of the floor of the pond where they have remained dormant in the dry phase. Gradually more complex animals such as crabs frogs and fish return to the pond. The vegetation in the water consists of floating weeds and rooted vegetation on the periphery which grow on the muddy floor under water and emerge out of the surface of the water. As the pond fills in the monsoon a large number of food chains are formed. Algae is eaten by microscopic animals, which are in turn eaten by small fish on which larger carnivorous fish depend. These are in turn eaten by birds such as kingfishers, herons and birds of prey. Aquatic insects, worms and snails feed on the waste material excreted by animals and the dead or decaying plant and animal matter. They act on the detritus, which is broken down into nutrients which aquatic plants can absorb, thus completing the nutrient cycle in the pond. The temporary ponds begin to dry after the rains and the surrounding grasses and terrestrial plants spread into the moist mud that is exposed. Animals such as frogs, snails and worms remain dormant in the mud, awaiting the next monsoon.

ii) Lake ecosystem: A lake ecosystem functions like a giant permanent pond. A large amount of its plant material is the algae, which derives energy from the sun. This is transferred to the microscopic animals, which feed on the algae. There are fish that are herbivorous and are dependent on algae and aquatic weeds. The small animals such as snails are used as food by small carnivorous fish, which in turn are eaten by larger carnivorous fish. Some specialised fish, such as catfish, feed on the detritus on the muddy bed of the lake. Energy flow through the lake ecosystem from the sunlight that penetrates the water surface to the plants. From plants energy is transferred to herbivorous animals and carnivores. Animals excrete waste products, which settle on the bottom of the lake. This is broken down by small animals that live in the mud in the floor of the lake. This acts as the nutrient material that is used by aquatic plants for their growth. During this process plants use Carbon from CO2 for their growth and in the process release Oxygen. This Oxygen is then used by aquatic animals, which filter water through their respiratory system.

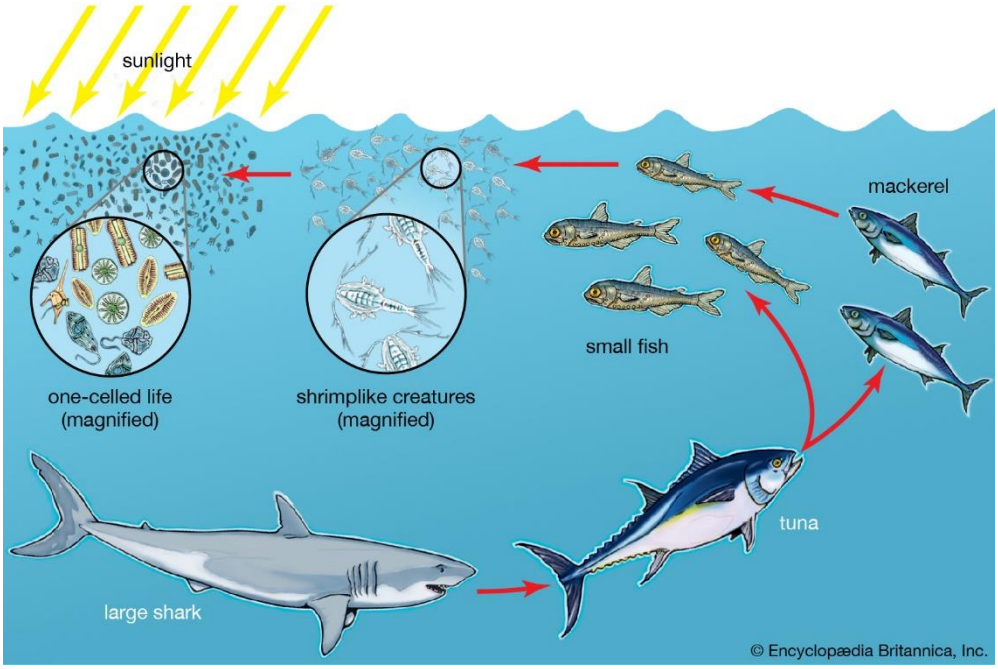
iii) Stream and River ecosystems: Streams and rivers are flowing water ecosystems in which all the living forms are specially adapted to different rates of flow. Some plants and animals such as snails and other burrowing animals can withstand the rapid flow of the hill streams. Other species of plants and animals such as water beetles and skaters can live only in slower moving water. Some species of fish, such as Mahseer, go upstream from rivers to hill streams for breeding. They need crystal clear water to be able to breed. They lay eggs only in clear water so that their young can grow successfully. As deforestation occurs in the hills the water in the streams that once flowed throughout the year become seasonal. This leads to flash floods in the rains and a shortage of water once the streams dry up after the monsoon. The community of flora and fauna of streams and rivers depends on the clarity, flow and oxygen content as well as the nature of their beds. The stream or river can have a sandy, rocky or muddy bed, each type having its own species of plants and animals.

b) Marine Ecosystem: Marine ecosystems are the biggest ecosystems. They cover around 71% of earth's surface and also contain almost around 97% of the total water present on earth. High amounts of minerals and salts are generally present in the water in the marine ecosystems and to better understand the amount and composition of the different minerals and salts in the water in different marine ecosystems. Marine ecosystems differ from freshwater ecosystems in that they contain saltwater, which usually supports different types of species than does freshwater. Marine ecosystems are the most abundant types of ecosystems in the word. They encompass not only the ocean floor and surface but also tidal zones, estuaries, salt marshes and saltwater swamps, mangroves and coral reefs.



i) Estuary Ecosystem: When rivers meet the sea (having saline water), at the junction develop the estuaries, where salinity level keeps fluctuating with tide. At high tide the inflowing sea water makes the estuary highly saline, while at low tide with water draining into the sea and river water flowing in, the salinity level drops. The organisms have evolved many adaptations to cope with tidal cycles and salinity changes. Tidal action promotes a rapid circulation of nutrients and food, and aids in the rapid removal of waste products of metabolism. The estuaries are one of the most productive regions of the world.

ii) Ocean Ecosystem: Scientists have identified around 300,000 different marine, or ocean, species. Together, these make up about 15 percent of all known plants and animals on the planet. However, the ocean is so vast that much of it has not yet been carefully explored. A million or more as yet undiscovered species might live in its waters.



The food chain here also starts from phytoplankton, algae, green oceanic plants. Zoo plankton, small fishes form the primary consumers. Large fishes like shark eat the small fish and belong to the upper trophic level. The bacteria and fungi decompose the dead marine animal and complete the cycle. When populations of top predator species shrink due to overfishing, it

can take years for them to recover. This is due to their slow rate of reproduction. The loss of these species can create problems throughout the entire food web.

Conclusion: Ecosystem of any type all over the world are of immense significance as they provide *several services like flow of energy, cycling the nutrients, provide habitats to all the organisms, effect the climatic condition, store house of resources, anthropocentric services and many more*. In present time most of the ecosystems, irrespective of their size, type and location, have come under human threat. Continuous loss of space and species is bringing the ecosystem at the verge of vulnerability. So, from now on it is quite important to redirect all the human activities in favour of the ecological condition of any region. In long future, this eco-centric livelihood will help all the living organisms including human being to live a more sustainable and healthy life on the earth surface.

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