Revision Notes

Class - 12 Biology

Chapter 14 - Ecosystem

Ecosystem: The ecosystem is the functional unit of nature in which living organisms interact with each other as well as their surrounding physical environment.

Biosphere: The biosphere is a global ecosystem that includes all of the world's local ecosystems.

Types of the ecosystem:

1. Aquatic ecosystem: Forest, grassland, desert, etc.

2. Terrestrial ecosystem: Pond, wetland, lake, estuary, river, etc.

These are the natural ecosystems.

An ecosystem can be artificial or man-made like the croplands, aquarium, etc.

14.1: Ecosystem- Structure and Function

Biotic Factors: This includes all the living organisms in an ecosystem.

Abiotic factors: This includes all the non-living factors in an ecosystem like sunlight, humidity, wind, etc.

The characteristic physical structure of an ecosystem depends on the interaction of biotic and abiotic factors.

Stratification: It is the vertical and also the horizontal distribution of different varieties that occupy different levels. For example, trees occupy the top vertical

strata or layers of a forest, shrubs are the second, and herbs and grasses occupy the bottom layers.

For an ecosystem to function as a unit the following factors are important:

1. Productivity

2. Decomposition

3. Energy flow

4. Nutrient cycling

The function of an ecosystem is that the conversion of inorganic into organic material by the subsequent steps:

- Use of the energy of the sun by the autotrophs.
- Consumption of the autotrophs by various heterotrophs.
- Decomposition and mineralization of all the dead organic interest release the nutrients back to the soil for reuse by the autotrophs.
- These events are repeated again and again.

As we move along the trophic levels energy moves in a unidirectional manner. Energy dissipates and is lost as heat to the environment. Example: Pond ecosystem.

Abiotic factors:

Water with all dissolved inorganic and organic nutrients, soil rich in nutrients at rock bottom of the pond, solar input, day-length, temperature, and other climatic factors.

Biotic Factors:

Producers or autotrophs: Algae, phytoplankton, floating, submerged, and marginal plants in the pond.

Consumers or heterotrophs: Zooplankton, free-living, and bottom-dwelling forms.

Decomposers: Fungi, bacteria, and flagellates are abundant in the bottom of the pond.

14.2 Productivity:

A constant input of solar power is that the basic requirement for any ecosystem.

Primary Production: It is the amount of biomass produced per unit area in a given time by plants during photosynthesis. It is expressed in terms of weight (g-2) or energy (kcal m-2).

Productivity: It is the rate of biomass production. It is expressed as g-2

yr-1 or kcal m-2 yr-1.

Gross primary productivity (GPP): GPP of an ecosystem is the rate of production of organic matter during photosynthesis.

Net primary productivity (NPP): Gross primary productivity minus respiration losses (R), is the net primary productivity (NPP).

GPP – R = NPP

The available biomass for the consumption of heterotrophs or herbivores and decomposers is the net primary productivity.

The rate of formation of new organic matter by consumers is termed secondary productivity.

The primary productivity of an ecosystem depends on the plant species and various environmental factors and therefore, varies from place to place.

For the whole biosphere, the annual net primary productivity is approximately 170 billion tons (dry weight) of organic matter. Despite occupying nearly 70% of the earth's surface, the productivity of the oceans is only around 55

billion tons.

14.3: Decomposition:

Decomposition: It is the process of break down complex organic matter into simpler inorganic substances such as carbon dioxide, water, and nutrients by the action of decomposers.

Detritus: Dead remains of plants and animals such as leaves, barks, flowers, fecal matter of animals, etc. constitute detritus.

Detritivores: Organisms that feed on detritus are called detritivores. Earthworms, fungi, etc. are examples of detritivores.

Steps in Decomposition:

1. **Fragmentation:** It is the breakdown of detritus into smaller particles by the action of detritivores.

2. Leaching: It's the phenomenon by which water-soluble nutrients sink to the soil horizon and precipitate as salts that aren't available.

3. Catabolism: It is the breakdown of detritus into simple inorganic nutrients by the action of bacterial and fungal enzymes.

4. Humification: It is the formation and continuous deposition of a dark-colored organic amorphous substance called humus. Humus is extremely resistant to microbial action and decomposes at a very slow rate. Because it is colloidal, it acts as a nutrient reservoir.

5. Mineralisation: It is the process by which some microorganisms further break down humus to form simple inorganic nutrients.

- Humification and mineralization occur in the soil.
- All steps of decomposition occur simultaneously on detritus.
- Decomposition is largely an oxygen-requiring process.
- On both the chemical composition of detritus and climatic factors the rate of decomposition is depending. When detritus is rich in lignin and chitin, the pace of decomposition is slower, and when detritus is rich in nitrogen

and water-soluble compounds like sugars, the rate of decomposition is faster.

- The most important climatic factors that plays important role in decomposition are temperature and soil moisture. They affect the activities of soil microbes.
- Decomposition is favored in warm and moist environments.
- Decomposition is inhibited by low temperature and anaerobiosis. This results in a build-up of organic materials.

14.4: Energy Flow:

- The Sun is the ultimate source of energy for all ecosystems on earth (except for the deep-sea hydrothermal ecosystem).
- **Photosynthetically Active Radiation (PAR):** The solar radiation that can be utilized by plants for photosynthesis. Of all incident solar radiation, only 50% is PAR. The plants can capture only $2-10\%$ of the PAR and it is this energy that sustains all life on earth.
- There is a unidirectional flow of energy that is the energy from the sun flows to the producers and then the consumers. Therefore, all organisms are directly or indirectly dependent on the sun.
- All ecosystems follow the First and the Second Law of thermodynamics.
- **First Law of Thermodynamics:** The First Law of Thermodynamics explains that energy can be converted from one form to another in the presence of heat, work, and internal energy, but it can neither be created nor destroyed, under any circumstances.
- The unidirectional flow of energy shows the First Law of Thermodynamics as energy from the sun is converted into chemical energy by the producers which are then utilized by the consumers. At any level energy can neither be created nor be destroyed.

- **Second Law of Thermodynamics:** The Second Law of Thermodynamics states that the state of entropy of the entire universe, as an isolated system, will always increase over time. The changes in the entropy in the universe can never be negative, this is explained by the second law.
- To counteract the universal tendency toward increasing disorderliness ecosystems need a constant supply of energy to synthesize the molecules they require.
- Energy flow in the ecosystem occurs in the form of the food chain.
- **Food chain:** A food chain is an arrangement of species in an ecological community based on the order of predation, in which each organism feeds on the organisms below it.

- **Producers:** All the green plants in the ecosystem utilize solar energy for photosynthesis. They are always autotrophic.
- **Consumers:** All heterotrophs, whether directly or indirectly reliant on plants for nourishment, are referred to as consumers. Depending on their position in the food chain the organisms can be divided into primary, secondary, tertiary, or quaternary levels.
- **Primary Consumers/herbivores:** The organisms that are directly dependent on the producers. In the above food chain, the grasshopper is the primary consumer.
- **Secondary Consumers/Primary carnivores:** The organisms that are dependent on the primary consumers. The frog in the above example is a secondary consumer.

- **Tertiary consumers/Secondary carnivores:** The organisms that are dependent on the secondary consumers.

- **Quaternary Consumers/Tertiary carnivore:** The organisms that are dependent on the tertiary consumers. They usually holds the top position that is the carnivore in a food chain.

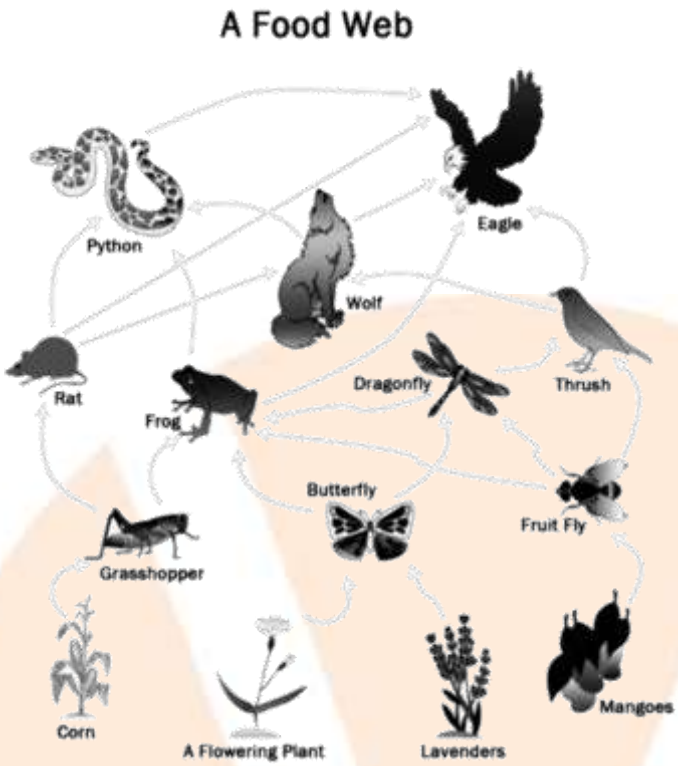
- A food chain cannot have more than a quaternary consumer because there would not be enough energy left for next level organism.

- The detritus food chain's (DFC) starting point is dead organic matter. It is consists of decomposers mainly fungi and bacteria which are heterotrophs too. They break down dead organic matter or detritus to meet their energy and nutrient requirements. These are also called saprotrophs in which sapro means to decompose. They secrete digestive enzymes outside their body to break down dead and waste organic materials into simple, inorganic materials. These simpler substances are subsequently absorbed by them.

- In an aquatic ecosystem, the major conduit for energy flow is the Grazing Food Chain (GFC). In a terrestrial ecosystem, a much larger fraction of energy flows through the detritus food chain in comparison with the GFC.

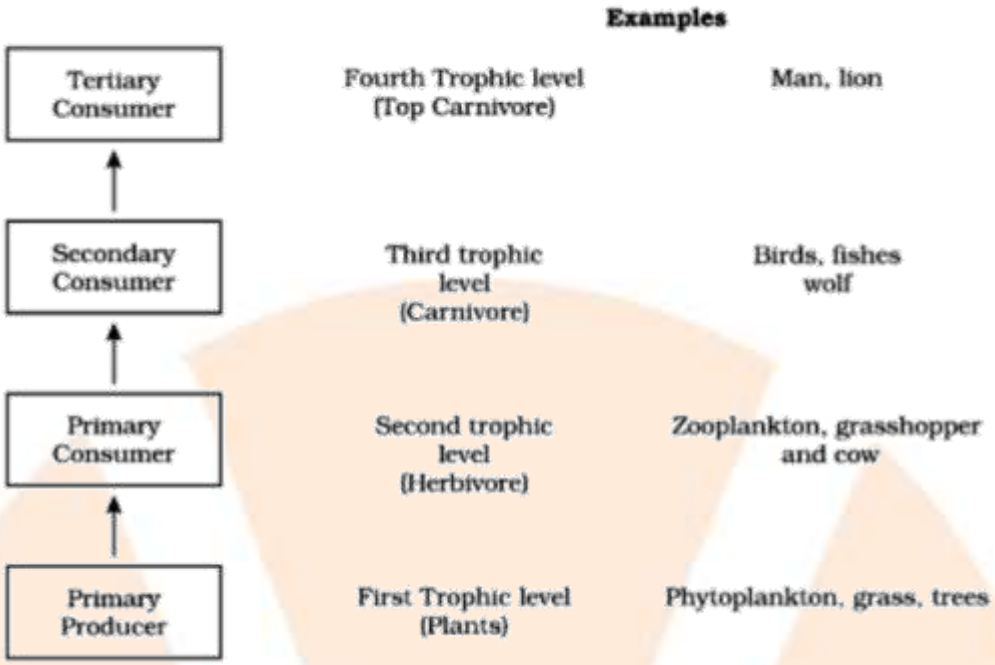
- Detritus food chain can be connected with the grazing food chain because some of the organisms of DFC are prey to the GFC animals. Also in a natural ecosystem, some animals that exist are omnivores such as cockroaches, crows, etc.

- **Food Web:** A system of food chains in which the interlocking and interdependency are found.

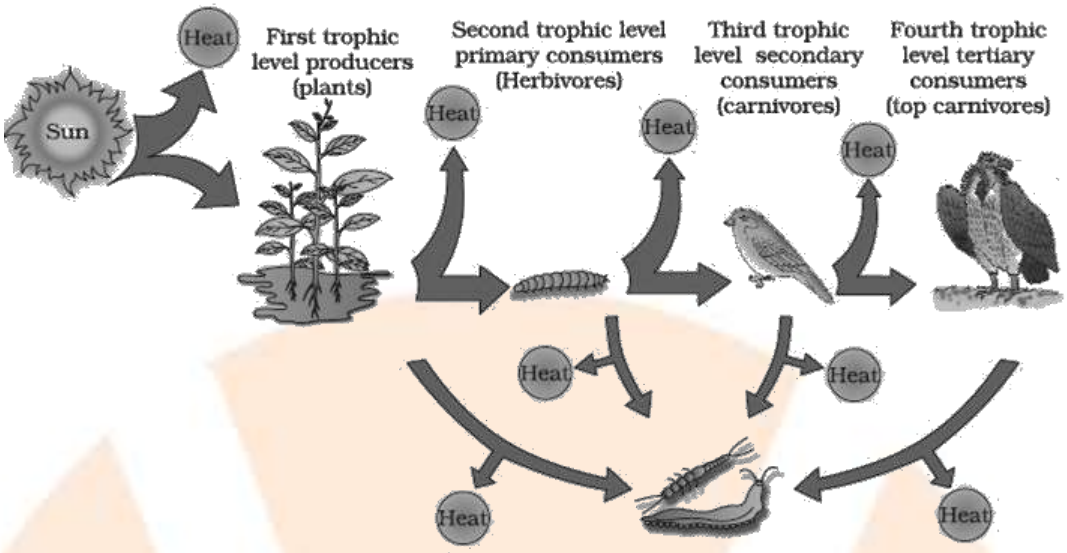


➢ **Trophic Level:** The specific place in the food chain occupied by an organism based on the source of their nutrition or food is called the trophic level.

- **First trophic level:** Producers occupy the first trophic level.
- **Second trophic level:** The primary consumers
- **Third trophic level:** The secondary consumers
- **Fourth trophic level:** The tertiary consumers
- **Fifth trophic level:** The quaternary consumers
- A food chain can have a maximum of five trophic levels as beyond that the amount of energy is insufficient to sustain another consumer.



- At successive trophic levels, the amount of energy gets decreases.
- When an organism dies it is converted into detritus which serves as a source of energy for the decomposers.
- **Standing crop:** At a particular given time the total mass at a trophic level is standing crop. It is measured as the mass of living organisms (biomass) or the number in a unit area.
- Biomass can also be expressed as fresh or dry weight. However, the use of the dry weight is more accurate.
- **10 percent Law:** This law states that only 10 % of the energy of a trophic level is transferred to the next level.



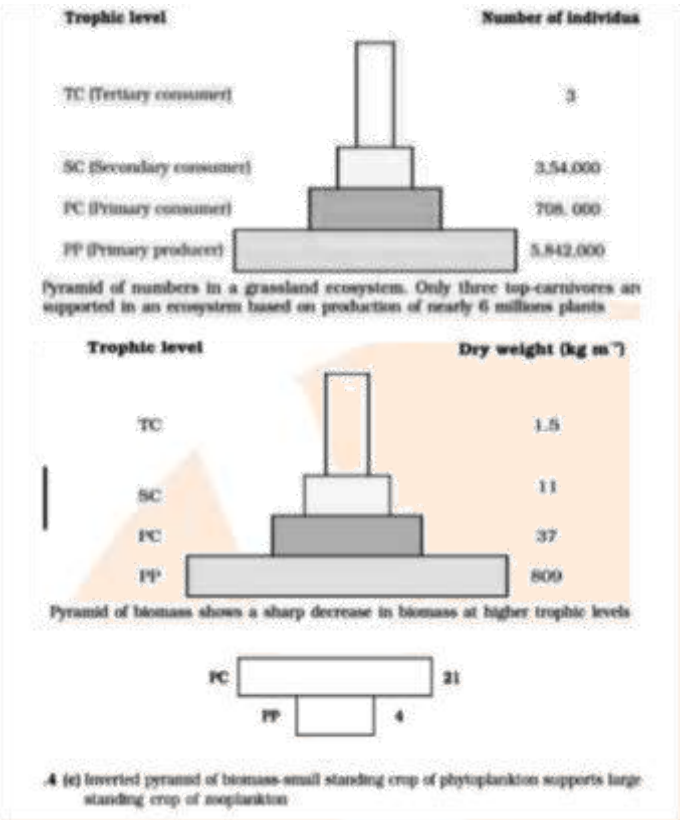
14.5: Ecological Pyramids:

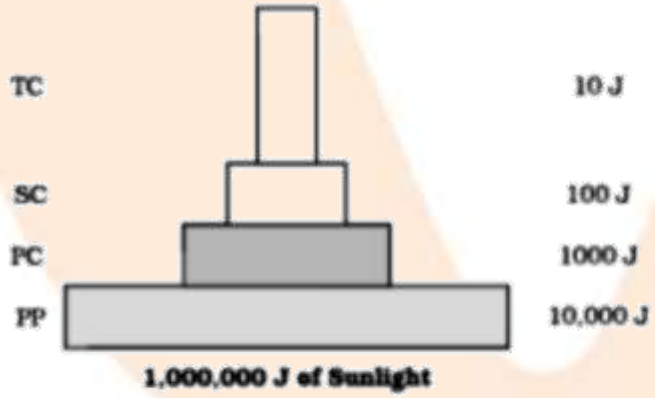
- An ecological pyramid is a graphical representation of the relationship between different organisms in an ecosystem.
- Each bar of the pyramid represents a specific trophic level along with their order. The order depends on who is been eaten by whom.
- This represents the flow of energy.
- The base of each pyramid is the representation of the producers or the first trophic level whereas the apex is the representation of the tertiary or top-level consumers.
- The three commonly studied ecological pyramids are:

  (a) Pyramid of number

  (b) Pyramid of biomass

  (c) Pyramid of energy





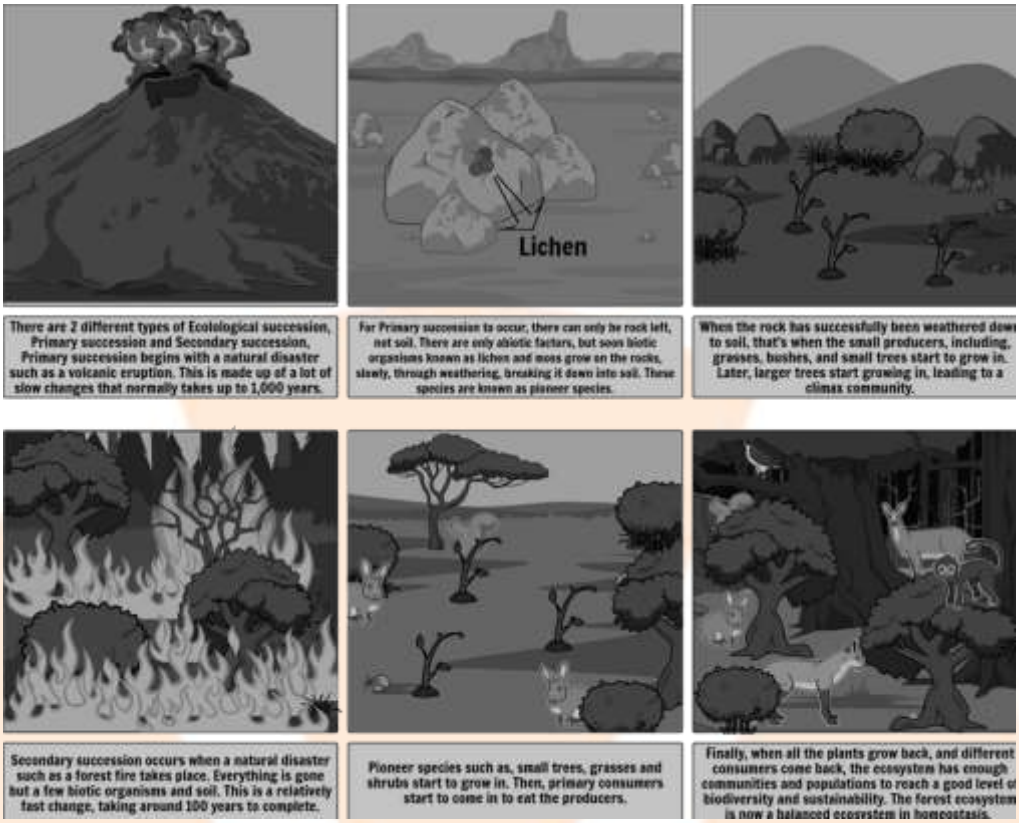
I (d) An ideal pyramid of energy. Observe that primary producers convert only 1% of the energy in the sunlight available to them into NPP

- All species at that trophic level should be included in any estimations of energy content, biomass, or population. At any trophic level, it is impossible to generalise based on merely a few individuals.
- An organism can be a part of more than one food chain and therefore belong to different trophic levels.

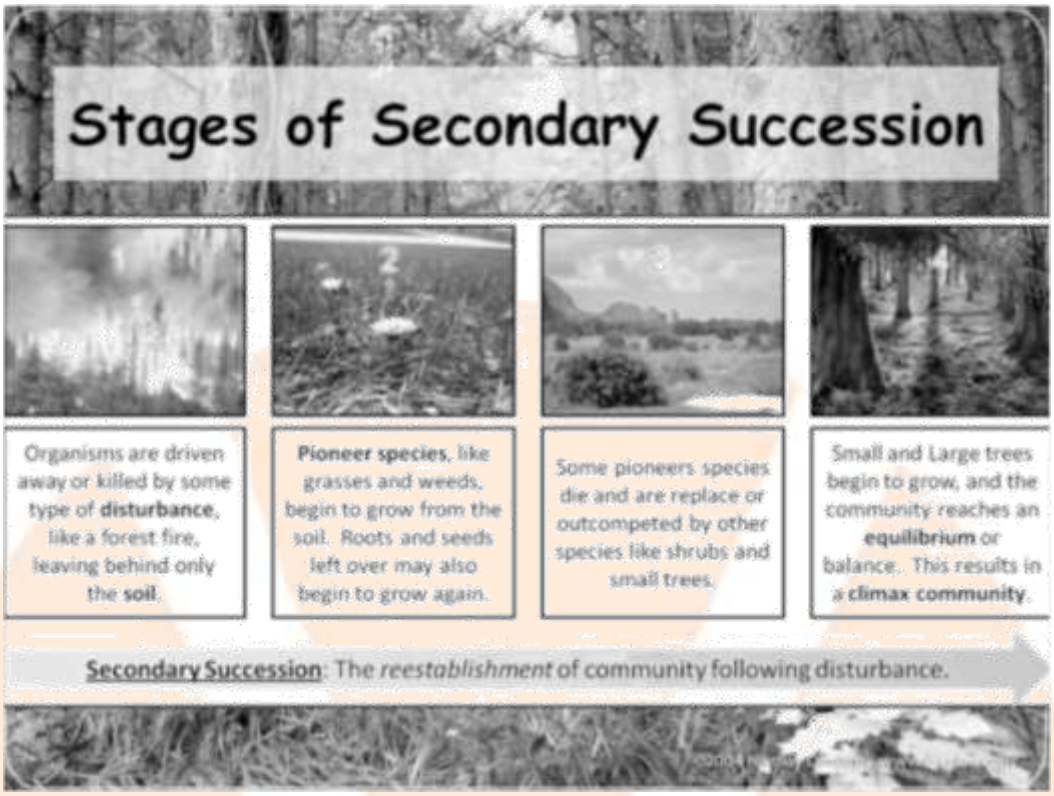
- The pyramids of biomass, energy, and number are upright in most ecosystems. That is, the producers are more in number than the herbivores, the herbivores are more than the carnivores, etc.
- Pyramids of number and biomass can be inverted in some cases but the pyramid of energy is always upright. This is due to the fact that when energy goes from one level to another, some of it is lost as heat.
- Only food chains, not food webs, can be accommodated in ecological pyramids. They are also incapable of depicting saprotrophs.

14.6: Ecological Succession:

- Ecological succession is the process of change in the structure of species that belongs to an ecological community over time. After a mass extinction, the time scale can be decades or even millions of years. This change occurs orderly and sequential, parallel with the changes in the physical environment.
- **Pioneer Species:** The species that invade a bare area are called pioneer species.
- **Pioneer Community:** The community that is capable to invade a bare area is known as the pioneer community.
- **Climax community:** A community that is almost near to equilibrium with the environment is called the climax community.
- **Sere:** A sequence of ecological communities arising in an area from the initial pioneer community to the final climax community
- **Primary succession:** Primary succession is a type of biological and ecological succession of plant life. It occurs in an environment in which a new substrate is deposited. This new substrate is not having any kind of vegetation and other organisms. It also usually lacks soil and organic matter. It occurs in places such as land after a lava flow or area left from the retreated glacier.



- **Secondary succession:** Secondary succession is a type of biological and ecological succession of plant life which takes place in a habitat that has been previously populated but has since been disturbed or damaged. For instance, regions where existing vegetation has been removed (due to tree-felling in a woodland or destructive events such as fires).



14.6.1: Succession of plants:

Hydrarch: A succession that begins in a water body or aquatic environment is called Hydrosere or Hydrarch Succession.

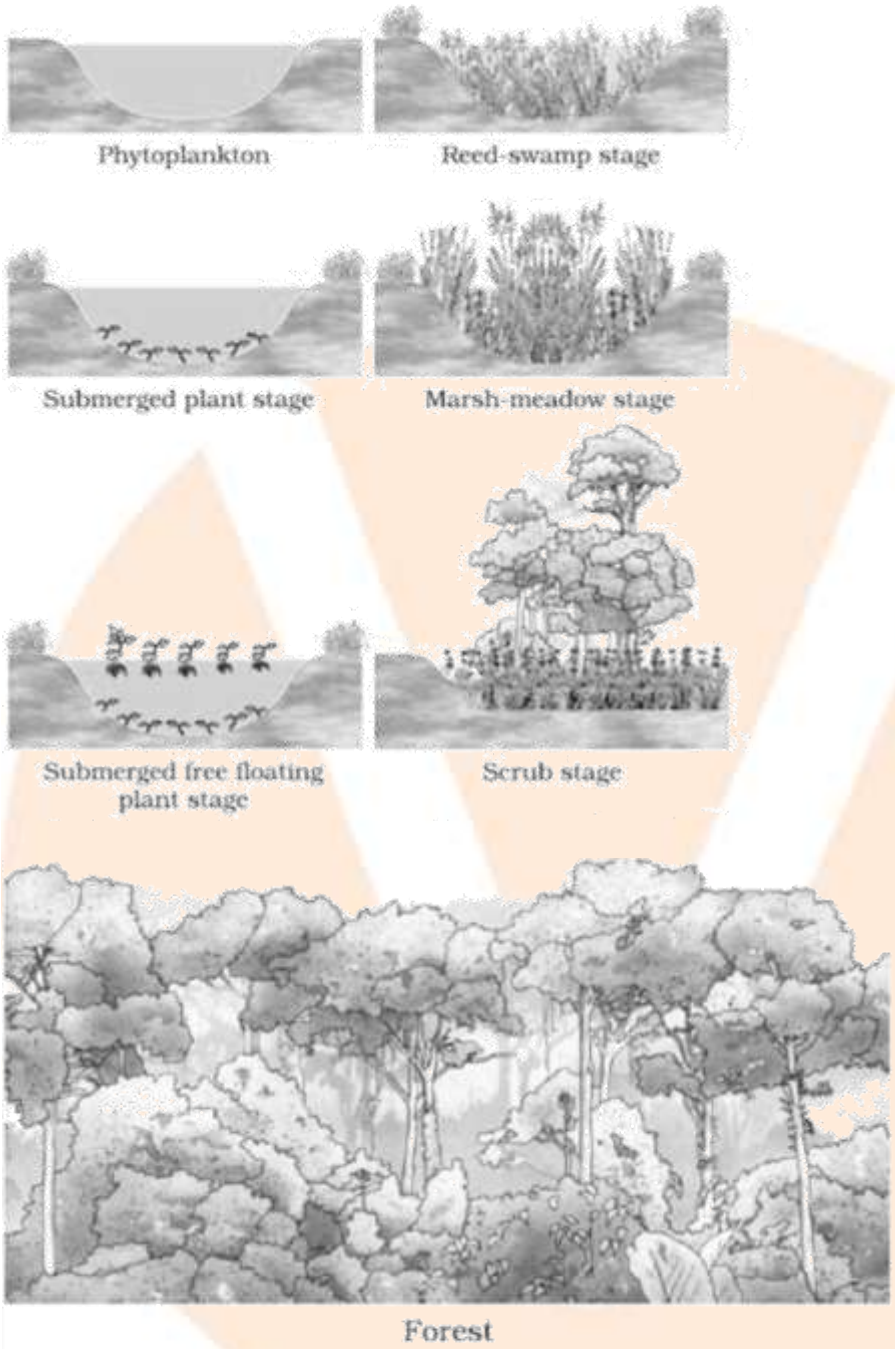
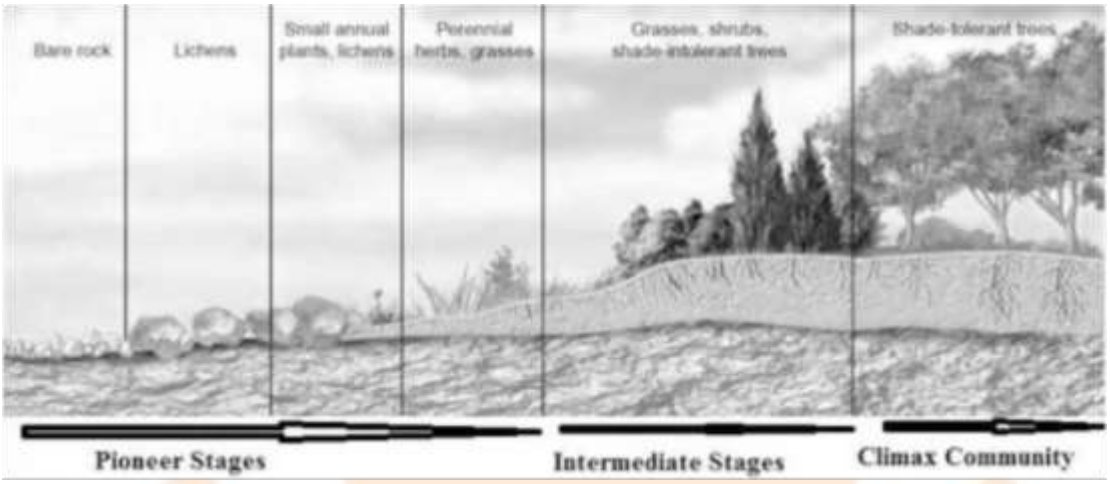


Figure 14.5 Diagramatic representation of primary succession

Xerarch: Xerosere is a succession of plants that are limited in the availability of water availability. It includes the different stages in xerarch succession. Xerosere originates in extremely dry situations such as sand deserts, dunes, salt deserts, rock deserts, etc.



In secondary succession, the invasion of species depends on the availability of water, conditions of the soil, and the environment. It also depends on whether any seeds or other propagules are present. Because soil is already existent, the pace of succession is substantially faster, and the climax community is reached much sooner.

Succession always proceeds towards the mesic community.

14.7: Nutrient Cycling:

The movement of nutrients through the various components that belongs to an ecosystem is called nutrient cycling. It is also called biogeochemical cycles (bio: living organism, geo: rocks, air, and water).

Types of nutrient cycles:

(a) Gaseous, and

(b) sedimentary.

Standing state: The total amount of various nutrients like nitrogen, carbon, phosphorus, calcium, etc., present in the soil at any given time, is referred to as the standing state. It differs in different kinds of ecosystems and also on the basis of season.

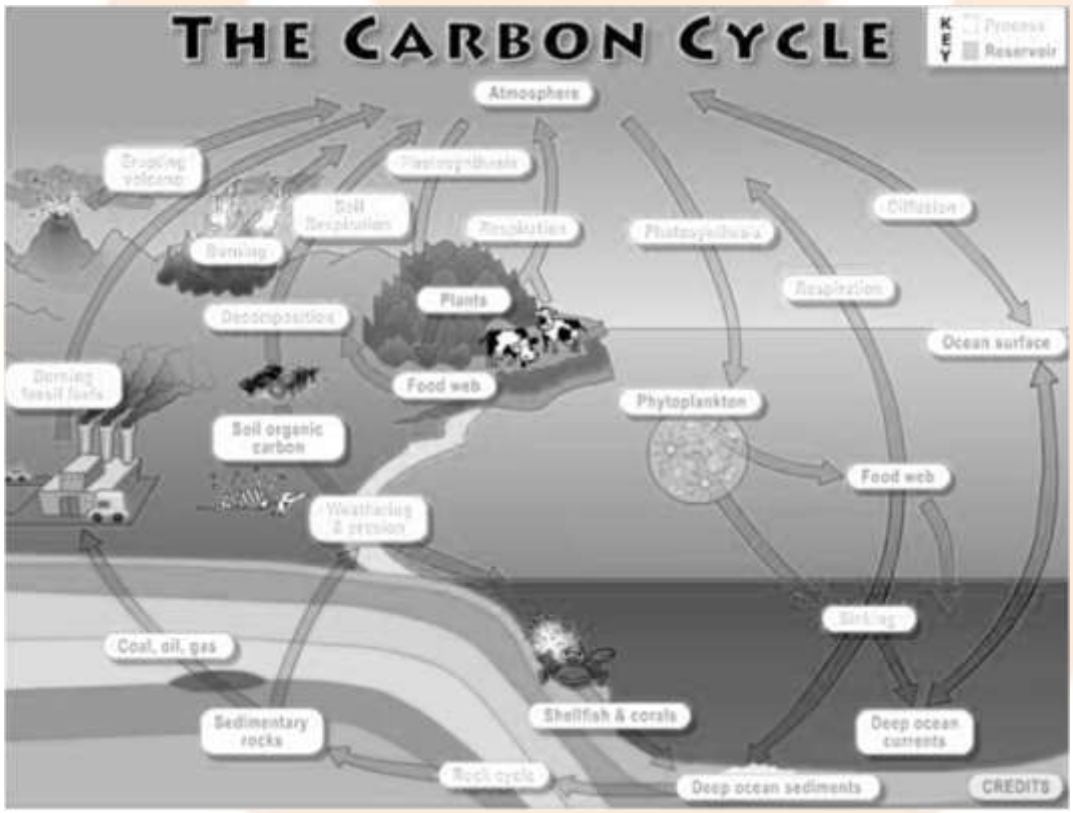
The atmosphere serves as a reservoir for gaseous nutrient cycles (carbon and nitrogen).

The reservoir for the sedimentary nutrient cycle (sulfur, phosphorus, etc.) exists in the earth's crust.

The rate of release of nutrients into the atmosphere is regulated by environmental factors.

The reservoir functions to meet with the deficit occurring due to an imbalance between influx and efflux.

14.7.1: Ecosystem – Carbon Cycle:



Carbon is contained by most of the chemicals that make up living tissue. When the organisms die the carbon contained by them is recycled to be used by future generations. The movement of carbon through the various components of the ecosystem is called the carbon cycle.

1. As a result of respiration and combustion, carbon is released into the environment as CO2.

2. Carbon dioxide is absorbed by producers during the process of photosynthesis to produce carbohydrates.

3. Animals feed on the producers. The food chain causes carbon to move along various trophic levels. During breathing, the majority of the carbon eaten is exhaled as CO2. The animals and plants eventually die.

4. Decomposers eat the dead organisms and break them down. This causes the carbon in their bodies to be returned to the atmosphere as carbon dioxide. In some extraordinary conditions, decomposition is blocked. The plant and animal material may then be turned into fossil fuel for use in the future for combustion.
5. Marine animals may convert some of the carbon in their diet to calcium carbonate which is then used to make the shells for their bodies. Over time these shells of dead organisms get collected on the seabed and form or converted into limestone. Due to various activities and movements of the earth, this limestone may eventually become exposed to the air where it is subjected to weathering. This results in the back release of carbon into the atmosphere as carbon dioxide. Carbon dioxide is also released through volcanic action.

6. Human activities have significantly influenced the carbon cycle. Rapid deforestation and massive burning of fossil fuels have increased the rate of release of carbon dioxide into the atmosphere.

14.7.2: Phosphorus Cycle:

The phosphorus cycle is the process by which phosphorus moves through the different layers of the atmosphere that is the lithosphere, hydrosphere, and biosphere.

Steps in Phosphorus Cycle:

1. Weathering

2. Fertilizer

3. Excretion and Decomposition

4. Dissolved Phosphates

5. Geologic Uplift

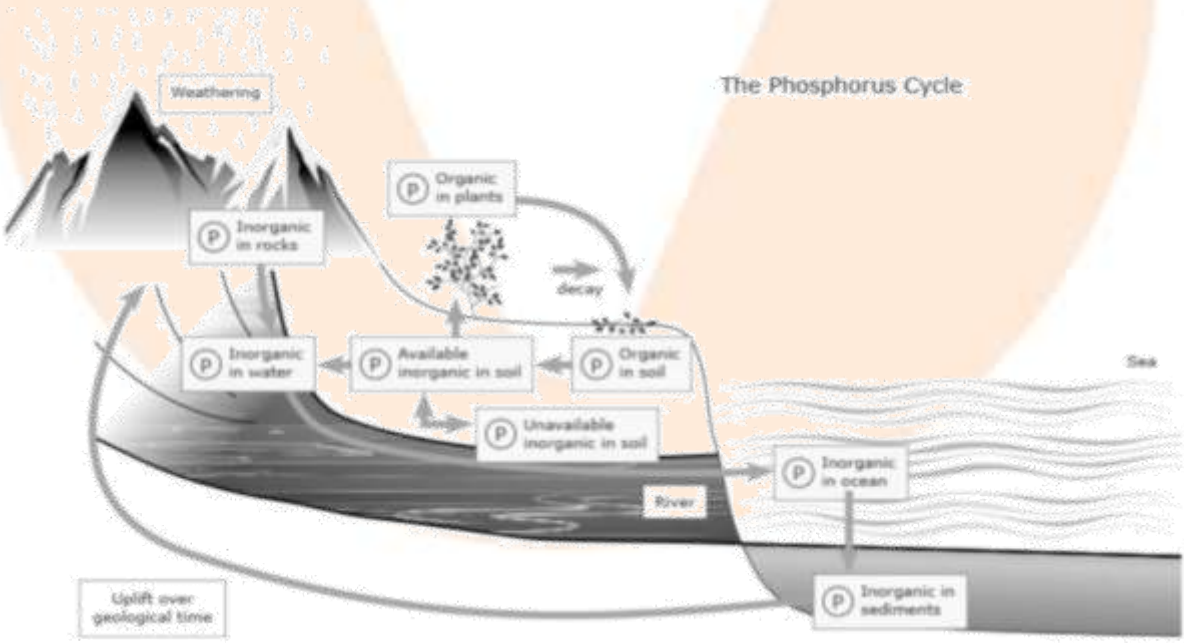
1. Weathering: Weathering of uplifted rocks adds phosphates to the land. Eventually, some phosphates reach the ocean again.

2. Fertilizers: Phosphate fertilizers from fields might run off straight into the streams. These may later become part of a soil pool or can be absorbed by the plants.

3. Excretion and decomposition: Animal excretion (on land or in the ocean) and animal and plant decomposition both produce phosphates on land and in water.

4. Dissolved phosphates: Dissolved phosphates plays important role in forming ocean sediments by precipitation. The process of conversion of these sediments into phosphate rocks is a very slow and gradual process.

5. Geological uplift: Geologic forces can lift up the phosphate rocks very slowly from the ocean floor or the rocks thick with phosphate in them to form the huge mountains.



Difference between the carbon cycle and Phosphorus Cycle

Carbon Cycle	Phosphorus Cycle
1. Its major component is gaseous.	1. Its major component is non-gaseous.
2. There is a respiratory release of carbon as carbon dioxide.	2. There is no respiratory release of phosphorus anymore.
3. Its cycling pool is present in the hydrosphere and atmosphere.	3. Its cycling pool is the lithosphere.
4. The atmospheric input of carbon through rainfall is measurable.	4. It is negligible.

14.8: Ecosystem Services:

The results or outcome of ecosystem processes is called ecosystem services.

➢ **Services of healthy forest ecosystems:**

- Purification of air and water
- Mitigation of droughts and floods
- Cycling of nutrients
- Generation of fertile soils
- Providing habitats to wildlife
- Maintenance of biodiversity
- Pollination of crops

- To provide storage site for carbon
- Providing aesthetic, cultural, and spiritual values.

➢ The average price tag of these ecosystem services is estimated to be the US 33 trillion annually. This is near twice the value of the global gross national product GNP (the US 18 trillion).

➢ **The calculation, out of the total cost of various ecosystem services:**

- Soil formation accounts for about 50% of the ecosystem services.
- Recreation for about 10% of these services.
- Nutrient cycling about 10% of them.
- The cost of climate regulation and habitat for wildlife is approximately 6% each.