14 Ecosystems and Energy flow

Can you recall?

1. What is environmental biology?
2. Meaning of the term habitat.
3. Importance of ecology for humans.

An ecosystem is a self regulatory and self sustaining structural and functional unit of nature (biosphere). It contains both biotic and abiotic components. Biotic components interact with each other and also with the surrounding environment. Tansley (1935) coined the term **ecosystem**. Ecosystems vary greatly in size from a small pond to large oceans or small farmland to village. Entire biosphere can be considered as one global ecosystem, made up of many local ecosystems. Since the earth ecosystem is too big and too complex to be studied, it is divided into two basic categories, *viz.* **terrestrial** and **aquatic**. Forest, grassland and desert are the types of terrestrial ecosystems while lakes, wetlands, rivers and estuaries are the types of aquatic ecosystems. The ecosystems can also be classified as Natural ecosystems and Artificial ecosystems. **Natural ecosystems** do not require any human inputs, in other words they are self-sustainable. **Artificial ecosystems** e.g. a farm land, a fish tank or even a large pond used for rearing fish, require constant input in terms of energy or materials.

In this chapter, we will study and analyse the structure of the ecosystem, in order to appreciate the input (productivity), transfer of energy (food chain/web, nutrient cycling) and the output (degradation and energy loss). We will also look at the relationships, chains and webs that are created because of the energy flows within the system.

14.1 Ecosystem :

Structure and Function :

We have already studied the various biotic and abiotic components of the environment. We know that all these biotic and abiotic components influence each other. Let us now look at these components with an integrated approach and see how the flow of energy takes place in ecosystem. Interaction of biotic and abiotic components, results in a physical structure that is characteristic for each type of ecosystem. Identification and enumeration of plant and animal species of an ecosystem gives its species composition.

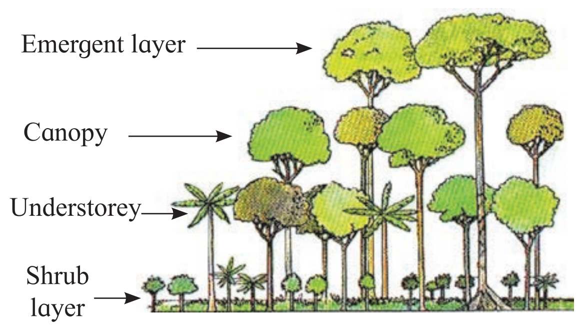


Fig. 14.1 : Stratification of plants in forest

Biotic and abiotic components differ as the locations vary in space and time. The variation due to space results in **spatial pattern**. There are two types of spatial patterns. viz. Stratification and Zonation.

Vertical distribution of different species of plants and animals occupying different levels, is known as **stratification**. For example, trees occupy top vertical strata or layer of a forest, shrubs the second and herbs and grasses occupy the bottom layer. Similar stratification is also observed in the open seas as epipelagic, meso-pelagic, bathy-pelagic and benthic zones.

Find out

Stratification of animals in amazon rain forest.

Horizontal distribution of plants and animals on land or in water, is called **zonation**. Zonation is observed in aquatic (wetlands) as well as terrestrial ecosystems, but it is easily seen at the junction of the two. Edges of a large lake or beach show pronounced zonation in the form of Inter-tidal, Littoral, Sub-littoral zones.

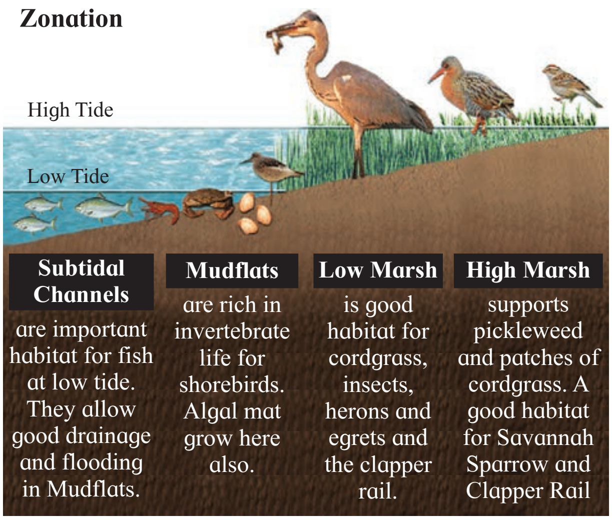


Fig. 14.2 : Zonation in wetland

Think about it

Why is zonation more pronounced at the edges of habitat?

The biotic and abiotic components of an ecosystem are all linked together to function as an 'ecosystem unit' through various processes like, **Productivity, Decomposition, Nutrient cycling and Energy flow.** In fact, these are functional aspects of ecosystem.

Any ecosystem must perform these four processes for its sustainance (**to be self–sustaining**). The ecosystem understudy may be as small as a pond or entire biosphere as a whole. The process of **productivity** involves conversion of inorganic chemicals into organic material with the help of the radiant energy of the sun by the autotrophs and consumption of the autotrophs by heterotrophs. The **Decomposition** is the break down of dead organic material and mineralization of the dead matter. The **nutrient cycling** is the storage and transport of nutrients. (minerals released in decomposition process are used again by autotrophs). The **energy flow** is unidirectional flow of energy from producers to consumers and finally dissipation and loss as heat.

Example- Think of a small pond ecosystem. It is fairly a self-sustainable unit that explains the complex interactions which exist in any aquatic ecosystem. A pond is a shallow water body in which all the above four aforesaid basic processes of an ecosystem are observed. The abiotic component is water with all the dissolved inorganic and organic substances and also the rich soil deposit at the bottom of the pond. The solar input, the cycle of temperature, day-length and other climatic conditions regulate the rate of function of the entire pond. The producers include the phytoplankton, algae and other aquatic plants. The consumers are represented by the zooplankton, aquatic insects and fish. The decomposers are the fungi, bacteria located at the bottom of the pond.

a. Productivity :

A constant input of solar energy is the basic requirement for any ecosystem to function and sustain. **Productivity** refers to the rate of generation of biomass in an ecosystem. It is expressed in units of mass per unit surface (or volume) per unit time, for instance grams per square metre per day (g/ m^2/ day). The mass unit may relate to dry matter or to the mass of carbon generated.

It can be divided into **gross primary productivity** (GPP) and net primary productivity (NPP). **Gross primary productivity** of an ecosystem is the rate of production of organic matter during photosynthesis. Plants themselves use a considerable proportion of this GPP for their respiration. Hence, gross primary productivity minus respiratory losses (R) constitute the net primary productivity (NPP).

$$GPP - R = NPP$$

Net primary productivity is the available biomass for the consumption, to heterotrophs (herbivores, carnivores and decomposers). The annual net primary productivity of the whole biosphere is approximately 170 billion tons (dry weight) of organic matter. Of this, the productivity of the oceans is only 55 billion tons. Rest of course, is from land based ecosystems.

Use your brain power

What could be the reason for the low productivity of ocean?

Primary productivity (GPP) depends on the plant species inhabiting a particular area. It also depends on a variety of environmental factors, availability of nutrients and photosynthetic capacity of plants. Therefore, it varies in different types of ecosystems. **Secondary productivity** is defined as the rate of formation of new organic matter by consumers. Alternatively, it is the rate of assimilation of food energy at the level of consumers. It is the amount of energy available to consumer for transfer to the next trophic level.

b. Decomposition :

Decomposers break down complex organic matter into inorganic substances like carbon dioxide, water and nutrients, and the process is called **decomposition**. Dead remains of plants and animals, including fecal matter, constitute detritus, which is the raw material for decomposition. The important steps in the process of decomposition are fragmentation, leaching, catabolism, humification and mineralization.

Detritivores (e.g. earthworm) break down detritus into smaller fragments or particles. This process is called **fragmentation**.

By the process of **leaching**, water soluble inorganic nutrients go down (percolate) into the soil horizon and get precipitated as unavailable salts. Bacterial and fungal enzymes degrade detritus into simpler inorganic substances. This process is called as **catabolism**. It is important to note that all the above steps in decomposition operate simultaneously on the detritus.

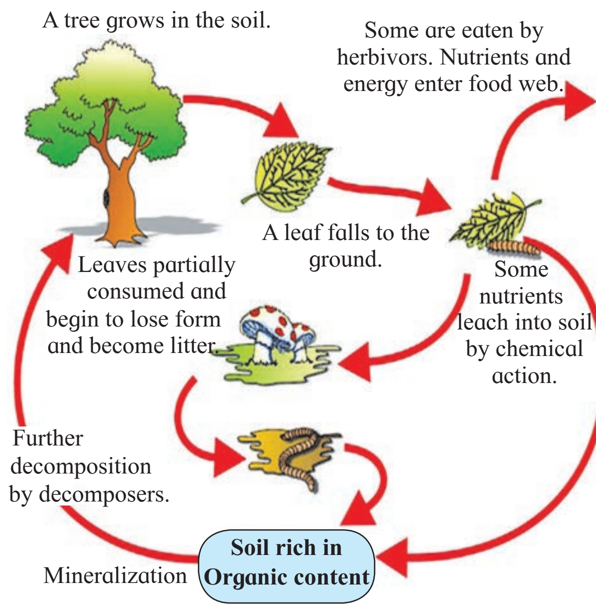


Fig. 14.3 : Decomposition cycle

Humification and mineralization occur during decomposition in the soil. Humification leads to accumulation of partially decomposed, a dark coloured, amorphous, colloidal organic substance called **humus** that is resistant to microbial action and undergoes decomposition at an extremely slow rate. Humus formation changes soil texture and increases water holding capacity of soil.

Being colloidal in nature humus serves as a reservoir of nutrients. The humus is further degraded by some microbes and release of inorganic nutrients occurs by the process known as **mineralisation**.

Decomposition as a process requires oxygen. Temperature and soil moisture are the most important factors that regulate decomposition indirectly to help soil microbes. Warm and moist environment favours decomposition whereas low temperature and anaerobic conditions inhibit decomposition.

Can you recall?

1. What is a food chain?
2. What are trophic levels in a food chain?

14.2 Energy Flow :

Sun is the only source of energy for all ecosystems on the earth except for the deep-sea ecosystems. Of the total incident solar radiation, less than 50 % of it is **photosynthetically active radiation (PAR)**. Plants and photosynthetic bacteria (autotrophs) fix energy to prepare food from simple inorganic materials. Plants capture only 2-10 % of the PAR and this small amount of energy sustains the entire living world.

Therefore, it is very important to know how the solar energy captured by plants flows through different organisms of an ecosystem. Directly or indirectly, all organisms are dependent for their food on producers. Hence there is **unidirectional flow of energy** from sun to producers and then to consumers. The direction can not be reversed. Energy can be used only once in the ecosystem.

The autotrophs need a constant supply of energy to synthesize the molecules they require. The autotrophs are called **producers**. In a terrestrial ecosystem, major producers are herbaceous and woody plants. Likewise, producers in an aquatic ecosystem are phytoplankton and algae.

Find out

1. Is there any presence of living organisms in the perpetual darkness of deep oceanic trenches?
2. In absence of solar radiation, what is their source of energy?
3. Which organisms do serve as producers in the food chains of deep oceans?

All animals directly or indirectly depend on plants for their food. They are hence called **consumers** (heterotrophs). If they feed directly on the plants, they are called **primary consumers**, and if the animals eat other animals which eat plants, they are called **secondary consumers**. Likewise, you could have **tertiary consumers** too.

The primary consumers are also known as **herbivores**. Some common herbivores are insects (grasshopper, aphids), birds (parrot) and some mammals (sheep, cattles, goat, donkey) in terrestrial ecosystem and molluscs in aquatic ecosystem. The consumers that feed on these herbivores are **carnivores**, (secondary consumers). Those animals that depend on the primary carnivores for food are called secondary carnivores.

		Examples
Tertiary Consumer	Fourth Trophic level (Top carnivore)	Man, lion
↑		
Secondary Consumer	Third trophic level (Carnivores)	Birds, fish and wolf
↑		
Primary Consumer	Second trophic level (Herbivores)	Zooplankton, grasshopper and cow
↑		
Primary Producer	First Trophic level (Photoautotrophs)	Phytoplankton, grass, trees

Chart 14.4 : Trophic levels

You have studied several food chains and food webs that exist in nature. Food chains are always straight and usually have four or five trophic levels. There are three types of food chains viz. **grazing**, **detritus** and **parasitic**. Starting from the plants (or producers) food chains and food webs are formed such that an animal feeds on a plant or on another animal and in turn is food for another. The energy trapped by the producer, is either passed on to a consumer or remains trapped till the producer organism dies. Death of organism is the beginning of the detritus food chain/web.

A simple grazing food chain (GFC) is depicted below:

Grass (Producer) ⟶ Deer (Primary Consumer) ⟶ Leopard (Secondary consumer)

The detritus food chain (DFC) begins with dead organic matter. It is composed of decomposers which are heterotrophic organisms, mainly fungi and bacteria. They meet their energy and nutrient requirements by degrading the detritus. These are known as **saprotrophs.** Decomposers secrete enzymes that breakdown dead organic materials into simple, inorganic materials, which are absorbed by them. Detritus food chain may be connected with the grazing food chain at some levels. In a natural ecosystem, some animals like cockroaches, crows, bears, man, etc. are **omnivores**. Omnivores eat producers as well as consumers. These natural interconnection of food chains make it a **food web**.

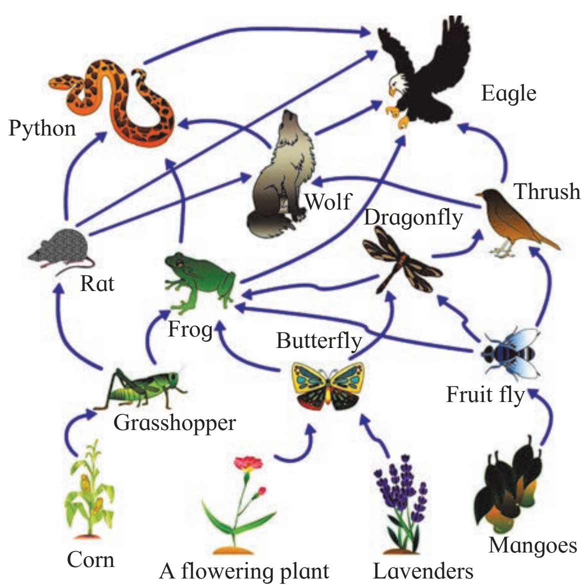


Fig. 14.5 : Food web

Can you tell?

From the given food web diagram, give the trophic levels where the eagle is present.

Use your brain power

1. What could be the connecting points between the GFC and DFC?
2. How will you classify man as carnivore (primary/ secondary) or omnivore? Why?
3. How many trophic levels human beings function in a food chain?

Every organism occupies a place in ecological community according to the source and method of obtaining its food. Organisms occupy a specific place in the food chain that is their **trophic level**. Producers belong to the first trophic level, herbivores (primary consumer) to the second and carnivores (secondary consumer) to the third trophic level.

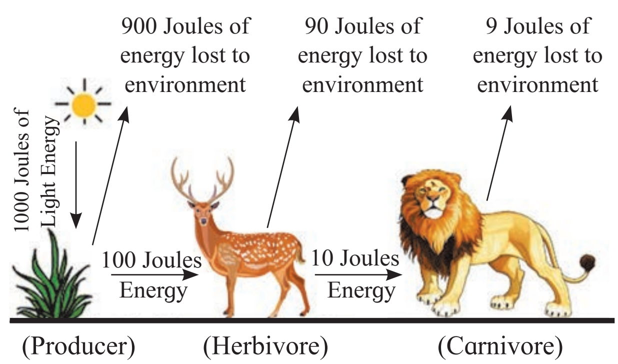


Fig. 14.6 : Energy loss with increasing trophic level

The amount of energy available decreases at each successive trophic level. The number of trophic levels in any food chain is restricted as the transfer of energy follows '**10% Law**' (R. Lindermann, 1942). The law states that 'only 10 % of the energy is transferred to each trophic level as net energy, from the previous trophic level'. In nature, it is possible to have different trophic levels - producer, herbivore, primary carnivore, secondary carnivore, tertiary carnivore and ultimate carnivore.

Think about it

What is the maximum number of trophic levels in a food chain?

Beyond secondary carnivores, however the amount of energy available is too less, hence, there is no tertiary carnivore that feeds exclusively on secondary carnivore, even though the secondary carnivore many times will feed on herbivores directly. This is the reason why food chains do not exist in isolation, but are always interconnected to form food web that maintains the stability of an ecosystem.

14.3 Ecological Pyramids :

Ecological pyramid is a graphic representation of the relationship between the organisms of various successive trophic levels with respect to energy, biomass and number.

Pyramid is a structure which has broader base that gradually narrows upwards forming an inverted cone like structure. This concept was developed by C. Elton in 1927.

The base of each pyramid represents the producers or the first trophic level while the apex represents tertiary or top level consumer. Any calculations of energy content, biomass, or numbers, has to include all organisms at that trophic level.

The three ecological pyramids which are usually studied are : **Pyramid of biomass**, **Pyramid of numbers** and **Pyramid of energy**.

The relative number of individuals per unit area at different trophic levels, constitutes the **number pyramid**; of biomass/ unit area, is **biomass pyramid** and of amount of accumulated energy per unit area, is **energy pyramid**.

In most well balanced ecosystems, all the pyramids, of number, energy and biomass are upright, i.e. producers are more in number and biomass than the herbivores, and herbivores are more in number and biomass than the carnivores. There are exceptions to this, e.g. oceanic ecosystem show inverted biomass pyramid.

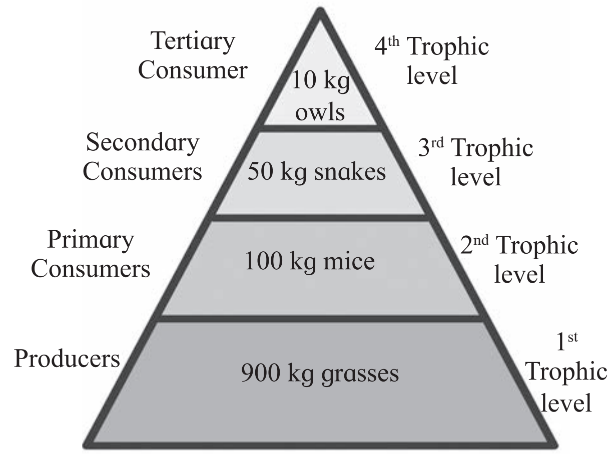


Fig. 14.7 : Pyramid of Biomass

Think about it

How would you explain inverted pyramid of biomass in oceanic ecosystem?

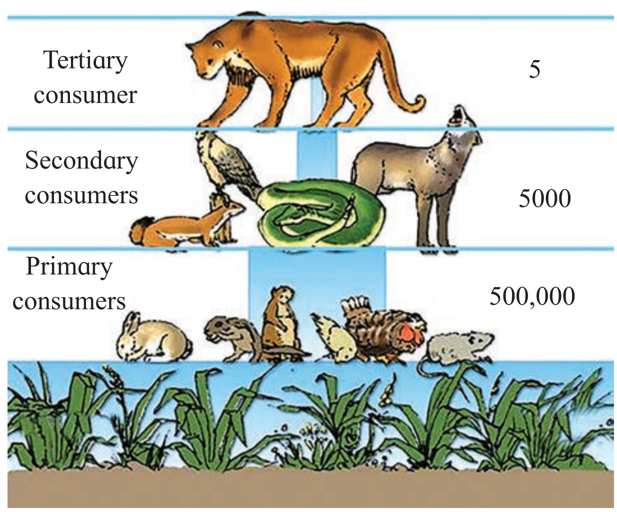


Fig. 14.8 : Pyramid of Numbers

Similarly, pyramid of numbers can also be sometimes inverted. e.g. if we plot the number of insects on a single tree, smaller birds feeding on insects, and parasites on those birds, we get an inverted pyramid.

Use your brain power

What will happen, if in the above example, we substitute larger bird of prey feeding on small insect eating birds?

Pyramid of energy is always upright, can never be inverted, because when energy flows from a particular trophic level to the next trophic level, some energy is always lost as heat at each step. In smaller food chains, more energy is available than in the longer food chains.

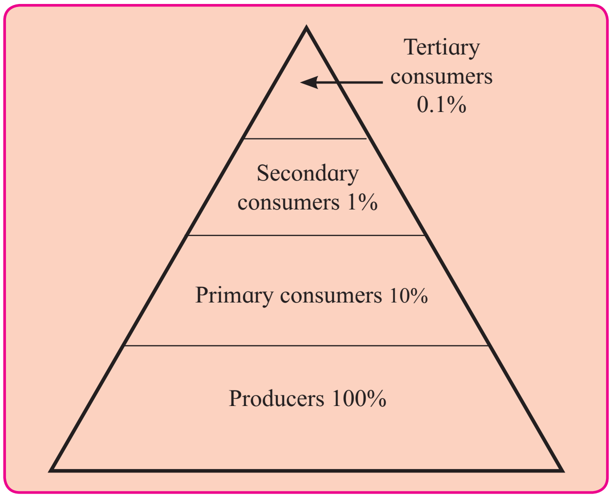


Fig. 14.9 : Pyramid of Energy

There are certain limitations of ecological pyramids. It assumes a simple food chain, something that almost never exists in nature. It does not accommodate a food web. Moreover, saprophytes are not given any place in ecological pyramids even though they play a vital role in the ecosystem.

A given species may occupy more than one trophic levels in the same ecosystem at the same time, e.g. a sparrow is a primary consumer when it eats seeds, fruits, peas, and a secondary consumer when it eats insects and worms.

14.4 Nutrient Cycles :

We have studied in earlier classes that all organisms need a constant supply of nutrients to grow, and reproduce. The amount of nutrients, such as carbon, nitrogen, phosphorus, calcium, etc. present in the soil, varies in different kinds of ecosystems on a seasonal basis. These nutrients, which are never lost from the ecosystems, are recycled indefinitely. The movement of nutrient elements through the various components of an ecosystem, is called **nutrient cycling**. Another name of nutrient cycling is **biogeochemical cycle**. Here, essential elements are cycled from abiotic to biotic world and back.

Types of Nutrient cycles : There are two types of nutrient cycles viz. (a) gaseous and (b) sedimentary. The reservoir for gaseous type of nutrient cycle (e.g., nitrogen, carbon cycle) is the atmosphere and for the sedimentary cycle (e.g. phosphorus cycle) the reservoir is Earth's crust. The function of the reservoir is to meet with the deficit, which occurs due to imbalance in the rate of influx and efflux in any ecosystem.

Carbon Cycle :

All life forms on earth are carbon based because carbon is the main component of all the organic compounds of protoplasm. It constitutes 49% of dry weight of organisms. If we look at the total quantity of global carbon, we find that 71% carbon is found dissolved in oceans. This oceanic reservoir regulates the amount of carbon dioxide in the atmosphere.

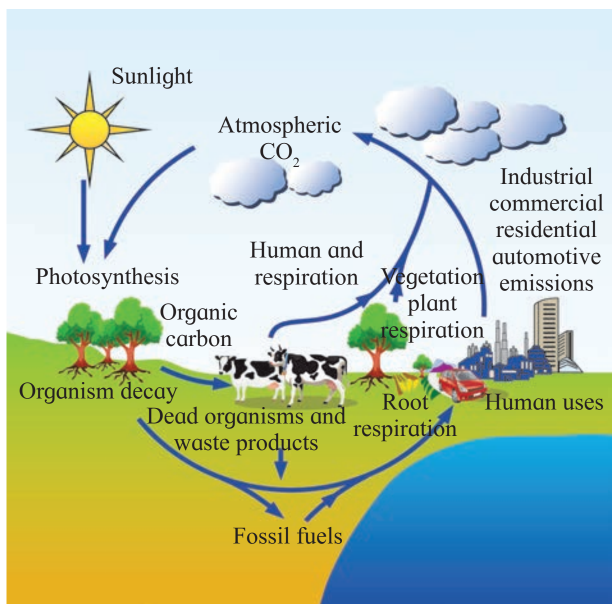


Fig. 14.10 : Carbon cycle

Carbon that is a part of rocks and fossil fuels like oil, coal and natural gas, has been away from the rest of the carbon cycle for a long time. These long-term storage places are known as "**sinks**". When fossil fuels are burned, carbon that had been underground is released back into the air as carbon dioxide.

The element carbon is a part of seawater, the atmosphere, rocks such as limestone and coal, soils, as well as all living things.

- Carbon as CO_2 moves from the atmosphere to plants. Through the process of photosynthesis, carbon dioxide is pulled from the air to produce food.
- Carbon moves from plants to animals, through food chains, i.e. the carbon present in plants moves to the animals.
- Carbon moves from living things to the atmosphere. Each time you exhale, you are releasing carbon dioxide gas (CO_2) into the atmosphere.
- Decomposers also contribute substantially to CO_2 in atmosphere, by their processing of waste materials and dead organic matter of land and oceans.
- When fossil fuels burn to power factories, power plants, motor vehicles, most of the carbon quickly enters the atmosphere as carbon dioxide gas. Each year, 5.5 billion tons of carbon is released through combustion of fossil fuels. Of this massive amount, 3.3 billion tons stays in the atmosphere. Most of the remainder is dissolved in seawater and deposited as calcium or magnesium carbonate compounds which make up shells of marine animals.
- Burning of wood, forest fire and combustion of organic matter, fossil fuel and volcanic activity, are additional sources for releasing CO_2 in the atmosphere.
- Carbon moves from the atmosphere to the oceans. The oceans and other water bodies, absorb some carbon in the form of CO_2 from the atmosphere. The carbon is dissolved into the oceanic water. Some amount of the fixed carbon is lost to sediments and removed from circulation.
- Fossil fuels represent a reservoir of carbon. Carbon cycling occurs through atmosphere, ocean and through living and dead organisms. Human activities have significantly influenced the carbon cycle.
- Rapid deforestation and massive burning of fossil fuel for energy and transport, have significantly increased the rate of release of carbon dioxide into the atmosphere.

Thus, the entire carbon cycle is run by basic processes *viz*. Photosynthesis, Respiration, Decomposition, Sedimentation and Combustion.

Phosphorus Cycle :

Cyclic movement of phosphorus through hydrosphere, lithosphere and biosphere constitutes 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, hooves 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. Herbivores and other animals obtain this element from plants. The waste products and the dead organisms are decomposed by phosphate-solubilizing bacteria releasing phosphorus. Unlike carbon cycle, there is no respiratory release of phosphorus into atmosphere.

There are two major differences between carbon and phosphorus cycle. Atmospheric inputs of phosphorus through rainfall are much smaller (meagure) than carbon inputs, and secondly, exchanges of phosphorus between organism and environment are negligible as compare to carbon.

Unlike carbon and nitrogen, Phosphorus is always in short supply and hence acts as

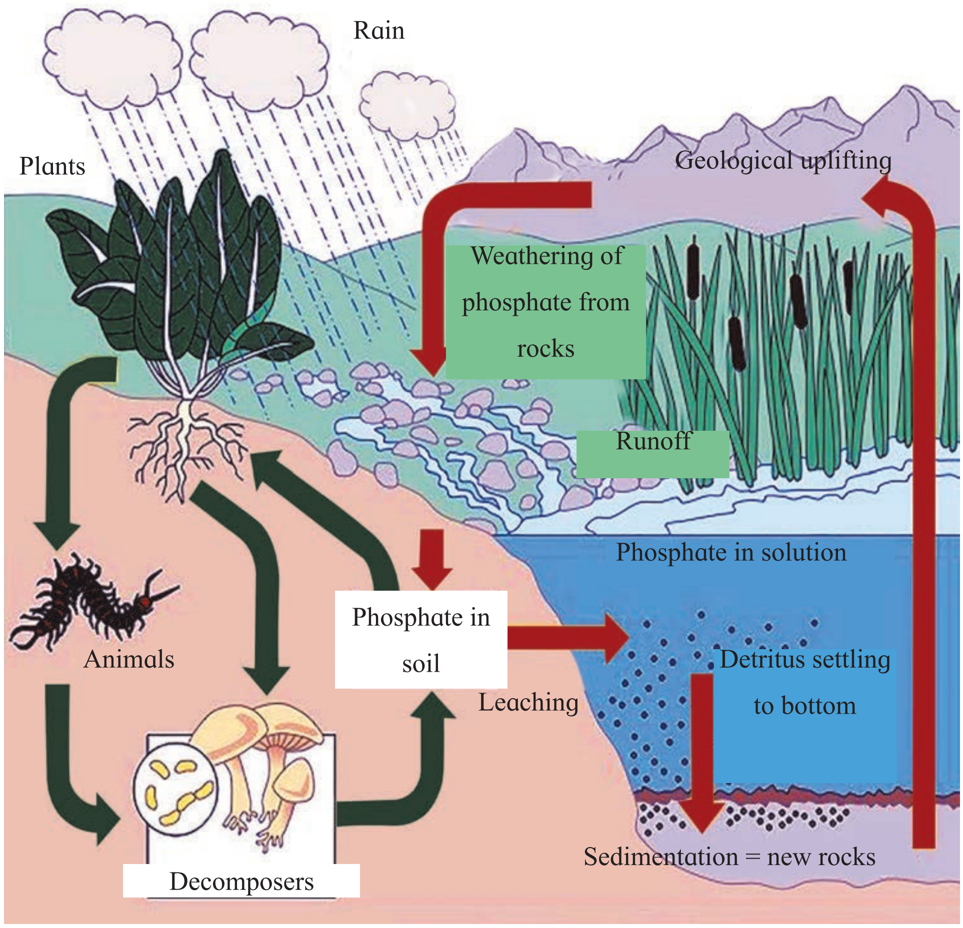


Fig. 14.11 : Phosphorus Cycle

limiting factor for the plant growth. Sudden influx of phosphorus in the form of agricultural runoff or industrial effluents rich in phosphate content, leads to **eutrophication** in water bodies. Eutrophication is due to overgrowth of algae at the instance of high phosphorus disolved in water. The overgrowth of algae kills or harms the aquatic life.

Internet my friend

What are the long term and short-term effects of eutrophication in water bodies?

14.5 Ecological Succession :

Succession : It is a spatial pattern which occurs over the time. Time is a crucial factor. The ecosystem is occupied by the pioneer species. As time passes, species diversity increase giving way to more complex organisms. Eventually, it leads to **climax community**. Climax community does not evolve further.

The gradual and predictable change in the species composition of a given area is called **ecological succession**. The change is sequential and environmentally regulated.

Process of succession involves sequential steps like Nudation, Invasion, Ecesis, Aggregation, Competition and co-action, Reaction and stabilization.

During succession, some species colonize an area and their populations become more numerous, whereas populations of other species decline and even disappear.

The entire sequence of communities that successively change in a given area, constitute what is called **sere(s)**. Alternatively, it is an entire gradient of organisms from pioneer stage to climax stage.The individual transitional communities are termed **seral communities**. In the successive seral stages, there is a change in the diversity of species of organisms, increase in the number of species and organisms as well as an increase in the total biomass.

The present day communities in the world have come to be, because of succession that has occurred over millions of years since life started on earth. Succession is hence a process that starts where no living organisms were present before - like on a newly formed volcanic island. This is called **primary succession.**

Other examples of areas where primary succession occurs are newly cooled lava, rocks and newly created pond or reservoir. The establishment of a new biotic community is generally very slow. Before a biotic community of diverse organisms can become established, there must be soil. Depending mostly on the climate, it takes natural processes, several hundred to several thousand years to produce fertile soil on bare rock.

Secondary succession begins in areas where natural biotic communities have been destroyed such as in abandoned farm lands, burned or cut forests, lands that have been flooded, etc. Since some soil or sediment is present, succession is faster than in primary succession. Description of ecological succession usually focuses on changes in vegetation. However, these vegetational changes in turn affect food and shelter for various types of animals. Thus, as succession proceeds, the numbers and types of animals and decomposers also change. At any time during primary or secondary succession, natural or human induced disturbances (fire, deforestation, etc.), can convert a particular seral stage of succession to an earlier previous / preceding stage. Also, such disturbances create new conditions that encourage some species and discourage or eliminate other species.

Succession of Plants :

Based on the nature of the habitat – whether it is water (or very wetland areas) or it is on very dry areas – succession of plants, is called hydrarch (hydrosere) or xerarch (xerosere), respectively.

Hydrarch succession takes place in wetter areas and the successional series progress from hydric to the mesic conditions. As against this, xerarch succession takes place in dry areas and the series progress from xeric to mesic conditions. Hence, both hydrarch and xerarch successions lead to medium water conditions (mesic) – neither too dry (xeric) nor too wet (hydric).

The species that invade a bare area, are called **pioneer species**. In primary succession on rocks these are usually crustose lichens which are able to secrete acids to dissolve rock, helping in weathering of rocks and soil formation. These pave the way for bryophytes, mosses that are able to take hold in the small amount of soil.

They are, with time, succeeded by herbaceous plants, and after several more stages, ultimately a stable climax forest community is formed. The **climax community** remains stable as long as the environment remains unchanged.

In **primary succession** of aquatic habitat, (steps 1 to 7 in fig. 14.13) the pioneers are the small phytoplankton. They are replaced with time by rooted-submerged plants (e.g. *Hydrilla*), rooted-floating angiosperms (e.g. Lotus) followed by free-floating plants (e.g. *Pistia*), then reed swamp (e.g. *Typha*), marsh-meadow (e.g. *Cyperus*), scrub (e.g. *Alnus*) and finally the trees (e.g. *Quercus*). The climax again would be a forest. With passage of time, the water body is converted into land.

In **secondary succession**, the species that invade depend on the condition of the soil, availability of water, the environment as also the seeds or other propagules present. Since soil is already there, the rate of succession is much faster and hence, climax is also reached more quickly. Figure 14.14 shows the sequence of stages 1 to 8 in a forest ecosystem after fire.

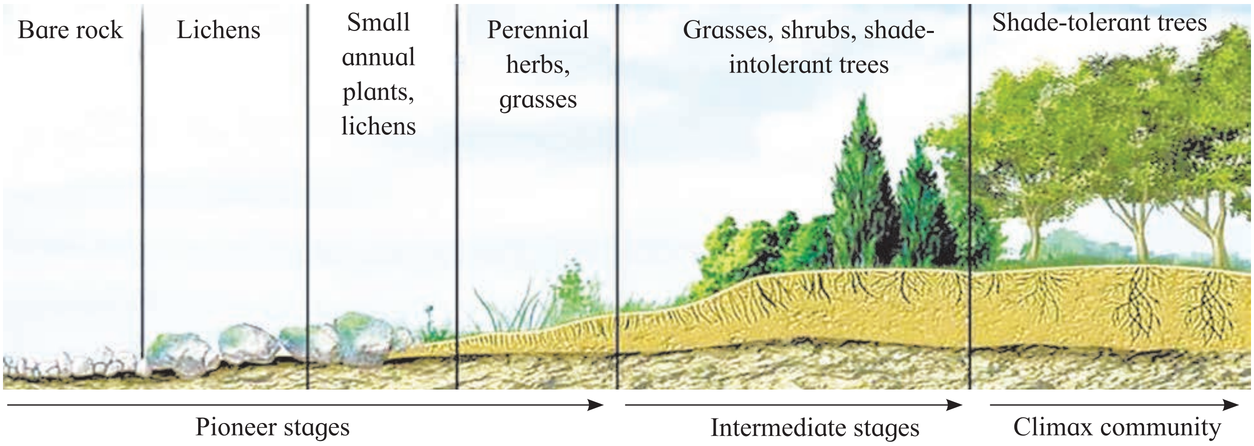


Fig. 14.12 : Xerarch Succession of Plants

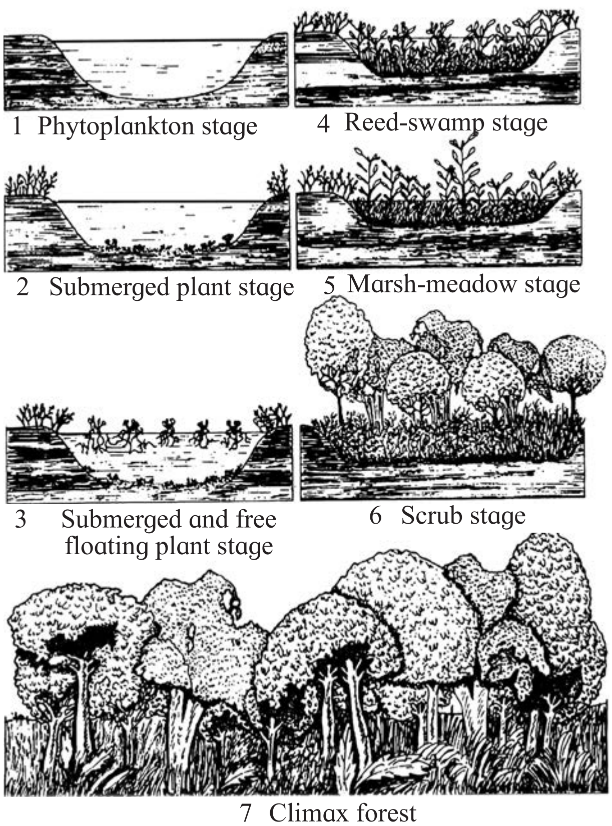


Fig. 14.13 : Hydrarch Succession of Plants

It is important to understand that succession, particularly primary succession, is a very slow process, maybe requiring thousands of years for the climax to be reached.

Another important fact to understand is that all the successions whether taking place in water or on land, proceed to a similar climax community – the mesic.

14.6 Ecosystem Services :

Healthy ecosystems are the base for a wide range of economic, environmental and aesthetic goods and services. The products of ecosystem processes are named as **ecosystem services**, for example, healthy forest ecosystems purify air and water, mitigate droughts and floods.

The Millennium Ecosystem Assessment report 2005 defines *Ecosystem services* as benefits people obtain from ecosystems and identifies four categories of ecosystem services as follows.

- **Supporting services** include services such as nutrient cycling, primary production, soil formation, habitat provision and pollination maintaining balance of ecosystem.
- **Provisioning services** include food (including seafood), raw materials (including timber, skins, fuel wood), genetic resources (including crop improvement genes, and health care), water, medicinal resources (including test and assay organisms) and ornamental resources (furs, feathers, ivory, orchids, butterflies, etc.)
- **Regulating services** include Carbon sequestration, Predation regulates prey populations, Waste decomposition and detoxification, Purification of water and air, and pest control.

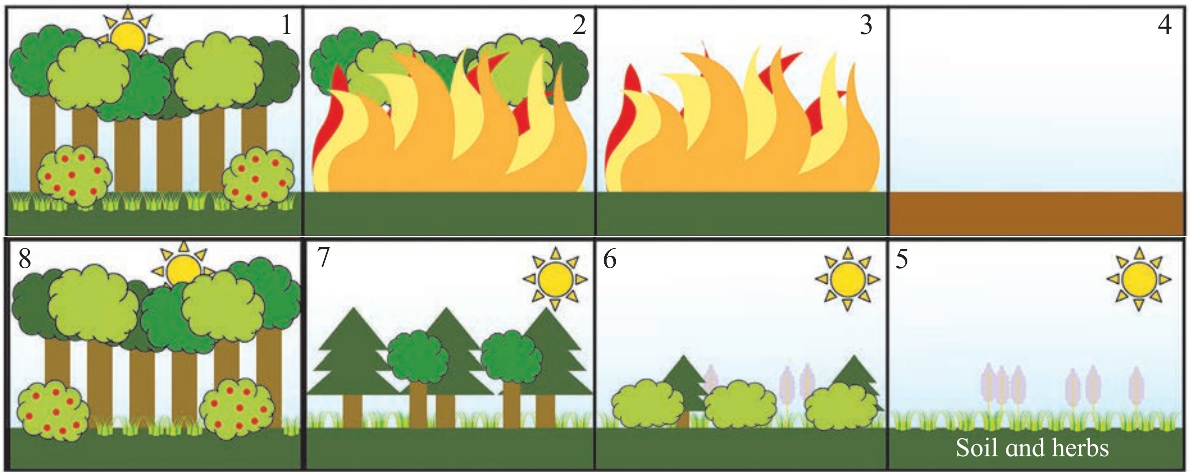


Fig. 14. 14 : Secondary succession in a forest ecosystem after fire

- **Cultural services** include cultural, spiritual and historical, recreational experiences, science and education, and Therapeutics (including animal assisted therapy)

Following are the main ecological services :

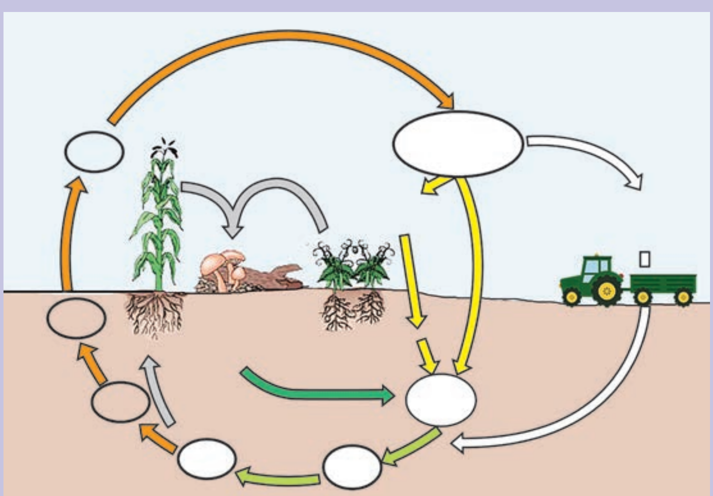
Fixation of atmospheric CO_2 and **release of O_2** are the most important services provided by an ecosystem. Photosynthetic activity of photoautotrophs sequesters carbon (in CO_2 form) from the atmosphere and releases O_2 as a byproduct. O_2 not only purifies air but is also used for respiration by all aerobes.

Pollination of plants brought about by wind, water or other biotic agencies, is also an important ecosystem service, without which there would be no crops and no fruits.

Though the value of all such services of biodiversity is difficult to determine, it seems reasonable to think that biodiversity should carry a hefty price tag.

Activity :

1. **Fill in the banks in the given diagram and identity.**



2. **Collect information and prepare a chart of the sequential steps involved in the ecological succession, explaining each step.**

Exercise

Q. 1 Multiple choice questions

1. Which one of the following has the largest population in a food chain?
   a. Producers
   b. Primary consumers
   c. Secondary consumers
   d. Decomposers

2. The second trophic level in a lake is ________________
   a. Phytoplankton   b. Zooplankton
   c. Benthos   d. Fishes

3. Secondary consumers are __________
   a. Herbivores   b. Producers
   c. Carnivores   d. Autotrophs

4. What is the % of photosynthetically active radiation in the incident solar radiation?
   a. 100%   b. 50 %
   c. 1-5%   d. 2-10%

6. Give the term used to express a community in its final stage of succession?
   a. End community
   b. Final community
   c. Climax community
   d. Dark community

7. After landslide which of the following type of succession occurs?
   a. Primary   b. Secondary
   c. Tertiary   d. Climax

8. Which of the following is most often a limiting factor of the primary productivity in any ecosystem.
   a. Carbon   b. Nitrogen
   c. Phosphorus   d. Sulphur

Q. 2 Very short answer question.

1. Give an example of ecosystem which shows inverted pyramid of numbers.
2. Give an example of ecosystem which shows inverted pyramid of biomass.
3. Which mineral acts as limiting factor for productivity in an aquatic ecosystem.
4. Name the reservoir and sink of carbon in carbon cycle.

Q. 3 Short answer questions.

1. Distinguish between upright and inverted pyramid of biomass
2. Distinguish between Food chain and Food web.

Q 4. Long answer questions.

1. Define ecological pyramids and describe with examples, pyramids of number and biomass.
2. What is primary productivity? Give brief description of factors that affect primary productivity.
3. Define decomposition and describe the processes and products of decomposition.
4. Write important features of a sedimentary cycle in an ecosystem.
5. Discribe carbon cycle and add a note on the impact of human activities on carbon cycle.

Project :

1. Collect the information on the various services offered by dense forest ecosystem.
2. Collect the information of various types of pollinators and the impact of human activity on them.