CHAPTER 14
ECOSYSTEM

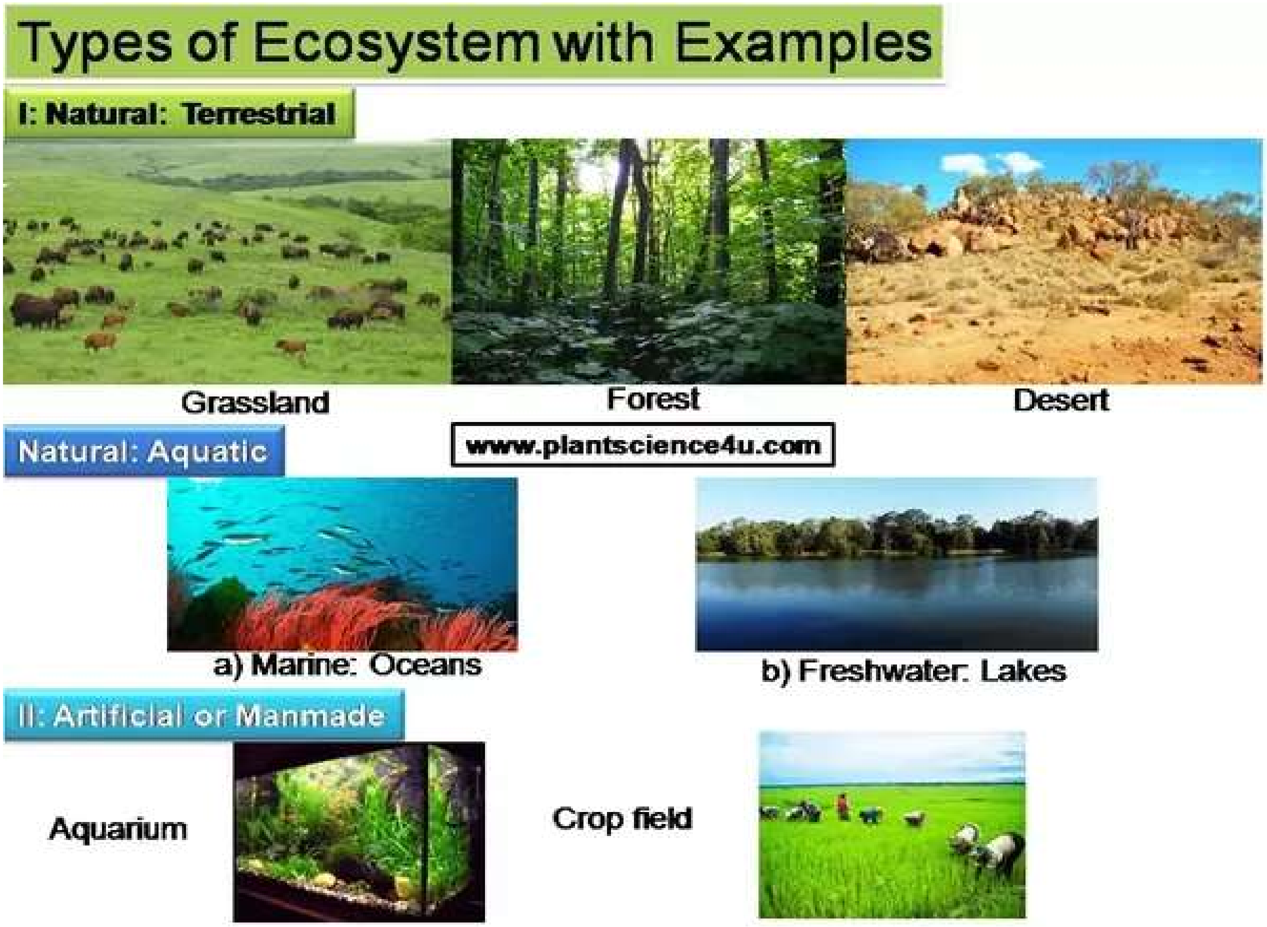
- An ecosystem is a functional unit of nature, where living organisms interact among themselves and also with the surrounding physical environment.
- The term 'Ecosystem' was coined by **A.G. Tansley** (1935).
- Ecologists consider the entire biosphere as a global ecosystem, comprised of many local ecosystems on the Earth varying in size from a small pond to a large forest or a sea.
- Ecosystem is an open system.
- It receives inputs in the form of solar energy and inorganic nutrients which results in productivity or synthesis of food.
- Food, with its contained energy, passes through various components of ecosystem through food chain or food web and nutrient cycling.
- As the matter circulates in the ecosystem, it gives out energy as well as matter as output.
- Ecosystem is considered as an interactive system, where biotic and abiotic components interact with each other via energy exchange and flow of nutrients.
- An ecosystem can be either **Natural** or **Artificial**.

Natural Ecosystem:

- These are ecosystem that are capable of maintaining and operating themselves without interference of man.
- They are further classified as:
  - **1. Terrestrial Ecosystem –** Forest, grassland, desert etc.
  - **2. Aquatic Ecosystem –** Pond, lake, river, estuary, sea etc.

Artificial Ecosystem:

- These are maintained and manipulated by man for different purposes. E.g. cropland, aquarium, garden, orchard, green house etc.



COMPONENTS OF ECOSYSTEM

- An ecosystem has two major components: **Abiotic components** and **Biotic components.**

Abiotic Components:

- The abiotic or non-living components consists of temperature, water, light, soil etc.

Biotic Components:

- Various biotic or living components of an ecosystem are further classified as:

1. Producers:

- All green plants are called producers.
- In terrestrial ecosystem, herbaceous and woody plants are producers.
- In aquatic ecosystem phytoplankton and some algae are producers.
- They are also called **autotrophs**.

2. Consumers:

- All animals which depend directly or indirectly on plants for their food requirements are called consumers.
- They are also called as **heterotrophs**.

3. Decomposers:

- These are also called saprobes or saprophytes or mineralizers.
- Moulds and mushrooms are the largest decomposers of forest floor.

ECOSYSTEM : STRUCTURE AND FUNCTION

- We know that in an ecosystem there is constant interaction among biotic and abiotic components.
- This interaction of biotic and abiotic components results in a physical structure that is characteristic for each type of ecosystem.
- The two important structural features of an ecosystem are:
  - **Species composition** and
  - **Stratification.**

1. Species composition:

- It refers to all the different types of organisms that make up an ecosystem.
- Thus, identification and enumeration (listing) of plant and animal species of an ecosystem gives its species composition.

2. Stratification:

- It is the vertical distribution of different species occupying different levels in an ecosystem.
- For example, trees occupy top vertical strata or layer of a forest, shrubs the second and herbs and grasses occupy the bottom layers.

- **Stratification**:- Vertical distribution of different species occupying different levels in an ecosystem is called stratifiction.

1. Top trees.
2. Shrubs.
3. Herbs.
4. Grass.

➢ The important functional aspects (aspects that make an ecosystem function like a unit) of an ecosystem are:

- **(i) Productivity**
- **(ii) Decomposition**
- **(iii) Energy flow** and
- **(iv) Nutrient cycling.**

➢ To understand the concept of an ecosystem, let us take a small pond as an example.

Pond Ecosystem

➢ A pond is fairly a self-sustainable unit that explains even the complex interactions that exist in an aquatic ecosystem.

➢ It is a shallow water body in which all the above mentioned basic structural and functional components are present.

➢ The abiotic components include the pond water with all the dissolved inorganic and organic substances and the soil deposited 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 autotrophic components include the phytoplankton, some algae and the floating, submerged and marginal plants found at the edges.

➢ The consumers are represented by the zooplanktons which may be free swimming and bottom dwelling forms.

- The decomposers are the fungi, bacteria and flagellates found abundantly in the bottom of the pond.
- This pond ecosystem performs all the functions of an ecosystem and of the biosphere as a whole as follows:
- Autotrophs convert inorganic materials into organic material with the help of solar energy.
- Heterotrophs consume autotrophs.
- Decomposers decompose and mineralize dead organic matter to release them back for reuse by the autotrophs.
- These events are repeated over and over again.
- However, energy flow is unidirectional towards the higher trophic levels.
- At each trophic level, a part of energy is dissipated and lost as heat to the environment.

FUNCTIONAL ASPECTS OF AN ECOSYSTEM

1. PRODUCTIVITY

- A constant input of solar energy is the basic requirement for any ecosystem to function and sustain.
- The amount of organic matter or biomass produced by an individual organism, population, community or ecosystem during a given period of time is called productivity.
- It is expressed in terms of weight (gm^{-2}) or energy ($kcalm^{-2}$).
- Productivity of an ecosystem can be categorized as **primary** and **secondary productivity**.

Primary Productivity:

- It is the amount of organic matter or biomass produced per unit area over a time period by plants during photosynthesis.
- It is expressed in terms of $gm^{-2}yr^{-1}$ or $kcalm^{-2}yr^{-1}$.
- Primary productivity is divided into
  - **Gross primary productivity** (GPP) and
  - **Net primary productivity** (NPP).

(i) Gross Primary Productivity (GPP):

- Gross primary productivity of an ecosystem is the rate of production of organic matter during photosynthesis.
- A considerable amount of GPP is utilized by plants in respiration.

(ii) Net Primary Productivity (NPP):

- It is the available biomass for the consumption by heterotrophs (herbivores and decomposers).
- It is actually the amount of energy left in the producers after utilization of some energy during respiration.
- Thus, Gross primary productivity minus the respiration losses (R) gives net primary productivity (NPP).
- GPP – R = NPP
- where, R = Respiration loss

Factors Affecting Primary Productivity:

- Primary productivity varies from ecosystem to ecosystem.
- This is because of the various factors given below.
  - (i) The plant species inhabiting a particular area.
  - (ii) Photosynthetic efficiency of plants: C4 plants are more productive as compared to C3 plants.
  - (iii) Nutrient availability: Nutrients are essential for the growth of plants. Thus, higher availability of nutrients ensures greater primary productivity.
  - (iv) Various environmental factors such as light, temperature, moisture or water also contribute to primary productivity.

(a) Light:

- Sunlight is the ultimate source of energy.
- Due to less availability of light in an aquatic ecosystem, its productivity is less than that of terrestrial ecosystem.
- The annual net primary productivity of the whole biosphere is approximately **170 billion tons** (dry weight) of organic matter.

- Of this, despite occupying about 70 per cent of the surface, the productivity of the oceans are only 55 billion tons.
- What are the main reasons for the low productivity of ocean?
- Some of the reasons for the low productivity of ocean are:
  - 1. Presence of small floating autotrophic plants (less vascular plants).
  - 2. Sunlight is not available beyond a certain depth.
  - 3. Less availability of proper minerals and nutrients and
  - 4. Less photosynthetic efficiency of marine plants compared to terrestrial plants.
- On land, tropics will have more productivity than poles.
- This is because maximum light is available in tropics and poles receive minimum sunlight.

(b) Temperature:

- It regulates the activity of enzymes.
- So, optimum temperature is required for proper functioning of an ecosystem.

(c) Water:

- Availability of water in the form of rain or moisture increases the productivity of the ecosystem, but it tends to decrease with the scarcity of water.
- Therefore, deserts have the lowest primary productivity as soil is deficient in water.

Secondary Productivity:

- Secondary productivity is defined as the rate of formation of new organic matter by consumers.
- It is small as compared to primary productivity and tend to decrease with an increase in the trophic level.

2. DECOMPOSITION:

- It is the process of breaking down of complex organic matter into inorganic substances like water, carbon dioxide and nutrients by decomposers.
- **Detritus** is the raw material for decomposition.

- It includes dead remains of plant such as leaves, bark, flowers and dead remains of animals and fecal matter.
- Different steps involved in the process of decomposition are:
  - **Fragmentation,**
  - **Leaching,**
  - **Catabolism,**
  - **Humification** and
  - **Mineralization.**

1. Fragmentation:

- It is the process of breakdown of detritus into smaller particles by detritivores.

2. Leaching:

- It is the process by which water soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts.

3. Catabolism:

- It is the process of degradation of detritus into simpler inorganic substances by the action of bacterial and fungal enzymes.
- It is important to note that all the above steps in decomposition operate simultaneously on the detritus.

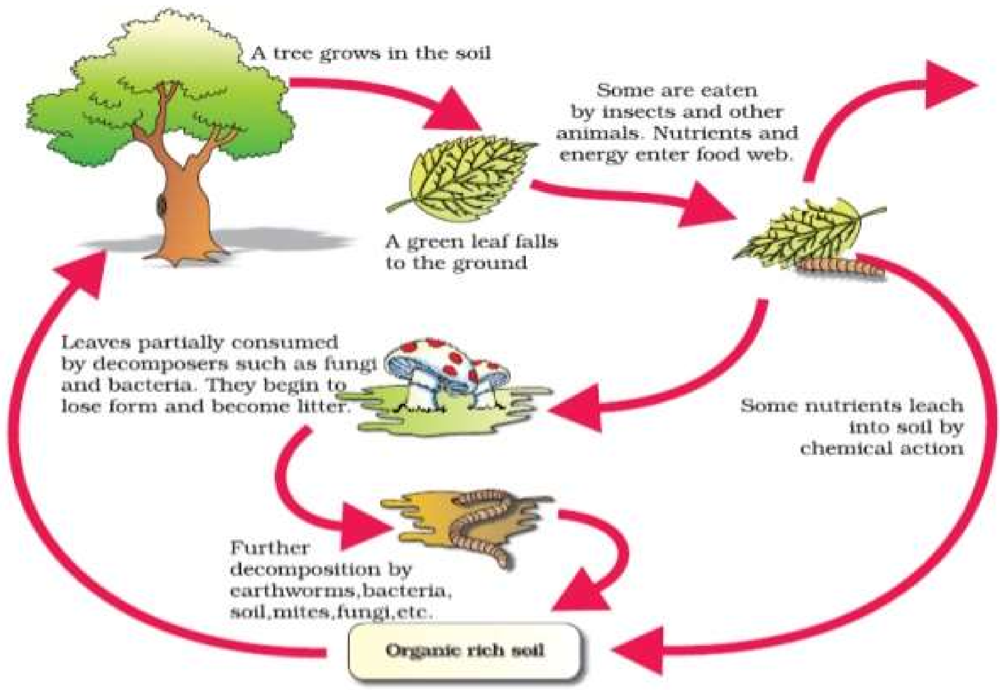


Figure 14.1 Diagrammatic representation of decomposition cycle in a terrestrial ecosystem

4. Humification:

- It is a process that leads to the accumulation of a dark coloured amorphous substance called **humus** that is highly resistant to microbial action and undergoes decomposition at an extremely slow rate.
- Being colloidal in nature it serves as a reservoir of nutrients.

5. Mineralization:

- It is the process of degradation of humus by microbes and release of inorganic nutrients.

Factors Affecting rate of Decomposition:

- Decomposition is largely an aerobic (oxygen consuming) process.
- The rate of decomposition is controlled mainly by the following two factors:
  - **Chemical composition of detritus** and
  - **Climatic factors**.

1. Chemical composition of detritus:

- The rate of decomposition is slower if detritus is rich in lignin and chitin, and quicker, if detritus is rich in nitrogen and water-soluble substances like sugars.

2. Climatic factors:

- Temperature and soil moisture are the most important climatic factors that regulate decomposition.
- Warm and moist environment favours decomposition whereas low temperature and anaerobiosis (unavailability of oxygen i.e., anaerobic conditions) inhibit decomposition resulting in buildup of organic materials.

3. ENERGY FLOW:

- Sun is the only source of energy for all the ecosystems on earth, except for the deep-sea hydro-thermal ecosystem.
- Of all the incident solar energy, less than 50 per cent is Photosynthetically Active Radiation (PAR).
- Plants utilize only 2-10 per cent of the PAR and this small amount of energy sustains the entire living world.

- Plants as well as photosynthetic and chemosynthetic bacteria (autotrophs), fix sun's radiant energy to make food from simple inorganic materials.
- Thus, all organisms are dependent on producers either directly or indirectly for their food.
- The flow of energy is unidirectional, i.e. it flows from the sun to producers and then to consumers and thus, maintains the first law of thermodynamics.
- The first law of Thermodynamics states that "Energy can be neither created nor destroyed'; but can be transformed from one form to another."
- Further, ecosystems are not exempt from the Second Law of thermodynamics.
- The second law of Thermodynamics states that energy cannot be transformed from one form to another without energy loss.
- Thus, when energy is transformed from one form to another, a part of it is wasted or lost in the form of heat energy.
- In this way, after transformation, the capacity of energy to perform work is decreased.
- Energy always flows from higher level to lower level.
- This energy is first trapped by the producers or the green plants.
- In a terrestrial ecosystem, major producers are herbaceous and woody plants.
- Likewise, primary producers in an aquatic ecosystem are various species like phytoplankton, algae and higher plants.
- They need a constant supply of energy to synthesize the molecules they require, to counteract the universal tendency toward increasing disorderliness.
- No energy that is trapped into an organism remains in it for ever.
- The energy trapped by the producer, hence, is either passed on to a consumer or the organism dies.
- The consumers may be of following types:
  - **Primary consumer**
  - **Secondary consumer** or
  - **Tertiary consumer.**

1. Primary consumer:

- The consumers that feed on plants directly are called primary consumers

2. Secondary consumer:

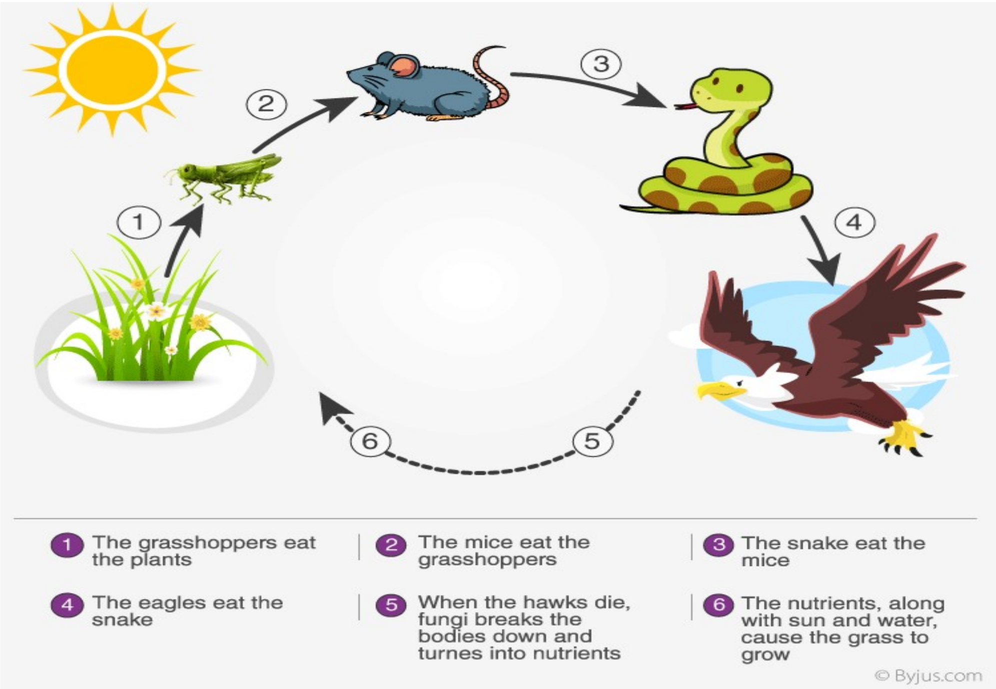
- Those animals that eat other animals who eat plants are called secondary consumers.
- They are also referred to as **primary carnivores**.

3. Tertiary consumer:

- These are animals who feed on secondary consumers for their nutrition.
- These are also called **secondary carnivores**.
- Therefore, due to this interdependence of food/energy between organisms, food chains or food webs are formed in the ecosystem.

FOOD CHAIN:

- The transfer of energy from green plants through a sequence of organisms, in which each eats the one below it in the chain and is eaten by the one above is called a food chain.
- It is actually a chain that represents the feeding of organisms in an ecosystem.



Types of Food Chain:

- There are mainly two types of food chains

- **Grazing Food Chain** and
- **Detritus food chain.**

1. Grazing Food Chain (GFC):

- It begins with the producers, which capture the solar energy and feeds the energy into the food chain through photosynthesis.
- In a terrestrial ecosystem, GFC is the major channel for energy flow.

Grass ------→ Goat ------→ Man ------→

(Producer) (Primary Consumer) (Secondary consumer)

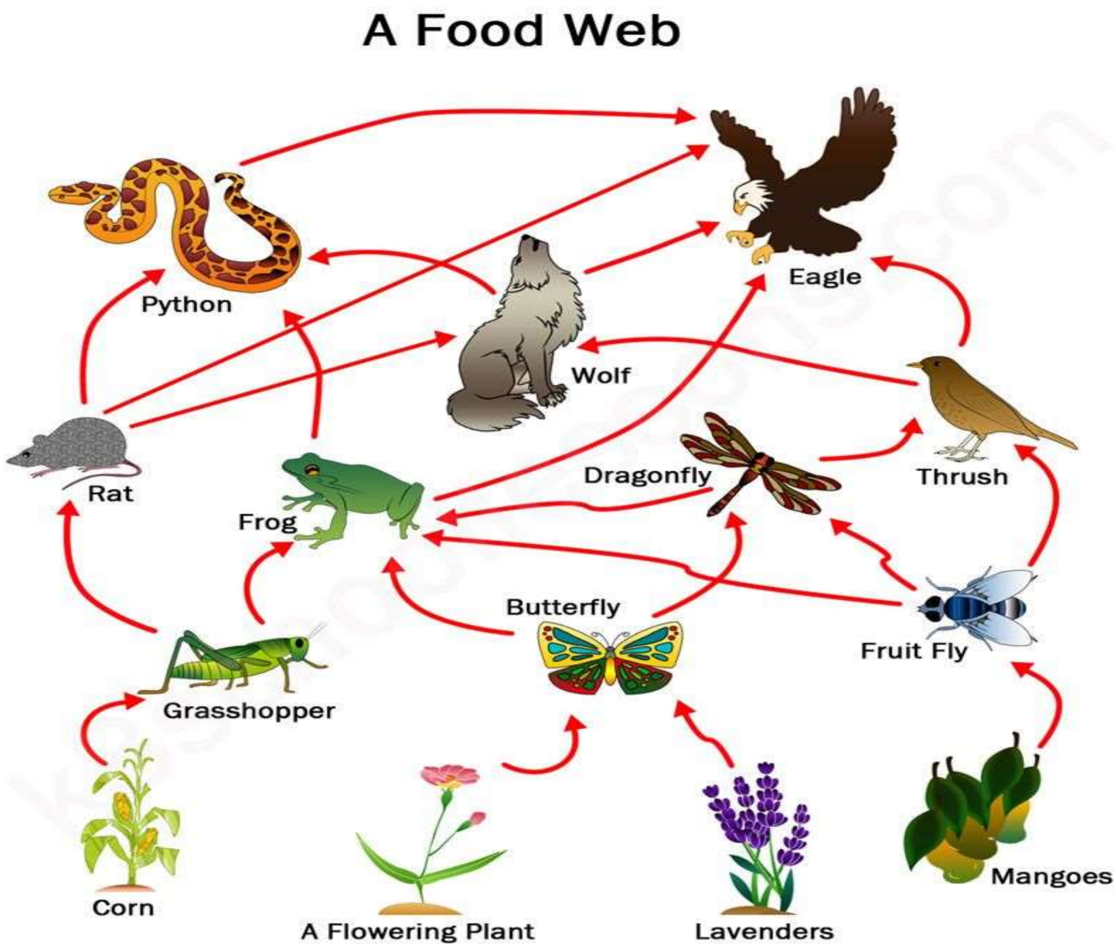
2. Detritus Food Chain (DFC):

- 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.
- Decomposers secrete digestive enzymes that breakdown dead and waste materials into simple, inorganic materials, which are subsequently absorbed by them.
- These are also known as **saprotrophs** (*sapro:* to decompose).
- Dead leaves → Woodlouse → Black bird

	Grazing Food Chain	Detritus Food Chain
Definition	The grazing food chain starts from the autotrophs (green plants).	Detritus food chain begins from the detritivores.
Energy Source	In grazing food chain the energy is taken from the sunlight as green plants prepare food in the presence of it.	In detritus food chain the main energy source is remain of detritus.
Organisms	In grazing food chain macroscopic organisms are involved.	In detritus food chain subsoil organisms are involved, which can either be macroscopic or microscopic.
Amount of Energy	Produces a less amount of energy to the atmosphere.	Produces a large amount of energy to the atmosphere.

FOOD WEB:

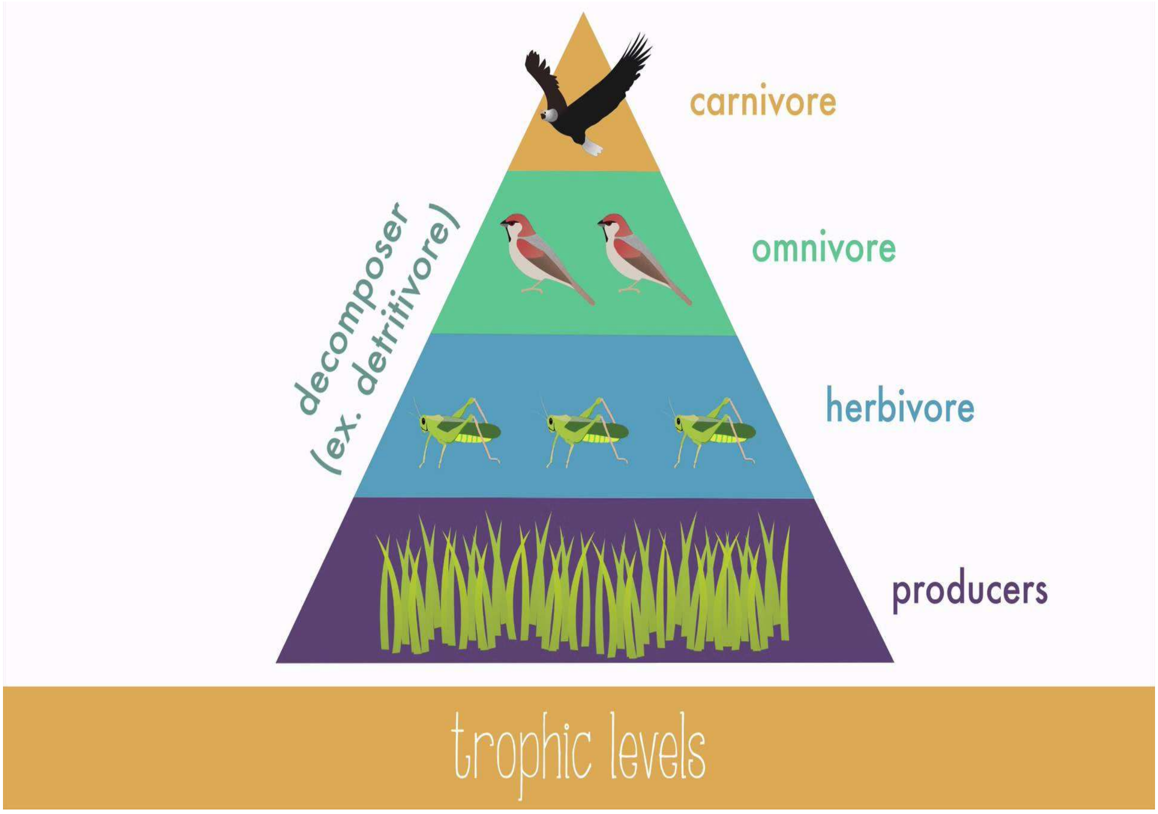
- A food web consists of all the food chains in a single ecosystem.
- Each living thing in an ecosystem is part of multiple food chains.
- Each food chain is one possible path that energy and nutrients may take as they move through the ecosystem.
- All of the interconnected and overlapping food chains in an ecosystem make up a food web.
- Food webs consist of many interconnected food chains and are more realistic representation of consumption relationships in ecosystems.



TROPHIC LEVELS

- All organisms occupy a particular place in their natural surroundings or in a community according to their feeding relationship with other organisms.
- Based on the source of their nutrition or food, organisms occupy a specific place in the food chain that is known as their **trophic level**.

- Producers occupy the first trophic level, herbivores (primary consumer) occupy the second and carnivores (secondary consumer) occupy the third and the fourth level is occupied by the top carnivores (tertiary consumers).



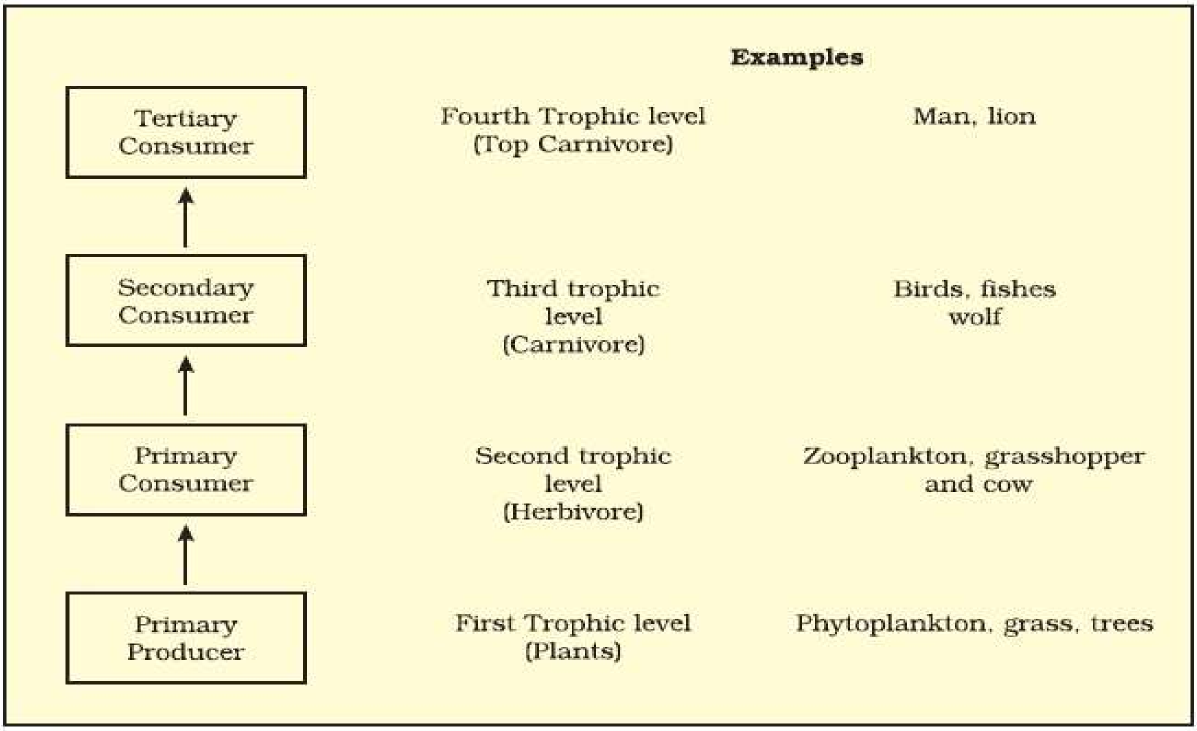


Figure 14.2 Diagrammatic representation of trophic levels in an ecosystem

- Organisms at each trophic level depend on those at the lower trophic level for their energy demands.
- The important point to note is that the amount of energy decreases at successive trophic levels.

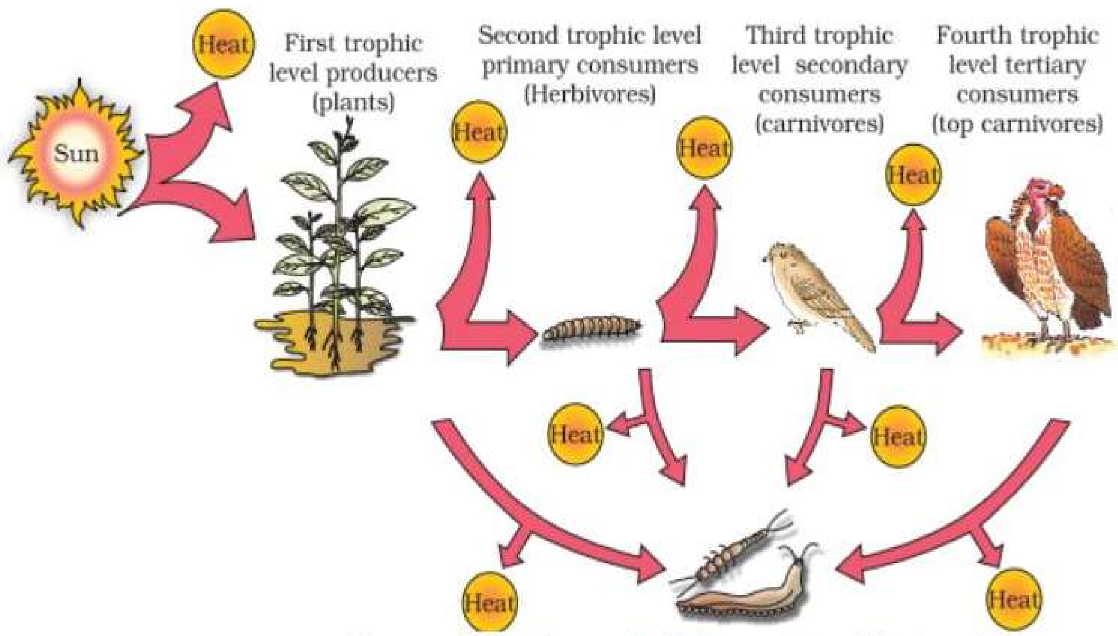
- When any organism dies it is converted to detritus or dead biomass that serves as an energy source for decomposers.

Standing Crop:

- It is the mass of living material at a particular trophic level at a specific time.
- The standing crop is measured as the mass of living organisms (biomass) or the number in a unit area.
- The biomass of a species is expressed in terms of fresh or dry weight.
- Measurement of biomass in terms of dry weight is more accurate. Why?
- Dry weight is the exact mass of any body which remains constant but wet mass or body with water have variable mass as per water present in the body.
- The moisture content of a biomass may vary depending upon environmental or physiological conditions.

Ten Percent Law (10% Law):

- This law was proposed by **Lindeman** in 1942.
- According to this law, in each step of food chain when food energy is transferred from one trophic level to the next higher trophic level, some energy is lost as heat and only 10% is transferred to the next level.
- Due to this, the number of trophic levels in the grazing food chain is restricted as the transfer of energy follows 10% law.

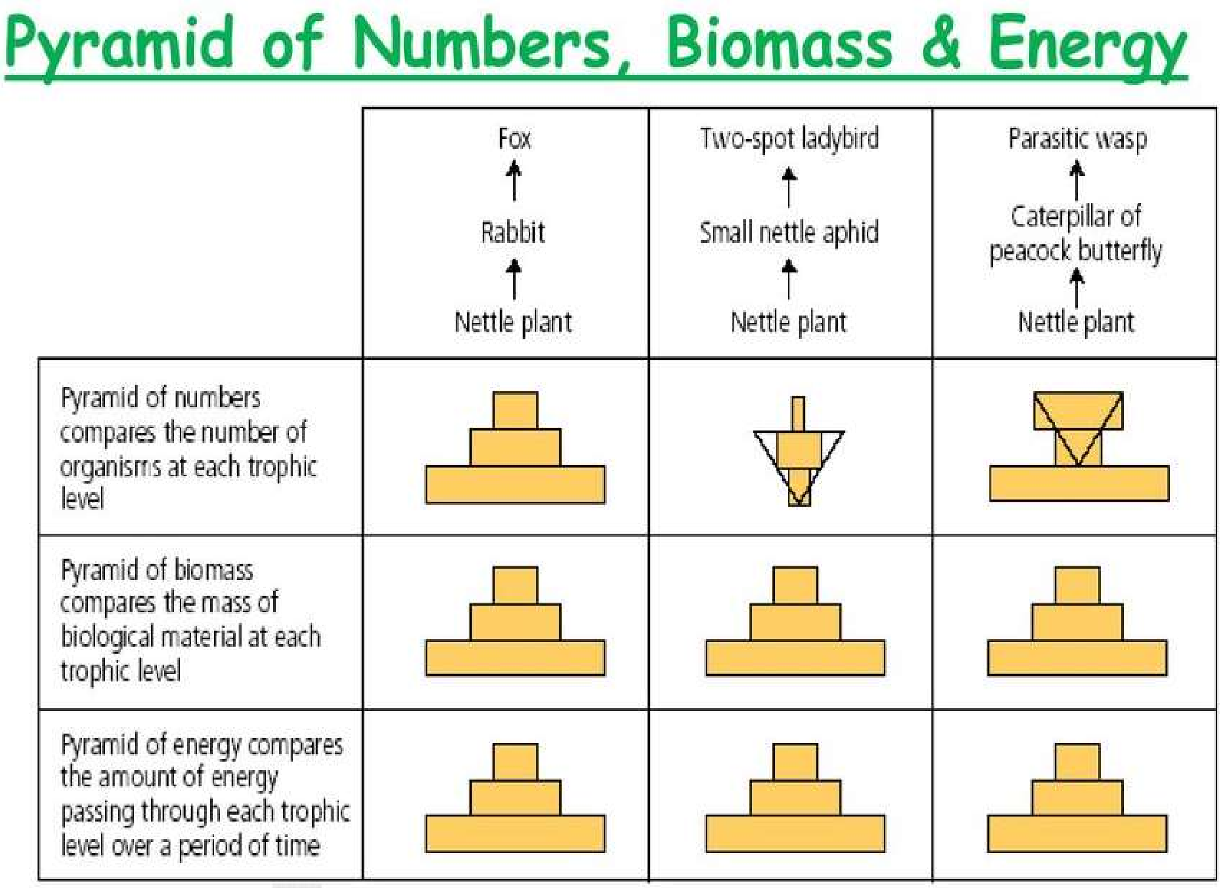


Energy flow through different trophic levels

- After five trophic levels, negligible amount of energy would be transferred to the next level of organisms making it impossible for it to survive.
- Moreover, detritus food chain starts with decomposing matter which is already low in energy content so these are shorter than grazing food chains.

ECOLOGICAL PYRAMIDS

- Ecological pyramids are the graphical or diagrammatic representation of connection between different trophic levels in terms of energy, biomass and number of organisms.
- The base of each pyramid represents the producers or the first trophic level while the apex represents tertiary or top-level consumer.
- There are three ecological pyramids that are usually studied.
    - **(a) pyramid of number**;
    - **(b) pyramid of biomass** and
    - **(c) pyramid of energy**.



1. Pyramid of Number

- It represents the total number of organisms at each trophic level.
- In most ecosystems, the pyramid of number is upright.
- There are also exceptions.
- If we count the number of insects feeding on a big tree, we would get an inverted pyramid.
- Now, if we count the number of small birds depending on the insects and the number of larger birds eating the smaller birds, then the pyramid will again become upright.
- Inverted pyramid of number is usually seen in parasitic food chain where one primary producer or consumer supports numerous parasites which in turn supports more hyper-parasites.

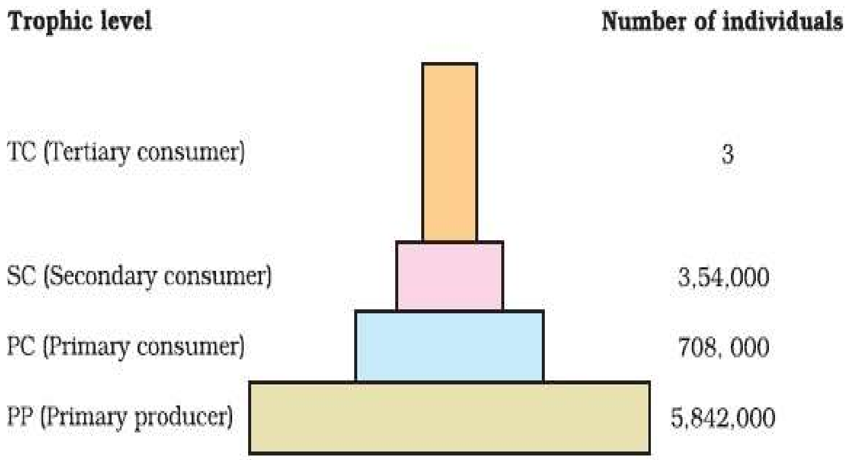
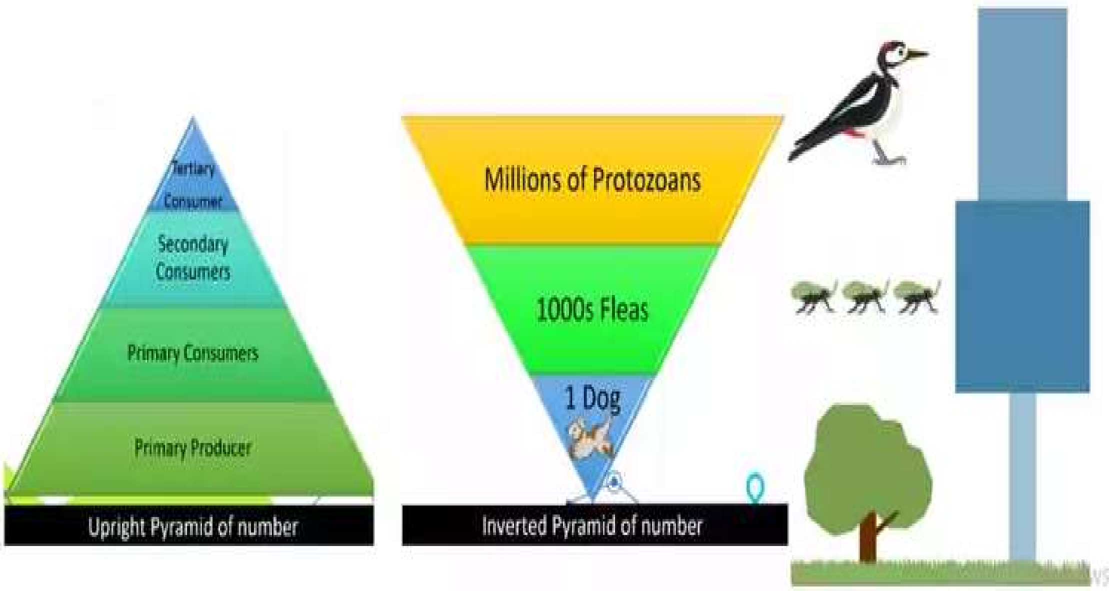
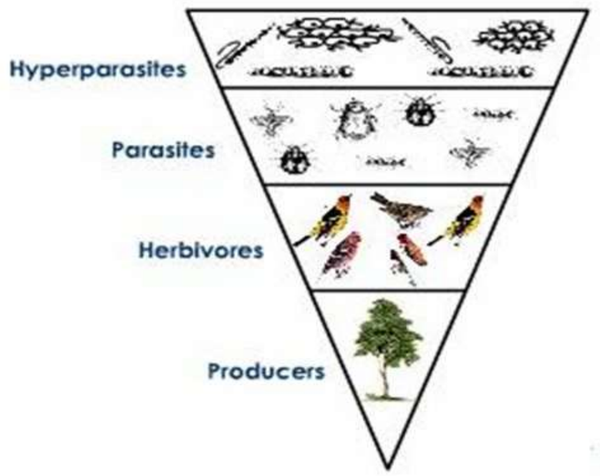


Figure 14.4 (a) Pyramid of numbers in a grassland ecosystem. Only three top-carnivores are supported in an ecosystem based on production of nearly 6 millions plants



Inverted pyramid of numbers

This type of ecological pyramid is seen in parasitic food chain where one primary producer supports numerous parasites which support more hyperparasites.



Inverted pyramid of number

2. Pyramid of Biomass

- It represents the total weight of organisms at each trophic level.
- In other words, pyramid of biomass represents the amount of potential food available at each trophic level.
- There are two types of biomass pyramids: Upright and Inverted.
- An upright pyramid is one where the combined weight of producers is larger than the combined weight of consumers.
- Examples are grassland ecosystem and forest ecosystem.

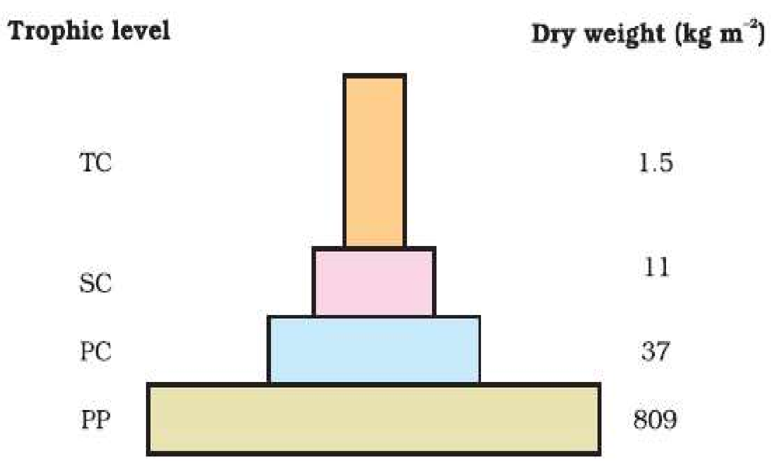


Figure 14.4 (b) Pyramid of biomass shows a sharp decrease in biomass at higher trophic levels

- An inverted pyramid is one where the combined weight of producers is smaller than the combined weight of consumers.
- Example is an aquatic ecosystem.

- The pyramid of biomass in sea is also generally inverted because the biomass of consumers (zooplankton and other predatory fish) is greater than the producer (phytoplankton) because of their small size and low weight.
- In this case the biomass of trophic level depends on the reproductive potential and the longevity of the member.
- This happen because the ocean's primary producers are tiny phytoplankton that grow and reproduce rapidly, so a small mass can have a fast rate of primary production.

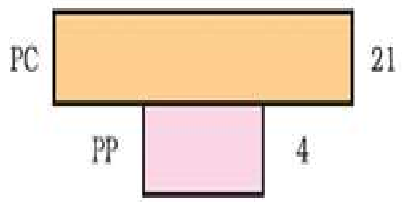
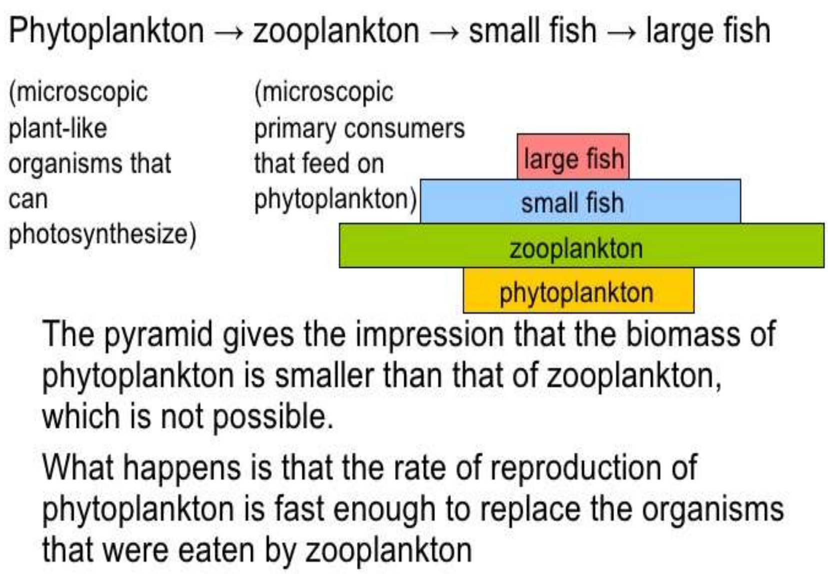


Figure 14.4 (c) Inverted pyramid of biomass-small standing crop of phytoplankton supports large standing crop of zooplankton



3. Pyramid of Energy:

- It represents total energy of the organisms in each trophic level.
- Pyramid of energy is always upright, it can never be inverted, because when energy is transferred from one trophic level to the next trophic level, some energy is always lost as heat at each step.

- Each bar in the energy pyramid indicates the amount of energy present at each trophic level in a given time or annually per unit area.

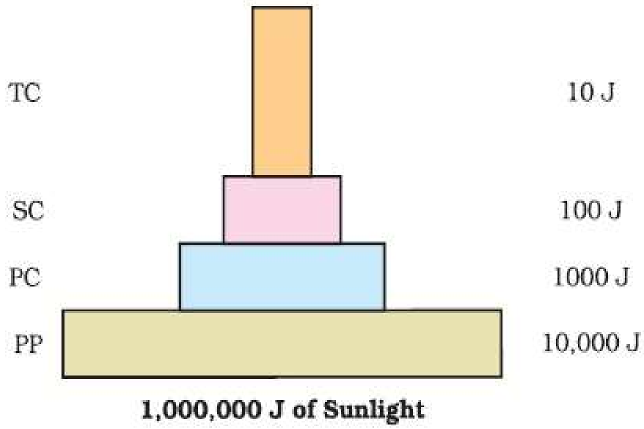


Figure 14.4 (d) An ideal pyramid of energy. Observe that primary producers convert only 1% of the energy in the sunlight available to them into NPP

Limitations of Ecological Pyramids:

- It never takes into account the same species belonging to two or more trophic levels. For example, a sparrow is primary consumer when it eats seeds, fruits etc. and a secondary consumer when it feeds on insects and worms.
- It assumes a simple food chain, something that almost never exists in nature.
- It does not accommodate a food web.
- Saprophytes are not given any place in ecological pyramids even though they play a vital role in the ecosystem.

ECOLOGICAL SUCCESSION

- The biotic communities are not stable.
- They constantly change in composition and structure in response to the changing environmental conditions.
- This change is orderly and sequential, parallel with the changes in the physical environment.

What is Ecological Succession?

- The gradual and predictable change in the species composition of a given area is called ecological succession.

- 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 are called **sere**(s).
- The individual transitional communities are termed **seral stages** or **seral communities**.
- The species that invade the bare area are called **pioneer species**.
- These changes during ecological succession lead finally to a community that is in near equilibrium with the environment and is called a **climax community**.
- In other words, climax community means a stable group of plants and animals that is formed at the end of succession.

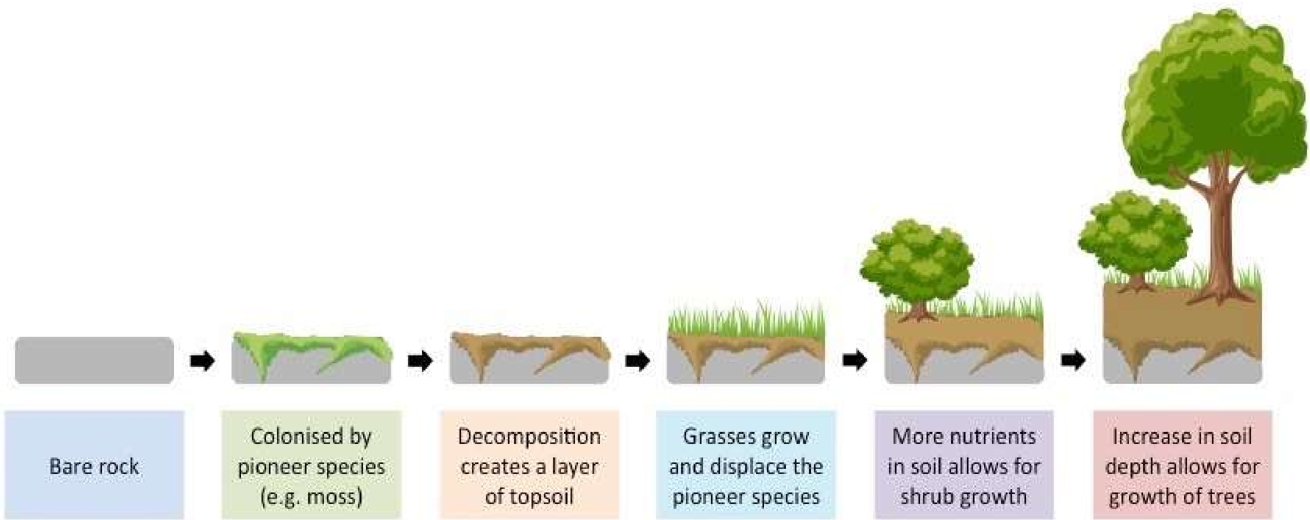
- To reach a climax community, the following changes occur in successive seral stages:
  - Change in the diversity of species of organisms,
  - Increase in the number of species and organisms
  - Increase in total biomass.
- The communities present today in the world have come to be because of succession that has occurred over millions of years since life started on earth.
- Actually, succession and evolution are parallel processes.

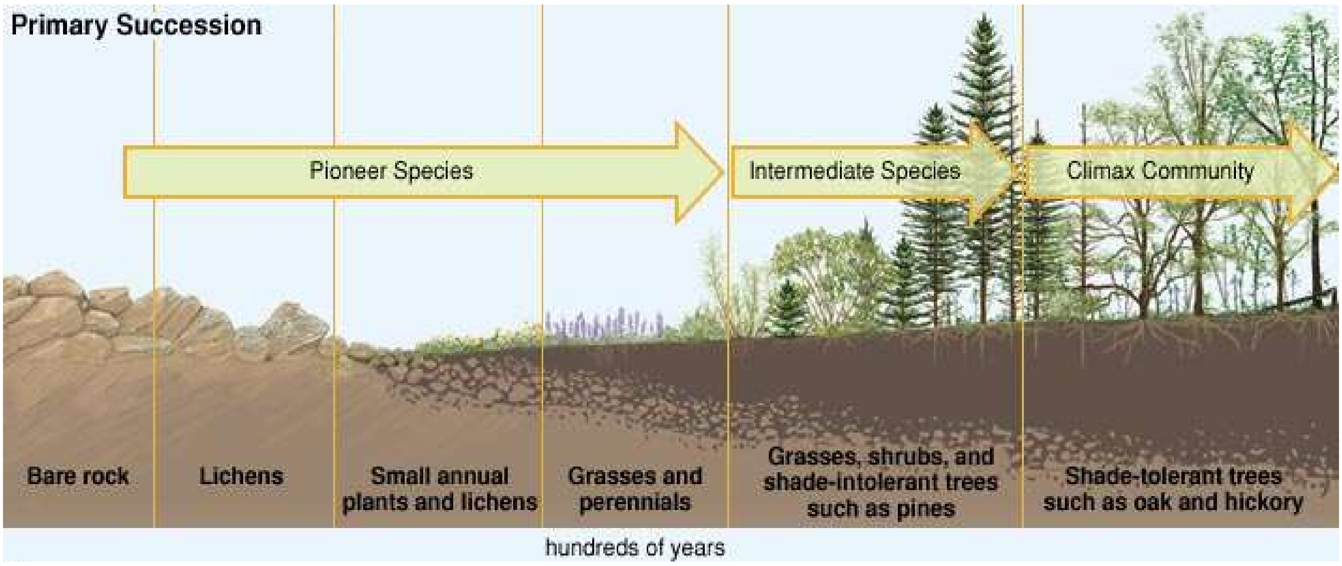
Types of Ecological Succession:

- Succession is a process that starts where no living organisms are there i.e., the areas where no living organisms ever existed (e.g., bare rock); or in areas that somehow, lost all the living organisms that existed there.
- Thus, there are two types of ecological successions:
  - **Primary succession** and
  - **Secondary succession**.

1. Primary Succession:

- It begins in an area where no living organisms ever existed.
- Examples include bare rocks, newly formed pond or reservoir, newly cooled lava etc.
- The establishment of a new biotic community is generally a slow process.
- Before a biotic community of diverse organisms can become established, there must be soil.
- As we know soil formation is an extremely slow process.
- It takes several hundred to several thousand years to produce fertile soil on bare rock.

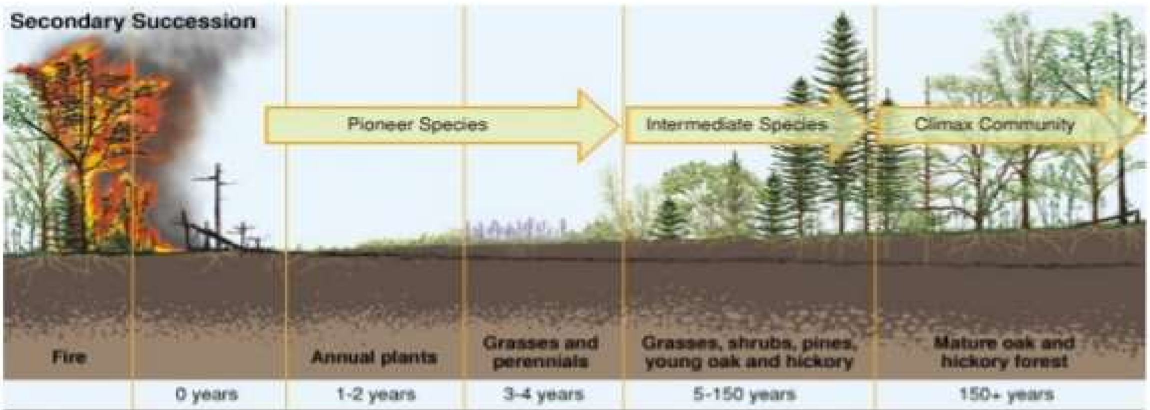




2. Secondary Succession:

- Secondary succession begins in areas where natural biotic communities were present in the past but have been destroyed such as in abandoned farm lands, burned or cut forests, lands that have been flooded.
- It is faster than primary succession because of the availability of some soil or sediment and water.
- Hence, the climax community is also reached more quickly.

- Secondary Succession - the development of plant and animal communities over time in an area where there was a disturbance but the soil was still present



- During an ecological succession, there are changes in the type of vegetation.
- These changes in the vegetation during succession also affects the food and shelter for various animals.

- Therefore, during the course of succession, number and type of animals and decomposers also change.
- At any time, natural or human induced disturbances like fire and deforestation can change the events of succession.
- These changes can convert a particular seral stage of succession to an earlier stage.
- Such disturbances can also 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 wet areas) or it is on very dry area, there are two types of – successions of plants:
  - **Hydrach succession** and
  - **Xerarch succession.**

1. Hydrarch Succession:

- It takes place in wetter areas and the successional series progress from hydric to the mesic conditions.
- During primary succession in water, pioneer species are the small phytoplanktons.
- These phytoplanktons are replaced with time by free-floating angiosperms, then by rooted hydrophytes, sedges (grass-like monocotyledonous flowering plants), grasses and finally the establishment of trees occurs.
- At last, formation of stable climax forest takes place.
- Thus, as time passes by, the water body is converted into land.

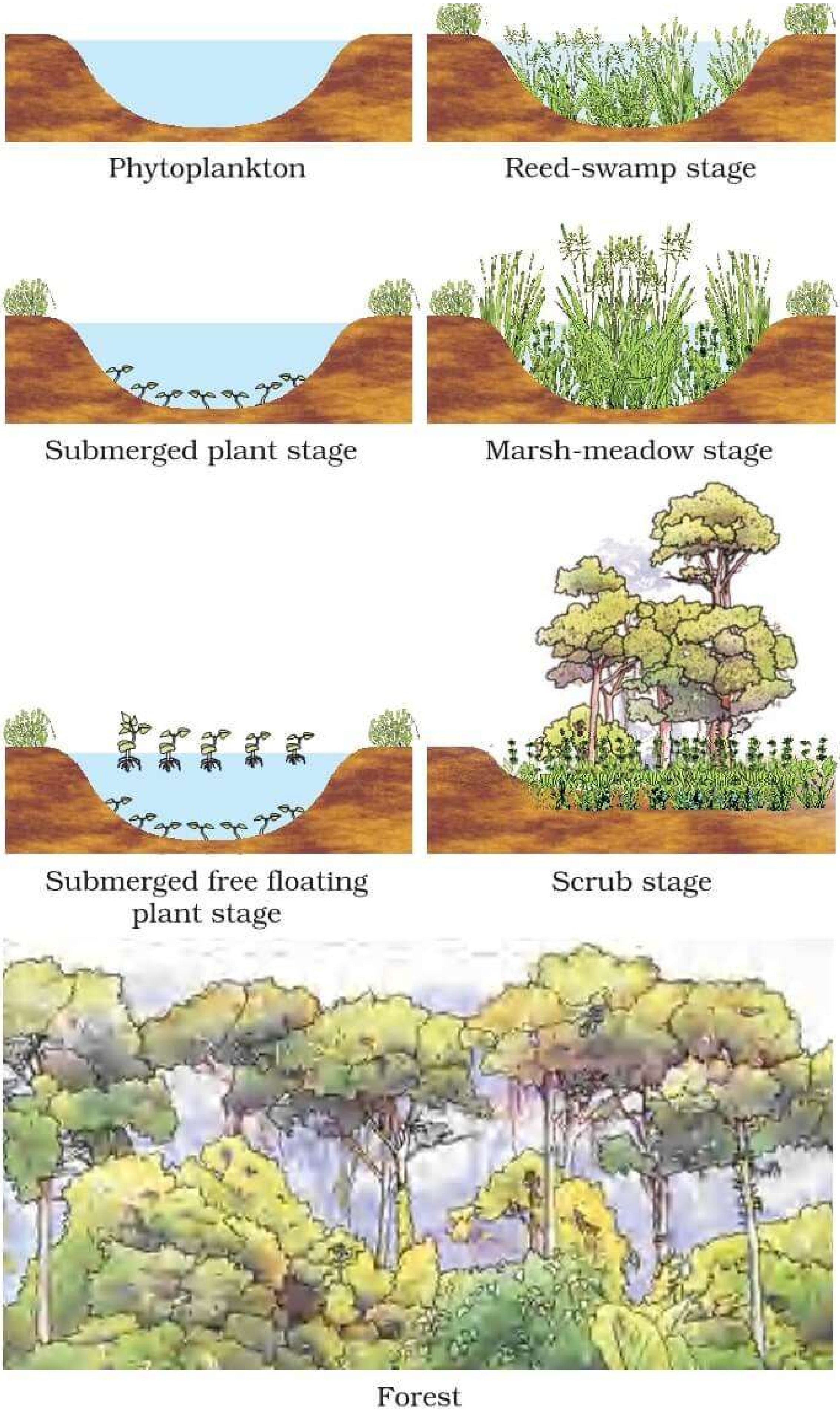
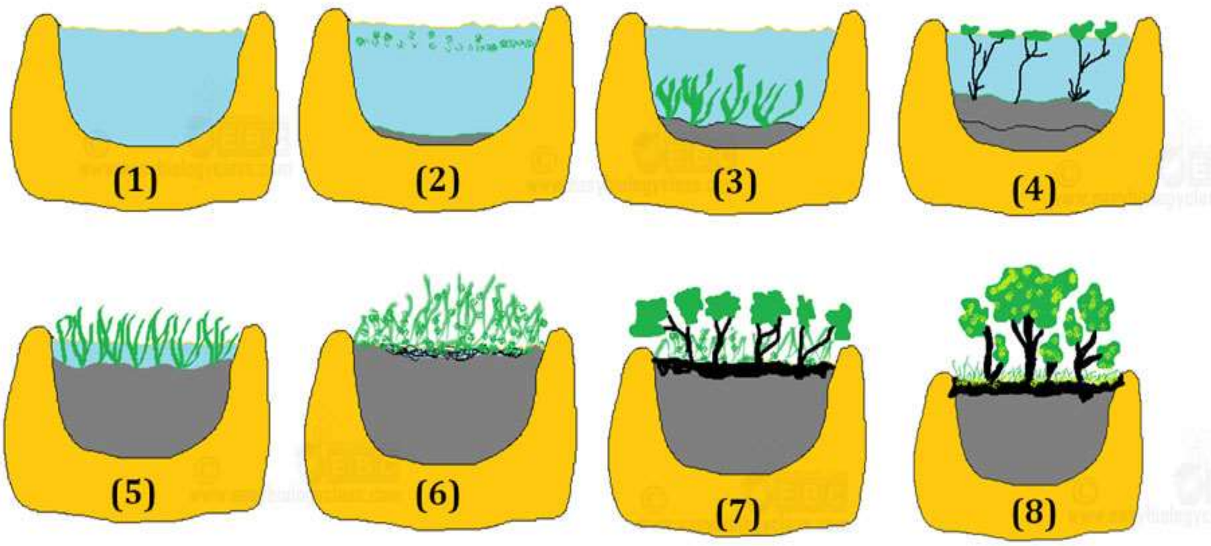


Figure 14.5 Diagramatic representation of primary succession

Hydrosere: Stages of Hydrarch Succession



(1). Newly formed water body; (2). Phytoplankton Stage; (3). Rooted Submerged Stage; (4). Rooted Floating Stage; (5). Reed-Swamp Stage; (6). Sedge Marsh or Meadow Stage; (7). Woodland Stage; (8). Forest Stage

2. Xerarch Succession:

- It takes place in dry areas and the series progress from xeric to mesic conditions.
- Lichens are the pioneer species in the primary succession on rocks as they secrete acids that dissolve rocks helping in weathering and soil formation.
- Later, small plants like bryophytes emerge which are able to take hold in the small amount of soil.
- These bryophytes, with time were succeeded by bigger plants.
- After several more stages of successions, ultimately a stable climax forest community is formed.
- The climax community remains stable as long as the environment remains unchanged.
- In this way, xerophytic habitat gets completely converted into a mesophytic one.
- Both hydrach and xerarch succession lead to medium water conditions (mesic), neither too dry (xeric) nor too wet (hydric).
- The important fact is that all successions whether taking place in water or on land, proceeds to a similar mesic climax community.

NUTRIENT CYCLING

- Organisms need a constant supply of nutrients to grow, reproduce and regulate various body functions.
- The amount of nutrients, such as carbon, nitrogen, phosphorus, calcium, etc., present in the soil at any given time, is referred to as the **standing state**.
- It varies in different kinds of ecosystems and also on a seasonal basis.
- The nutrients which are present in the ecosystem are never lost from the ecosystems; they are recycled time and again indefinitely.
- The movement of nutrient elements through the various components of an ecosystem is called **nutrient cycling**.
- Another name of nutrient cycling is **biogeochemical cycles** (bio: living organism, geo: rocks, air, water).
- Nutrient cycles are of two types:
  - **Gaseous** and
  - **Sedimentary**.
- The reservoir (storehouse) 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.
- In both the gaseous and sedimentary cycles, environmental factors, like temperature, pH, soil type and moisture 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.

Carbon Cycle (Gaseous Cycle):

- Carbon constitutes 49 % of dry weight of organisms and is next only to water.
- 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.
- The fossil fuels also represent a reservoir of carbon.

- Therefore, carbon cycling occurs through atmosphere, ocean and through living and dead organisms.
- According to one estimate **4×10^{13} kg** of carbon is fixed in the biosphere through photosynthesis annually.
- **Carbon Fixation** or **Carbon Assimilation** refers to the conversion process of inorganic carbon (carbon dioxide) into organic compound.
- Carbon dioxide is returned to the atmosphere through the respiratory activities of the producers and consumers.
- Decomposers also contribute substantially to CO_2 pool by their processing of waste materials and dead organic matter of land or oceans.
- Burning of wood, forest fire and combustion of organic matter, fossil fuel, volcanic activity are additional sources for releasing CO2 in the atmosphere.
- Some amount of the fixed carbon is lost to sediments and removed from circulation.
- 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.

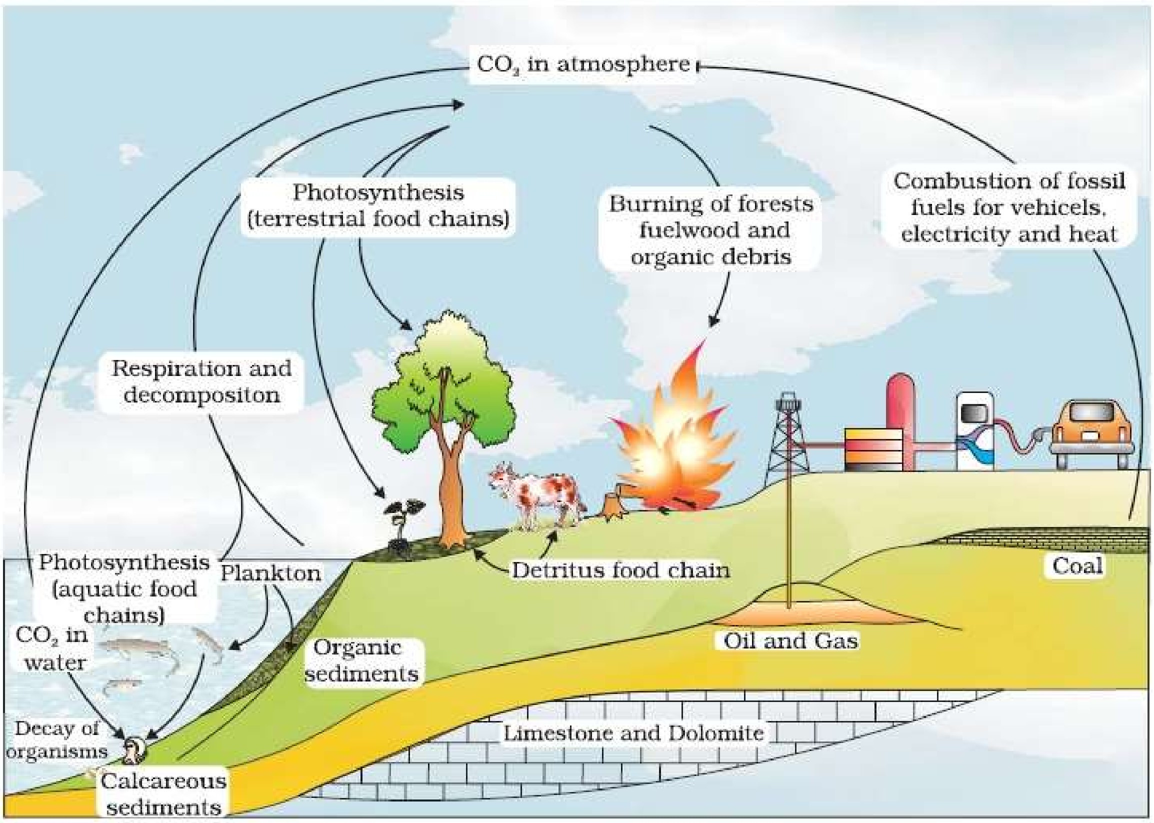


Figure 14.6 Simplified model of carbon cycle in the biosphere

Phosphorus Cycle (Sedimentary 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.
- Herbivores and other animals obtain phosphorus from plants.
- The waste products and the dead organisms are decomposed by phosphate-solubilizing bacteria releasing phosphorus.

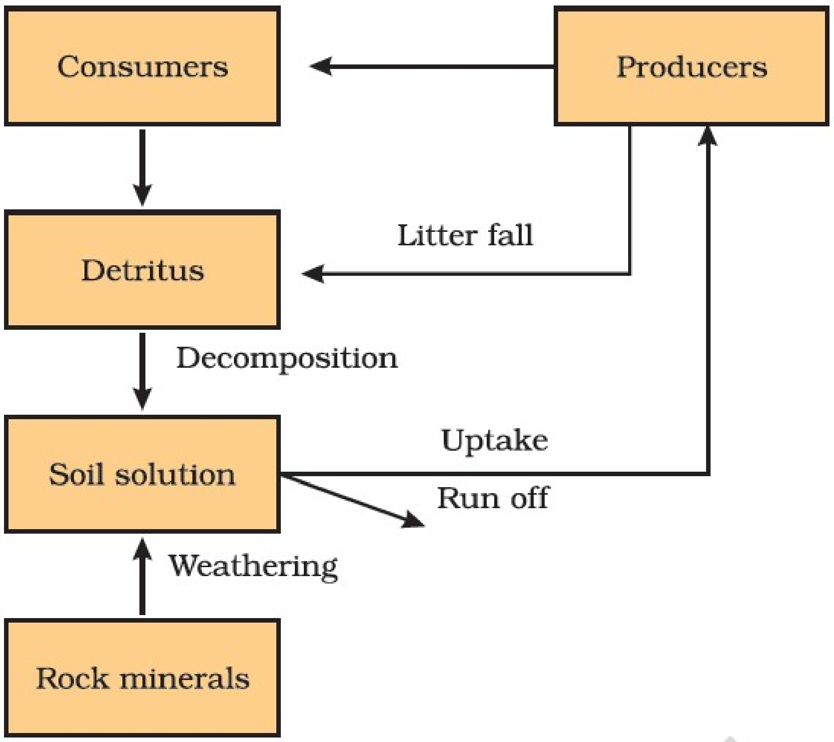


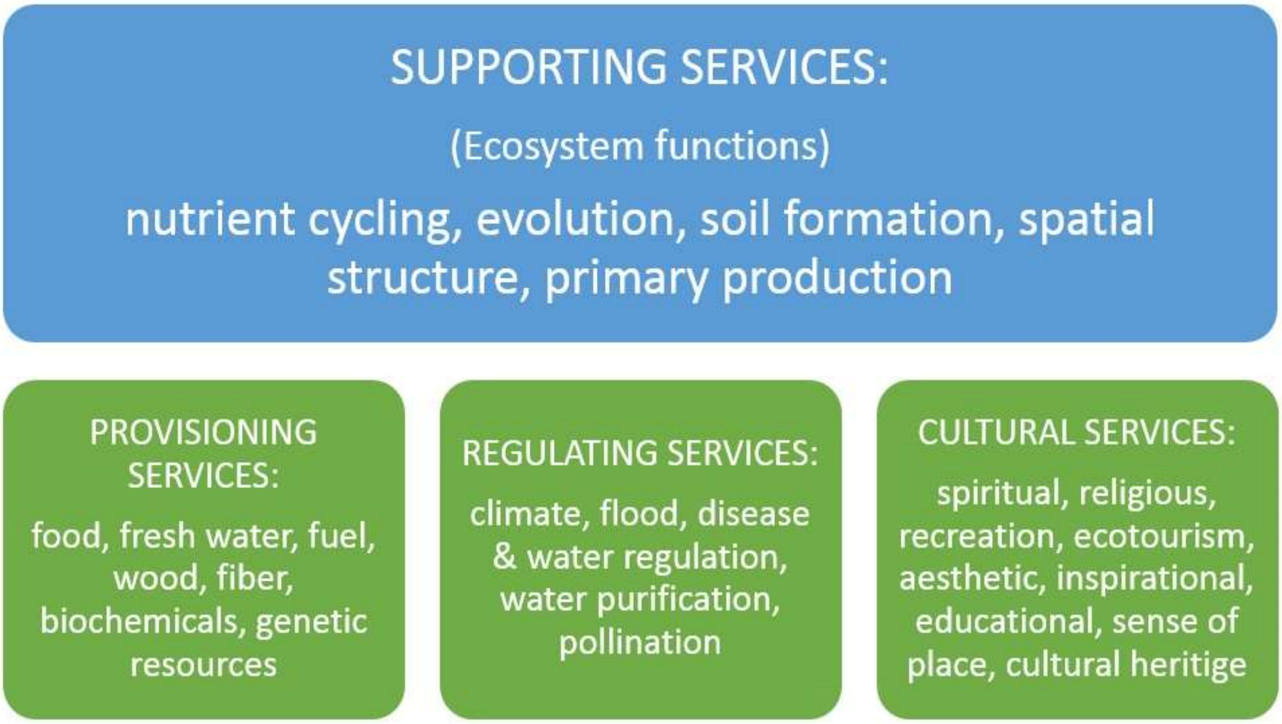
Figure 14.7 A simplified model of phosphorus cycling in a terrestrial ecosystem

Carbon cycle	Phosphorus cycle
There is respiratory release of carbon into the atmosphere.	There is no such release of phosphorus into the atmosphere.
Atmospheric inputs of carbon through rainfall are higher.	Atmospheric inputs of phosphorus through rainfall are much smaller than carbon.
An appreciable amount of gaseous exchange of carbon between organisms and environment occurs.	The gaseous exchange of phosphorus between organisms and environment are negligible.

ECOSYSTEM SERVICES

- Healthy ecosystems are the base for a wide range of economic, environmental and aesthetic goods and services.
- Ecosystem services are the products of ecosystem processes.
- For example, a healthy forest ecosystem purifies air and water, mitigates droughts and floods, cycles nutrients, generates fertile soils, provides wildlife habitat, maintains biodiversity, pollinates crops, provides storage site for carbon and also provides aesthetic, cultural and spiritual values.
- Although it is is difficult to determine the monetary value of such services, still it is reasonable to think that biodiversity should carry a hefty price tag.
- **Robert Constanza** and his colleagues have very recently tried to put price tags on nature's life-support services.
- Researchers have put an average price tag of US $ 33 trillion a year on these fundamental ecosystem services, which we utilize free of cost.
- This is nearly twice the value of the global Gross National Product (GNP) which is US $ 18 trillion.
- Out of the total cost of various ecosystem services, the soil formation accounts for about 50 per cent.
- Contributions of other services like recreation and nutrient cycling, are less than 10 per cent each.
- The cost of climate regulation and habitat for wildlife are about 6 per cent each.

Benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other non-material benefits.



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