ECOSYSTEM

(1) INTRODUCTION

- Ecosystem is a functional unit of nature, where living organisms interact among themselves and the surrounding physical environment, e.g., a small pond, a large forest or a sea.
- Entire biosphere is a global ecosystem, composite of all local ecosystems on Earth.
- Forest, grassland and desert are terrestrial ecosystems; pond, lake, wetland, river and estuary are aquatic and crop fields and an aquarium is a man-made ecosystems.
- Input (productivity), transfer of energy (food chain/web, nutrient cycling) and the output (degradation and energy loss) are the major functions of ecosystem.

(2) ECOSYSTEM – STRUCTURE & FUNCTION

- Interaction of biotic and abiotic components result in a physical structure.
- Vertical distribution of different species occupying different levels is called **stratification**, like trees at top vertical strata, shrubs second and herbs and grasses occupy bottom layers.

ECOSYSTEM COMPONENTS FUNCTION AS A UNIT IN THE FOLLOWING ASPECTS

- Productivity
- Decomposition
- Energy Flow
- Nutrient Cycling

(3) PRODUCTIVITY

- Amount of biomass or organic matter produced per unit area over a time period by plants during photosynthesis is primary production, expressed in terms of weight (gm^{-2}) or energy (K cal m^{-2}).
- Rate of biomass production is productivity, expressed as $gm^{-2}\ yr^{-1}$ or (K cal m^{-2}) yr^{-1}.

It can be divided into:

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

(ii)Net primary productivity (NPP) is the available biomass for the consumption to heterotrophs (herbivores and decomposers)

GPP – R (respiratory loss) = NPP.

- Primary productivity depends on the plant species inhabiting a particular area.

It also depends on environmental factors, availability of nutrients and photosynthetic capacity of plants.

It varies in different ecosystems.
  - Annual net primary productivity of whole biosphere is approximately = 170 billion tons (dry wt.) of organic matter.
  - Productivity of oceans (70 % of surface) = 55 billion tons, rest is on land
- Secondary productivity is the rate of formation of new organic matter by consumers.

(4) DECOMPOSITION

- Breakdown of complex organic matter into inorganic substances like CO_2, water and nutrients is decomposition.
- Detritus i.e. dead plant remains like leaves, bark, flowers and dead remains of animals, including fecal matter, is the raw material for decomposition.
- Largely oxygen requiring process.

DECOMPOSITION(IMPORTANT STEPS)

Fragmentation	Leaching	Catabolism	Humification	Mineralisation
Break down of detritus into smaller particles of detritivores (eg., earthworm).	Water soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts.	Bacterial and fungal enzymes degrade detritus into simpler inorganic substances.	Accumulation of dark, amorphous humus which is highly resistant to microbial action. Colloidal reservoir of nutrients. Humus undergoes decomposition at an extremely slow rate in soil.	Humus is further degraded by microbes to release inorganic nutrients.

- **Fragmentation, leaching and catabolism operate simultaneously on the detritus.**

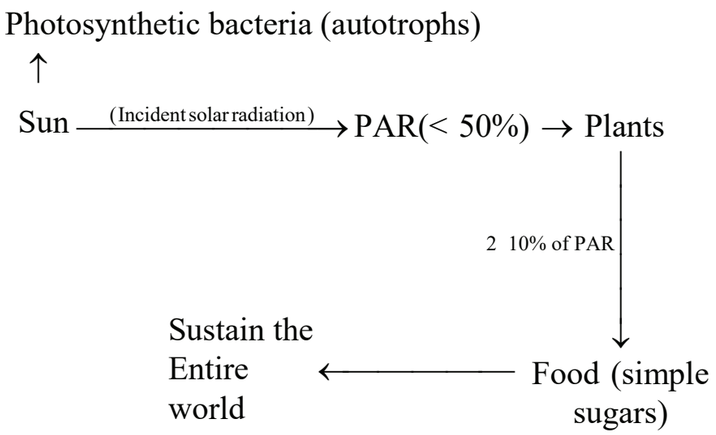
RATE OF DECOMPOSITION
- Slower
- Quicker

Composition of Detritus
- Rich in lignin & chitin
- Rich in nitrogen & water soluble substances like sugar

CLIMATIC FACTORS
- Low temperature.
- Warm and moist environment.
- Oxygen requiring process.

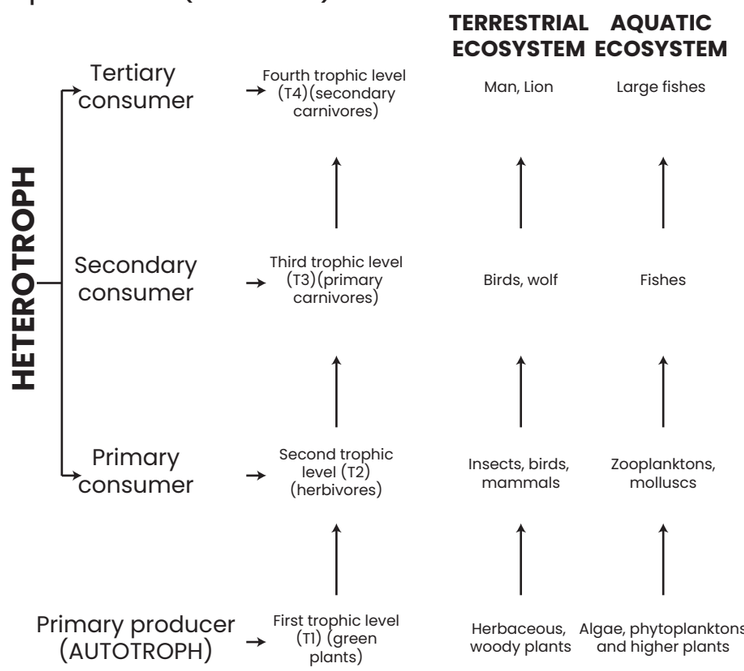
(5) ENERGY FLOW

- Unidirectional from sun to producers and then to consumers.



(6) TROPHIC LEVELS IN AN ECOSYSTEM

- Amount of energy decreases at successive trophic levels.
- Only 10 % of the energy is transferred to each trophic level from the lower trophic level (10 % Law).



(7) DETRITUS FOOD CHAIN (DFC)

- Begins with dead organic matter.
- 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 known as Saprotrophs.
- In a terrestrial ecosystem, a much larger fraction of energy flows through the DFC than through the GFC.

GRAZING FOOD CHAIN (GFC)

- Sun is the source of energy.
- Autotrophs assimilate food using simple inorganic materials and radiant solar energy.
- The energy flows from autotrophs to heterotrophs as per the law of thermodynamics.
- In an aquatic ecosystem, GFC is the major conduit for energy flow.

(8) STANDING CROP

- Each trophic level has a certain mass of living material at a particular time called as the standing crop.
- Standing crop is measured as the mass of living organisms (Biomass) or the number in a unit area.
- Measurement of biomass in terms of dry weight is more accurate.

STANDING STATE

- 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 called standing state.
- It varies in different kinds of ecosystems and also on a seasonal basis.

(9) ECOLOGICAL PYRAMIDS

- Food or energy relationship between organisms at different trophic levels, is expressed in terms of number, biomass or energy.
- The base of each pyramid represents the producers or the first trophic level while the apex represents tertiary or top level consumer.
- The trophic level represents a functional level, not a species as such. A given species may occupy more than one trophic level in the same ecosystem at the same time. eg. A sparrow is a primary consumer when it eat seeds, fruits, peas, and a secondary consumer when it eats insects and worms.
- Three types of ecological pyramids are usually studied - (a) pyramid of number; (b) pyramid of biomass and (c) pyramid of energy.

LIMITATIONS OF ECOLOGICAL PYRAMIDS

- It does not take into account the same species belonging to two or more trophic levels.
- It assumes a simple food chain, that 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

PYRAMID OF NUMBER

- Upright in most ecosystems
- A big tree ecosystem is inverted or spindle shaped.

PYRAMID OF BIOMASS

- Upright in most ecosystems.
- In sea, it is generally inverted because the biomass of fishes far exceeds that of phytoplanktons.

PYRAMID OF ENERGY

- Always upright and can never be inverted
- When energy flows from a particular trophic level to next trophic level some energy is always lost as heat.

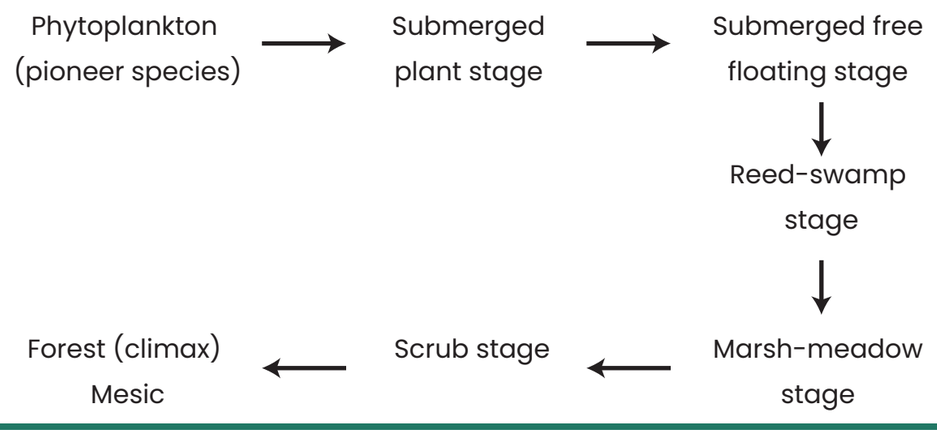
(10) ECOLOGICAL SUCCESSION

- The composition and structure of all communities constantly change in response to the changing environmental conditions, which is orderly and sequential, parallel with changes in the physical environment, leading finally to a community that is in near equilibrium to the environment and is called **climax community**.
- This gradual and fairly predictable change in the species composition of a given area is called **ecological succession.**
- The entire sequence of communities that successively change in a given area are called sere(s) and individual transitional communities are termed seral stages or seral communities.
- In the successive seral stages change in diversity of species of organisms, increase in the number of species and organisms as well as an increase in total biomass is seen.

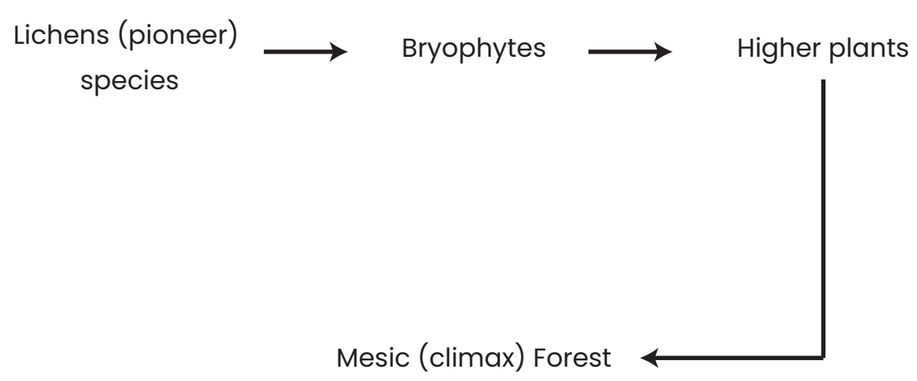
- Actually succession and evolution would have been parallel processes.
- Primary succession starts in an area where no living organisms ever existed, like on bare rock, newly cooled lava, newly created pond or reservoir, so it is slow and can take several hundred to thousand years.
- Primary succession is very slow process.
- Secondary succession takes place in areas that somehow, lost all the living organisms that existed there, like abandoned farm lands, burned or cut forests, lands that have been flooded. Since some soil or sediment is present, succession is faster than primary succession.
- In secondary succession, since soil is already there, the rate of succession is much faster and hence, climax is also reached more quickly.
- As succession proceeds, the numbers and types of animals and decomposers also change.
- The species that invade a bare area are called **pioneer species.**
- After several more stages ultimately a stable climax forest community is formed.

(11) SUCCESSION OF PLANTS

HYDRARCH (In wet areas)



XERARCH (Xeric/dry conditions)



(12) NUTRIENT CYCLING

- Nutrients which are never lost from the ecosystems, they are recycled time and again indefinitely. It is called biogeochemical cycles (bio-living organism, geo-rocks, air, water).
- Nutrient cycles are of two types:
  - (a) Gaseous (eg. nitrogen, carbon cycle)
  - (b) Sedimentary (eg. sulphur, phosphorus cycle)

CARBON-CYCLE

- Carbon constitutes 49 % of dry weight of organisms and is next only to water.
- 71 % of global carbon is dissolved in oceans, which regulates amount of CO_2 in atmosphere.
- Fossil fuel represent a reservoir of carbon.
- 4 × 1013 kg of carbon is fixed annually in biosphere through photosynthesis.
- Respiratory activities of producers and consumers return a lot of CO_2 to the atmosphere. Decomposers contribute substantially to CO_2 pool.
- Burning of wood, forest fire, fossil fuel, volcanic activity, deforestation etc. also contribute to the atmospheric CO_2.

PHOSPHORUS-CYCLE

- Phosphorus is major constituent of biological membranes, nucleic acids and cellular energy transfer system.
- Needed to make shells, bones and teeth.
- Natural reservoir is rock.
- Herbivores and other animals get it from plants.
- There is no respiratory release of phosphorus into atmosphere.
- Atmospheric inputs of phosphorus through rainfall are much smaller than carbon inputs and also gaseous exchanges of phosphorus between organism and environment are negligible.

(13) ECOSYSTEM SERVICES

- Healthy forest ecosystem purify air and water, mitigate droughts and foods, cycle nutrients, generate fertile soils, provide wildlife habitat, maintain biodiversity, pollinate crops, provide storage site for carbon and also provide aesthetic, cultural and spiritual values.
- Robert Constanza tried to put price tags of average US $ 33 trillion a year for these ecosystem services, which is largely taken for granted, because they are free. This is nearly twice the value of global GNP of US $ 18 trillion.
- Out of the total cost soil formation accounts for about 50 %, recreation and nutrient cycling less than 10% each and climate regulation and habitat for wildlife 6 % each.

MISCELLANEOUS

- In ecosystem there is unidirectional movement of energy towards higher trophic levels and its dissipation and loss as heat to the environment.
- Some organisms of DFC are prey of the GFC animals.
- Some animals like cockroaches, crows etc. are omnivores.
- Both hydrarch and xerarch lead to medium water conditions (Mesic Condition).
- Environmental factors, e.g., soil, moisture, pH, temperature, etc., regulate the rate of release of nutrients into the atmosphere.
- The climax community remains stable as long as the environment remains unchanged.
- Products of ecosystem processes are named as ecosystem services, e.g., purification of air and water by forests.