UNIT – X

CHAPTER 13 – ORGANISMS AND POPULATIONS

ECOLOGY: Branch of Science which deals with relationship between organisms & their physical & biological environment.

LEVELS OF ORGANISATION:

- Organisms- every individual of a species
- Population- individuals of the same species at a given place
- Communities- assembly of population of all diff species living in area and interacting.
- Biomes- large unit of flora and fauna in a specific climatic zone

ENVIRONMENT : Sum total of all biotic and abiotic factors that surround and influence an organism in it is survival and reproduction.

Factors affecting environment:

- Rotation of earth
- Seasonal and annual variation in temperature and precipitation
- Habitats

MAJOR BIOMES

1. 1.Artic & Alpine Tundra
2. Coniferous Forest
3. Temperate Forests
4. Grassland
5. Tropical Forest
6. Desert

MAJOR ABIOTIC FACTORS

- Temperature
- Water
- Light
- Soil

Temperature

- **Ecologically most imp. Factor**
- **Decreases progressively from equator towards pole and from plane to mountain tops**
- **Polar Region and high altitudes- sub zero level Tropical deserts > 50°C**
- **Organisms survive only in suitable range of temperature**
- **Based on tolerance to temperature**
  - **Eurythermal**

    Organisms that tolerate wide range of temperature
  - **Stenothermal**

    Organisms that tolerate only narrow range of temperature

Water

- **Life on earth originated in water**
- **Productivity and distribution of plants depends on water**

Based on tolerance to salinity

- **Euryhaline**

  Organisms that can tolerate wide range of salinity
- **Stenohaline**

  Organisms that can only tolerate narrow range of salinity

- **Freshwater animals cannot live in sea water and vice versa because of osmotic problems.**

Light

- **sunlight source of energy- photosynthesis**
- **Small plants (canopied by tall plants) adapted to photosynthesize at low light conditions.**
- **Flowering dependent on sunlight**

- **Foraging, Reproductive and migratory activities of animals depend on seasonal variation in light intensity**
- **UV component – harmful to organisms**

Soil

- **Nature of soil depends on**

I. climate
II. weathering process
III. sedimentary or transported
IV. soil development

Characteristics of soil

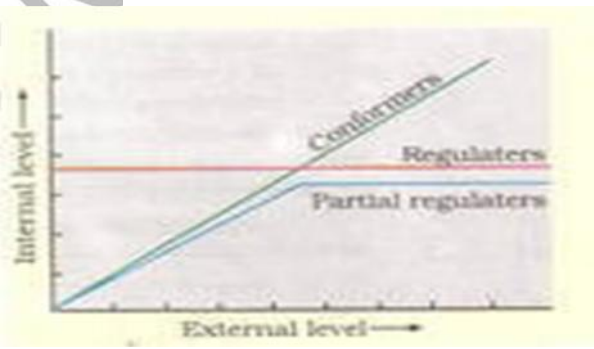
a. **soil composition**
b. **grain size**
c. **aggregation- determine percolation and water holding capacity of soil**

RESPONSES TO ABIOTIC FACTORS

Homeostasis: The ability of an organism to maintain the constancy of its internal environment despite varying external environmental conditions.

Q: How does Homeostasis occur?

1. **Regulate:** maintain homeostasis by ensuring constant body temp (thermoregulation), and constant osmotic concentration (osmoregulation). Examples – mammals regulate temperature by shivering in cold and sweating in heat



2.**Conform:** internal environment of conformers changes with external environment

Q:Why small animals are rarely found in polar regions?

A: Small animals have large surface area compared to volume so they lose heat easily in cold and have to expend energy to generate body heat.

But, if stressful external conditions are localized or remain for short duration, Then alternatives are migrate / suspend.

3. Migrate: Move from stressful habitat temporarily to hospitable area and return when stressful period over.

E.g.- Migration of birds to Keolado National Park, Rajasthan from Siberia

4. Suspend: Organisms develop mechanisms to deal with stressful situation

Examples- Spores (bacteria and fungi)

- Seeds (angiosperms)- dormancy
- Hibernation (Bears)
- Aestivation (snails)
- Diapause (stage of suspended development) in zoo plankton

Adaptation

Any ability of an organism that enables an organism to survive and reproduce in its habitat

ADAPTATIONS IN ORGANISMS

1. Kangaroo rat: internal fat oxidation to produce water as by product- concentrated urine

2. Desert plants: thick cuticle, stomata in deep pits to minimize transpiration and special photosynthetic pathway (CAM). Ex. OPUNTIA- leaves reduced to spines, photosynthetic stems

3. Cold climate mammals: short ears and limbs to minimize heat loss. This is Allen's Rule.

4. People living at high altitude: increased RBC production and increased breathing rate

5. Desert lizards: bask in sun when cold and move to shade when hot.

POPULATION

Group of individuals living in a well defined area which share or compete for similar resources and potentially interbreed

Example: lotus plants in a pond, bacteria in a culture plate.

Population ecology is therefore, an imp. area of ecology because it links ecology to population genetics and evolution

POPULATION ATTRIBUTES

1.Birth rate- Average no. of young ones born in in a period of time w.r.t members of the population.

2. Death rates- Average no. of deaths in a period of time w.r.t members of the population.

3.Sex Ratio- No. of females and males per 1000 individuals

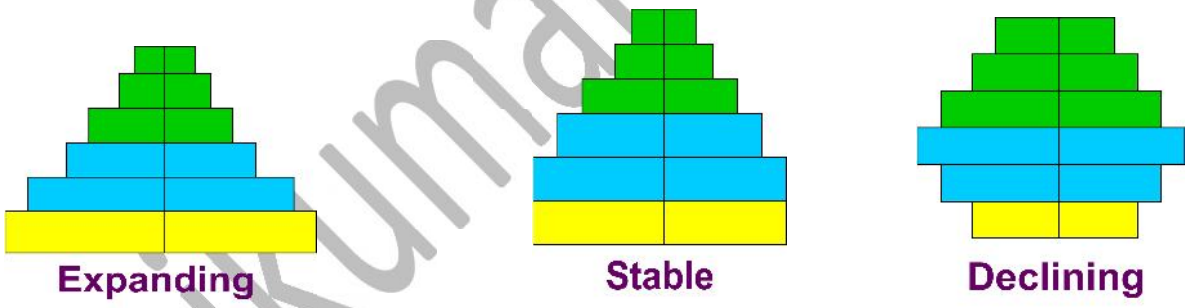
4. Age pyramid: Plot of age distribution (% individuals of a given age or age group)

It reflects whether growth is

(i) **Expanding**

(ii) **Stable**

(iii) **Declining**



→ Pre reproductive

→ Reproductive

→ Post reproductive

POPULATION DENSITY:

Number of individuals present per unit area at a given time.

POPULATION GROWTH

Factors affecting change in population density

1. Food availability
2. Predation pressure
3. Weather

Density changes by change in four basic processes

(a) Natality - Increase population

(b) Immigration - Increase population

(c) Mortality - Decrease population

(d) Emigration - Decrease population

1.Natality (B) : Number of births during given period in the population that are added to the initial density

2.Mortality (D) : Number of deaths in the population during a given period.

3.Emigration (E) : Number of individuals of the population who left the habitat and went elsewhere during the given period

4. Immigration (I) : Number of individuals of the same species that have come into the habitat from elsewhere during the time under consideration.

- If N is the population density at time 't', then its density at time 't+1'

$$N_{t+1} = N_t + [(B + I) - (D + E)]$$

- Population density will increase if **(B+I) > (D+E)**

GROWTH MODELS

- EXPONENTIAL
- LOGISTIC

EXPONENTIAL GROWTH

- When resources are unlimited, each species realizes its innate potential to grow in no. – population grows exponentially

- N – Population size

  b – Birth rates(per capita births)

  d – Death rates (per capita deaths)

  dN/dt – increase/decrease in N during time t

Then, dN/dt = (b – d)*N

Let (b – d) = r, then

dN/dt = r*N

Where, r – intrinsic rate of natural increase

For human population in 1981, r = 0.0205

Integral form of exponential growth eq.

$\mathbf{N_t = N_0 e^{rt}}$

Where N_t = Population density after t

N_0 = Initial population density

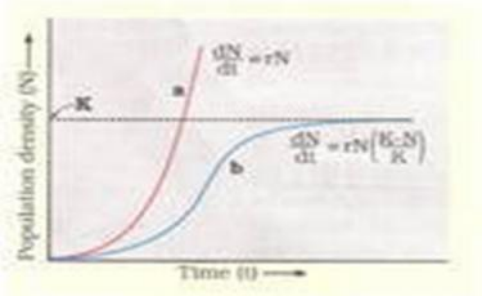
r = Intrinsic rate of natural increase

e = base of natural logarithms

- Species growing exponentially under unlimited resources reaches enormous population density in short time.

LOGISTIC GROWTH

- No population has unlimited resources-leads to competition for resources
- Fittest individual survive and reproduce
- Carrying capacity (K)- Max. population density a habitat's resources can support
- When a population has limited resources it shows
  - lag phase
  - phase of acceleration
  - asympote- population density = K



Verhulst Pearl Logistic Growth

dN/dt = rN [(K – N)/K]

- As resources for most organisms are finite logistic growth more realistic

LIFE HISTORY VARIATIONS

- **Darwinian fitness** – Reproductive fitness
- Organisms adopt most efficient reproductive strategy suited to their habitat
- Examples

1. Breed once in lifetime – pacific salmon fish Bamboo

2. Breed many times in life time – birds, mammals

3. Produce large no. of small sized offspring - Oysters, pelagic fishes

4. Produce small no. of large sized offspring - birds, mammals

Ecologists say life history traits depend on constraints of biotic and abiotic parts

Population Interactions

Minimum requirement of species-one more species to feed on.

Interspecific interactions - Interactions of populations of two different species.

Types of Interactions:

Name of Interaction	Species A	Species B
Mutualism	**+**	**+**
Competition	**-**	**-**
Predation	**+**	**-**
Parasitism	**+**	**-**
Commensalism	**+**	**0**
Ammensalism	**-**	**0**

+ Positive effect **- Detrimental effect** **0 Neutral effect**

PREDATION : Interspecific Interaction is where one animal kills and consumes the other weaker animal.

Roles of Predators

- Transfer energy from plants to higher trophic levels (position of organism in food chain)
- Control Prey population – Prickly pear cactus- moth
- Biological control of Agricultural pest
- Maintain species diversity by reducing intensity of competition among competing prey species- pisaster starfish.

Q: **Why predators are prudent?**

A: Over exploitation of prey by the predators results in extinction of prey and predator.

Defense to lessen impact of predation

- Insects and frog – camouflage
- Monarch butterfly – poisonous

PLANTS MORPHOLOGICAL AND CHEMICAL DEFENCE

- Thorns- cactus and Acacia
- Produce and store chemical – Calotropis
- Nicotine, Caffeine, Quinin, Strychnine, opium – against grazers & browsers

COMPETITION

Interaction can be either among individuals of same species or between individuals of diff species.

It cccurs among closely related species but not always true

1. Unrelated species also compete- flamingo & fish compete for zooplankton

2. Feeding efficiency of a species reduce due to other species even if resources are plenty – Abingdon tortoise.

Evidence for competition

Competitive release – species distribution is restricted to small areas due to competitively superior species.

GAUSE'S COMPETITION EXCLUSION PRINCIPLE

"Two closely related species competing for same resources cannot coexist as the competitively inferior one will be eliminated."

Resource partition- Two competing species avoid competition by diff. feeding and foraging patterns-Mc Arthur (warblers foraging activities)

PARASITISM

Interaction when 1 species parasite) depends on the other species (host) for food and shelter, host is harmed.

- Parasites and host self-evolve.
- Adaptations of parasites
  - loss of unnecessary sense organs
  - Hooks and sucker

- Loss of digestive system

- High Reproductive capacity

- Parasites-

(i) Reduce the survival of host

(ii) Growth and reproductive rate are reduced

(iii) Render the host vulnerable to its predators by making them weak

Types of parasite

ECTOPARASITES - depend on external surface of host

Eg- head lice on humans, ticks on dogs

ENDOPARASITES - take shelter within the body of the host organism

Eg- Liverfluke, Plasmodium

MUTUALISM

interaction in which both the interacting species are benefited

Examples

1. Lichen – fungi and algae

2. Mycorrhizae - fungi and roots of higher plants

3. Pollination of plants by insects

4. Mediterranean orchid- sexual deceit for pollination- appears as female bee

AMENSALISM

Interaction between two diff species, in which one species is harmed and the other species is neither harmed nor benefited.

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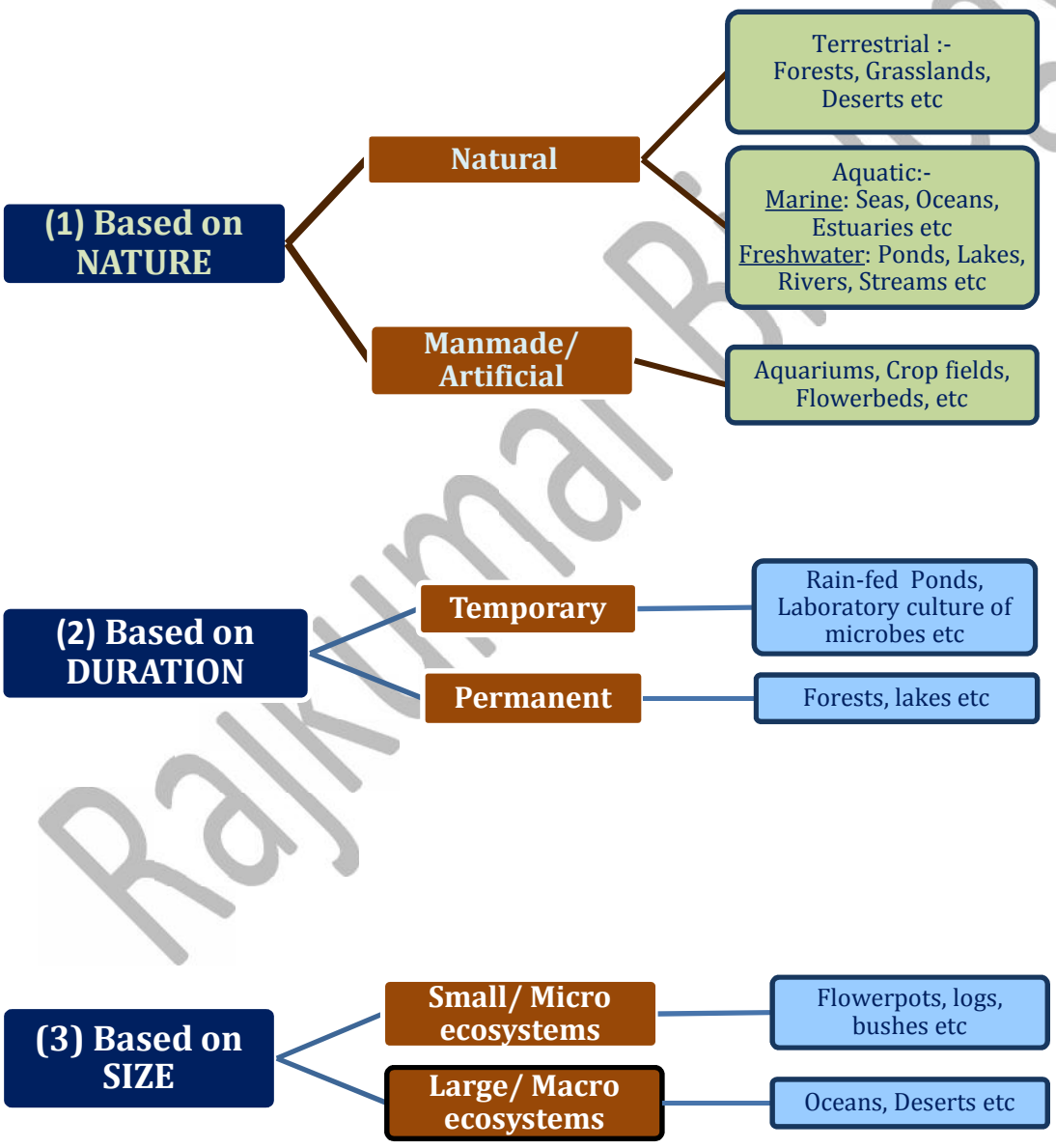
CHAPTER – 14 : ECOSYSTEM

What is an Ecosystem?

British ecologist **Arthur Tansley** first defined the term Ecosystem.

ECOSYSTEM :- the functional unit of nature, where living organisms interact among themselves and with the surrounding physical environment.

Types of Ecosystems:



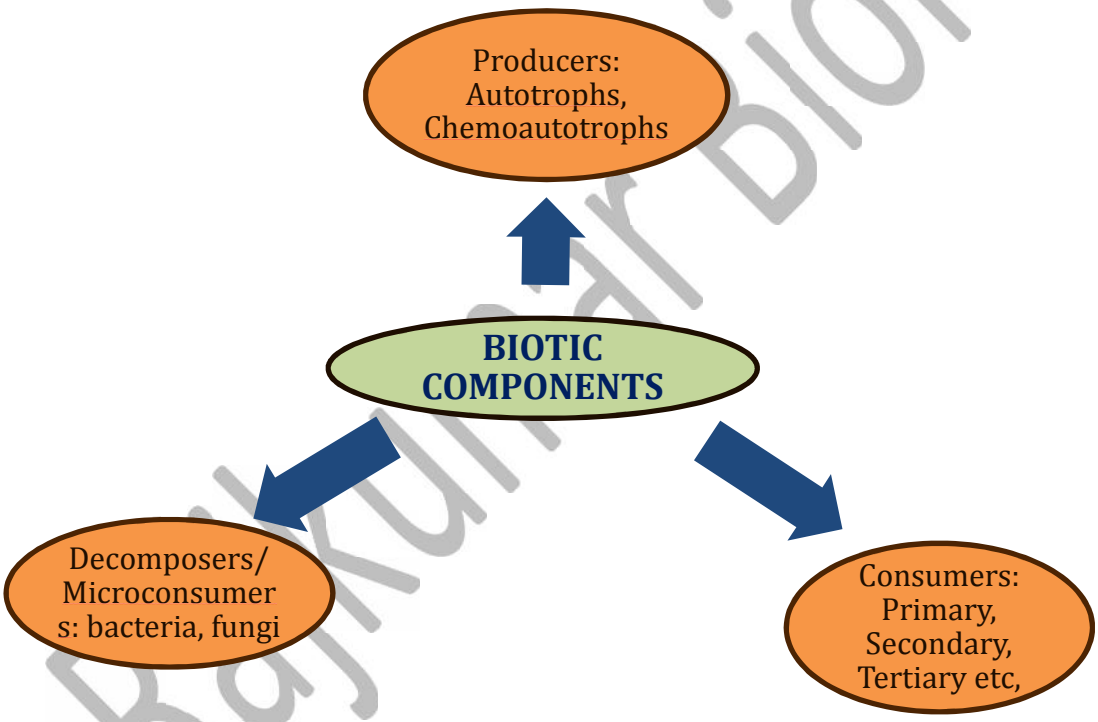
New Species Discovered in Different Ecosystems:

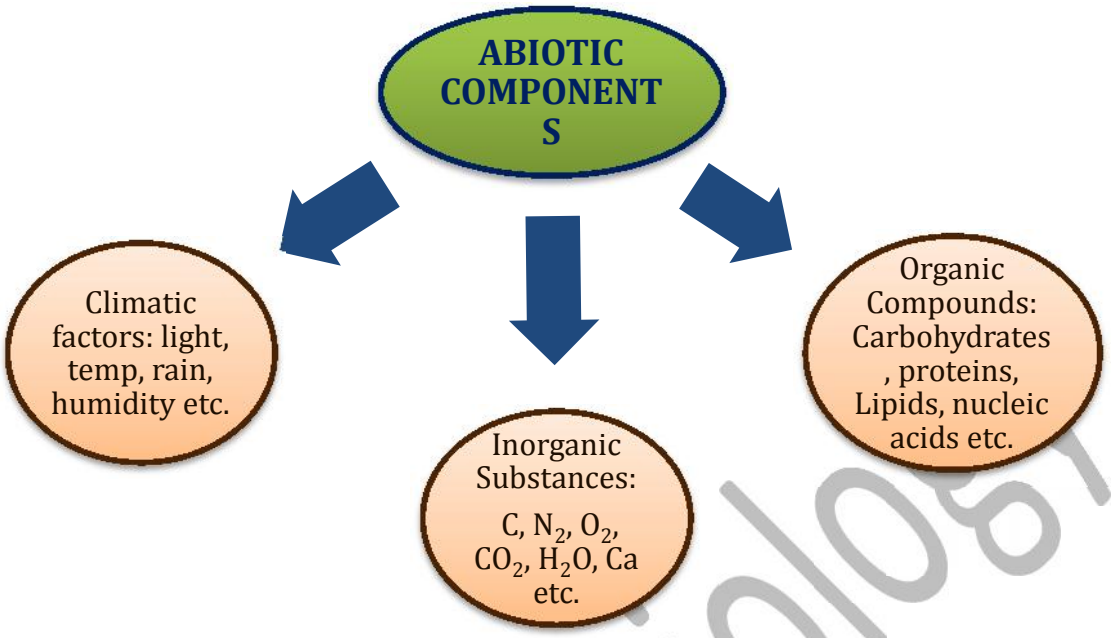
- Pinocchio: long nosed frog found in Indonesia
- Bald headed parrot in Amazon
- Yeti Crab (*Kiwa hirsuta)* near Easter islands.

Structure of Ecosystems

An Ecosystem has two components:

- Biotic components and
- Abiotic components

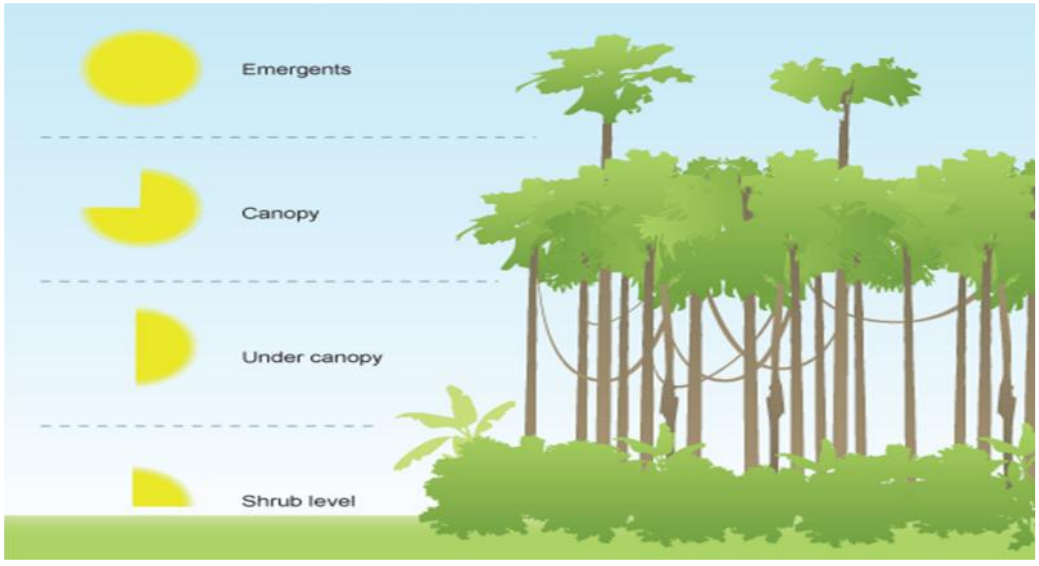




Stratification:

This is the Vertical Distribution of Different Species occupying Different Levels.

The levels are called STRATA.



Aspects Affecting the Functioning of an Ecosystem are:

1. PRODUCTIVITY

The rate of synthesis of organic matter (biomass) during a given period of time. It is measured as weight (g^{-2}) or as energy (kcal m^{-2}). It is used to compare productivity of different ecosystems.

- **PRIMARY PRODUCTIVITY**:

It is the amount of biomass produced per unit area in a given time period by Plants during Photosynthesis.

GPP – R = NPP

*GPP-Gross Primary Productivity *NPP-Net Primary Productivity

- **SECONDARY PRODUCTIVITY**

It is the amount of biomass produced at any of the Consumer levels in a given period of time.

2.DECOMPOSITION

It is the process of breaking down of dead organic matter into smaller organic molecules and inorganic molecules by **Decomposers** (bacteria, fungi)

DETRITUS: Dead remains of plants and animals is called detritus.

DETRITIVORES: Animals that feed on decaying organic matter (detritus).

Eg: earthworms, termites, snails etc

Mechanism of Decomposition:

1. Fragmentation of Detritus: Detritivores feed on detritus ---breakdown --- increases the surface area of detritus particles for microbial action.
2. Leaching: Soluble inorganic nutrients dissolve in water -– percolate through the soil --- removed due to leaching action.
3. Catabolism: Decomposers (bacteria, fungi) release enzymes --- decompose detritus --- simpler inorganic compounds.
4. Humification: Simplified detritus--- converted to HUMUS
    - Humus is a Dark, Amorphous substance.
    - Highly resistant to Microbial Action

- ❖ Undergoes Decomposition very Slowly.
- ❖ Reservoir of nutrients (due to colloidal nature)

5. Mineralisation: Humus is degraded – releases inorganic substances (CO2, H2O etc) and nutrients (Ca^{2+}, Mg^{2+},K^{+} etc)

NOTE: Factors affecting rate of Decomposition= Chemical comp. of detritus & Climatc conditions.

3. ENERGY FLOW

- ► SUN- Main Source of energy
- ► **50%** of incident light is PHOTOSYNTHETICALLY ACTIVE RADIATION (**PAR**)
- ► **2- 10 %** of PAR is captured by plants.
- ► Only a small fraction of this (stored as organic compounds) is transferred to consumers; the rest is used up in respiration and other life-supporting activities of the plants.
- ► As energy is transferred as food, most part is lost as heat at each stage (**10% LAW**)

Unidirectional flow of Energy:

Sun --> Producers --> Consumers

Interdepence of different organisms in each other for food forms the basis of **FOOD CHAINS.**

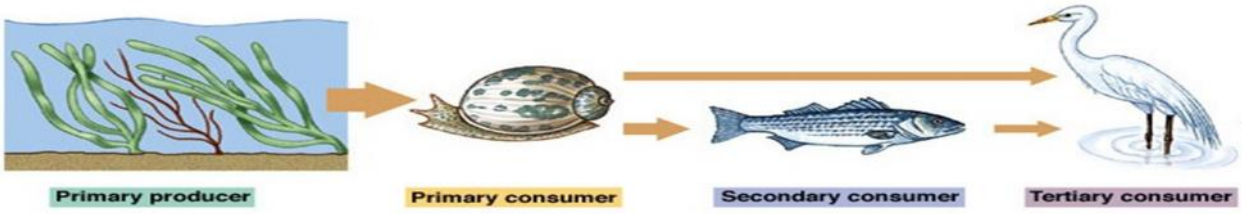
FOOD CHAINS

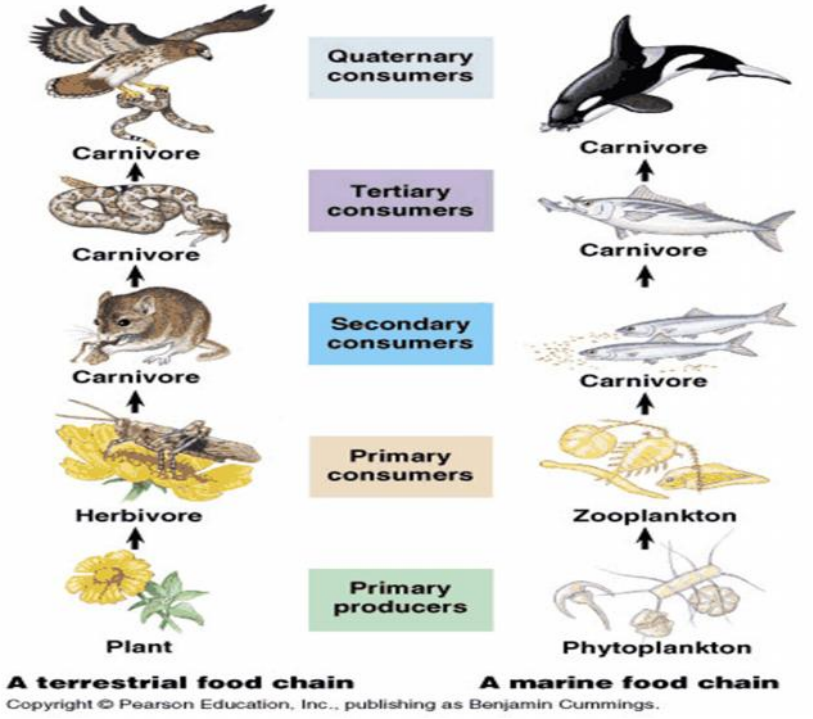
- ❖ Food chains represent energy flow through ecosystems.
- ❖ Different steps in a food chain are TROPHIC LEVELS
- ❖ Basic terms:
  Producers, Herbivores, Carnivores, Omnivores.

1.GRAZING FOOD CHAIN (GFC)

- ❖ Primary source of energy - Solar radiations.
- ❖ First trophic level includes - All Producers.

❖ -GFCs are Long-sized chains

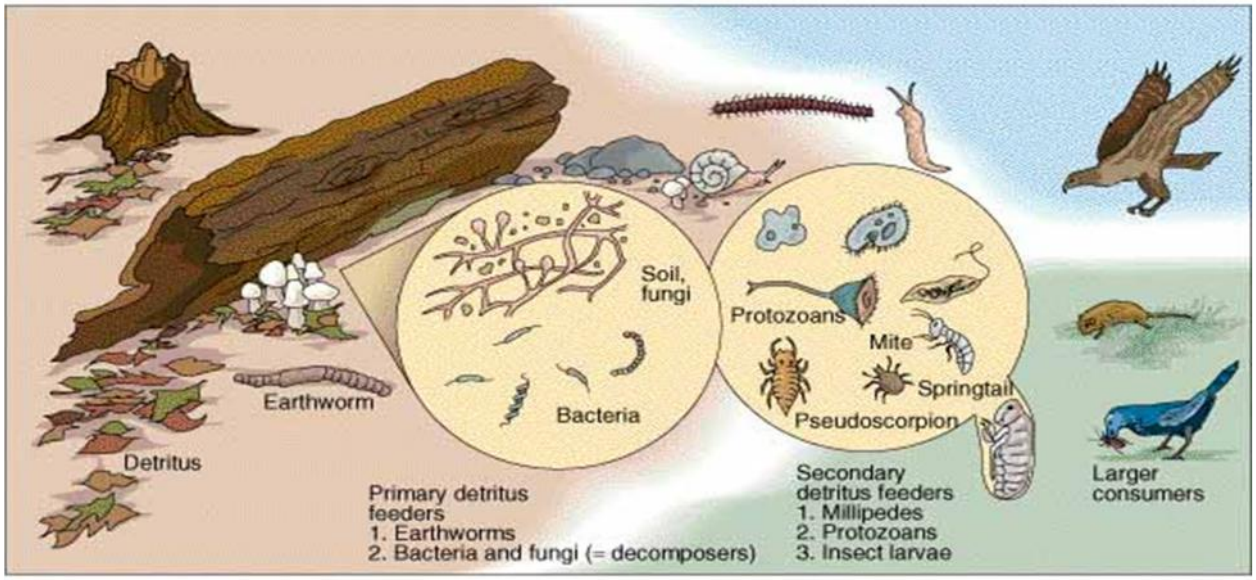




2) DETRITUS FOOD CHAIN (DFC)

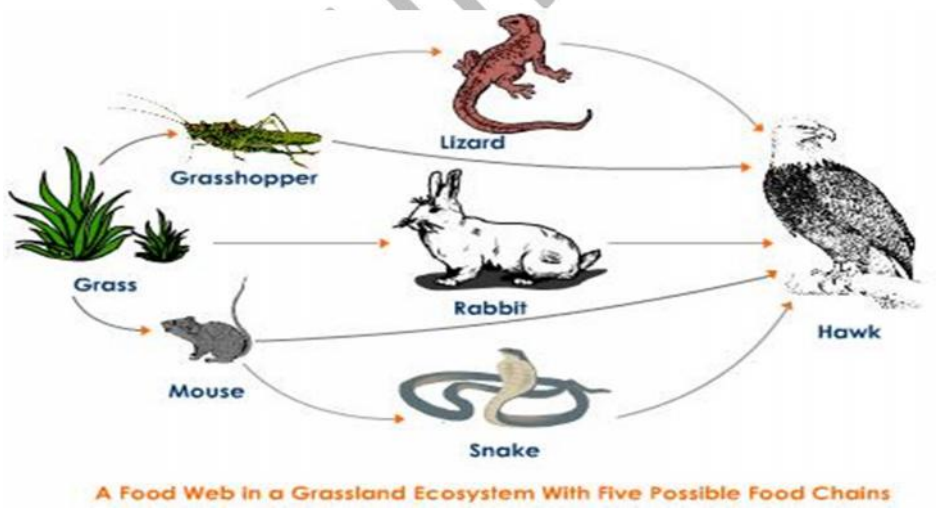
- Primary source of energy is Detritus.
- First trophic level includes Detritivores.
- DFCs are small-sized chains.

SAPROPHYTES: These include decomposers (fungi, bacteria) which feed on detritus.



FOOD WEBS

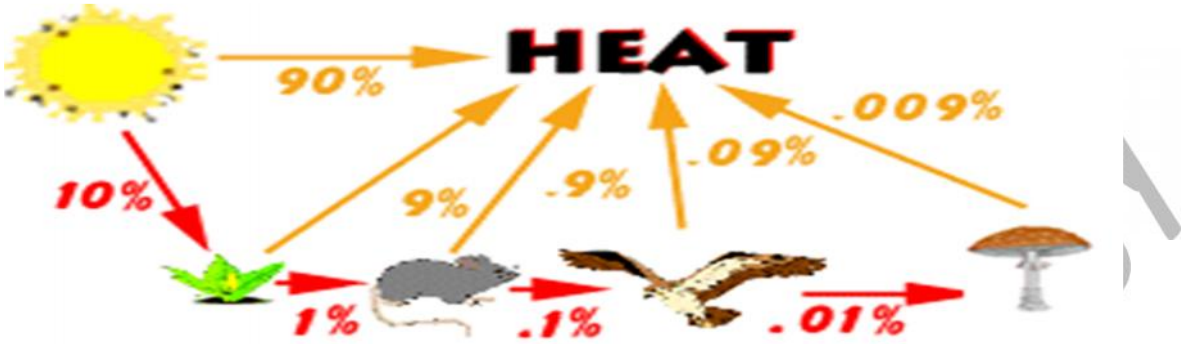
- The Natural Interconnection of Several Food Chains form a FOOD WEB.
- Provides alternate pathways for food availability.
- Unlike food chains, food webs are never straight.
- Help in ecosystem development an stability.



A Food Web in a Grassland Ecosystem With Five Possible Food Chains

TEN PERCENT LAW:

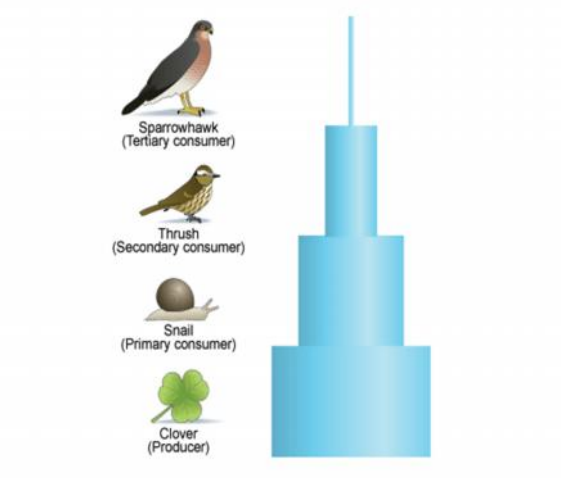
- By Lindemann in 1942
- States that : during transfer of energy from one trophic level to another, only about 10% is stored at higher levels; remaining 90% is lost in respiration (heat)

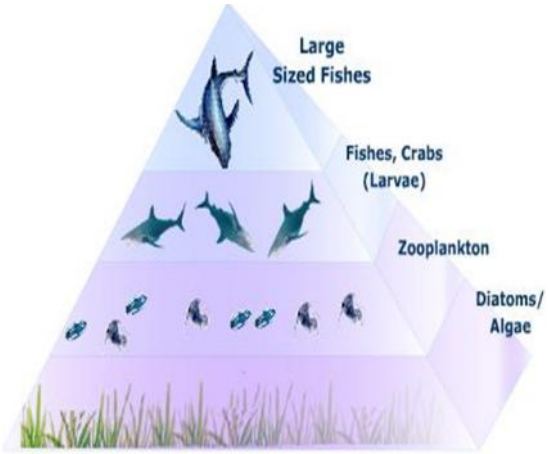


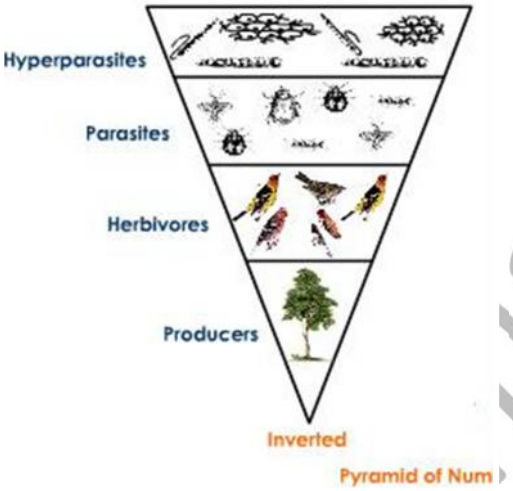
4. ECOLOGICAL PYRAMIDS

- Developed by Charles Elton in 1927.
- Pyramids are an expression of the relationship between organisms at different trophic levels in terms of their number, biomass or energy.
- Three types of pyramids:
    1. Pyramid of Number
    2. Pyramid of Biomass
    3. Pyramid of energy

Pyramid of Number:

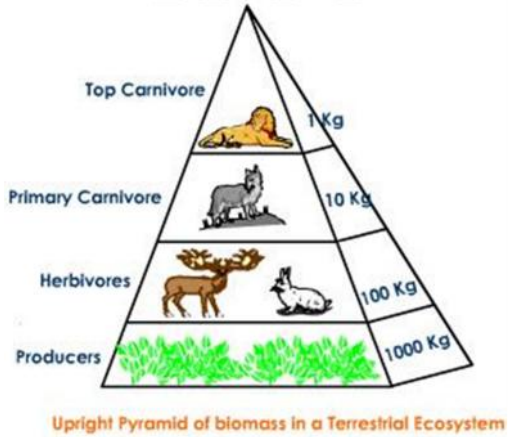




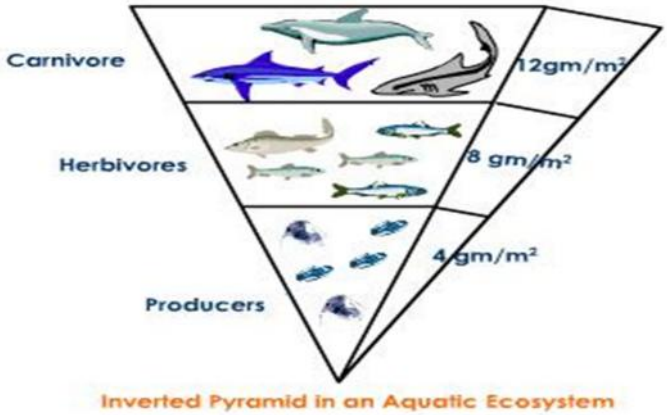


Pyramid of Num

Pyramid of Biomass:

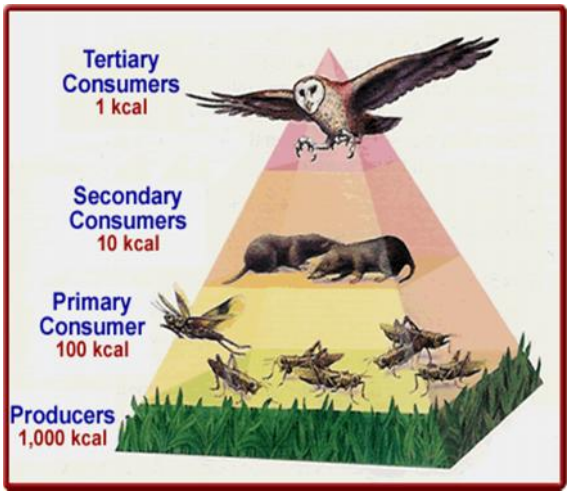


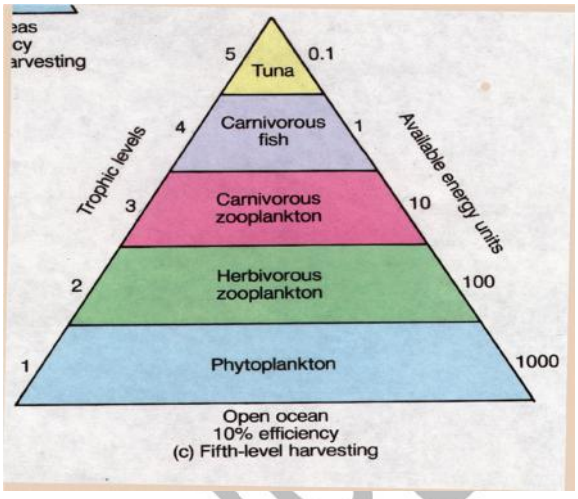
Upright Pyramid of biomass in a Terrestrial Ecosystem

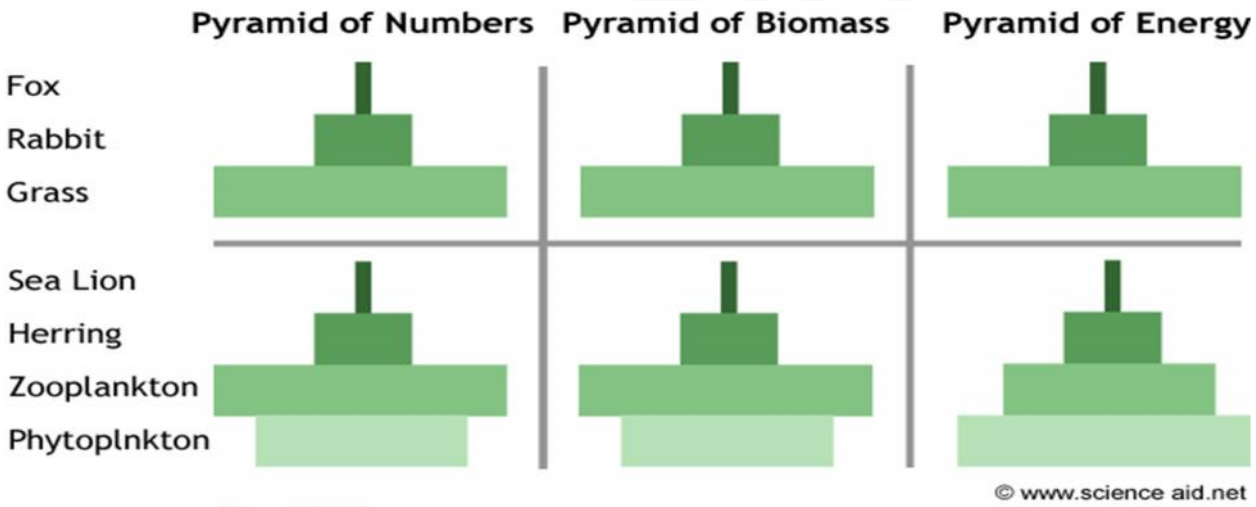


Inverted Pyramid in an Aquatic Ecosystem

Pyramid of Energy:







Limitations of Ecological Pyramids:

- It does NOT consider the same species belonging to two or more trophic levels.
- It is based on simple food chains, which hardly exist. It does NOT accommodate food webs.
- Saprophytes (decomposers) are NOT given any place in the ecosystem.

Climax Community:

- Changes that lead finally to a community that is in near equilibrium with the environment.

- It remains stable as long as the environment remains unchanged.

The Daintree Rainforest in Queensland, Australia is an example of climax community ecosystem.

Ecological Succession:

- Refers to predictable and orderly change in the composition or structure of a community.
- May be initiated either by formation of new, unoccupied habitat or by some form of disturbance of an existing community.
- Sere – entire sequence of community that successively change in a given area.
    - Seral stages – individual transitional communities.

Seral Communities:

Hydrosere - **Community in freshwater**

Lithosere - Community on rock

Pssamosere - Community on sand

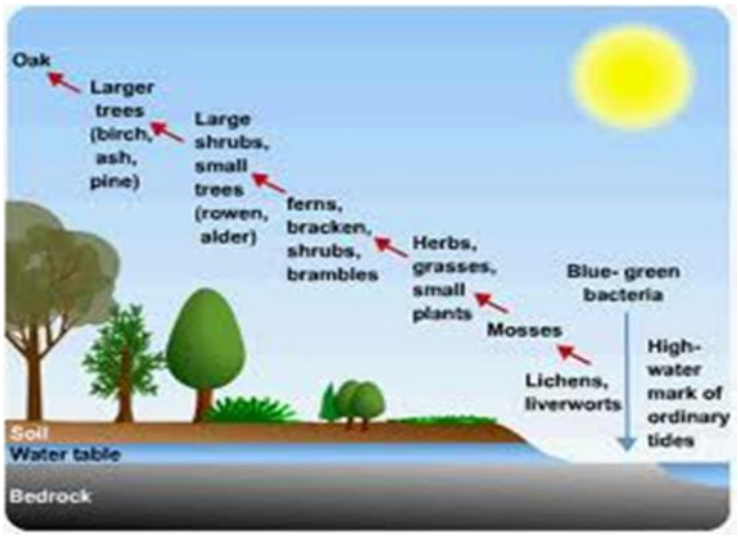
Halosere - Community in saline body

Xerosere - Community in dry area

Xerosere - Community in dry area

Primary Succession

- **If the development begins on an area that has not been previously occupied by a community.**
- **Pioneer species – lichens, phytoplankton, etc.**
- **Egs:**
    - **newly exposed rock or sand surface**
    - **a lava flow**
    - **glacial tills**
    - **newly formed lake**



Secondary Succession

- **If the community development is proceeding in an area from which a community was removed.**
- **Pioneer species – grasses, wildflowers, algae.**
- **Egs:**
  - **an abandoned crop field**
  - **cut-over forest**
  - **natural forces such as wind storms and floods**

Succession in Plants:

Hydrarch succession

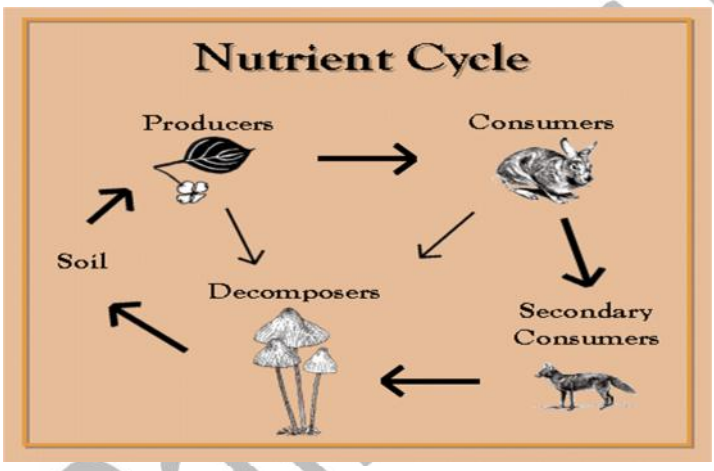
- **It takes place in wetter areas and the succession series progress from hydric to the mesic conditions.**

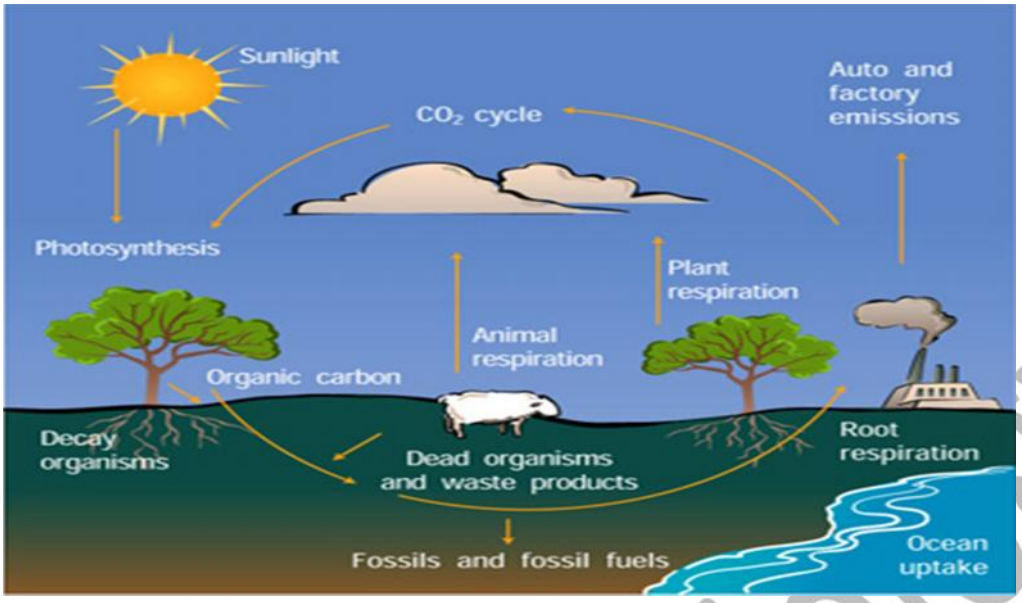
Xerarch succession

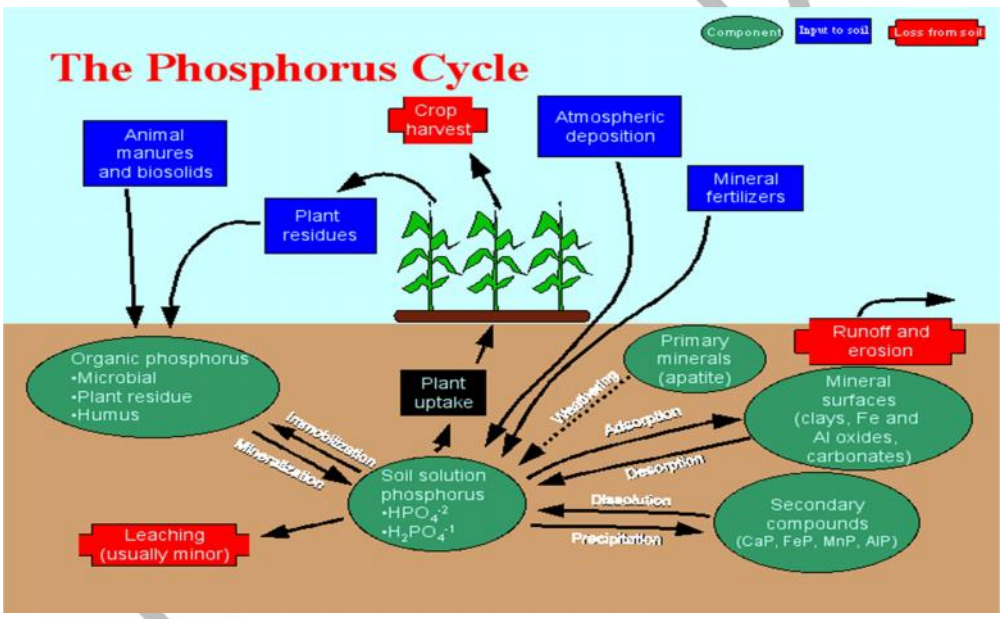
- **It takes place in dry areas and the series progress from xeric to mesic condition.**

The Nutrient Cycle

- **Also known as biogeochemical cycle.**
- **Environmental factors like soil, moisture, temperature, etc. regulate the rate of release of nutrients into the atmosphere.**
- **Standing state – amount of nutrients, such as C, N, P, Ca, etc. present in the soil at any given time.**
- **Nutrients are never lost from the ecosystem, they are recycled in time again indefinitely.**
- **There are two types:**
  - **Gaseous cycle**
  - **Sedimentary cycle**







Ecosystem Services

- **Humankind benefits from a multitude of resources and processes that are supplied by natural ecosystems. Collectively, these benefits are known as ecosystem services.**
  - **Purify air and water**
  - **Decomposition of waste materials**
  - **Cycle nutrients**
  - **Pollinate crops**
  - **Maintain biodiversity**
- **Researchers have put an average price tag of US $33 trillion a year on these fundamental ecosystems services, which is largely taken for granted because they are free.**

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CHAPTER 15 – BIODIVERSITY & CONSERVATION

- **Definition- Biodiversity can be defined as the totality of genes, species and ecosystems of a given region.**
- **This term was coined by EDWARD WILSON**
- **Diversity ranges from macromolecules to biomes.**
- **Biodiversity can be studied at-**

  1. Genetic diversity

  2. Species diversity

  3. Ecological/Ecosystem diversity

1. GENETIC DIVERSITY

- Greater the genetic diversity among organisms of a species, more sustenance it has against environmental perturbations.
- Genetically uniform populations are highly prone to disease harsh environment.
- *Rauwolfia vomitoria* shows genetic variation in terms of concentration and potency of chemical reserpine
- There are more than 50,000 varities of rice and nearly 1000 varieties of mangoes.

2. SPECIES DIVERSITY

Important measures-

1. Species richness: It refers to the number of species per unit area.
2. Species Evenness: It refers to the relative abundance with which each species is represented in an area.

- The variety and number of individuals determine the level of diversity of an ecosystem.
- The Western Ghats have a greater diversity of amphibian species than the Eastern Ghats.

3. ECOLOGICAL DIVERSITY

- Ecological Diversity is related to species diversity.
- India has greater ecosystem diversity than any other Scandinavian country.
- India has several biomes like alpine meadows, rain forests, deserts, wetlands, mangroves…etc..

GLOBAL BIODIVERSITY

- According to the IUCN (2004) the total number of plant and animal species is about 1.5 million.
- More than 70% of the species recorded are animals and plants account for about 22%; 70% of the animals are insects.
- A more conservative and scientifically sound estimate has been made by Robert May ; it puts the global species diversity at about seven million.

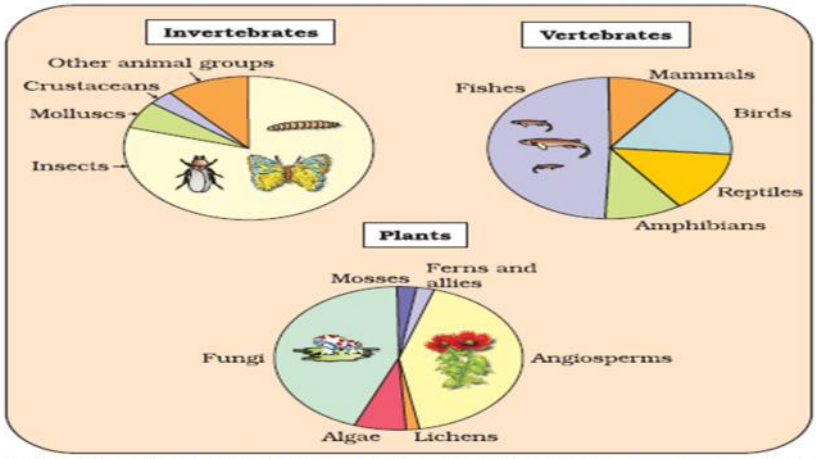


Figure 15.1 Representing global biodiversity: proportionate number of species of major taxa of plants, invertebrates and vertebrates

These estimates do not give any figure for prokaryotes for the following reasons:

1. The conventional taxonomic methods are not sufficient for identifying these microbial species
2. Many of these species cannot be cultured under laboratory conditions.
3. Biochemical and molecular biology techniques would put their diversity into millions.

BIODIVERSITY IN INDIA

- India is one of the twelve mega biodiversity countries of the world.
- India has only 2.4% of the land area of the world; it has 8.1% of the global species biodiversity.
- There are about 45,000 species of plants and about 90,000-1,00,000 species of animals.
- New species are yet to be discovered and named.
- Applying Robert May's global estimate that only 22% of the total species have been recorded, India has probably more than 1,00,000 species of plants and 3,00,000 species of animals to be discovered and described.

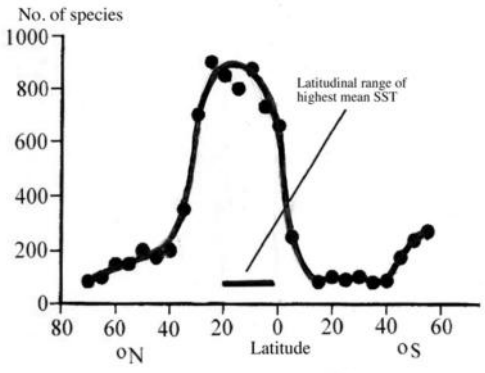
PATTERNS OF BIODIVERSITY

- Biodiversity is not uniform throughout the world but varies with latitude and altitude.
- Favorable environmental conditions favor speciation and make it possible for a larger number of species to exist there, i.e., biodiversity is more in such areas than the others.

1.Latitudinal Gradients

- Species diversity decreased from equator towards poles.
- The tropics harbor more species than temperate and polar regions.
- Example- Colombia (near equator)has 1400 species of birds whereas New York(41° N) has 105 species, Greenland(71 ° N) has 56 species and India(equator region) has 1200 species.

VARIATION OF SPECIES WITH LATITUDE

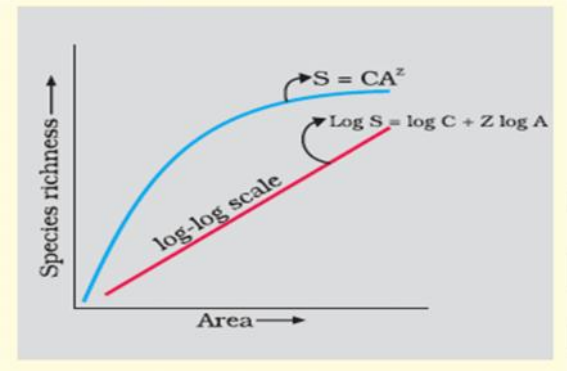


- The number of species of vascular plants in tropics is about ten times more than that of temperate forests.
- Amazonian Rainforest has the greatest biodiversity on earth. It has more than 40000 species of plants, 1,25,000 species of insects, 300 species of fish, 427 of amphibian and 378 of reptiles, 1300 species of birds and 427 of mammals.

2.Species-Area Relationship

- Alexander Von Humboldt has observed that within a region, species richness increased with explored area, but only up to a limit.
- The relationship between species richness and area for a number of taxa like angiospermic plants, fresh water fishes and birds is found to be a rectangular hyperbola.

Graph showing Species-Area Relationship



The equation is described by –

$$\log S = \log C + Z \log A$$

S – Species Richness

Z – Slope of the line (regression coefficient)

A – Area

C – y-intercept

- Ecologists have found that Z-line ranges between 0.1 & 0.2 irrespective of the taxonomic group or the region.
- In very large area like continents, Z-line ranges between 0.6 & 1.2.

IMPORTANCE OF SPECIES DIVERSITY TO ECOSYSTEM

- Ecologists believe that communities with more species tend to be more stable than those with less species.
- Attributes of a stable community-

1. It shall not show too much of variations in the year-to-year productivity.
2. It must be either resistant or resilient to seasonal disturbances.
3. It must be resistant also to alien species.
4. Feature of David Tilman's ecology experiments-

1. The plots with more species showed less year-to-year variation in the total biomass.

2. Plots with increased diversity showed higher productivity.

Hence, we realize that species richness and diversity are essential for ecosystem health as well as survival of human race on earth.

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CHAPTER 16 – ENVIRONMENTAL ISSUES

Human population is increasing tremendously; therefore there is a lot of demand for food, electricity, clothing, roads, housing, vehicles etc. These are exerting a lot of pressure on land, water, air and other resources. This leads to pollution and degradation of the environment and biodiversity that is a part of it.

What is pollution?

Pollution is any undesirable change in physical, chemical or / and biological composition of air, water and land, and the agents that cause these are called pollutants.

What is air pollution?

It's the increase in amount of particles in the air, especially particles smaller than 2.5um such as CO, NO, lead, arsenic, cyanide CFCs ammonia etc that cause respiratory diseases, lung cancer, Tuberculosis, lack of O_2 to the brain and premature deaths.

How is it caused?

Use of vehicles is the main cause of air pollution due to release of harmful gases. Use of petrol & coal in industries and cigarette smoking also contribute to air pollution. Improper disposal of domestic & industrial wastes led to the release of methane.

Smog: Mixture of air pollutants (like arsenic, lead, NO, CO etc), dust & fog is called smog and is deadly to the body as it results in deposition of dry mucus in the alveoli of lungs, tuberculosis, lung cancer, aging, premature death etc

Health fact: Studies show that living in cities like Delhi, Mumbai, Bangalore, Kolkata and many others is equal to smoking an average of 20 cigarettes a day and this problem is fast increasing.

Ways we can help reduce air pollution and global warming:

- Reducing the use of vehicles for travelling short distances & carpooling.
- Use of hydrogen power in cars & machines or Hybrid cars.
- By planting trees across town or growing plants in our homes.
- Use of Electrostatic precipitators, Baghouses, Particulate scrubbers.
- Use of magnetic trains.
- Upgrading industries, factories & aircraft with better engines & turbines

- Use of renewable sources of energy such as wind, water, solar & infrared, geothermal, tidal etc

- Carbon credits are the most effective way of reducing carbon footprint. These credits can be sold to companies or individuals for cash and at the same time reduce CO_2 production.

- An electrostatic precipitator is a particulate removing device that removes particles such as dust, smoke etc from air using force of an electrostatic charge. They are highly effective & consume very less energy for their use.

- In particulate scrubbers, the polluted gas is passed through a layer of scrubbing liquid, or forced through a pool of liquid. These are highly effective in the removal of pollutants from the gas. But these scrubbers have a high chance of corrosion as the toxic gases removed are highly acidic & these scrubbers require large amount of power. Also it is hard to dispose of the waste – water.

Laws passed by some countries to control Air Pollution:

- Environmental Protection Act (1990)_Environment Act (1995)_British Clean Air Act (1956)~UK

- Air Pollution Control Act (1955)_Clean Air Act (1963,1970,1990)~US

- Air Act (1981)_Environment Act (1986)~India

- Environmental Promotion Act (1994)_Environmental Compatibility Act (1994)~Austria

What is water pollution?

- It's the pollution of water bodies with substances like domestic wastes, industrial, thermal, mineral, toxic, nitrogen & phosphorous rich wastes. The nutrient rich wastes multiply the algae concentration in the water bodies & this leads of depletion of oxygen in these bodies & hence leads to the death of fish and other biodiversity in the area.

It's harmful effects include:

- Biomagnification i.e. increase in the toxicity among the food chain at successive tropic levels. This phenomenon is well known with mercury and DDT.

- Accelerated Eutrophication. Eutrophication is the aging of a lake to convert into land, which generally takes 1000s of years or more. But human activities have accelerated this

natural process & as a result many lakes are already extinct. It is caused due to dumping of nutrient rich and thermal waste into lakes.

- Death of biodiversity living near the polluted water bodies, accelerated global warming & extinction of many species.

Note: DDT reduces fat levels, is an endocrine disruptor, causes cancer, causes developmental and reproductive toxicity, Parkinson's & asthma & thinning of eggshells.

India has the most polluted rivers in the world. The excuse of religion & spirituality has been the main reason for their degradation.

BOD : Biochemical Oxygen Demand for various organisms.

BOD is the amount of oxygen required by the biodegradable material & the organic matter living in a certain water body like lake or pond.

Invasive plant water hyacinth: It is used to control and remove BOD, suspended solids, nutrients (phosphorous, nitrogen), heavy metals & organochlorides from water bodies that have been polluted with mineral, industrial & chemical wastes. Water Hyacinth Scrubbers manage and optimize water hyacinth's natural capability to extract nutrient pollutants to ensure sustainability and increased treatment performance. But if their growth is unchecked then it spreads across water bodies quickly. In India it is also called 'Terror of Bengal'.

It is necessary to control water pollution as it leads to diseases like jaundice, cholera, typhoid, dysentery, dengue, malaria etc many of which are very hard to cure.

- The waste water should be treated before dumping in rivers and lakes.
- Domestic waste water can be mildly treated and used for irrigation.
- Planting of trees to reduce acid rain & pollution of ground water.
- Rainwater harvesting to conserve water and reduce wastage of fresh water.
- Prevention/control of use of rivers for purposes related to religious ceremonies.
- Use of dry composting toilets that do not require water, also the human waste collected can be used as a good natural fertilizer.

Some important actions taken by governments to reduce pollution of water bodies:

- The International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978.

- International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990.
- International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances (HNS) by Sea.
- Water Act 1974-India
- Agricultural Nitrates Directive-UK
- Anything that is thrown out along with garbage such as wastes from our homes, schools, offices, shops, hospitals etc are classified as solid wastes. These include glass, plastic, wood, metals, organic matter, food, electrical equipment etc.

It is classified into three main types:

- Bio Degradable waste.
- Non-Bio Degradable waste.
- Recyclable waste.
- Everyday humans produce millions of tonnes of waste all over the world. But what happens to this waste produced?
- In many countries the waste produced is burnt to reduce it is volume, but burning is not an effective way to reduce waste as it causes pollution & release of toxic wastes.
- Wastes are also dumped in landfills- a landfill is a deep trench covering a very large area in which waste is dumped. In countries like Germany, the methane produced from the wastes is collected & used as fuel, & the decomposed waste is used as fertilizer as it is highly rich in nutrients. Modern landfills are designed such that the waste is fully made use of & such that they do not pollute the ground water levels. The toxic seepage from under the landfills is collected & treated before being used as fertilizer.

Landfills aren't much of a solution to solving the problem of the large amounts of wastes generated as they get filled up overtime, faster than the waste can be removed or recycled.

Only we can reduce the amount produced by us. We could:

- Use jute bags for shopping instead of plastic or even paper.
- Glass or metal waste must be recycled & reused.

- Waste produced from hospitals must be incinerated before dumping into landfills as these wastes contain pathogens & harmful germs, & toxic chemicals.
- Using E-Book readers for reading and writing instead of using books. Use of E-Books can save hundreds of millions of trees around the world every year.
- Recycling of electronic items instead of dumping or burning them.
- Use of bio degradable plastic for packaging.

Agro-chemicals and their effects

Over the years the use of agro chemicals has increased considerably. Most of the crops are treated with Pesticides, in-organic fertilizers, insecticides etc to increase crop yield.

- But use of these chemicals results in bio-magnification & eutrophication.
- Many useful insects, rodents & microorganisms are also killed by the use of these chemicals.
- These chemicals seep into the ground & pollute the soil & ground water.
- These cause cancer and inhibit development of brain and the body.

The use of agro-chemicals can be overcome by smart farming strategies.

- Bee-keeping. Placing a bee hive in the centre of a crop field drastically increases crop yield & provides honey & beeswax that can be sold for profit. Also bees help keep elephants away as elephants are afraid of bees.
- Use of ladybugs and worms. Lady bugs help protect the crops against smaller insects & worms help aerate the soil.
- Using cow manure or plant waste to fertilize the soil.
- Planting tree belts around the crop fields helps protect the crops from winds & rains.
- Growing more than one crop in a given farmland per year not only provides variety but also helps replenish nutrients in the soil.
- Placing guard dogs such as German Shepards helps protect the farmlands against animals like rabbits & wild cattle.

Steps such as these can help reduce the use of chemicals in growing crops and help increase crop yield. Growing of crops in such a manner is called organic farming.

Radioactive wastes

The waste produced from the nuclear fission of heavy atoms such as uranium, thorium etc for the production of power is radioactive waste.

This waste is highly toxic and causes mutations and cancer. It has to be dealt with utmost caution.

The nuclear waste should be stored after heavy treatment and packed in special containers. It should be buried deep under the ground for minimum of 60 – 80 years for the waste to stabilize. Even then there is a high chance of nuclear contamination of the surrounding areas & the ground water. Failure of nuclear power plants can have disastrous consequences. The use of nuclear fuels should be avoided if possible.

Greenhouse effect and global warming

Global warming refers to the heating up of the Earth due to greenhouse effect. Greenhouse effect is caused when gases such as CO_2, CH_4 etc increase in the atmosphere & this leads to the heating up of the earth as these are good absorbers of heat. These gases prevent the excess heat from leaving the Earth's atmosphere thus resulting in greenhouse effect.

Presently the earth is $0.9^{o}C$ hotter than normal, if earth's temperature continues to rise then it could give rise to runaway global warming or the El Nino Effect. Over time this could disrupt the delicate pattern of ocean currents & give rise to another Ice Age which could be followed by mass extinction of several species and even endanger the Human Race.

Global warming can have grave consequences on the health of the planet & the biodiversity within it. Already thousands of species of flora & fauna have become extinct. The melting of ice caps will result in flooding of low lying areas; massive tsunamis; more powerful, fierce & unpredictable tornados; terrible storms & droughts etc.

Scientists predict that about 3 – 4 billion humans would lose their lives mostly from developing countries by the year 2050. Finally the resulting Ice Age would have a devastating effect on the planet.

We must control global warming to ensure that the biodiversity on Earth is conserved. The following steps can help reduce global warming:

- Use of Hydrogen fuels & reducing the dependence on fossil fuels.
- Improving the efficiency of engines & turbines can drastically reduce pollution & also help save millions of Dollars\Euros every year.

- Controlling & reducing the human population.
- Planting hundreds of trees across cities & in homes.
- Using Magnetic trains. Mag - Lev trains are faster than planes & cause very little or no pollution compared to electric trains.
- Preventing Deforestation & use of Carbon Credits.

These are some of the few ways to help protect Earth & conserve it is biodiversity.

Depletion of ozone layer

The depletion of ozone layer is one of the major contributors of cancer.

Ozone is formed in the stratosphere by the effect of UV rays on O_2. The thickness of ozone is measured in Dobson units.

The UV rays act on the CFCs to release freons that react with ozone to release pure oxygen. The freons merely act as catalysts & are not used up in the reaction. Hence the released freons have a continuous harmful effect on the ozone layer.

The CFCs released in the lower part of the atmosphere move upwards towards the south pole, hence depleting the ozone layer over Antarctica.

There are around 10 types of UV rays. Out of these the most common ones are UVa, AVb, AVc.

UV-a or black light (long wave) : It is used in tanning beds & to find counterfeit money.

UV-b (medium wave) : Absorbed by ozone layer under normal conditions. If exposed to the body, causes snow blindness, cataract, inflammation of cornea, aging of skin and skin cancer.

UV-c (short wave) : Used as a germicidal & in laboratories & in the treatment of water.

Realizing the harmful effects of CFCs an international treaty called the Montreal Protocol was signed at Montreal, Canada in 1987 (effective 1989) to control CFCs emission throughout the world.

Degradation by improper utilization & maintenance of resources

Soil erosion & Desertification: It is a result of poor maintenance of top soil. Fertile top soil takes years to form but it can easily be removed especially due to human activities such as over – cultivation, over – grazing, deforestation, poor irrigation practices, use of chemicals etc. It results in degradation of the top soil & the land becomes barren. Urbanization is also a major problem of desertification.

Water logging & soil salinity: Over irrigation especially without proper drainage leads to water logging of the soil. It also increases the salt content of the soil which heavily affects the health of plants. It is a post – green revolution problem.

Deforestation

Deforestation refers to the cutting down of trees for wood for furniture, fire wood, paper, to make cigarettes, to clear land for cultivation, due to the expansion of cities etc. Jhum cultivation is also a major contributor to deforestation in India.

Deforestation has a very harmful effect on the environment. It leads to desertification, global warming, acid rain, depletion & pollution of ground water levels, loss of biodiversity in the affected areas etc.

There are various efforts to conserve the forests.

- Hug a tree movement.
- Organizations fighting to save trees.
- In India Amrita Devi Bishnoi Wildlife Protection Award is given to individuals or organizations that show courage & dedication towards biodiversity.

There are various ways in which we can help conserve trees:

- Avoiding the use paper to read books & news.
- Reforestation
- Controlling growth of Human population & the expansion of cities.
- Forming groups and communities to fight against deforestation.
- Seeking help from governmental and non – governmental organizations for the conservation of forests.
- Creating awareness about illegal selling of forestlands to companies & rich social groups.
- Pressurizing the governments to pass laws to conserve trees & to check the deforestation caused by private companies, to limit the deforestation they cause.

Help conserve trees as they are the lungs of Earth & provide us with our most basic needs.

- **Stop Planet Earth's degradation or we'll pay the price.**
- **It is our responsibility to conserve the biodiversity on Earth.**

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