Concepts of Ecosystem

Ecosystem :

The term "ecosystem" refers to the self-sustaining network of interactions between biological communities and the physical environment (the habitat) in which they are found. Ecosystems generally refer to a specific region of the physical environment, and all the living organisms found there. By this definition, a pond can be considered an ecosystem, or a grassland, or a deciduous forest.

Ecosystem (also called, *Ecological System*) forms an essential unit of a broader branch of studies called ecology. Thus, a better understanding of ecosystem necessitates an acquaintance with the concept and principles of ecology.

Introduction to Ecology

The term ecology (derived from the Greek word *oikos*, which means 'house' or 'dwelling place') literally refers to the study of organisms in their natural environment (or the study of an organism and its environment). As the science of ecology flourished, its emphasis was progressively directed towards the interaction between organisms and their environment, rather than mere descriptions of the organism and the environment. Eugene Odum defined ecology as 'the study of the structure and function of ecosystems (or mutually interactive and stable communities).

The science of ecology can be categorized into *autecology* (study of individual organism / species) and *synecology* (study of group of organisms which are associated together as a single unit or community).The *synecology* can again be divided into aquatic or water- ecology (which includes freshwater, estuarine and marine ecologies) and terrestrial or land-ecology (which includes forest, cropland, grassland, desert, etc.). Besides, based on the level of organizations, kinds of environment, mode of study and taxonomic positions, ecology can be divided into nine more branches, namely, habitat ecology (study of different habitats of the biosphere), conservation ecology (management and preservation of natural resources), production ecology (study of estimation and maximization of productivity from different ecosystems), radiation ecology (effect of radioactive

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substance or radiation over organisms and nature), taxonomic ecology (ecology of different taxonomic groups – plant, insect, invertebrate, etc.), human ecology (study of relationship between man and environment), space ecology (study of regeneration of eosystems affected by human being), system ecology (modeling and mathematical tools in understanding the functions and structures of ecosystems) and ecosystem ecology (structural and functional analysis of ecosystem, including their relationship with biotic or physical and abiotic or biological components of the nature).

Ecology in relation to Environmental Studies

With technological advancement and subsequent explosive industrial growth, the environment has been exposed to differential stresses, as manifested in terms of pollution, deforestation, desertification, and so forth. Most of the anthropogenic (i.e. manmade) activities lead to a drastic change in the existing ecological balance, thereby resulting in a series of counter-action by nature, which threatens even the very existence of human beings. Thus, it is imperative that, for any environmental studies, the field of ecology need to be sufficiently consulted for stability of the broader sphere of human beings and their environment.

Basic Principles of Ecology

1. All organisms and the physical environment are interdependent and affect each other.

2. In an environment, alteration of any one component affects all the other components too.

3. Each organism has certain limits of tolerance towards various factors of environment and only within these limits, the organisms can survive.

4. The environment is modified by each of the organisms according to its needs and the *carrying capacity* of the environment determines the size of organism's population that can survive in that environment.

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5. The existence of life depends upon the flow of energy through food chains and on the cycling of nutrients. These processes ensure the stability of the ecosystem.

6. The nature strives for greater diversity i.e. a greater variety of organisms in a system, for her stability.

Modern Branches of Ecology

Branches	Field of specialization
Paleo - Ecology	study of the organaisms and their environment in the geological part
Plant Ecology	study of ecology with special reference to plants
Animal Ecology	study of ecology with special reference to animals (includes the study of animal behaviour under natural conditions)
Pedo - Ecology	study of soil and its influence on organisms
Eco - Geography	study of geographical distribution or organisms and their dispersal (due to interactions between the individuals and their environment)
Limnology	study of fresh water ecology, that is, study of lakes, ponds, rivers and their organisms
Marine Ecology or Oceanography	study of marine ecology, ie, study of seas, oceans and their organisms
Terrestrial Ecology	study of grassland, cropland, desert, forest, mountain, cave and tundra ecosystem
Ecosystem Ecology	study of inter-relations between organisms and their environment
Population Ecology	study of population
Production Ecology	study of the factors of environment which have a direct bearing on the functional aspects of organisms
Chemical Ecology	study of adaptions of animals, e.g., insects to particular chemical substances.
Cyto - Ecology	study of the cyto-ecological details in a species in relation to the populations in different environment
Applied Ecology	study of forestry, conservation and management of wildlife, animal husbandry, insect control, herb control, etc.
Radiation Ecology	study of effects of radioactivity on the organisms and their

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	environment.
Space Ecology	study of development of ecosystems which support human's life during high-space-flight.
Evolutionary Ecology	Study of with the problems of niche segregation and specification
Human Ecology	study of population ecology and man's relation to environment especially man affecting the biosphere and vice versa.
System Ecology	analysis and study ecosystem by use of applied mathematics, e.g.,advanced statistical techniques, mathematical modeling, etc.

Tools used for Ecological Studies:

The ecological studies can be carried out in two basic approaches – descriptive and analytical. The descriptive ecologists carry out extensive correlative study between the quantitative characteristics of organisms (as individual or as a member of community) as responded by abiotic components (such as, climatic variability, soil types, resource availability and so forth.). Bergman's rule, for instance, as advocated by the descriptive ecologists, declares that animals living towards north tend to be larger. Similarly as per Allen's rule, the extremities of organism (such as ears, legs and tails) appears to be shorter in colder climate. Rensch's rule says that as the region becomes colder, there is more accumulation of races of birds with more acuminate (tapered to a slender point) and narrow wings. Similarly, as per Gloger Rule, the same species of organisms (insects, birds and mammals) develop darker pigmentation in warm humid climates than in cool and dry climates.

Although, such rules are generally applicable, based on effect of abiotic components on specific biotic community, yet there are exceptions, which are analyzed by the analytical ecologists, using various physical, chemical, mathematical and biological techniques. Several analytic instruments (viz. chromatographs, spectrophotometers, calorimeter, analyzers, micrometers, spectroscopes, etc.), and mathematical tools (viz. correlation, regression, factor analysis, matrix analysis, modeling, simulation etc.) are employed in such pursuits. The present understanding of ecological sciences are a result of the field, laboratory and mathematical studies.

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Significance of Ecology for Mankind

Man, himself, being an important biotic component of environment, depends upon the other biotic and abiotic components of the environment, need to learn the basic principles of ecology which guides his own survival as well as which affects the sustainability of the other organisms by his action. Ecology is expected to endow man with adequate rationality to guide his action in a way non-threatening to the other creations of the nature (and thus, in turn, endangering his own existence).

* * *

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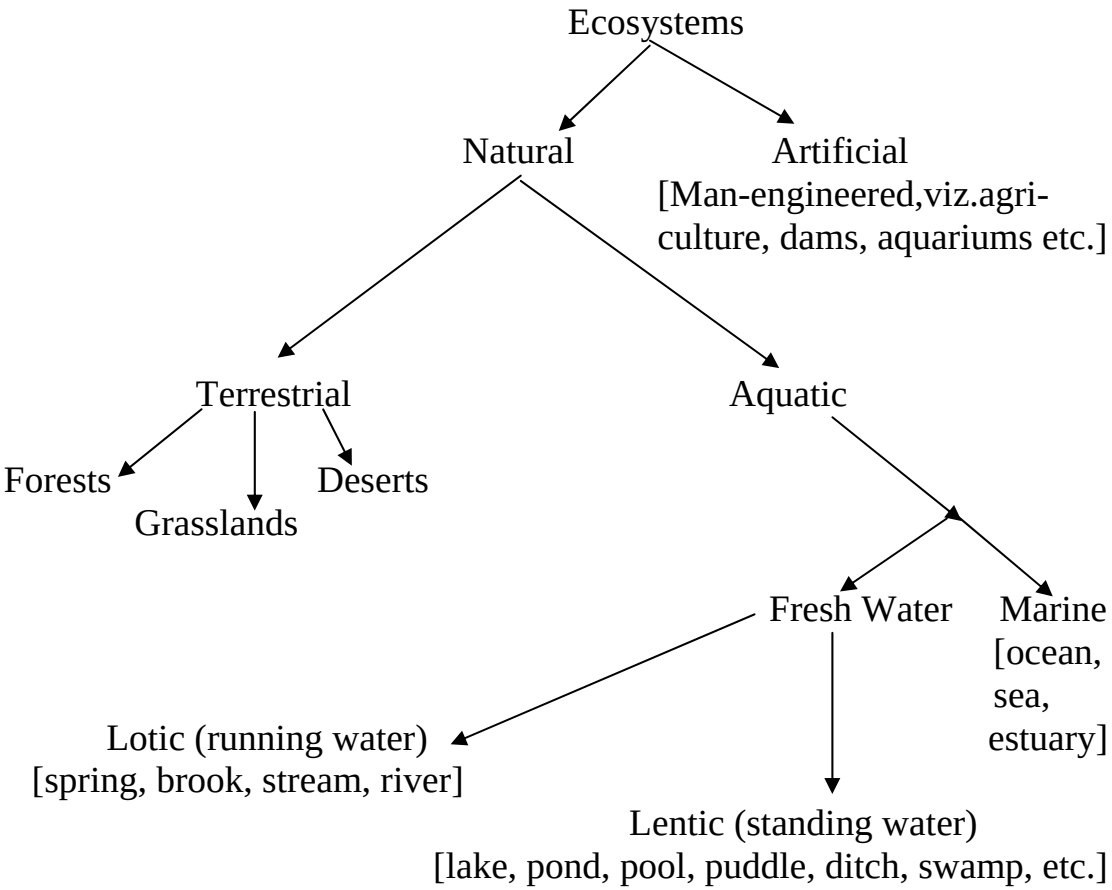
Structure and Function of an Ecosystem

Definition of Ecosystem

An ecological unit that includes all organisms which interact among themselves and with the physical environment with a well-defined nutritional relationship, biotic diversity and material exchange (cycle) in the system is called 'Ecological System' or 'Ecosystem'.

The term ecosystem was coined by A.G. Tansley in the year 1935. As per the above-mentioned definition the earth constitute the biggest ecosystem (called, biosphere). But, for the sake of convenience in handling and understanding, the biosphere is studied as a combination of a set of artificially delineated smaller ecosystems based on specific physico-climatic regime (viz. terrestrial and aquatic, and their further subdivisions, see figure).



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Structure of an Ecosystem

An ecosystem has two components :

1. abiotic (non-living) component
2. biotic (living) component

Abiotic Components

This includes three components :

1. Climatic Conditions - Air, Water, Soil, Temperature, Light (both intensity and duration), humidity, pH, etc.
2. Inorganic Substances – Water, Carbon, Nitrogen, Sulphur, Phosphorous, etc. (help in cycling nutrients in ecosystem)
3. Organic / Biochemical Substances – Protein, Carbohydrate, Lipids, humic substances, etc. (link the biotic and abiotic components of the ecosystem)

Biotic / Living Components

The living organisms of an ecosystem can be divided into various trophic (i.e., nutritional levels), such as,

(a) Autotrophic Components (Auto = Self; Trophic = Nourishing) : The living entities which utilizes solar energy to form complex organics (such as carbohydrate, protein, lipid etc.). They can be of two types – PHOTOAUTOTROPHS (organisms with photosynthetic pigments, called chlorophyll, which employs solar energy; examples: trees, algae, phytoplanktons) and CHEMOAUTOTROPHS (organisms which use energy in oxidation-reduction process, play a much lower role as producer than the photoautotrophs; examples: sulphur bacteria, Beggiatoa, etc.)

(b) Heterotrophic Components (Hetero = Other) : Also called consumer, these are the organisms that survive by consuming the autotrophs. These are of two types : MACROCONSUMERS or PHAGOTROPHS (animals who consume other organisms or organic matters; these can be either plant-eaters, called **herbivores** or **primary consumers**, or flesh-eaters, called **carnivores**, which may again include two more categories, i.e., **secondary consumer** or **tertiary consumers**, depending on whether they consume on primary

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consumers and secondary consumers, respectively. This group also includes **omnivores** or all-eaters, both plants and animals); MICROCONSUMERS or DECOMPOSERS or REDUCERS or SAPROTROPHS (sapro = decompose) or OSMOTROPHS (osmo = to pass through a membrane) or SCAVENGERS (animals which cause breaking down of complex organics or organisms and releases the inorganic nutrients in the environment, thus enabling the autotrophs to utilize them again; examples: microorganisms, viz. bacteria, actinomycetes, fungi etc. and invertebrates, viz. protozoa, oligochaeta like earthworm etc.)

The organisms responsible for disintegration of dead organic matter, called, organic detritus (Deterere = to wear away), are known as **detritivores** (=decomposers).

Function of an Ecosystem

The function of an ecosystem can be viewed in terms of the dynamics of energy and nutrients. The main principle behind these equilibrium are the flow of energy in ecosystem and the cycling of nutrients. The physicochemical environment and the biotic communities form the heart of dynamics of ecosystem.

Productivity of Ecosystem :
This refers to rate of production or the rate of organic matter accumulated in any unit time. This can be expressed in three ways :

1. Primary Productivity : This is defined as the rate of storage of the radiant energy by the producer, due to photosynthesis and chemosynthesis. This is again of two types:
   (i) Gross Primary Productivity : It is the total rate of photosynthesis, which includes the utilization of organic matter in photosynthesis during the measurement period, and is dependent on the chlorophyll content. It is expressed as chlorophyll content/dry weight in gm/area (chl/g/cm^2) or photosynthetic number (amount of CO_2 fixed/g chl / hour)

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(ii) Net Primary Productivity : It is the rate of storage of organic matter in plant tissues in excess of the amount utilized in respiration by it during the measurement period.

The methods used for measurements of primary productivity are: harvest method, oxygen measurement method, oxygen diurnal curve method, carbon dioxide measurement method, aerodynamic method, pH method, radioactive mthod and chlorophyll estimation method.

2. Secondary Productivity : This refers to the rate of storage of energy at the level of consumers (i.e. herbivores, carnivores, decomposers). This remains mobile, moving from one organism to other, and does not sat *in situ*, unlike primary productivity.

3. Net Productivity : This is defined as the rate of storage of organic matter, which is remained in an ecosystem after the consumption of the consumers.

   Net Productivity (during the unit period as a season or year) = Net Primary Production – Consumption by heterotrophs

Flow of Energy in an Ecosystem :

An ecosystem is open with respect to energy, indicating that it is sustained by distinct supply of energy from the surrounding through its organic component. In fact, energy flows through feeding (or ***trophic***) levels of an ecosystem

The linear pattern of consumption of a living organism or being consumed by another living organism is called a **food chain**, and all food chains start with producer. **Trophic level** of an organism refers to the position of the living organism in the food chain. The energy flows from one trophic level to the other in a succession.

For most ecosystems, energy flow begins with light energy from the sun The primary ***producers*** (plants and certain bacteria) use photosynthesis to harvest solar energy (but only about 2% of the total) and pass it along to ***consumers*** (the herbivores) then to ***secondary consumers*** (carnivores) to ***tertiary consumers*** (carnivores that eat other carnivores--e.g. Great White Sharks, weasels, Indigo snakes). Most ecosystems have only four

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trophic levels, and the top carnivores are very rare. All the leftovers are consumed by ***detritivores*** (the decomposers). Some ecosystems get their energy from sources other than the sun (e.g. deep-sea thermal vent ecosystems) using ***chemosynthesis*.**

The primary producers utilize the radiant energy of sun to form chemical energy in organic molecules of their body (such as, carbohydrates, proteins and fats). Herbivores, in turn, during their consumption of the plants, oxidizes these organic molecules to release the energy trapped by the producer. But a major part of the energy thus released is utilized by the herbivore in inefficiency, heat and for their own survival (i.e., respiration for constitution of their own cellular matter), thus resulting a smaller portion of the energy available as useful energy. If the carnivore consumes the herbivores, the available energy is further reduced on account of the same causes as in the case of the herbivores (i.e., for self-maintenance and as heat). Since, with successive increase in the trophic level the available energy reduces, in any food chain the maximum number of steps is limited to four or five.

In fact, at each trophic level, the amount of organic material (the ***biomass***) is approximately one-tenth of that in the level below it. This means that one pound of hamburger actually requires 10 pounds of grain to produce, and if a person subsisted entirely on a carnivore diet, it would take nearly 100 pounds of grain to support each pound of body weight. This explains why top carnivores in an ecosystem are so rare. The shape of the "***trophic pyramid***" also has important implications for the concentration of environmental toxins when they are introduced into an ecosystem. The toxin becomes more and more concentrated as it moves up the food chain, reaching its highest concentrations in organisms at the top of the trophic pyramid This phenomenon is refered to as "***biomagnification.***"

FOOD CHAINS AND FOOD WEBS – EXAMPLES & IMPORTANCE

A typical food chain of an Indian river is:

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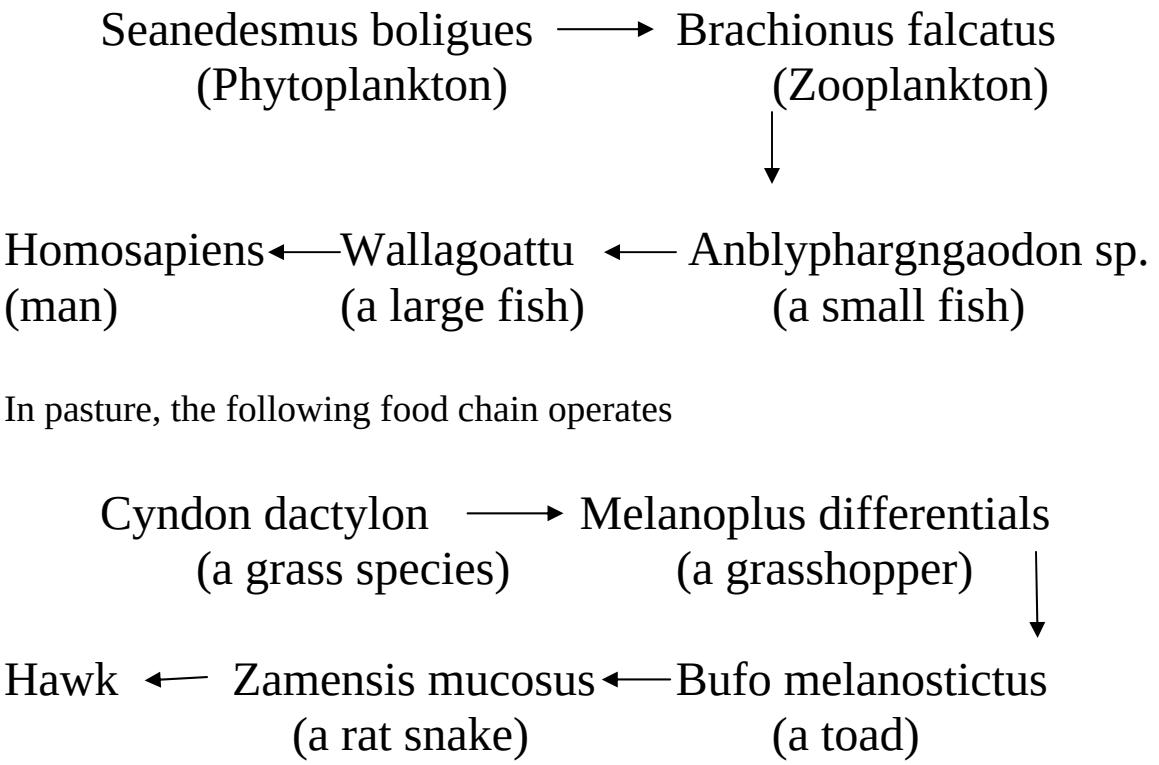

In pasture, the following food chain operates

Basically two types of food chains are recognized

1. Grazing food chain
2. Detritus food chain

1. Grazing Food Chain

Start from living green plants, goes to grazing herbivores and on to the carnivores.

- Directly dependent on an influx of solar radiation.
- Most of the ecosystem in nature follow this type of food chain.

2. Detritus Food Chain

The organic waste, exudates and dead matter derived from the grazing food chain are termed detritus.This is an important component in the energy flow of an ecosystem. In fact, more energy flow thro' the detritus than thro' the grazing.

Important organisms present in this chain include : Algae, bacteria, slime molds, actinomycetes fungi, protozoa, insects, etc.

Significance of food chain

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understand the feeding relationships and the interaction between organisms in any ecosystem.
to appreciate the energy flow mechanism and matter circulation in ecosystem
understand the movement or toxic substance in the ecosystem and the problem of biological magnification.

FOOD WEBS

In an ecosystem various food chains are linked together and intersect each other to form a complex network called **food web**.This network of feeding relationships in an ecosystem can be very complex. Human interference in these complex interactions can often have unforeseen circumstances. For example, a DDT spraying with an intention to control mosquitoes can be reduced the incidence of malaria, a mosquito-carried disease, when instead, the DDT was passed through the food web and ultimately magnified in the predators found in the ecosystem, leading to a decline in their numbers. In general, webs are not not too complex with more and more species involved, except in insects and carnivores.

Complex food web, one can recognize several different trophic levels.

1. Producers :	Greenplants	(1st trophic level)
2. Primary Consumers:	Herbivores	(2nd trophic level)
3. Secondary Consumers:	Carnivores, Insectivores	(3rd trophic level)
4. Tertiary Consumers:	Higher Carnivores insect hyper parasites	(4th trophic level)

The complexity of food web can very greatly, and we express this complexity by a measure called connectance of the food web.

$$\text{Connectance} = \frac{\text{Actual number of interspecific interactions}}{\text{Potential number of interspecific interactions}}$$

Ecological Pyramids

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In food chain some energy in lost as heat and respiration in each transformation the steps become progressively smaller near the top is called ecological pyramid. This represent the trophic structures and also trophic function. In many pyramids, producer from the base and the successive trophic level make up the apex. The terrestrial and shallow water ecosystem contain a lesser sloping pyramids because here producers remain large.

Types of Ecological Pyramids

a) Pyramid of Number

It depicts the number of individual organisms at different trophic levels or food chain, where number of organism present in the lower end form the base. This ignores the biomass of organisms, as well as the energy transferred by the groups involved. A lake ecosystem forms a typical example of pyramid of number. A detritus food chain forms an inverted pyramid of number.

2. Pyramid of Biomass

It expresses the biomass of the members or the food chain present at any one time, thus resulting in a pyramid structure, indicating decrease of biomass in each trophical level from base to apex. Usually, the total biomass of the producers ingested by herbivores is more than the total biomass of the herbivores in ecosystem and total biomass of the primary carnivores is less than the biomass of the herbivores. However, the pyramids of aquatic systems is inverted (due to their rapid growth and short life-cycle)

3. Pyramid of Energy

The pyramid is mainly considered in terms of energy and indicates not only the amount of energy flow but actual role, the various organism play in the transfer of energy. It is constructed in the quantity of organisms produced per unit time. Pyramids of energy are always slopping because less energy is transferred from each level than was paid into it.

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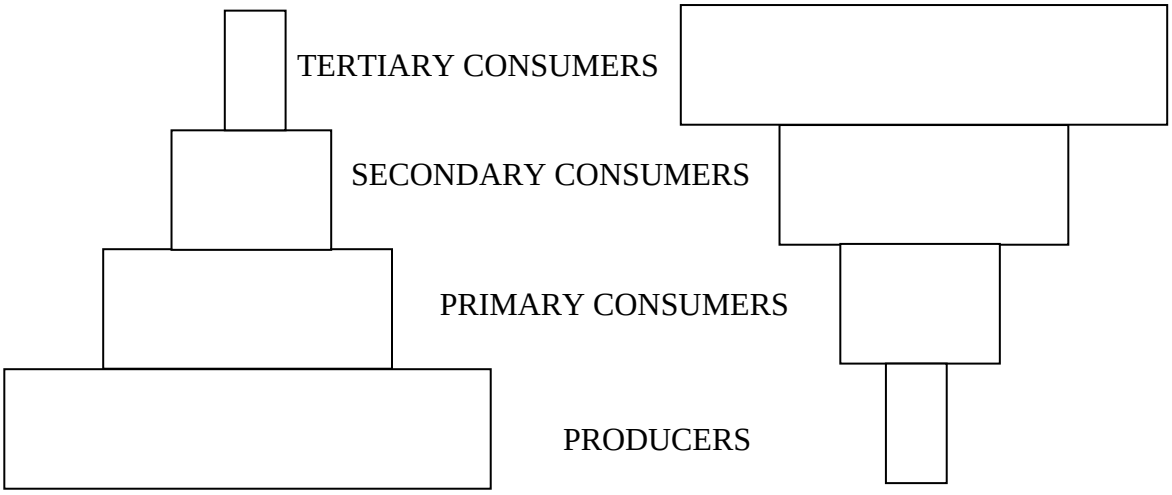

[NORMAL] Ecological Pyramids [INVERTED]

Nutrient (Biogeochemical) Cycles in an Ecosystem

An ecosystem is mostly close with respect to the nutrients, i.e., most of the nutrients are conserved in the ecosystem itself. In few cases, however, for example in running water ecosystem (called, lotic ecosystem), although, there is a constant flux of nutrients, yet the ecosystem maintain a dynamic equilibrium. The nutrients or abiotic components of an ecosystem include water, nitrogen, carbon, potassium, sulfur, phosphorus, etc. Four especially critical examples are presented below.

- **Water** cycle -- The availability of water is one of the key factors in determining the richness of an ecosystem. There are two parts to the water cycle -- environmental water cycle and the organismic water cycle. The organismic water cycle involves uptake of water by plants and then loss by transpiration. The transpired water loss from the plants in a tropical rainforest is the main source of local rainfall. Destruction of the rainforest can alter the local weather conditions and create semi-arid deserts. Groundwater (water beneath the surface) is an important source for human populations. Large reservoirs of groundwater are called aquifers, and when they become polluted it is virtually impossible to remove the pollutants.

- **Carbon** cycle -- atmospheric carbon dioxide (~0.03%) "fixed" by plants in photosynthesis. Fixed carbon (e.g. sugars & carbohydrates) is then either passed along through the trophic levels, or it ends up as fossil fuel. Burning

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of fossil fuel increases levels of carbon dioxide in the atmosphere (25% increase over the past 100 years), potentially enhancing the greenhouse effect.

- **Nitrogen** cycle--nitrogen is an essential componenent of the amino acids in proteins. However, it cannot be used directly by living organisms in the gaseous form, but must instead be "fixed" into nitrates by the nitrogen-fixing bacteria. Nitrogen is a critical resource for terrestrial plants, and primary productivity is often limited by nitrogen availability. Leguminous crops (beans, alfalfa, clover) have nitrogen-fixing bacteria in their root nodules and can increase the amount of fixed nitrogen in a field. Crop rotation takes advantage of this capacity. However, most large farms used industrially prepared fixed nitrogen, often at great expense.
- **Phosphorus** cycles -- phosphorus is often a limiting nutrient for plant growth. When it is dumped into ponds or streams (as it has for the past 300 years in Connecticut due to runoff from fertilized fields) the potential is there for an explosion of algal growth (an algal "bloom"). These can be prevented if the phosphorus is kept on the bottom of ponds. "Thermal stratification" in lakes-- warm water at the surface, cold water at the bottom -- has the effect of holding the phosphorus at the bottom of the lake where algae can't use it. However, hot weather, heavy rains, and strong winds can undo the thermal stratification, releasing phosphorus at the surface, leading to dense "blooms" of plant growth. Phosphorus can also be brought to the surface by cosmetic fountains and sprinklers, with the unintentional consequence of creating algal blooms.

Conclusions :

The ecosystem, as explained in the preceding paragraphs forms, a sound structural and functional unit for stability of the living planet, with their mutual interaction. The anthropogenic activities must be directed in a way so as to cause minimum disruption of the ecosystem, for a sustainable development.

* * *

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Primary Ecosystems : Structure and Function

Earth as a Biosphere

Global weather patterns

- **Temperature** driven by **angle of incidence of solar radiation** (e.g. winter versus summer) and adiabatic cooling along an elevational gradient. Air cools as it rises due to work required for expansion. These explain the two major gradients in global temperature -- latitude and altitude.

- **Atmospheric circulation** -- warm air rises at the equator, descends at 30 degrees and 60 degrees latititude north and south. This creates, through the **coriolis effect,** the trade winds between 30 degrees and the equator, and the westerlies between 30 degrees and 60 degrees. It also results in the distribution of the world's great deserts (Atacama, Mojave, Khalahari, Sahara, Australian interior desert) at or near 30 degrees latitude north and south.
- **Oceanic currents** are created by wind blowing over the ocean. **El Nino** is a "backward" flow of warm water from the south Pacific toward South America that can have a dramatic effect on global weather and biological communities.

Biomes refer to unique associations of vegetation types and climatic conditions found at various localities around the globe. Biomes are variously classified by different ecologists. Some widely recognized examples include:

- **Temperate forests**--These forest are dominated by broadleaf deciduous trees (trees that lose their leaves during the winter), with warm summers and cold winters. The forests of Connecticut are included in this biome.

- **Northern Coniferous Forests**- The taiga-Cold snowy winters and short summers, coupled with forests that are dominated by conifers like pine, fir, spruce, and hemlock. This biome stretches across much of Canada, Northern Europe and Asia.
- **Deserts**--Areas that receive less than 10 inches of rain per year. Plants include catci, "succlents", etc. Most of the great deserts of the world occur at 30 degrees latitude North and South. This is due to cool, dry winds blowing in off the ocean (due to coriolis effect) across a warm land mass.

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- **Grasslands**--Receive 75-150 cm rainfall per year. Economically the most important biome.
- **Tropical rainforests** receive 80 to 160 inches of rain per year and have an average temperature of 77^{o} F. Enormous biological diversity, rapidly being destroyed.
- **Tundra**--Surface soil is frozen all year except for 6-8 weeks during the summer. Below surface is permafrost, frozen all year. Lichen, grasses, and small shrubs dominate.

The **marine biome** is characterized by relatively high concentrations of dissolved salts (about 3.5% in most situations), mostly sodium chloride (table salt). The marine biome is the largest, covering more than 70% of the earth's surface. It consists of the following recognized habitats.

- **Estuaries**-Regions where fresh water enters the marine habitat, sometimes used to describe collectively any body of water surrounded by land with open connection to sea water. Estuaries often have a "salt wedge" in which light fresh water flows over a "wedge" of heavy salt water at the point of entry. There is a wide range of salinites, depending on tides and wate flow. Estuaries are nutrient rich and very fertile. They serve as the breeding ground for many invertebrates and some fish.

- **Continental shelf**--Up to several hundred meters deep, usually containing fertile area of upwellings in which nutrients are brought from the bottom to the surface. The **benthic** zone is the bottom of the marine habitat.
- **Open ocean**--The water column is refered as the "**pelagic** zone," with the deepest parts described as the "abyssal plain." The zone in which enough sunlight penetrates for photosynthesis to occur is called the **euphotic** zone, usually about 200 meters deep. This is the least productive of marine habitats, due to lack of nutrients and very small planktonic organisms in warmer waters. Often called the "deserts" of the ocean.
- **Coral reefs**--Found in the warm ocean waters (temp> 21 C), but too high is also bad. At high temperatures the amount of oxygen produced by the symbiotic photosynthetic organisms becomes toxic to the coral animals. Coral bleaching is a recent phenomenon, the cause of which is not clear, although it appears to be related to high temperatures. Most reefs are found between 5-15 degrees latitude north and south. The reefs are contructed by mutualistic cnidarians in association with photosynthetic protists. The calsium in the coral is secreted by the coral animals. Reefs are among the most complex and diverse biological communities in the world. Fish that live in the reefs are adapted to habitats that require precise control over

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movement, versus the premium on speed and stream-lining found in pelagic fish.

- **Ocean edges**--The **littoral**, or intertidal zone may be sandy, rocky, or muddy. In all cases, exposes organisms to extremes of salinity and desiccation.

Biomes are different to ecosystem which is a natural unit of living and non-living components that interact to form a stable system in which the exchange of materials following a circular paths. So an ecosystem might be a small pond or a large area coextensive with a biome. Each biome the kind of climax vegetation in uniform grasses, conifers, deciduous trees – but the particular species of plant may vary in different parts of the biome.

There is no sharp line of demarcation between biomes. A transition zone will be there (Tundra and Coniferous forests). Such broad transition zone is ecotone.

Primary Ecosystems

The different biomes, as outlined above, are characterized with respect to distinctive habitats, with specific combination of biotic and abiotic components, maintaining a definite characteristic signatures. Although the ecosystems form the components of the biomes, both structurally and functionally, yet many a times large ecosystems are considered to be biomes. Principal ecosystems or biomes can be broadly divided into two categories, AQUATIC and TERRESTRIAL.

AQUATIC ECOSYSTEMS

Aquatic ecosystems are either freshwater (stagnant or lentic : ponds and lakes; mobile or lotic: streams and rivers) or marine (estuaries and oceans).

1. Lentic Ecosystem

Standing water bodies, with least current and wave effects, low turbulence (mixing), with a tendency for seasonal thermal stratification. The degree of turbidity determines the penetration of light and thus the degree of

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photosynthesis and productivity. The gradation of oxygen, light and temperature profoundly influences the lives in this ecosystems, their distribution and adaptation.

Ponds and Lakes

These are results of glacial erosions and deposition or a combination of both. Although both ponds and lakes are stagnant water bodies (commonly called LENTIC ECOSYSTEMS), yet a pond is a relatively small reservoir of water, mostly manmade, whereas a lake is often referred to a large body of natural water.

In these systems, the organisms those depend on substratum (or support) are called pedonic forms whereas those which are free from substratum are the limnetic forms.

The aquatic organisms sustaining in these ecosystems are classified as follows:

(1) Neuston – unattached organisms – live at air water interface – include floating points an animals – animals that spent their time on the top of the air-water interface are epineuston while others hyponeuston.

(2) Plankton – moving rivers controlled by currents – very small plants which can more fast, more active known as nektoplankton.

(3) Nekton – swimmers – 2 mm long – too larger size like blue whale.

(4) Benthos – bottom moving – the group living above the sediment-water interface are known as benthic epifauna whereas those living in the sediments known as infauna.

Biota :

Neustons of lentic aquatic environment -free floating by hydrophytes such as *Wolffia, Lemna, Spirodella, Azolla, Salvinia, Pisti and Eichhorni*

Biota of limnetic zone – region of rapid variation in water level, temperature and oxygen..

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Macrobiotus, Rotaria, Philodina, Volvox, Euglena

Biota of profundal zone – the deep life consists of bacteria, fungi, blood worms and other small animals living little light and low oxygen.

Benthos of lake bottom – in young lakes may of the original rock – several species of insect larva – small mosquito such as midges, burrowing mayflies, calms, snails.

Productivity of a lake

This depends on the availability of oxygen and nutrients in the littoral zone.In the pelagic zone, these are exceedingly uneven, although in epilimnion zone well oxygenated nutrients, highly valuable, it controls the rate of productivity.The amount of product is determined by the amount of detritus reaching to it.Here, the production and oxygen remain inversely proportional.

The oligotrophic lakes has no production, no the oxygen is well saturated. It shows an orthograde oxygen curve where as eutrophic lake. It is other way, namoclane oxygen.

2. Estuary

An estuary (Aestus = Tide) is the wide lower tidal part of a river which is strongly affected by tidal action. It consists of a very complex system of *current and salinity*. Salinity varies vertically and horizontally (from 0.5-0.35 per cent) and in a day it varies to the level of 1-10.*Temperature* fluctuates diurnally and seasonally.

Classification:

A. On the basis of geomorphology

1. drowned river valleys
2. ford-type estuaries
3. bar-built estuaries
4. estuaries produced by tectonic processes
5. river delta estuaries

B. Based on water circulation and stratification

1. highly stratified or salt-wedge estuaries
2. partially mixed stratified estuaries

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3. completely mixed estuaries
4. hyper-saline estuaries

C. On the basis of energetic

1. physically stressed systems of wide latitudinal range
2. natural arctic ecosystem with ice stress
3. natural temperate ecosystems
4. natural tropical coastal ecosystems of high diversity
5. emerging new systems associated with man.

Biota:

The animals moving in the estuary is classified oligohaline (0.5 to 5 per cent), mesohaline (5 to 18 per cent), polyhaline (18 to 25 per cent) and euhaline (30 to 50 per cent). Transitional zone between the freshwaters and seas:

Synedra,Navicula,Rhizostoma,Fragilaria,Asteriobella,Biddulphia,Planktoniella,Hemidiscus,Chaetoceros,Cyclotella,Stephanodiscus,Triceratium, Zygonema,Pandorina,Volvox,Chlorella,Spartina,Salicornia,Scirpus,Cladophora,Chara,Enteromorpha

The estuarine animal communities include:

Arcella,Difflugia, Vorticella, Branchionus, Keratella, Asplanchna, Diaptomus, Pseudodiaptomus,Cyclops

3. Lotic Ecosystem

This refers to running or moving water. They are variables ranging in size. e.g. Ganga, Yamuna, Cauvery, Mahanadi, etc.These vary widely in length and most of the abiotic factors can be observed in them.

Characteristics of Lotic Environment

These ecosystems differ in three major aspects from lentic ecosystems :

- current is a controlling and limiting factor
- land – water interchange is maximum due to less depth and more movement
- temperature extremes are greater than standing water

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These scosystems are related to the motion of the water, i.e., rate of flow (m^3/sec) and stream velocity (m/sec).Based on the rate of flow it can be divided as laminar flow (mutually parallel movement of water particles) or turbulent flow (highly irregular movement of water particles)

Lotic environment is divided into two ecosystems depending upon the velocity and rate of flow

1. Rapidly flowing water
2. Slowly flowing water

1. Rapidly flowing water

a. Plant inhabiting terrestrial form

- live among the mosses and flowing plant
- animals possess hook-like structure

b. Rock inhabitant form

- live on the tops of exposed rock and they have an efficient mechaism for staying in group. Otherwise they will be swept away. E.g. Caddish fish

c. Inhabitant form of spaces between rock
- live in the spaces between the rock. E.g. mayfly prawn

d. Inhabitant occurring beneath rock
- Flatworm, some snails, etc., live beneath rock

2. Slowly flowing water

It is very different from fast stream., where the erosive power is greatly reduced, with higher depositional environment and higher temperature. Planktonic organisms occur in large number in this ecosystem (such as : sphaenius, chironomus)

Terrestrial Ecosystem

It is much complex than aquatic system. It is activated by three factors. In other words, it is a three-phase system (1) atmosphere and

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climate, (2) the soil and (3) the biotic community, in contrast to single phase (water) characteristics in case of aquatic ecosystem. The atmospheric oxygen (O2) and carbon dioxide (CO2) are essential for plants and air provides a medium of support (mixing).Organism needs more strong support to live on land strong skeleton.Climate is much variable than in the case of aquatic systems as indicated by a wide interrelationship between temperature and water, resulting in variability in annual temperature, rainfall and their fluctuations (both degree and time) and potential evapotranspiration.
The behaviour of temperature is much more variable in land than water. Aquatic system is heated by absorption of radiation and water has a high specific heat, whereas in terrestrial system, heat is by absorption by soil, rock and vegetation whose specific heat is much low. Heat gained lost rapidly by terrestrial ecosystem resulting in wide fluctuations of temperatures both diurnally and seasonally.

Here soil support for living organisms, yields a source of nutrients except C, O2, H2, provides a site of entire detritus food and forms a center of biogeochemical cycle. Productivity of terrestrial ecosystem tied to soil chemistry unlike aquatic, here the plants leave a mark by its role in weathering cycle. Here, the succession is entirely carried out by the organisms of the system only, whereas in aquatic ecosystem, washed out materials dump plays major role in succession (example: lake eutrophication).

TERRESTRIAL ECOSYSTEMS

1. Forest Ecosystem

This ecosystem includes a complex assemblage of different kind of biotic communities. Optimum conditions of temperature and ground moisture (and rainfall) determines the establishment this ecosystem, whereas its distribution and abundance is determined by the soil, wind and air current. The forest communities, commonly studied by ecologists, based on their behaviour with season as evergreen (presence of leaves thoughout the year), deciduous (seasonal fall of leaves) and their shape as broad-leaved (temperate forests) and needle-like-leaved (coniferous forest). The major types of forest ecosytems are : coniferous, tropical and temperate (arranged on a

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gradient from poles to equator or from high latitude to low, respectively).

CONIFEROUS:

Also called taiga, these are cold regions with high rainfall and strong seasonal climates (with long winter and short summer), this ecosystem is observed across the border of North America and Eurosia (just south of tundra). The predominant plants are evergreen, such as Picea glauca (spruce), Abies balsamea (fir) and Pinus resinosa (pines). The common organisms in this ecosystem are animals such as shoe hare, lynx, wolf, bear, red fox, porcupines, squirrels, amphibians, etc. and several large species of birds.. Species diversity is low and plant species are mostly pure.

The soil is mostly thin podozol (acidic and mineral deficient) and poor, due to slow weathering and slow decay of litter due to cold climate. The productivity is poor.

TEMPERATE DECIDUOUS:

Characterized by moderate climate and broad-leaved deciduous trees, which shade their leaves in winter, with fresh growth of foliage during spring. Commonly found in North America, Europe, Eastern Asia, Chile and parts of Australia and Japan. Winter is cold with an annual rainfall of 75-150cm and a temperature of 10-20 0C. Precipitation is found throughout the year uniformly and is found above 9000-12000 feet elevations in India.

Soil in this area are podzolic and fairly deep. Trees are tall (40-50m) with thin and broad leaves. The predominant genera of this ecosystem are :Maple (Acer), Beech (Fagus),Oak (Quercus), Hickory (Carya), Basswood (Tilia), Chestnut (Castnea), Cottonwood (Populas), Sycamore (Platanus), Elm (Ulmus), Willow (Salix),White pine (Pinus strubos), Hemlock (Tsuga Canadensis), Red cedar (Juniperus virginianus)

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TEMPERATE EVERGREEN

Mediterraean type forests, with warm and dry summer and cool and moist winter, these are inhabitated by low evergreen trees with small hard needles, slightly broader leaves. These are found in North America – Chaparral of the Pacific coast, Mediterranean – maquis, Spain – encinar, Australia – melle scrab. Here trees are generally lacking and shrub are of 3 to 4 m in height.

Fire is an important factor in the systems, yet the plants are capable of regenerating quickly.Species diversity is intermediate between temperate deciduous and dry grassland.Characteristics animals are mule deer, brush rabbits, wood rats, chipmunks, lizards wem-tits and brown towhees.

TEMPERATURE RAINFORESTS

A colder ecosystem, separate seasons, temperature and rainfall varying throughout the year. High rainfall, diversity much less, the dominant trees (canopies) are coast redwood (Sequoia sempervirens) of the Pacific coast of North America and the alpine ash (Eucalyptus regnans) of Australia and Tasmania.

TROPICAL RAINFORESTS

Found near the equator, with both high temperature and high humidity. Rainfall ranges from 200-225 cm per year and distributed evenly throughout the year.

Flora are highly diversified with above 300 different trees, with extremely dense vegetation, with vertical stratification (vines, creepers, lianas, epiphytic orchids and bromeliads). All plants evergreen, with tall trees (25-35m) and continuous evergreen carpet below. The invertebrate density and abundance is high, more than any other ecosystem, which include worms, snails, millipedes, centipedes, scorpions, isopods, spiders, insects, plantarians and leeches.

Soil is red latosols with diverse vertebrates populations, such as, Kangaroo (Dendrolagus sp.), Tiger (Panthera tigris), Elephant (Elephas maximus), Samber deer (Rusa unicolor), Muntjac (Muntiacus muntjak), Gaur (Bibos gaurus), Spotted deer (Axis axis) and Swamp deer (Rucervus duraucelli)

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TROPICAL SEASONAL FORESTS

Very high rainfall but segregated into wet and dry periods, the are of location being Southeast Asia, Central and South America, Northern Australia, Western Africa, Tropical islands of the Pacific as well as India and Southeast Asia.

It is known as monsoon forest, with annual precipitation several times higher than that of the tropical rain forests. The trees reach over a height of 40 m, commonly 20-30m. Stratification is simple with tree-layers, with deciduous canopy and evergreen understory. Teak and bamboo are the major large tree in tropical rain forests.

SUBTROPICAL RAINFORESTS

This ecosystem is known to have high rainfall and less marked difference in temperatures, and is found in Florida. Broadly evergreen plants, such as ferns, vines and strangler fig (Ficus aureus) are found, with simple stratification (with only one understory tree horizon). Animal lives are similar to that of tropical rainforests.

2. Grassland Ecosystems

These occupy 20 % of earth's surfaceand are of three types:
Tropical Grasslands (at 200 away from equator,ex. Africa, rainfall 40-100cm/yr, grasses of height 1.5-3.5m)
Temperate Grasslands(in Europe, Asia and North America, annual rainfall 25-75 cm/yr)
Alpine Grassland(in Higher latitude, medow-type, with many flowering herbs)

TROPICAL SAVANNA BIOMES

Scattered grasslands, drought resistant trees, not more than 10 m height and without any canopy, this ecosystem is found in Eastern Africa with rich diversity of grazing mammals and also in Australia, South America and Asia.Good rain from May to October (130 cm rainfall per annum) is observed, with more than 90% during rainy season. The soil is latosol type, and mostly leaching. The zone often

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undergoes wild fire and destruction of species. So, species diversity is much low. Evergreen dessication, hard resistant, grass goes to 2m.
Giant animals are : antelopes, giraffes, elephant, buffalo and lions. Besides, grasshopper and termites are encountered in large numbers.

GRASSLAND BIOMES

Found in Steppes of Eurasia veldt of Africa and Pampas of South America (Argentina), the ecosystem is marked by 25-75 cm rainfall per year, not enough to support a forest, showing a pronounced seasonality of grassland. Soil is rich and fertile black earth. Grasses are found to be as tall as 5m. However in prairies, arid grassland of North America, the grasses are short, with lack of trees. These are good pasture for grazing animals. The typical animals tend to be quite small, with few exceptions (horse, zebra and antelopes)

Major fauna include :Blue stern (Andropogon), Buffalo grass (Buchole dactyloides),Wild horse,Ass, Saiga antelope,Rabbits,Kangaroo and Grasshoppers,Crickets, Locusts-(Locusta migratoria, Schistocerca gregaria and Melanoplus sp.)

3. Desert Ecosystem

These are the driest ecosystem. They are of two types :
Hot deserts and Cold deserts. The hot deserts are situated in the zone of cancer and capricon, example :Sahara-Arabia-Gobi, Sind-Rajasthan, South America, Chile, North America and Australia. The cold deserts are found in higher altitudes, example: Ladakh in Himalayas, Tibet, Bolivia Artic. Both hot and cold deserts are succulent by plant population like cactus, palo verde trees, creosote bush.Many cold deserts are commonly occupied with sage bush.Temperature –variation in day and nights is too high, with low humidity and high insolation.

The common organisms found in the deserts are :Acacias,Euphorbias,Cacti,Prickly pears,Galeodes grant,Gryllus domesticus,Forficulid Labidura ripara,Tenebrionid bettle Akis spinosa,Centipede Scolopendra clavipes,Rat, Pocket mouse,Ostrich.

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The reptiles, insects and burrowing rodents, due to their special morphological, physiological and ethological adaptation are found to well sustain in the deserts, as much as the water-reserve xerophytes.

CONCLUSION :

The nature is provided with a wide range of physio-climatic regimes, and the floras and faunas compatible to them, and their congregation make the giant biome earth sustained. Although the individual ecosystems are well studied, yet the interaction between them are yet to be explored.

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Basic Definitions in Ecology

Adaptation:It is the process of adjustment of an organism in particular set of habitat conditions.
Arid Zone : A zone of very low rainfall with most of the deserts
Atmosphere: The gaseous envelope surrounding a planet.
Autecology : Ecology of individual organism of species
Benthos : Organisms living on or at the bottom of a water body
Biodegradation : Oxidative break down of synthetic natural organic substance by microbial activity
Biogeochemical Cycle : Pathways of circulation of elements within an ecosystem.
Biomass;living matter of living organisms in terms of weight,present at any given time in the environment.
Biome:A major ecological community of organisms maintained under aparticular climate zone.
Biosphere : The planet earth along with the living organisms and atmosphere, which sustains life.
Biota:The flora and fauna of an area.
Biotic and Abiotic :living and nonliving
Canopy : The leafy portion of a shrub or a tree
Carnivore : The animal which feed on the flesh of other animal.
Carrying Capacity : The maximum number of individuals that a habitats or its resources can support.
Climax:The final,stable community that maintains itself for over longer period in equlibrium with the prevailing environmental conditions,this stage is known as climax.
Community : A naturally occuring group of organisms living in common environment.
Community:It is a group of population of different species in a given area.
Crust : Outer envelope of the earth surface.
Detritus : The dead organic matter mainly of fallen leaves as leaf-litter in a forest. (Detritivores : The microbes decomposing detritus)
Ecological niche:It is the physical space occupied by an organisam and also itsfunctional role in the community.
Ecosystem: Ecological system formed by interaction of coacting organisms and their environment.

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Ecosystem:plants, animals and microorganisms live together with the environment is called ecosystem.
Ecotone:Atransition zone between two adjecent biomes,containing some organisms from adjacent biomes and some characterstic ones restricted to the zone itself.
Endemic : A group of organisms native to a given region.
Energy Flow : The passage of energy through the trophic levels of a food chain.
Environment : All the biotic and abiotic factors, that actually affect the individual organism at any point in its life cycle.
Epilimnion : The warmer uppermost layer of water above the thermocline in a lake.
Erosion : Removal of top soil by an external agent
Euphotic Zone : Upper zone of a sea or lake, where enough light can penetrate.
Eutrophication : The process of enrichment and aging in an aquatic ecosystem
Exosphere: Outermost layer of atmosphere lying beyond the ionosphere.(In this sphere there is a 50% chance of escape of molecules in the space.
Factor : Factor is any external force,substance or condition that affects organisms.
Fauna : Species content of animals present in an area.
Flora : Species content of plants in an area.
Food Chain : A series of organisms arranged in a linear manner with repeated eating and being eaten.
Food Web : Interlocking pattern of several interlocked food chains.
Forest : a biome in which dominant plants.
Grassland : Herbaceous vegetations dominated by grass.
Habitat:It is the natural place or locality of an animal, plant or person.ex:-water is the habit for aquatic animals.
Herbivore : An animal that feeds on plants.
Lentic Water : Standing water (pond and lake)
Limnetic Zone : Open water zone, a depth where effective light may penetrate.
Lithosphere : The crust and mantle (solid portion) of earth.
Littoral : Pertaining to the shore of the sea or a large lake; a shallow water zone with light penetration to the bottom and often occupied with rooted aquatic plants.

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Littoral Zone : A shallow water region near seashore lying between high and low tide region
Lotic : Running water
Macroenvironment:It is the sum of the physical and biotic conditions existing external to the organism.
Micro environment:The local and immediate surrounding of the organism is called micro environment.
Nekton : Animals of sea such as fish which can control their position by swimming.
Neritic : Pertaining to the area of the sea over the continental shelf
Neuston : Organism supported on water surface.
Omnivore : A living organism which consumes both plant and animal food.
Organism: It refers an individual unit constituted to carry the life
Pedogenesis:process of soil development.
Phenology:study of periodical changes inplants in relation to seasons of a year
Phytoplankton:floating or freely suspended plants.
Plankton : Floating or weakly swimming organisms in aquatic environment.
Pollutant:any unwanted substance which shows harmful effect on the environment.
Population:It is a group of individuals,usually of the same species.example:tiger population,elephant population
Profundal zone:The zone of a lake lying below the compensation depth.
Runoff:water in the form of rain or snow that comes down the land surface and into the streams and rivers.
Saprophyte : Organisms which obtain food from dead or decaying organic matter.
Secondary pollutants:a pollutant formed by the combination of other pollutants in the environment.
Smog:smoke arising from nitrogen oxides and hydrocarbons emitted by motor vehicles and photochemical action of sunlight.
Soil profile:a cross-section of soil horizons.
Soil:weathered surface material.
Species:Each kind of living organism in an ecosystem is called species.
Standing crop: the amount of living matter present in component

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population at any time in the ecosystem.this may be expressed in terms of number of organisms, their weight or energy content
Stratosphere: the region of atmosphere above the troposphere in which temperature rises with height.
Sublittoral : Lower division in the sea from a depth of 40 - 60 metre to about 200 metre.
Succession:a natural process by which different communities colonise the same area over a period of time in a definite sequence.
Swamp:an area saturated with water for most time in which soil surface is not deeply submerged.
Symbiosis : Living together of two or more species.
Thermocline : The subsurface layer of a lake characterized by a significant temperature changes.
Transpiration : The loss of water vapour through the surface of leaves.
Trophic Levels : One stage in a nutritive level including producers to consumers.
Trophic Structures : The organisation of community in trophic levels.
Wilting Point : Measure of soil water, the water remaining in the soil when the plants are in a state of permanent wilting from water shortage.
Zooplankton : Animal portion of a plankton which floats freely in the water independent of shore and bottom moving passively with the currents.

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