Unit-III * Ecosystem and plant communities (12 lec)

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Intro:-

It has been known that plant individuals do not live alone in nature. They are very much associated with animals.

The Plants and animals not only influence one another but also interact with their non-living environment.

- A square metre of a grassland, the edge of a pond or any large area of nature that has living organisms and non-living substances interacting and exchanging materials betn them is called an ecological system or ecosystem.
- The term ecosystem refers to the sum total of physical and biological factors operating in any area.
- The concept of ecosystem was first put forth by A. G. Tansley (1935).
- According to E. P. odum, the ecosystem is the basic functional unit of organisms and their environment interacting with each other and with their own components.
- There are two basic processes in an ecosystem, one is cycling of materials and other is constant input of energy.
- cycling of materials involves a cycle of exchange of materials between living things and their environment.

The plants synthesize complex organic materials from the raw materials.

The organic matter ultimately releases the raw material which are returned to the environment. This mechanism is known as cycling of materials. The minerals, nitrogen, CO_2 and water are continually cycled through this system.

The other process in an ecosystem is the constant input of energy.

- The ultimate source of energy is the solar energy which is captured by green plants.
- other organisms derive their nutrition and energy from the plants. The energy taken by these organisms is passed on to other organisms. In this way energy is transferred from one organism to another. This is known as flow of energy.
- In this process there is always loss of energy in each transfer.
- The energy has a unidirectional (one-way) flow and does not circulate like the nutrients.
- Ecosystems are often interrelated. Biological transfers of nutrients and energy from one system to another system bring about interdependence of the systems.

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* Components of Ecosystem

An ecosystem contains,
1) Biotic components.
2) Abiotic components.

[1] Biotic components.

The biotic component of an ecosystem has been classified into three groups,
(i) producers :- green plants which manufacture food.
(ii) consumers :- which feed on plants or plant products and
(iii) Decomposers :- Which decompose the producers as well as the consumers releasing the materials into the soil and atmosphere.

(i) producers :-

- Green plants are unique in the world since they are only living things that can take energy from the nonliving environment and convert it in another form to make it available to all other organisms. They are called the producers.
- Green plants covert light energy of the sun into potential chemical energy in the form of organic compounds.
- These are needed by plants for their own growth and reproduction. oxygen is produced as a byproduct of photosynthesis.

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This oxygen is needed by all living organisms for respiration.
- The animals are heterotrophs and therefore, depend upon plant products for their food. ~~This food~~

(ii) Consumers :-
The organisms that must obtain their energy from sources other than themselves (including ourselves) are known as consumers.
Directly or indirectly all animals are dependent on green plants. They can be regarded as parasites on the plants.

(a) primary consumer :- Insects like grasshoppers etc. chew up stem and leaves.
Animals like goat, cow, deer or rabbit eat up the entire aerial portions of green plants.
Man eat various plant products.
They all live directly upon green plants and are therefore known as herbivores. These animals constitute the primary consumers or macro-consumers.

(b) secondary consumers :- Some animals like frog, tiger, lion etc. are carnivorous. They eat the herbivores. They are all secondary consumers, because their food consists of primary consumers.

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(c) consumers of the third order :- The snake that eats the frog is a consumer of a still higher order since the solar energy has been handed on by further chemical steps of digestion and synthesis into still different compounds. They are called consumers of third order.
There is also a class of top carnivores, who are not killed and eaten by other animals, e.g. tiger, leopard, vulture, etc.

(iii) Decomposers :-

When organisms (producers and consumers) after completion of their life cycle die, they become food for bacteria and moulds, which are the decomposers or the microconsumers.
They simplify the organic constituents of each dead body. They release materials which are cycled back to the soil and the atmosphere. In this process they obtain energy and chemical substances for their own growth and reproduction.
The chemical substances which passed from organism to organism ultimately return back to the non-living environment and the materials are once again made available to the primary producers.
The decomposers thus play important role in the ecosystem. only they are capable of releasing the vital materials from the dead

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[2] Abiotic components:

Odum (1971) has classified the abiotic components of an ecosystem into three parts, viz.

(i) Inorganic nutrients like C, N, H, etc.
(ii) Organic compounds which constitute the organisms and.
(iii) The climatic factors such as moisture, wind currents and solar radiation (light).

- The abiotic components can be conveniently classified into three groups,

(a) Physical environment.
(b) Nutrients (materials cycling) and
(c) Energy circuits.

- The amount of abiotic materials present in an ecosystem is called the standing stage.

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Types of Ecosystem

In the broad sense, there are two major types of ecosystems namely terrestrial and aquatic.
- Terrestrial ecosystem operates on the land while the aquatic system operates in the aquatic habitat.
- Terrestrial ecosystem can further be divided into the following types,
  1. Forest ecosystem
  2. Grassland ecosystem
  3. Desert ecosystem.
  4. Artificial ecosystem which are man made. For ex. Aquarium, gardens.

- on the basis of salt contents in water, aquatic ecosystems can be divided into the following two types of minor ecosystems,
  1. Fresh water ecosystem.
  2. marine or oceanic ecosystem.

The fresh water ecosystems include pond ecosystem, lake ecosystem, river ecosystem.

~~Pon~~ pond Ecosystem

- pond ecosystem is a fresh water ecosystem in which, like other ecosystems, there are two main components,
  (i) Abiotic component and
  (ii) Biotic component.

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(i) Abiotic component :-
Abiotic components of pond ecosystem consists of water, dissolved minerals and CO_2. solar radiations are the main source of energy.

(ii) Biotic component
It includes the following.
(a) producers.
(b) consumers
(c) Decomposers and transformers.

- on the basis of water depth and types of vegetation and animals there may be three zones in the pond: Littoral, Limnetic and profundal.
- The littoral zone is the shallow water region which is usually occupied by rooted plants.
- The limnetic zone ranges from the shalow to the depth of effective light penetration and associated organisms are small crustaceaens, rotifers, insects, and their larvae and algae.
- The profundal zone is the deep water parts where there is no effective light penetration. The associated organisms are snails, mussels, crabs and worms.

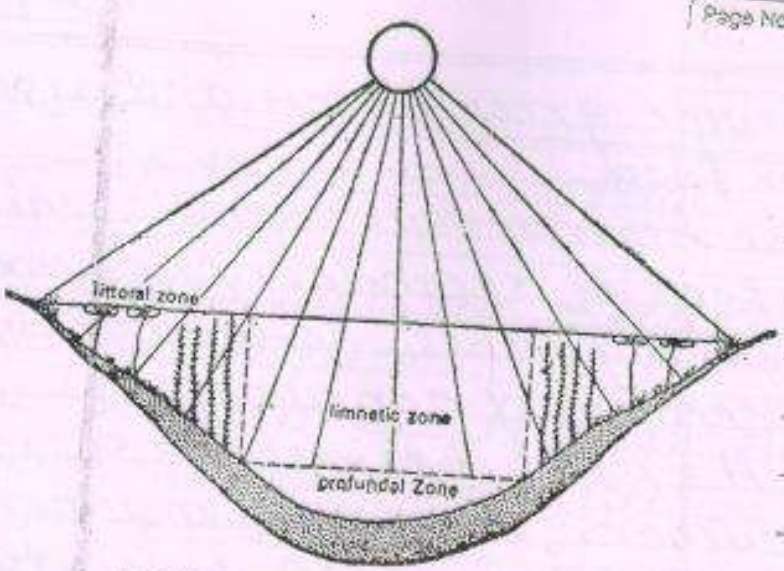

Fig. 3·3—Different zones of a fresh water pond.

Fig:- Different zones of a fresh water pond.

(a) producers :-

The main producers in pond ecosystem are algae and other aquatic plants such as Azolla, Hydrilla, Potamogeton, Pistia, Wolfia, Lemna, Nymphea, etc.

- These are either floating or suspended or rooted at the bottom.
- The green plants convert the radiant energy into chemical energy through photosynthesis.
- The chemical energy stored in the form of food is utilized by all the organisms.
- oxygen evolved in the process of photosynthesis is utilized by all the living organisms in respiration.

(b) Consumers :-

In a pond ecosystem, the primary consumers are tadpole larvae of frogs, fishes and other aquatic animals, which

consume green plants and algae as their food.
- These herbivorous aquatic animals are the food of secondary consumers. Frogs, big fishes, water snakes, crabs are secondary consumers.
- In the pond, besides the secondary consumers, there are consumers of highest order, such as water birds, turtils, etc.

(c) Decomposers and Transformers :-

When aquatic plants and animals die, a large number of bacteria and fungi attack their dead bodies and convert the complex organic substances into simpler inorganic compounds and elements. These micro-organisms are called decomposers.
The chemical elements liberated by decomposers are again utilized by green plants in their nutrition.

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* Forest Ecosystem.

Forest ecosystem is one of the example of terrestrial ecosystem.
Like other ecosystems, there are two main components of forest ecosystem.
(a) Abiotic component
(b) Biotic component

(A) Abiotic component

In a forest ecosystem soil, moisture, air and sunlight form the abiotic or physical component.

(B) Biotic component

Biotic components include,
(a) producers
(b) consumers
(c) Decomposers and transformers.

(a) producers:-

All the green plants of a forest are producers. They are the main sources of food for all the animals.
There are several layers of vegetation in the forest. The plants of top stratum are angiospermous and gymnospermous trees. These plants utilize radiant energy of sun to the greatest extent.
Below the level of trees there is layer of shrubs which consume light energy of low intensity coming through trees.

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- Just below the shrubs there are grasses, herbs, lichens and mosses. These also manufacture food. These plants get least light.

(b) Consumers :-

There are a number of consumers in an old dense forest.

- consumers of first order (primary consumers) in the forest are grasshappers, rabit, deer, monkey, birds and many other wild herbivorous animals which utilize plants directly as their food.
- secondary consumers are wolves, Pythons, jackal, etc. which consume the herbivores.
- Lion, tiger, hawks are the consumers of top level.

(c) Decomposers :-

These are microorganisms, chiefly bacteria and fungi which attack dead bodies of producers and consumers and convert complex organic compounds into simpler inorganic substances (elements).

- These free elements again return to the abiotic environment and are re-utilised by producers in their nutrition.

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* Energy Flow in an Ecosystem

The universal principle of ecology is one-way flow of energy like the cycling of materials.

- Energy flow in the ecosystem is according to known physical principles.
- According to the first law of thermodynamics energy can neither be created nordestroyed but transformed from one type to another.
- (According to the second law of thermodynamics there can be no transformation of energy unless the energy change is from a concentrated to a dispersed form.) one of the best examples of such a transformation is seen in photosynthesis where conversion of light energy into potential chemical energy is accompanied with the dispersion of some energy as heat energy.
- All the life processes, as for example, growth, development, reproduction etc. are accompanied with energy transfers, without which there could be no life and no ecological system.
- The sun gives out vast quantities of heat and light. Much of the heat and the ultraviolet light are absorbed by the atmosphere and never reach the surface. Ultraviolet light is absorbed by the ozone layer. only one percent of the light energy is utilised by plants in photosynthesis.

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- The producers i.e., the green plants convert the light energy into potential chemical (food) energy. They store more chemical energy than they can use.
- It is this energy that is available to animals, bacteria and fungi.
- Herbivores including man are the primary consumers. They feed on the producers and get lesser amount of energy for their own growth and development. Some energy is lost in the process.
- In the consumers of the second and third order, the energy is further depleted.
- Energy thus has in the long run a one-way flow in nature.
- It will be noted that at each step in the flow of energy, a large part of it is lost in the form of heat.

The energy becomes more and more dispersed and less and less available.

Trophic level :-

The producers and consumers in ecosystem can be arranged into several feeding groups, each known as trophic level (feeding level).

In any ecosystem, producers represent the first trophic level, herbivores represent the second trophic level, primary carnivores represent the third trophic level and top carnivores represent the last level.

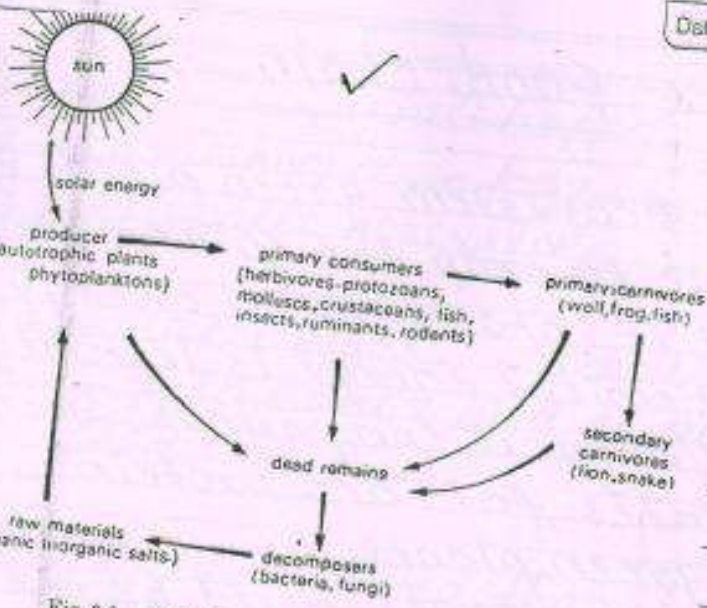

Fig. 3.6. Flow of energy at different levels of ecosystem.

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* Food chain.

- In the ecosystem, green plants alone are able to trap the solar energy and convert it into chemical energy.
- This chemical energy is locked up in the various organic compounds, such as carbohydrates, fats and proteins. present in the green plants.
- The food manufactured by the green plants is utilized by themselves and also by herbivores. Animals feed repeatedly. Herbivores fall pray to some carnivorous animals. In this way one form supports the other form of life.
- Thus food from one trophic level reaches to the other trophic level and in this way chain is established. This is known as food chain.
- A food chain may be defined as the transfer of energy and nutrients through a succession of organisms, through repeated process of eating and being eaten.
- In food chain initial link is a green plant or producer which produces chemical energy available to consumers.
For ex:- grass is consumed by grasshopper, the grasshopper is consumed by a bird and bird is consumed by hawk.

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Grass → grasshopper → bird → hawk
or Grass → Grasshopper → frog → snake → hawk
In a freshwater ecosystem,
algae → water fleas → small fish → large fish → fish eating bird or animals constitute a food chain.

Here it should be noted that if fewer steps in the food chain, greater availability of energy.
Conversely, in a longer food chain, more energy is dispersed as heat or it utilized in the respiration of consumers. Each level in the food chain is called a trophic level or energy level.
Food chains result in the establishment of food pyramids in the community.

Food chains can be of three types

(1) The predator or grazing food chain :- This starts from a plant base, goes from smaller to larger animals.
(2) The parasitic chain :- It goes from larger to smaller organism.
(3) saprophytic food chain :- It goes from dead matter to the microorganisms.

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* Food web

- Many food chains exist in an ecosystem, but these food chain are not independent.
- In ecosystem, one organism does not depend wholely on another.
- For ex. The marsh plants are eaten by variety of insects, birds, mammals and fishes. and
- As a matter of fact, besides the animals mentioned, many other animals may also act as consumers of first, second or third order.
- In the absence of rabbits, grasses may be eaten by mouse and the mouse may be eaten not by a snake but directly by an owl.
Similarly rabbit or mouse may also be eaten by certain other animals, may be man himself.
- This type of interrelationship interlinks the individuals of the whole community. In this way, food chain become interliked which constitutes a food web.
- A food web, therefore has several alternative pathways for the flow of energy.
- This pattern of the organisation of a community in a food web ensures the stability of an ecosystem.
- For ex. Sudden decrease in the number of a population of a primary consumer say rabbit results in the increase of

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of another consumers, say mice. This second consumer may be a favourite of a consumer of second order, and therefore, their number may soon decrease considerably.
- Meanwhile the first consumer the rabbits, multiply and build up large numbers.
- A community is, therefore, more stable if it has greater number of alternative pathways.

- The same organism may operate in the ecosystem at more than one trophic level i.e. it may derive its food from more than one source. Even the same organism may be eaten by several organisms of a higher trophic level.
- Thus in a given ecosystem various food chains are linked together and intersect each other to form a complex network called food web.

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* Ecological pyramids

- There is a proportionate relationship bet^n the numbers of producers, primary, secondary and tertiary consumers of food chain. This kind of relationship can be represented characteristically in the form of Eltonian pyramid, after a pioneer British ecologist, Charles Elton, who first devised this schematic method of expressing basic ecosystem structure.
- They can also be represented in the form of triangular pyramids which are also called ecological pyramids.

- The trophic structure of an ecosystem can be indicated by means of ecological pyramid.
- At each step in the food chain a considerable portion of the potential energy is lost as heat. As a result, organisms in each trophic level pass on lesser energy to the next trophic level.
- Longer the food chain the lesser energy is available for final members.
- Because of this tapering off of available energy in the food chain a pyramid is formed that is known as ecological pyramid.

Three types of pyramidal relations may be found among the organisms at different levels

in the ecosystem. These are as follows,

① Pyramid of numbers
② Pyramid of biomass
(biomass is the weight of living organism)
③ Pyramid of energy.

1 Pyramid of numbers

- The relationship between the numbers of producers, primary, secondary and tertiary consumers constitute the pyramid of numbers.
- In large ecosystems the number of primary producers is the largest.
The number of primary consumers is less than that of the producers and those of consumers of different orders decrease further in that order.
- If these numbers are represented in a diagrammatic way an upright pyramid is formed.
In a grassland ecosystem, the base of the pyramid represents the large number of primary producers.
The primary consumers, viz, the rabbit and the grasshoppers form the second large number next only to the producers, ie the grasses.
The tiger in the grassland are present in decreasing number in the foodchain.

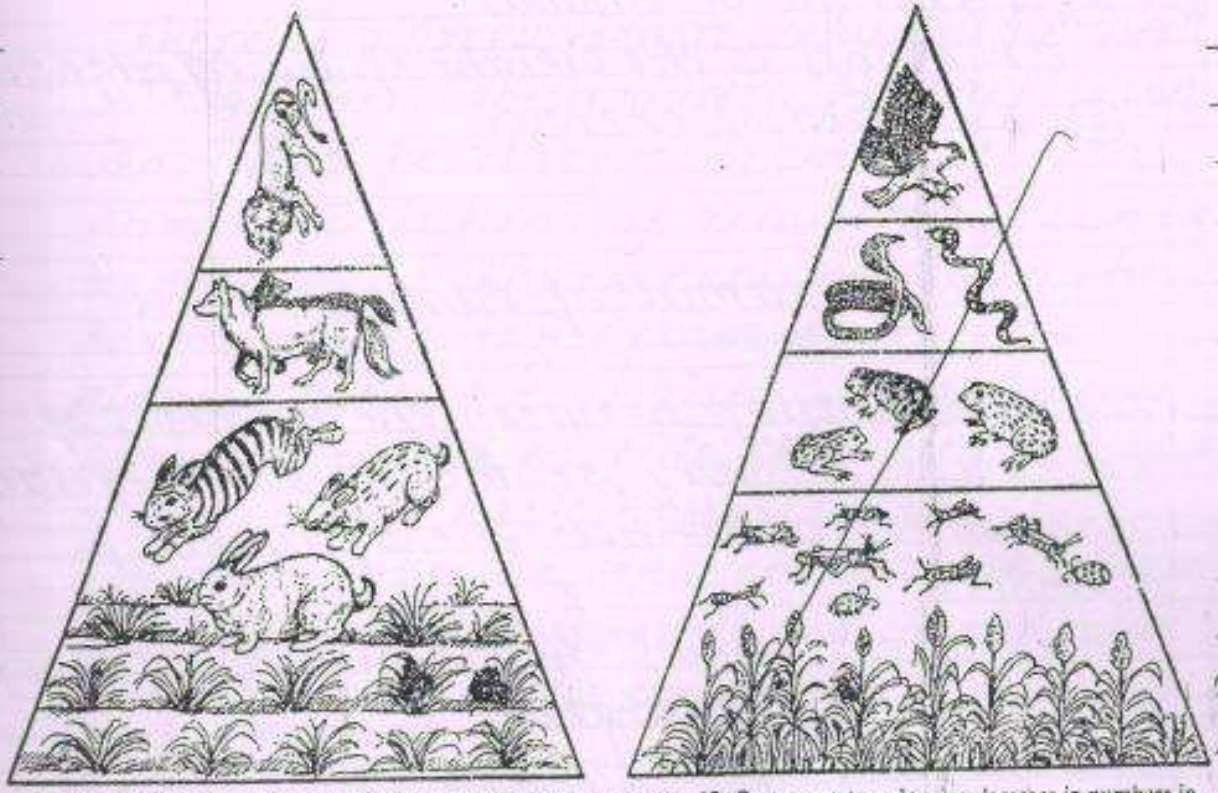

Fig. 84. Upright pyramids of numbers of (A) Grassland ecosystem (B) Crop ecosystem showing decrease in numbers in successive tropic levels.

In a tree ecosystem, the number of the primary producer is the least and that of the ultimate consumers is maximum. A single tree (primary producer) supports a large number of fruit eating herbivore birds (primary consumers), which in turn support a still higher number of parasites like bugs and lice (secondary consumers). This relationship of increasing numbers from producers to consumers of different orders constitute an inverted pyramid.

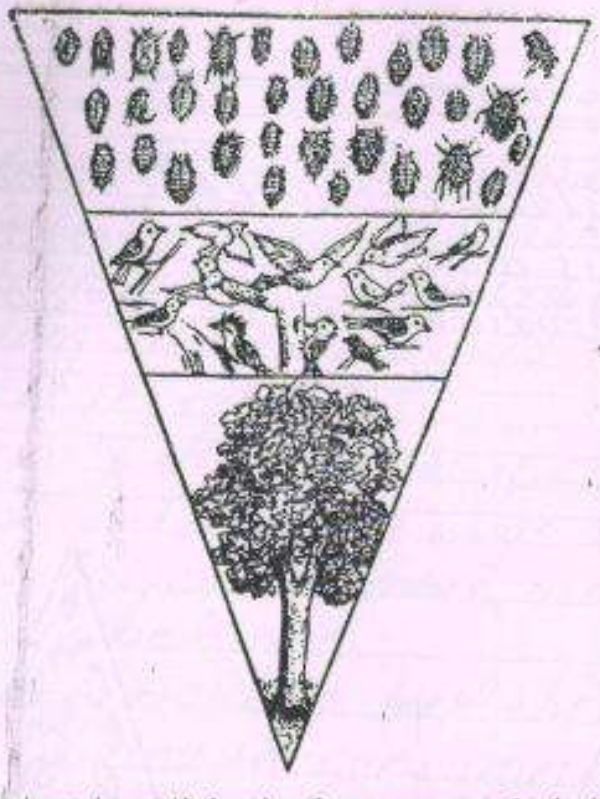

Fig. 86. An inverted pyramid of number of a tree ecosystem showing increase in numbers in successive trophic levels. The primary producer forms the base.

[2] Pyramid of Biomass

- Biomass of an individual or community is defined as the amount of organic matter present in it. ~~This~~
- pyramid of biomass indicates the decrease of biomass in each trophic level from base to apex, e.g. total biomass of producers eaten by herbivores is more than the total biomass of the herbivores.

Likewise, the total biomass of secondary consumers will be lesser than that of herbivores. Some energy and material are lost in each successive level.

Ex: In terrestrial ecosystems like those of a grassland or a tree the biomass of the producers is the highest of all the trophic

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levels
- In the grassland not only the number but the biomass also goes on decreasing from primary producers to the top carnivores.
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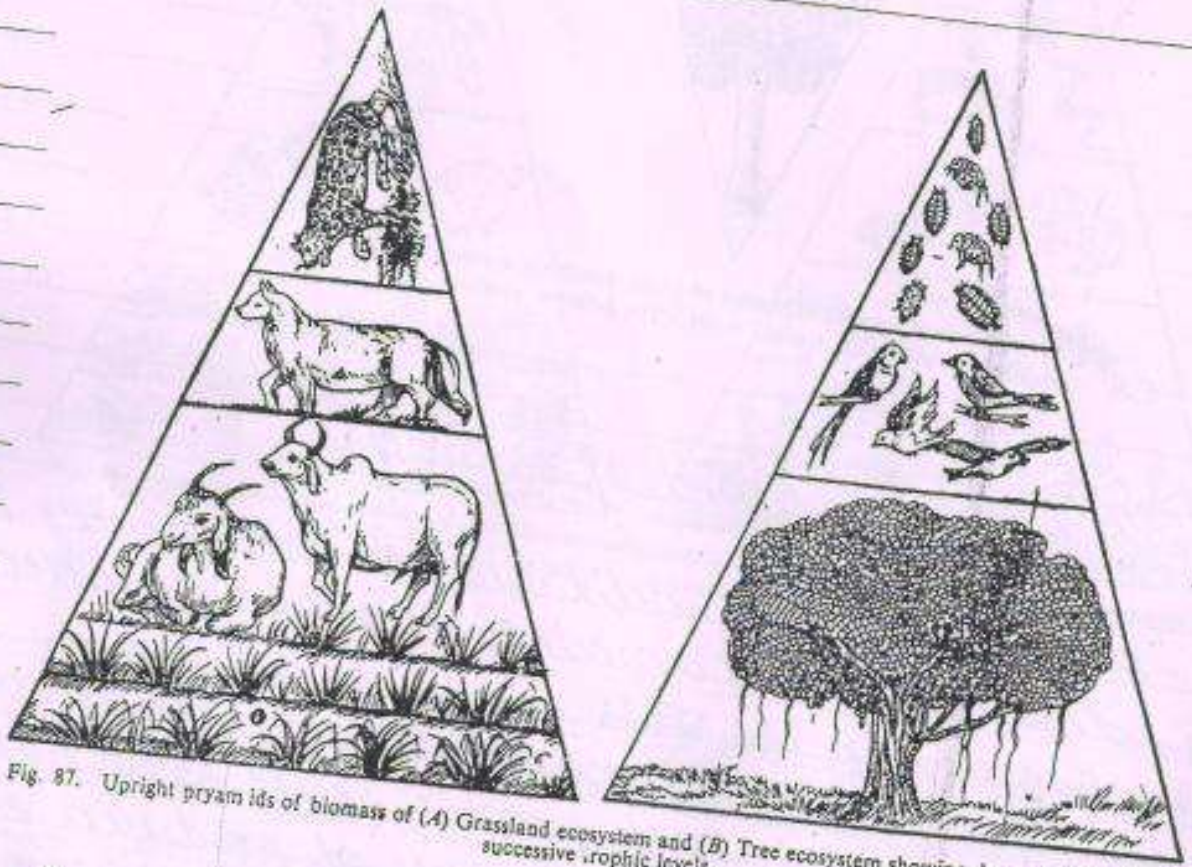

Fig. 87. Upright pryam ids of biomass of (*A*) Grassland ecosystem and (*B*) Tree ecosystem showing decrease in biomass in successive trophic levels.

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- In a tree, though the numbers increases from the base to the top, the biomass decreases.
- The biomass of all the fruit eating birds, feeding on a tree would remains less than that of the tree.
- similarly the biomass of consumers of the second order ie. the bugs and the lice, though large in number, would be less than that of the birds.
- This relationship bet^{n} the biomass of the producers and the consumers can be represented in the form of upright pyramids.

* It should be noted that while the pyramid of numbers is inverted that of biomass is upright in the case of a forest (tree) ecosystem.

Aquatic ecosystem (pond):-

In pond ecosystem the situation is entirely reverse.

- The biomass of diatoms and phytoplanktons (primary producers) is very little as compared to small herbivore fishes (primary consumers) that feed on them.
- The biomass of large carnivore fishes (secondary consumers) which feed on the small fishes is the highest of all the trophic level, and therefore, the relationship of biomass amongst organisms forms an inverted pyramid.

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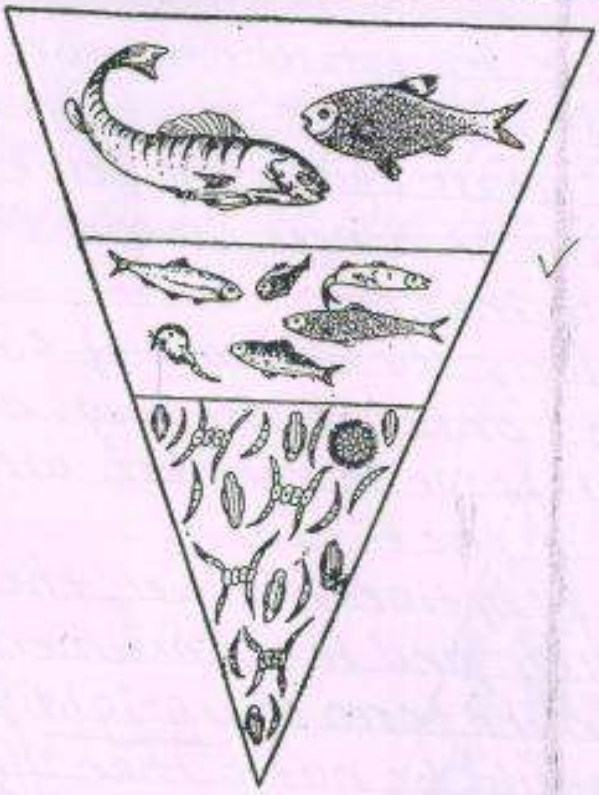

Fig. 88. An inverted pyramid of biomass of a pond ecosystem showing decrease in number but increase in biomass.

Pyramid of Energy

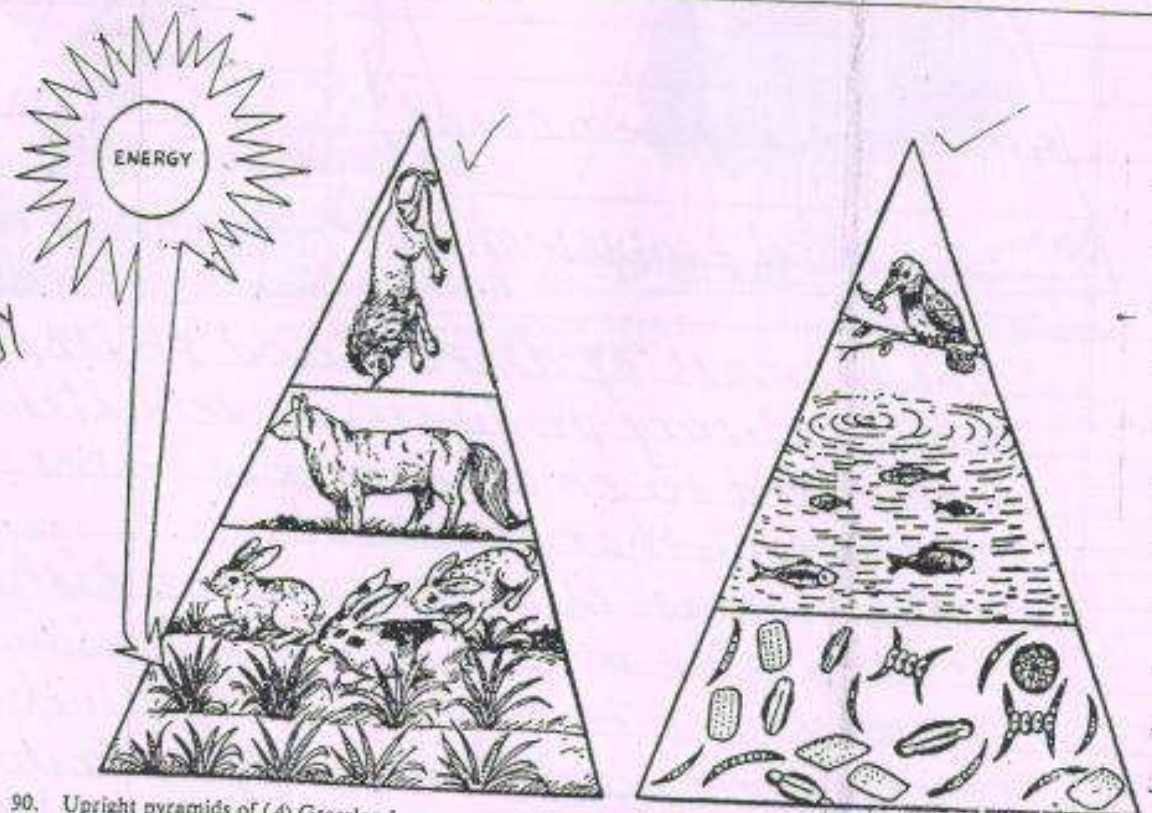

Fig. 90. Upright pyramids of (*A*) Grassland ecosystem and (*B*) Aquate ecosystem showing the rate of utilization of energy by successive trophic levels in a given area over a period of time.

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[3] Pyramid of Energy.

- The primary producers of an ecosystem trap the radiant energy of the sun and convert it into potential chemical energy.
- This trapped energy flows in the food chain from the producers to the top carnivore, decreasing at each level.
- If the relationship of the total quantity of energy utilized by different trophic levels is diagrammatically represent, an upright pyramid is formed.
- In a grassland the green plants (primary producers) trap the maximum light energy in a particular area over a fixed period of time.
- In a pond ecosystem, in a fixed area the phytoplanktons similarly trap much more energy than the herbivore fishes because of their large numbers and quicker rate of multiplication (complete several generations in a year).
- comparatively the amount of energy utilized in a year by the top carnivores is much less than that of the herbivore fishes.

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Community Ecology

- No plant or animal lives as isolated individual. plants and animals generally prefer to live in groups or colonies.
- Different plants and animals living in a habitat constitute a biotic community.
- When there is only assemblage of plants in a habitat is considered, it is called plant community.
- In any biological organization plants and animals are very closely related and interdependent. plant and animals share the same set of environmental conditions.

- Thus the study of the relationships of plants and animals making up natural community is termed as community ecology or synecology.

- The basic unit of vegetation is called plant community.
- Each community consists of a set of many different species which persist year after year.
- In a community, each plant species is represented by many individuals.
- A group of individuals of the same species is commonly known as population.
- Thus a population is a part of community and populations of different species may be intermingled in a community.

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- Oosting defines community as, "an aggregation of living organisms having mutual relationship among themselves and to the environment.
- According to Benton and Werner (1974) "a biological community consists of all the organisms living together in an interrelated fashion in a given environment."

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Characteristics of community

following are some of the characteristics of community

(1) Species diversity :-

- The biotic community is a natural assemblage of a large number of plant and animal species in an area.
- various species of plant and animals live in a community and exhibit species richness or species diversity.
- Because in any particular habitat there is no considerable variation in environmental conditions, the plants growing together in a community show unique uniformity in their behaviour.
- Each species of community has got definite range of tolerence towards the physical and biological conditions of the habitat.
The range of environment a species can tolerate is called its ecological amplitude.
- The nature of community of a particular habitat is determined by the species contents, ecological amplitudes of the species and physical and biotic influences in the community.

(2) Coexistence :-

- species occuring in their particular habitat do not live in complete isolation as pure cultures, but they coexist in mutual adjustment.

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- The coexisting populations are inter-related and they show some sorts of interaction.
- The relationships bet^n coexisting species may be obligatory in one direction or in both. (mutual)

For ex:- The trees in a forest community can live just as good as without shrubs and herbs which grow under them. This relationship is obligatory in one direction only.

- The nature of interaction bet^n two coexisting species may fall into one of the following types.

(i) Exploitation :- In this, one species lives at the expense of another.

(ii) Mutualism :- In this, two or more coexisting populations benefit from the relationship but noone suffers.

(iii) Competition :- In this, two populations may compete for same resources of the habitat.

(iv) Neutralism :- In this, two populations may be quite independent and neither population affects the other.

(3) Interdependency :-

- All the members of a community have ability to live under the conditions of habitat and they are interdependent upon one another. It is called dependency.

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- Thallophytes, mosses, ferns and many shade loving herbs that are found on the forest floor are dependent on the forest trees because trees provide shallow and moist conditions.
- If the trees of forest are removed, the ground vegetation may disappear.
similarly the fungi and saprophytes found in the forest depend ~~on~~ upon the roots of plants and on the humus and some fungi form mycorrhizal associations with the plant roots.

(4) Species Dominance :-

- Not all the species of a community are found in ~~abun~~ abundance. Only a few species are found in abundance, either in number or in biomass (weight) while the majority are rare.
- The common species which are more abundant and contain more biomass are considered to be dominants.
- Dominant individuals affect the associated individuals.

For ex:- In the forest tallest trees influence the under-storey plants and ground vegetation not only by decreasing the intensity of light reaching the forest floor and increasing the moisture content of air but also by changing the soil structure and its chemical composition.

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(5) Stratification :-

- In a plant community, the plants, which have relationship among themselves, may be trees, shrubs, herbs, mosses, lichens and thallophytes. These plants form distinct strata or layers or storeys on vertical as well as in horizontal planes. This is known as stratification.
- The individuals of different layers represent different "Life forms".
- Each layer of community may include individuals of different morphological classes. For ex. the layer of forest may be formed by tallest trees and lianes (woody climbers).
- In order to overcome this objection, plants belonging to different morphological classes are put in sinusiae (singular - sinusia), as for example, trees are put in sinusia of trees, epiphytes are put in sinusia of epiphytes, and so on.

- In forest vegetation five vertical subdivisions of life forms may be present.

(1) subterranean zone
(2) Forest floor
(3) Ground vegetation nearly extending upto a metre
(4) understorey tree and shrub layer extending to the height of 1-5 m and
(5) Tree layer or top storey extending to 5-15 m or sometimes 40-50 metres in rain forest.

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life - forms

Fig. 7.4. Vertical stratification in a complex forest community.

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* Life-forms (Growth form)

- Life form is the sum of the adaptation of the plant to the community.
- Ecologist generally use christen Raunkiaer's classification (1934) of plant life forms.
- Raunkiaer's classified plants into following five broad life form categories.
- His classification is based on the position of perennating buds on plants and the degree of their protection during adverse conditions.

(1) Phanerophytes :-

- The growing buds of these plants are naked or covered with scale (i.e. they are not well protected) and situated in upright shoots much above the ground surface.
- Phanerophytes include trees, shrubs and climbers.
- Phanerophytes are found mostly in tropical regions. ~~and~~

(2) Chamaephytes :-

- In chamaephytes the buds are situated close to the ground surface and these buds get protection from fallen leaves and snow cover.
- They commonly occur in high altitudes and latitudes, e.g. Trifolium repens which is found in North America.

germinating season to another, especially under unfavourable conditions such as drought or winter.

Bud :- An undeveloped, vegetative or floral shoot covered with ~~scales~~ protective scales.

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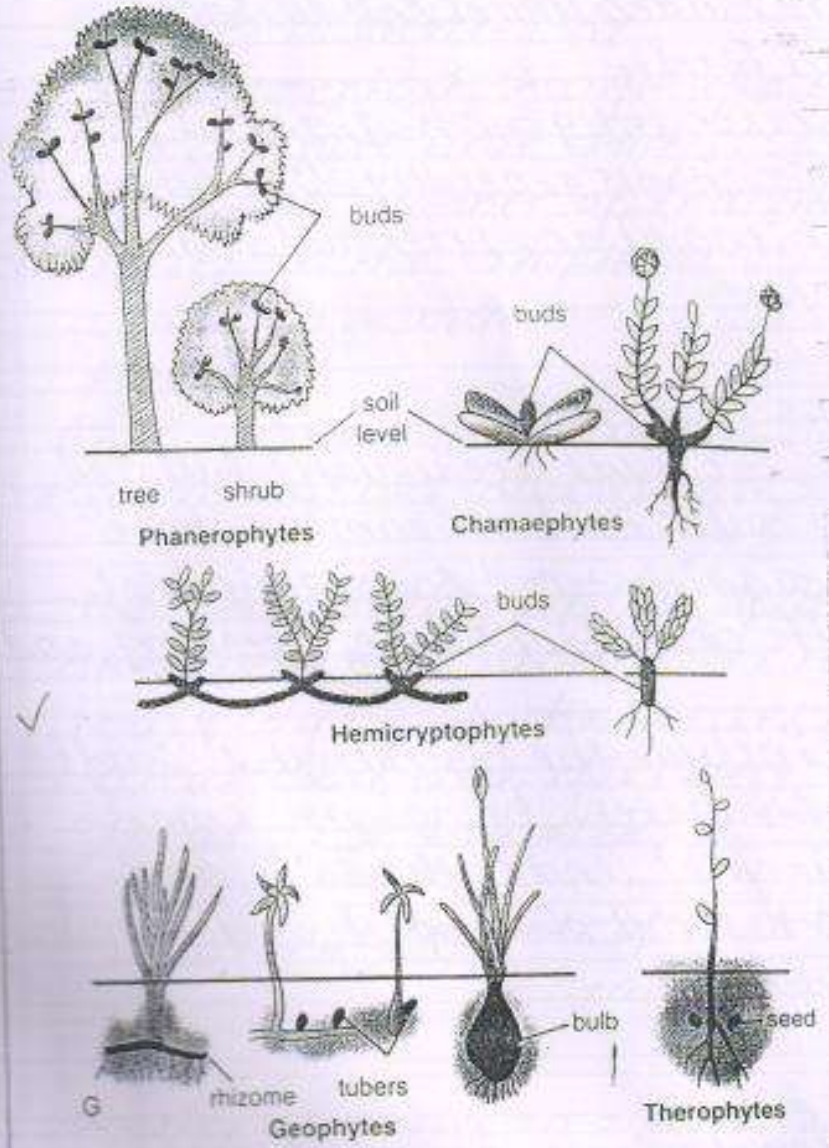

Fig. 7.7. Diagrammatic representation of Raunkiaer's life-forms. The barred regions survive during adverse periods of the growing season. Note the successive increasing degree of protection of renewal or perennial buds, organs or seeds from phanerophytes to therophytes.

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Bud :- An undeveloped, vegetative or floral shoot covered with ~~scales~~ protective scales.

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(3) Hemicryptophytes :-

- These are mostly found in cold temperate zone.
- Their buds are hidden under soil surface, protected in soil itself.
- In the warm season the growth of aerial parts is marked. Their shoots generally die each year, e.g. most of the biennial and perennial herbs including grasses.

(4) Cryptophytes or geophytes :-

- In these plants, the buds are usually buried in the soil or in bulbs and rhizomes where food is stored to withstand long periods of adverse climatic conditions (i.e. freezing and drying).
- Cryptophytes include the hydrophytes (buds remaining under water), helophytes (marsh plants with rhizomes under the soil) and geophytes (terrestrial plant with underground rhizomes or tubers).

(5) Therophytes :-

- These are seasonal plants, completing their life cycle in a single favourable season, and remain dormant throughout the rest unfavourable period of year in the form of seeds.
- Therophytes are commonly found in dry, hot or cold environments (i.e. deserts).

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* Density

(Population Density).

- Density indicates numerical strength of a species in an area or.
- The numerical strength of a species in relation to a definite unit space is called its density.
- The total number of individuals of each species in the sample area is assessed in a subjective manner by using the following terms,

(i) Dominant (ii) Abundant (iii) Frequent (iv) Occasional and (v) Rare

- Quantitatively density of a species is obtained by counting the number of individuals of the species in the sample areas and then dividing them by the total area sampled.

$$\text{Density} = \frac{\text{number of individuals of a species}}{\text{total area sampled}}$$

- Density of species in a field is determined by the method given in following table →
- In some cases, e.g. grass and vegetatively propagated plants, the term individual creates difficulty. In such cases, each aerial tiller or shoot arising out from the soil is generally regarded as one individual.

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The proportion of density of a species to that of stand as a whole is referred to as relative density.
The following formula is used for calculating relative density of a species:

$$\text{Relative density of a species} = \frac{\text{Total no. of individuals of a species}}{\text{Total no. of individuals of all species}} \times 100$$

Names of species	*Number of individuals in differsnt quadrats each of 1 square metre size*										*Total No. of individuals*	*Density*
	1	2	3	4	5	6	7	8	9	10		
1. *Evolvulus alsinoides*	5	4	7	×	1	3	9	2	8	5	44	$\frac{44}{10} = 4{\cdot}4$ plants/m²
2. *Indigofera sp.*	×	7	6	9	2	4	×	1	5	×	34	$\frac{34}{10} = 3{\cdot}4$ plants/m²
3. *Peristrophe sp.*	3	1	4	×	×	×	1	2	×	7	18	$\frac{18}{10} = 1{\cdot}8$ plants/m²
4.												
5.												
6.												

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* Frequency

- In the community, the individuals of all the species are not evenly distributed. Individuals of some species are widely spaced while those of some other species are found in clumps or mats.
- The number of plots in which a species occurs, divided by the total number of plots sampled, represents the frequency of that species.

For ex, if one or more individuals of a species is found in each of 30 of a total of 50 samples, its frequency is 60%.

- Frequency of a species relative to other species in a community is called relative frequency.

$$\text{Frequency} = \frac{\text{number of plots in which species occurs}}{\text{total number of plots sampled.}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Frequency of a species}}{\text{total frequencies of all species.}} \times 100.$$

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ex:
Suppose, species 'A' occured in 4 plots or quadrats out of total 10 quadrats studied, the frequency of species A will be,

$$\frac{4}{10} \times 100 = 40\%$$

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* Ecological succession

- ~~The~~ A plant community is a dynamic system.
- The population and the habitat constantly act and react upon each other leading to changes in the environment.
- This changed environment renders itself unsuitable for the growth and stabilization of the existing plants.
- This leads to the migration and establishment of other populations, which are better suited for the modified habitat.
- This unstable community-environment system by means of constant interaction and modification of the environment seeks to develop into more advance communities.
- This process continues until a relatively stable community is finally emerges.
- This successive colonisation of the same area by different plant communities in the course of development of vegetation is called plant succession or development of ecosystem.
- succession on a barren area which has never before borne a vegetative cover is known as primary succession. and on an area which once bore vegetation but was denuded later, is known as secondary succession.
- The different intermediate stages are called 'seral communities' or seral stages.
- A complete range of plant succession is called a sere.

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Causes of succession :-

(1) Physiographic processes, producing mostly primary bare areas,
- (a) Erosion, by water, wind etc.
- (b) Depocition, by water, wind, gravity
- (c) Emergence, of barren land surfaces.

(2) Climatic phenomena, producing mostly secondary bare areas,
- (a) Wind, eliminating the previous vegetation.
- (b) Drought, drying and killing the weaker species.
- (c) Snow, killing the previous vegetation.
- (d) Lightening, causing fires in forests.

(3) Biotic agents, producing secondary bare areas,
- (a) Man, destroying natural vegetation.
- (b) Animals, overgrazing, etc.
- (c) Bacteria, fungi, insects, eliminating species by disease or by eating.

Processes in succession

(1) Nudation :- An area may become nude by any of the several causes mentioned earlier.

(2) Migration :- A nude area is exposed to invasion by a number of plants from the surrounding areas. The structures like seeds, spores, runners etc. migrate from nearby places to the nude area.

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(3) Ecesis :- The process by which the migrants establish themselves in the new place is known as ecesis.

(4) Aggregation and competition :-
Increase of population number results in aggregation of individuals in an area leads to interspecific and intraspecific competition.

(5) Reaction :- The interaction and reactions among plant species and bet^n habitat and a population provide a continuing cause of succession.

(6) Stabilization :- The whole process of succession result in stabilization of the vegetation which is now in complete harmony with the environmental complex of the place.

* Kinds of succession

The succession of plants can be broadly classified into two kinds on the basis of the nature of the habitat.

(1) Hydrach :- When the succession takes place in a wetter area, i.e. the successional series progresses from hydric to mesic conditions. It can be of two kinds,

(a) Hydrosere :- When the succession starts in ponds, pools, lakes and marshes.

(b) Halosere :- when it starts in saline water.

(2) Xerach :- When the succession takes place in drier area, i.e. the successional series progresses from xeric to mesic conditions, the sere is called xerosere

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* Hydrosere

- When the succession starts in ponds, pools, lakes and marshes, it is called hydrosere.
- Hydrosere can be studied both in standing or running water but it would be better observed in the case of standing water, e.g. in ponds, pools or lakes, where various stages form distinct zones around a single body of water.
- There are about 7 stages in this sere.
- In a new pond hydrosere the colonization of phytoplankton starts and finally terminates in a forest. The process completes in 7 stages.

① Phytoplankton stage:

- It is the initial stage of succession in which algal spores are brought in the body of water.
- The simple forms of life like bacteria, algae and many other aquatic plants (phytoplanktons) and animals (zooplankton) floating in water are the colonizers.
- Due to life activities and death of all these organisms, large amount of organic matter is added in the water and settle at the bottom of pond to form a layer of muck.

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(2) Submerged stage :-

- The phytoplankton stage is followed ~~plant~~ by submerged plant stage.
- When a loose layer of mud is formed on the bottom of the pond, some rooted submerged hydrophytes begin to appear on the new substratum.
- The submerged aquatic vegetation develops in the regions of ponds or lakes where water depth is about 10 feet or more.
- The plants are Elodia, Potamogeton, Ranunculus, Utricularia, Vallisneria, chara, etc.
- These plants form tangled mass and have marked effects on the habitat.
- When these plants die, their remains are deposited at the bottom of ponds or lakes.
- The eroded soil particles and other transported materials are also deposited at the bottom.
- This gradually raises the bottom of the ponds and lakes up. As this process of stratification progresses, the body of water becomes more and more shallow resulting the habitat becomes less suited for the submerged vegetation but more favourable for other plants.

(3) Floating stage :-

When the depth of water reaches about 4-8 feet, the submerged vegetation starts disappearing from its original place

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and then the floating plants make their appearance gradually in that area.
In the begining the submerged and floating plant grow intermingled but in the course of time the submerged plants are replaced completely.
The most tolerent species of floating plants in the area are able to reproduce.
Their broad leaves floating on the water surface check the penetration of light to deeper layer of water.
This may be one of the main causes responsible for the death of submerged plants.
Due to continuous interaction between plant communities and aquatic environment, the habitat becomes changed chemically as well as physically.
More dead remains of plants are deposited at the bottom and thus, the substratum rises in vertical direction.
Important floating plants ~~are~~ that replace the submerged vegetation are Trapa, Pistia, Nymphaea, Nelumbium, etc.

(4) Reed-swamp stage (Amphibious stage):-

When the ponds and lakes become too shallow (water depth 1-3 feet) and the habitat is changed so much that it becomes less suited to the floating plants, some other plants which are well-adapted to new environment will then come in.

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- Under these conditions, the floating plants start disappearing gradually and their places are occupied by amphibious plants which can live successfully in aquatic as well as aerial environment.
- Important examples are Typha, Phragmites, (Reed), Bothriodova, etc.
- The foliage leaves of these plants cover the surface of water and roots are generally found either in mud or submerged in water.
- The foliage leaves form a cover over submerged and floating plants and thus they cut off light from the plants below of them.
- Under such conditions neither submerged nor floating plants can survive.
- Further deposition of soil and plant debris at the bottom reduces the depth of water and makes the habitat less suitable for the pre-existing plants.
- Under such conditions many secondary species, such as polygonum, sagittaria have appear.
- Later, they also bring about such reactions by which the habitat becomes less suitable for most of the existing species, and consequently new successional step follows.

(5) ~~Red~~ Sedge Marsh or Meadow stage :-

The filling process finally results in a marshy soil which may be too dry for the plants of preexisting community.

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- Now the plants well adapted to this new habitat begin to appear in the pre-existing community in mixed state.
- Important plant that are well suited to marshy habitat are the members of cyperaceae and graminae. The species are Themeda, Iris, Dichanthium, Eriophorum, Mentha, Gallium, Caltha, etc. All these are the first invaders of marshy area.
- As these plant grow most luxuriantly in the marshes, they modify the habitats in several ways.
- They absorb and transpire a large quantity of water and also catch and accumulate plant debris.
- consequently a dry habitat results which may be totally unfit for the growth of normal hydrophytes.
- Gradually the mesophytes start appearing and after some time the sedge vegetation is totally replaced by them.

⑥ Woodland stage :-

- In the begining some shrubs and later medium sized trees form open vegetation or woodland.
- These plants transpire very large quantity of water. Thus they make the habitat more dry.
- shade loving herbs may also grow under the trees and shrubs.
- The prominent species of woodland community are Buteaton, Acacia, Cassia, Terminalia, salix etc.

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(7) Climax Forest :-

- After a very long time the hydrosere may lead to the development of climax vegetation.
- As the level of soil is raised much above the water level by progressive accumulation of humus and soil particles, the habitat becomes more dry.
- In such habitat, well adapted self-maintaining and self-reproducing, nearly stable and uniform plant community consisting mostly of woody trees develops in the form of mesophytic forest.
- In the climax forest, all types of plants are present. Herbs, shrubs, mosses and shade loving plants represent their own communities.
- Trees are dominant and they have control over the entire vegetation.
- Bacteria, fungi and other microorganisms are more frequently found in the climax vegetation.
- They react upon the habitat and make the soil rich in the organic materials.
- At climax stage, a complete harmony develops between plant community and habitat.

- It is now clear that whole sere is a ~~community~~ continuously but gradually changing complex in which the changes are forced by biotic and climatic factors.

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- It is very slow process that can't be observed in nature. It may require thousands of years to reach the climax stage.

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* Analysis of plant communities (quadrant method)

- Intro:-
- The structure of sociological order in any plant community can not be studied by observing each and every individual of plant species growing in a habitat. It is rather impossible.
- Therefore, rough estimate of species content of a habitat is made by observing the plant species at different places or sample areas, in the habitat.
- several methods have been used by ecologist which are as follows,

(1) Quadrat method
(2) Transect method
(3) Loop method and
(4) pointless or point method

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* Quadrat method of sampling the vegetation

- The quadrat is a square sample plot or unit for a detailed analysis of vegetation.
- It is actually the sample-plot method proposed by Clements (1898).
- It may be a single sample plot or may be divided into several subplots.
- In vegetational analysis, quadrats of any size, shape, number and arrangement may be used.
- In the study of forest community quadrats of 1/5 acre are established to include maximum number of trees, while for studying shrubs and grass covers usually the quadrats of smaller sizes are used.
- For grassland community the quadrats of one square metre size or 50 cm x 50 cm size or even 20 cm x 20 cm size is used.
- The shape of quadrat is usually a square but rectangular, or even circular ones also used.

Kinds of quadrats

Quadrats are named according to the use. These are of the following types,

List quadrats :-

When the organisms encountered in the sample plot are listed by their names, the quadrat is called list quadrat.

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- It includes all the species botanically identified.
- A series of list quadrat gives floristic analysis of the community.
- This is used for studying the frequency of different species.

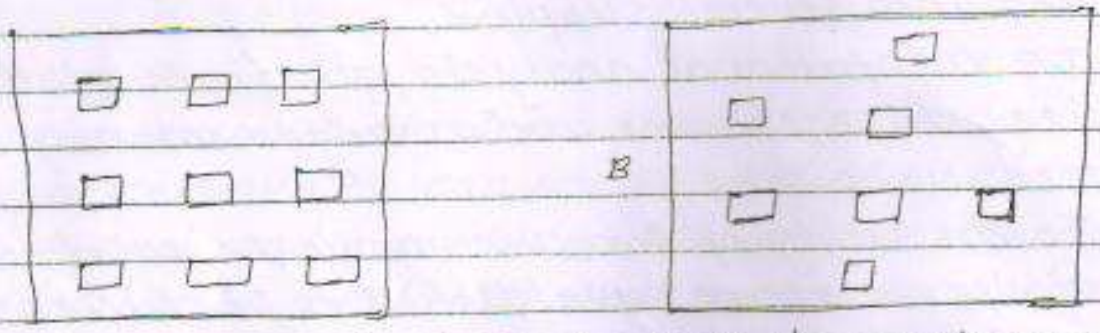

Fig:- Arrangement of quadrats in the study area.
A - systematically distributed quadrats.
B - Randomized quadrats.

(2) Count quadrat or List-count quadrat :-

- When the species name and the number of individuals of each species found in the sample are recorded, the sample plot is called count or list count quadrat.
- This type of plot is usually used in forest survey work.

(3) Cover quadrat :-

When the actual or relative coverage is recorded usually as percentage of ground area covered or shaded by vegetation, the sample area is known as cover quadrat.

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(4) Chart quadrat :-

Quadrats that are mapped to show the location of individuals of species are called chart quadrats.

- Individual plants are recorded on miniature quadrat on a graph paper with the help of an instrument called plantograph.

(5) Clip quadrat :-

- For studying the amount of yield of the vegetable matter, the vegetation is clipped from the quadrat at ground level and at various heights.
- The clipped matter is then determined in terms of fresh or dry weight. This sampling technique is called clip quadrat.

- sometimes quadrats of different sizes are laid down at different heights for the study of different life forms present in a community.
- The quadrat is the smallest at the ground level and largest at the top.
such superimposed quadrats are termed as nested quadrats.

Shape and size of Quadrats

The quadrats are usually square-shaped but they can also be rectangular.

- The proper size of the quadrat to be used in a given community is determined by

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constructing a species-area curve. This is done by sampling vegetation in nested sample areas and listing the species in the smallest plot.

The size of the quadrat is increased and newly encountered species are listed separately.

The plot area is increased in this manner and every time the number of new species encountered is listed.

The richness in species of a community influences the form of the curve, called a species-area curve.

Usually 1 square metre quadrats are used for herbaceous vegetation.

10-20 square metres for communities containing plants 3-4 m high, and 100 square metres quadrats for forest community.