Unit - III

* Ecosystem and plant communities

(12 lec)

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 proces 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.

* 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.

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.

(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 organisms.

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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.

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,
  1. Abiotic component and
  2. Biotic component.

(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 shallow to the depth of effective light penetration and associated organisms are small crustaceans, 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.

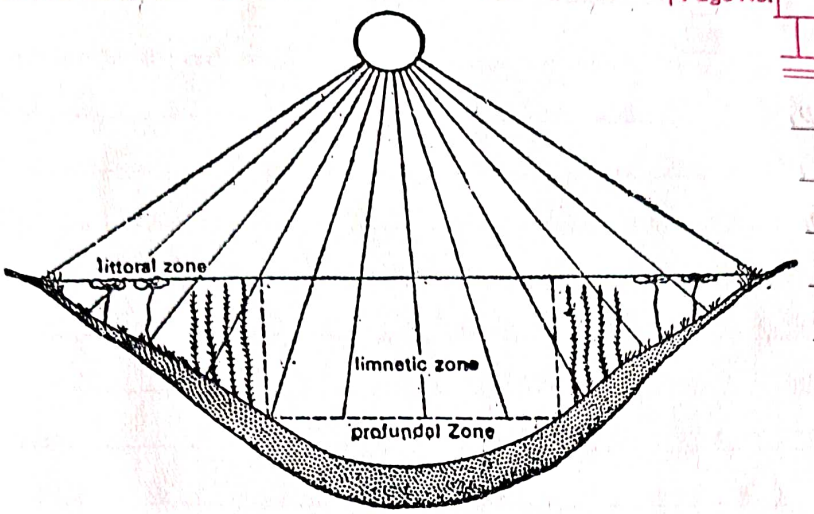

Fig. 3·3—Different zones of a fresh water pond.

mogeton Pistia Wolffia Lemna Eichhornia Nymphaea Jussiaea.

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 a 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 high 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.

* 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 ~~and~~ 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 grasshoppers, 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 (element)
- 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 nor destroyed 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.

- 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.

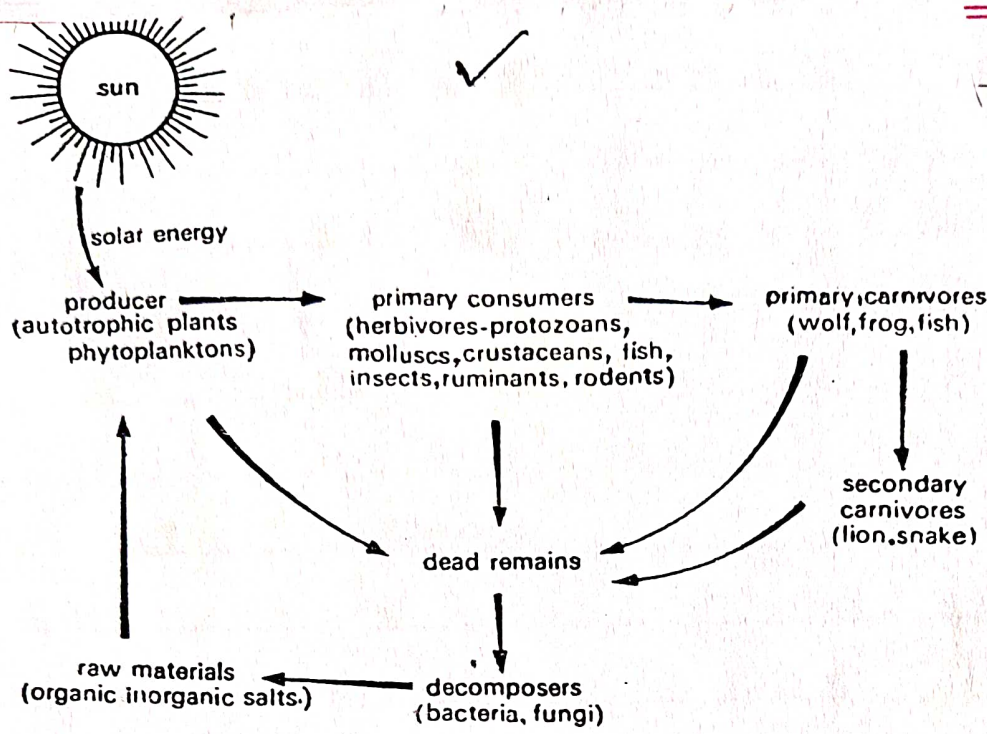

Fig. 3.6. Flow of energy at different levels of ecosystem.

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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 plant is utilised 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.

Grass → grasshopper → bird → hawk.
or Grass → Grasshopper → frog → snake → hawk.
In a freshwater ecosystem, हिंदी संस्करण

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.

* 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 interlinked 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

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.

* Ecological pyramids

- There is a proportionate relationship between 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.

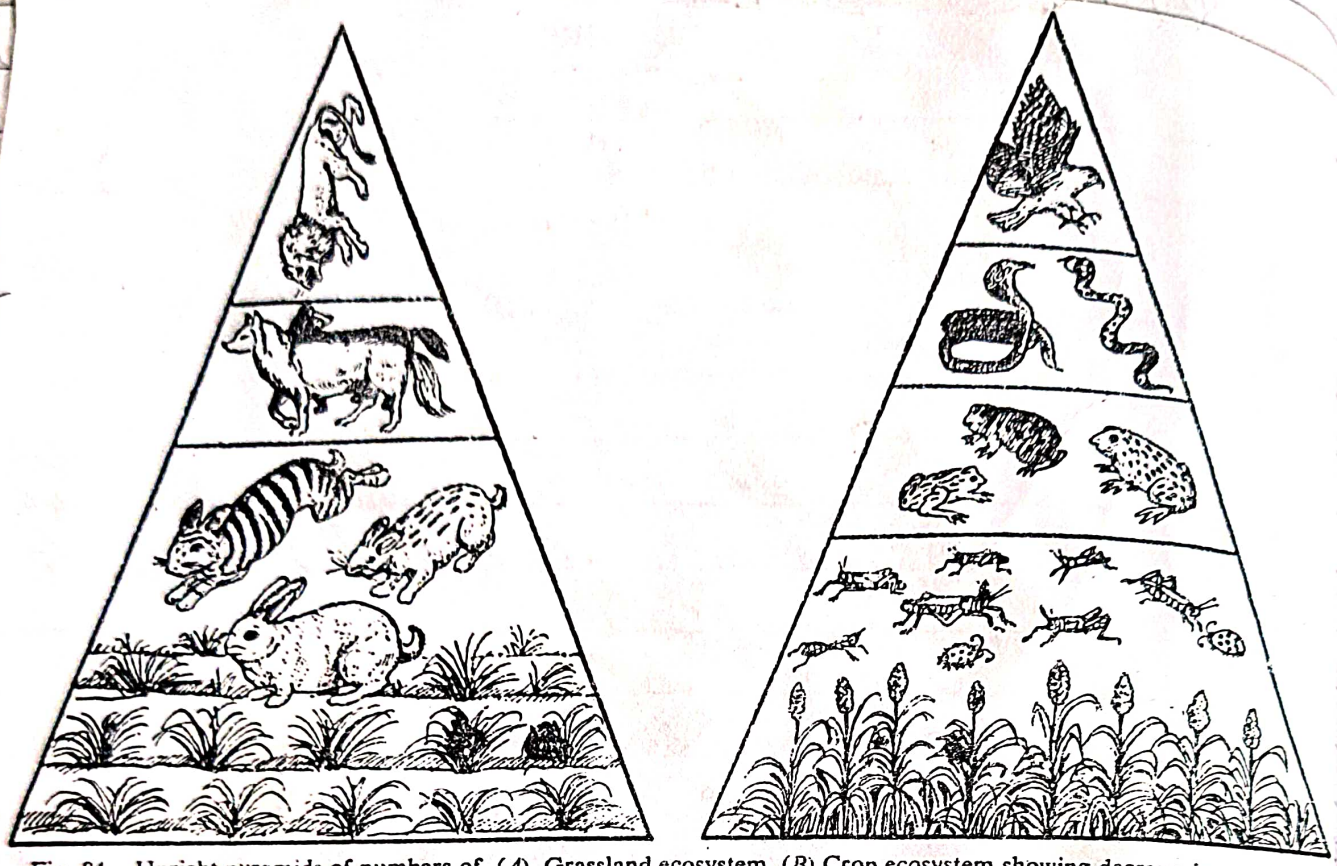

Fig. 84. Upright pyramids of numbers of (*A*) Grassland ecosystem (*B*) Crop ecosystem showing decrease in numbers in successive tropic levels.

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.

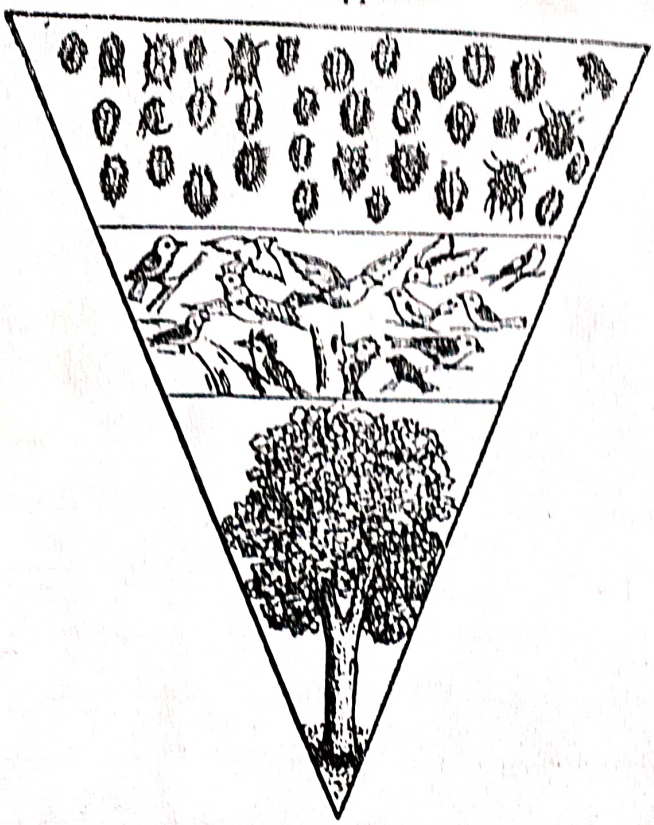

Fig. 86. An inverted pyramid of number of a tree ecosystem showing increase in numbers in successive trophic levels. The primary producer forms the base.

[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.

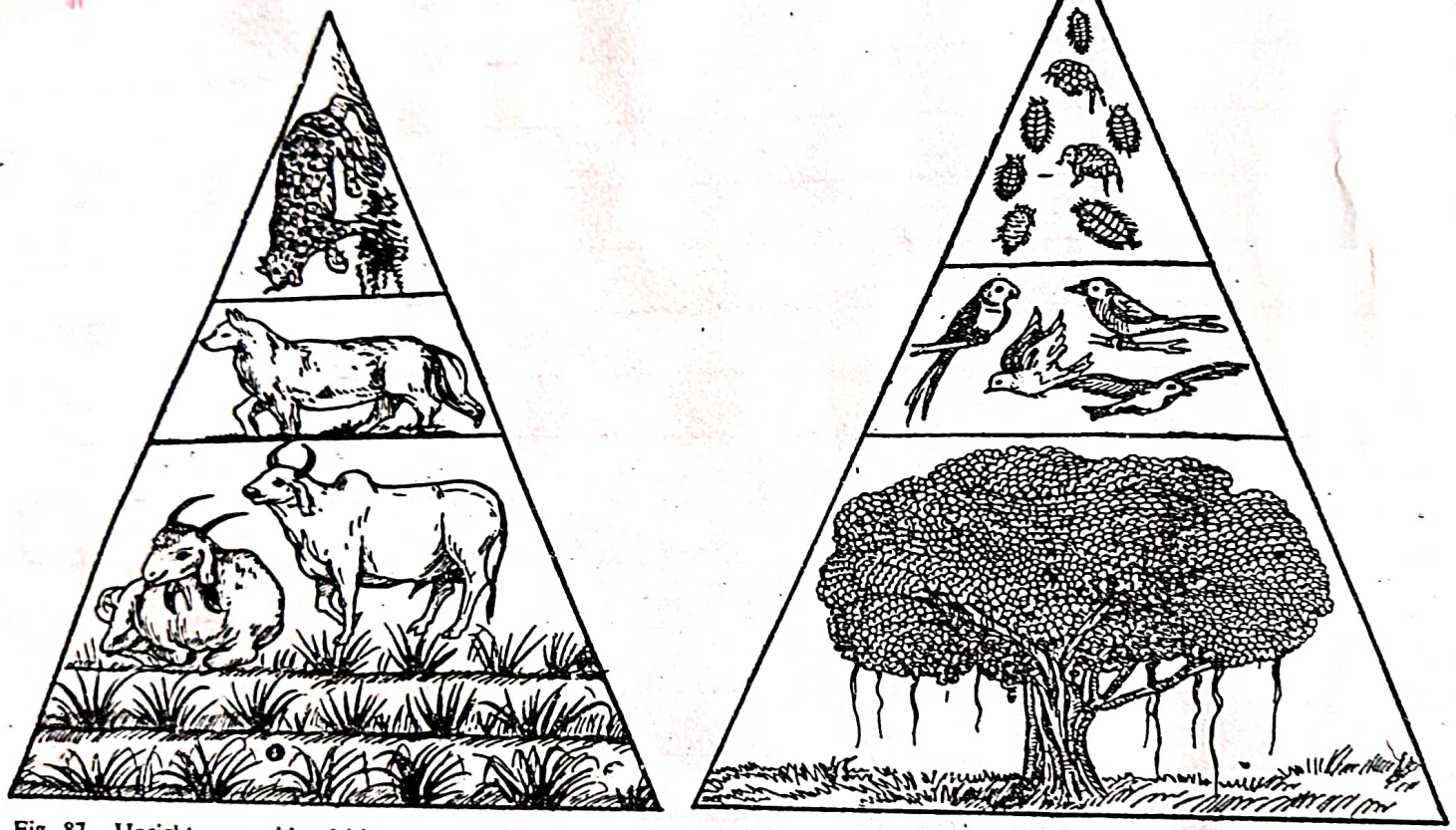

Fig. 87. Upright pryam ids of biomass of (*A*) Grassland ecosystem and (*B*) Tree ecosystem showing decrease in biomass in successive trophic levels.

- 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.

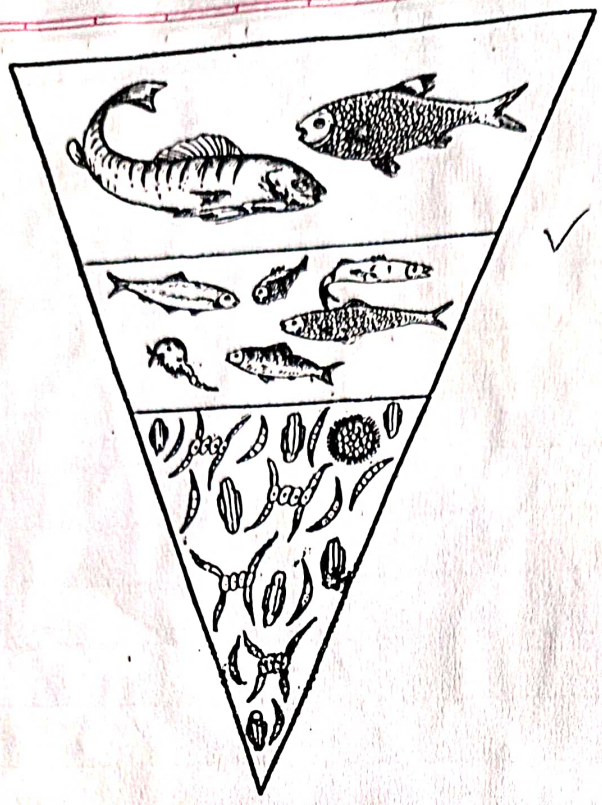

Fig. 88. An inverted pyramid of biomass of a pond ecosystem showing decrease in number but increase in biomass.

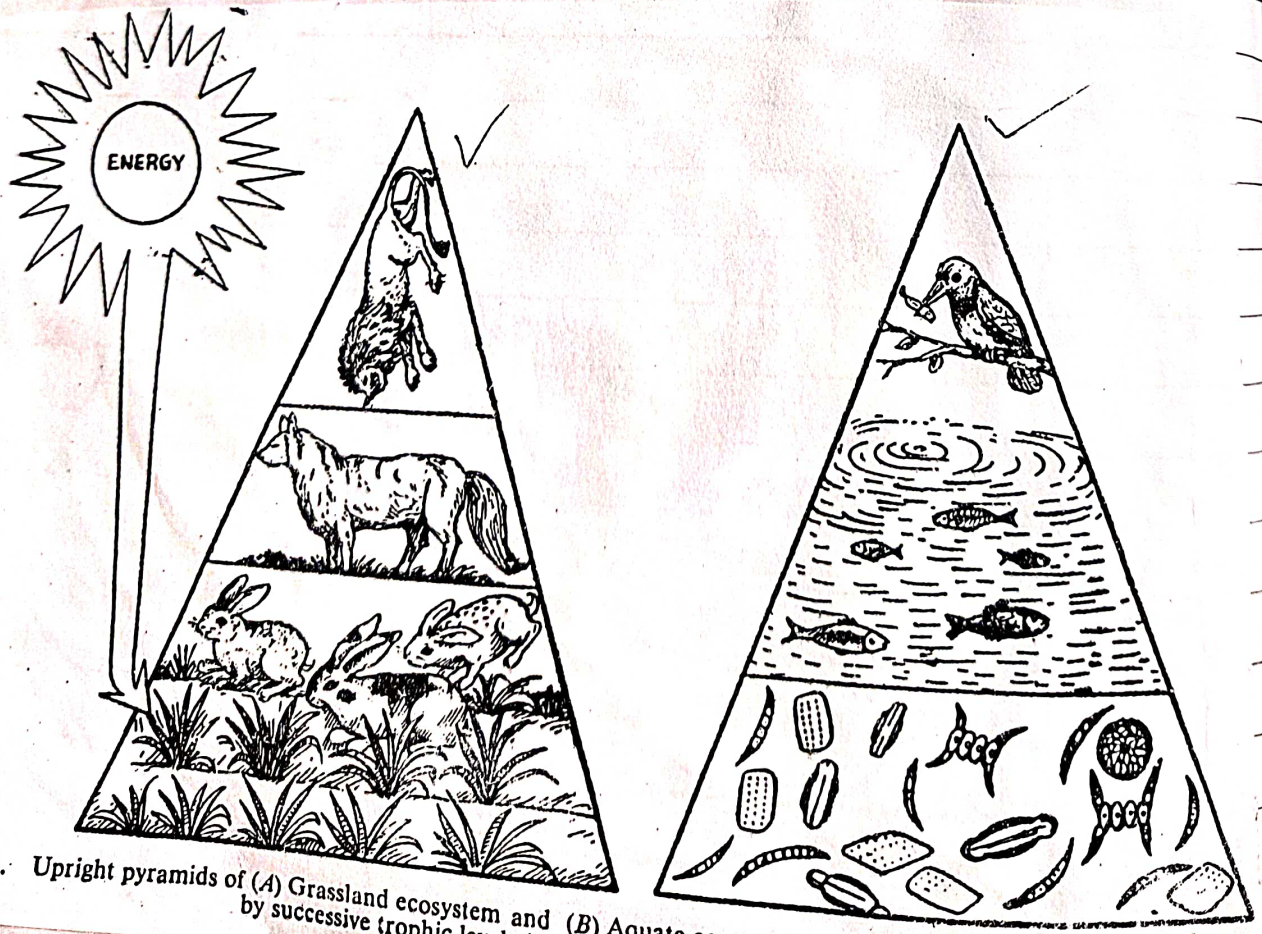

Fig. 90. Upright pyramids of (*A*) Grassland ecosystem and (*B*) Aquate ecosytem showing the rate of utilization of energy by successive trophic levels in a given area over a period of time.

[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 generation 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.