CHARACTERISTIC FEATURES OF VARIOUS ECOSYSTEMS

Homeostatis, Management and Optimization of Ecosystem

Ecosystems are capable of self-maintenance and self-regulation as their component population and organisms. However, they have a delicate balance of inputs and outputs, and this balance is often insufficient to avoid instability. The term homeostatis (homeo = same; statis = standing) is generally applied to the tendency for biological system to resist change and to remain in a state of equilibrium. An essential feature of such regulatory mechanism is the process of feedback operating both at the level of individual and the entire system.

Many of the large-scale human activities- industrial, agricultural or transport - tend to alter the natural balance of biotic and abiotic components in a stable ecological system. These activities frequently lead to acceleration of hydro geochemical cycles, disturbance of input-output balances, accumulation of toxic substances such as hydrocarbons, metals and gases, overproduction or depletion of certain essential substances, and eutrophication. All these involve simplification of ecosystem resulting into shortening of food webs, decrease in species diversity and counteraction of forces of natural selection and organic evolution has developed a theory of ecosystem stability based on energy-matter constraints in living systems. Some important features of the theory are:

Ecosystems have a zero state trending tendency, pertinent to stability. The concept of stability incorporates two ideas, (a) resistance to change, and (b) restoration to the near original state after the change has occurred;

Curtailment of energy and material inputs tends to lead decay or extinction of ecosystems to zero state; such decay is guaranteed by the second law of thermodynamics;

Ecosystems have only one free (unforced) equilibrium, the zero state;

Ecosystems tend to revert to nominal, no equilibrium dynamics when perturbed by uniformly vanishing disturbances;

Ecosystems have only one forced steady state;

Ecosystems are structurally stable;

Ecosystems adapt and evolve in small degrees by parameter variation within fixed structure, and

Ecosystems adapt and evolve in large degrees by structure variation.

Proper management is essential for maintaining the stability of the ecosystem. This will require an adequate knowledge of the nature and kinds of system components, functional relationship between them, and the degree of tolerance and resistance to the environmental strain and stress

has listed the following features contributing to stabilization of ecosystem: (a) tolerance to extreme and harsh conditions, (b) ability for rapid recovery upon the recurrence of favourable growth conditions, (c) flexible and opportunistic feeding habitat, (d) nomadic migration of animals, etc. Similarly, some destabilizing features include: (i) sensitivity to damage to reserves, (ii) sensitivity to lagging components, (iii) low density, biomass and productivity, and (iv) sensitivity to soil erosion.

Evolution of Ecosystems

Life began on earth more than three billion years ago. The first ecosystems then were populated by tiny anaerobic heterotrophs that lived on organic matter synthesized by abiotic processes. Following the origin and population explosion of algal autotrophs, which converted a reducing atmosphere into an oxygenic one, organisms have evolved through the long geological ages into increasingly complex and diverse systems that (i) have achieved control of the atmosphere and (ii) are populated by larger and more highly organized multi cellular species. Within this community component, evolutionary change is believed to occur principally through natural selection at below the species level, but natural selection above this level may also be important, especially (i) co evolution, i.e., the reciprocal selection between interdependent autotrophs and heterotrophs, and (ii) group or community selection, which leads to the maintenance of traits favourable to the group. Similarities between major biomass or ecosystems in respect to ecosystem structure and function can be attributed to evolutionary convergence as a consequence of their evolution under similar environmental conditions.

Major Ecosystems

Introduction

Various ecosystems like a pond, a lake, a river, a stream, a spring, an estuary, the sea, a forest, grassland, a desert, a coral reef and a cropland are operating as self-sufficient interacting systems in the biosphere. These ecosystems have a more or less similar fundamental plan of their gross structure and function. However they differ in respect of their species composition and productivity rates. In brief, organization pattern of some of the major ecosystems is described here.

THE FOREST ECOSYSTEM

Forests are natural plant communities with dominance of phanerophytes and occupy nearly 40% of the land. In India, the forests occupy roughly 10% of the total land area. According to Champion and Seth (1968), Indian forests are of 11 types, which are classified on the basis of

physiography, physiognomy floristics, habitat etc. The different components of forest ecosystems are as follows:

Abiotic components

These include inorganic and organic substances present in the soil and atmosphere. The climate (temperature, light, rainfall, etc.) and soil (minerals) vary from forest to forest. In addition to minerals the occurrence of litter is characteristic feature of majority of forests.

Biotic components

a) Producers

These are mainly trees that show much species diversity and greater degree of stratification especially in tropical moist deciduous forests. Besides trees, there are also present shrubs and ground vegetation. In these forests, the producers include the dominant tree species such as Tectona grandis, Butea frondosa, Shorea robusta and Lagerstroemia parviflora. In temperate coniferous forests, shrubs and ground flora are insignificant. In temperate deciduous forests the dominant trees are species of Quercus, Acer, Betula, Thuja, Picea, etc., whereas in temperate coniferous forests, the producer trees are species of Abies, Picea, Pinus, Cedrus, Juniperus, Rhododendron, etc.

b) Consumers

These are as follows:

i) Primary consumers

These are the herbivores that include smaller animals feeding on tree leaves as ants, flies, bettles, leaf hoppers, bugs, spiders, etc., and larger animals grazing on shoots and/ or fruits of producers as elephant, neelgai, deer, moles, squirrels, shrews, flying foxes, mongooses, etc.

ii) Secondary consumers

These are the carnivores like snakes, birds, lizards, fox, etc. feeding on the herbivores.

iii) Tertiary consumers

These are the top carnivores like lion, tiger, etc., that eat carnivores of secondary consumers level.

c) Decomposers

These are wide variety of microorganisms including fungi (species of Aspergillus, Polyporus, Alternaria, Fusarium, Trichoderma, etc.), bacteria (species of Bacillus, Pseudomonas, Clostridium, etc.), and actinomycetes (species of Streptomyces). Rate of decomposition in tropical and subtropical forests is more rapid than in the temperate ones.

THE GRASSLAND ECOSYSTEM

Grasslands occupy roughly 24% of the earth's surface (Shantz, 1954). Whyte (1957) divided grassland into 8 types based on the floral characteristics. The different components of a grassland ecosystem are:

Abiotic components

These include nutrients present in soil and the atmosphere. Thus the elements like C, H, O, N, P, S, etc. are supplied by carbon dioxide, water, nitrates, phosphates and sulphates present in air and soil of the area.

Biotic components

These are as follows:

a) Producers

They are mainly grasses, as species of Dichanthium, Cynodon, Desmodium, Dactyloctenium, Digitaria, Setaria, Sporobolus, etc. Besides them a few forbs and shrubs also contribute to primary production.

b) Consumers

These are as follows:

i) Primary consumers

The herbivores feeding on grasses are mainly such grazing animals as cows, buffaloes, deers, sheep, rabbit, mouse, etc. Besides them, there are also present some insects as Leptocorisa, Dysdercus, Oxyrhachis, Cicindella, Coccinella, some termites and millipeds, etc. that feed on the leaves of grasses

ii) Secondary consumers

Snake, lizard, birds, jackals, fox, etc. are common secondary consumers which feed on herbivores.

iii) Tertiary consumers

These include hawks which feed on secondary consumers.

c) Decomposers

Several fungi (Mucor, Aspergillus, Penicillium, Cladosporium, Rhizopus, Fusarium, etc.), actinomycetes and bacteria decay the dead organic matter of different forms of higher life. They bring about minerals back to the soil, thus making them available to the producers.

CROPLAND ECOSYSTEM

This is an artificial or man - engineered ecosystem aimed primarily to grow a single species of one's choice. To secure maximum production, man makes much planned manipulation in the

physico-chemical environment. These include addition of fertilizers to the soil, use of chemicals for disease control, proper irrigation practices, etc. This may include the dominant species like maize, sugar-cane, jowar, paddy, vegetables, etc. The following are the main components of a maize cropland ecosystem:

Abiotic components

These include the climatic conditions of the region, where the crop may grow most successfully, and the various minerals and gaseous elements such as C, H, O, N, P, K in soil and atmosphere. Maize generally grows best in slightly alkaline soil with good aeration.

Biotic components

These occur in the following order:

a) Producers

In the field, in addition to dominant species of maize, a number of weeds like Cynodon dactylon, Launaea nudicaulis, Euphorbia hirta, Cyperus rotundus, Digitaria species., and Alysicarpus also contribute to primary production of the field.

b) Consumers

These are as follows:

i) Primary consumers

These are herbivores. The smaller animals include chiefly the insects as aphids, thrips, beetles, etc., which feed and lay their eggs on maize leaves. The larger animals include birds, rats, rabbits and man feeding on leaves, flowers and fruits on the crop.

ii) Secondary consumers

These are carnivores like frogs and some birds that eat insects.

iii) Tertiary consumers

Snakes and hawks belong to this category which can eat frogs and small birds, respectively.

c) Decomposers

Several microbes such as actionmycetes, fungi and bacteria found in soil and climate decompose dead organic matter of plants as well as animals and help in circulation of minerals making available them to producer again.

THE DESERT ECOSYSTEM

The areas with an annual rainfall of less than 25 cm come in deserts. They occupy about 17% of land. Due to extremes of both, water and temperature factors the biota is much more varied and is poorly represented. The various components of the ecosystem are:

Abiotic components

In desert ecosystem temperature is found to be very high and rainfall is very low. A dry atmosphere, high temperature and intense illumination favour the rate of transpiration.

Biotic components

These are as follows:

a) Producers

These are shrubs, especially bushes, some grasses, and a few trees. The shrubs have widespread branched root system with their leaves, branches and stems variously modified. Sometimes a few succulents like cacti are also present. Some lower plants like lichens and xerophytic mosses may also be present.

b) Consumers

Insects, reptiles, nocturnal rodents, birds, camels, etc. are the main consumers.

c) Decomposes

These are very few, as due to poor vegetation the amount of dead organic matter is correspondingly less. They are some fungi and bacteria, most of which are thermophilic.

THE MOUNTAIN ECOSYSTEM

The chief components of the ecosystem are:

Abiotic components

It is the altitude which provides different climates.

Biotic components

These are as follows:

a) Producers

They differ to difference in climatic conditions even on the same mountain e.g., in the forests, trees are the main producers, while in desert the chief producers are shrubs, herbs and only a few trees.

b) Consumers

They vary with the type of producers in the area.

CAVE ECOSYSTEM

A cave is a natural hollow opening under the surface of the earth, or a mountain or a hill. Many caves are found in North America and Europe, e.g., Mammoth cave in North America. The main components of the cave ecosystem are as follows:

Abiotic components

Absence of light is the most striking feature since it has telling effect on the cave dwelling organisms. Temperature is nearly uniform, except some fluctuations with the depth of the cave. Several fluctuations in moisture level occur. Atmospheric pressure varies as that of the terrestrial environment.

Biotic components

These are as follows:

a) Producers

They are almost absent.

b) Consumers

Both vertebrates and invertebrates of cave dwelling existence are found. They may be temporary, such as bats, owls, etc., or permanent, such as turbellarians, Leeches, insects, etc., (invertebrates). Mammals are rare; birds are absent.

c) Decomposers

Fungi and bacteria are present

TUNDRA ECOSYSTEM

Tundra means a barren land or a hostile territory. Tundra biomes occur in the polar regions in northern Canada, Greenland, other islands of Arctic oceans, and northern Europe (northern hemisphere). Since, Antarctic Ocean has not been exploited much; this biome has been designated as Arctic Tundra. Tundra biome also occurs on the peaks of High Mountain of world and has been called as the Alpine Tundra. The chief components of the Tundra ecosystem are as follows:

Abiotic components

These include temperature, light, moisture, pressure, soil, etc. Of these temperature exerts a very powerful influence so that only a few organisms have successfully got adapted to the Tundra conditions. In the Arctic Tundra, the winters are very long and cold, during which the ground remains frozen. The summer is short and sharp during which snow melts to some depth only, hence the deeper layer of soil remains permanently frozen and is known as permafrost. Due to this Tundra soil is very shallow. In the Alpine Tundra, Alpine climate prevails.

Biotic components

These are as follows:

a) Producers

Suitable conditions for plant growth exist only for about 60 days. The dominant producers are the hardiest of plants like bushes, lichens, mosses, grasses and grass like herbs.

b) Consumers

These include mammals like carbou, hares, reindeers, foxes, and polar bears, amphibians and reptiles are totally absent. However, some species of birds and insects are present. The insects are represented by black flies, bumble bees, etc. The birds are migratory and are represented by arctic loon, goose, hawks, gulls, larks, etc. The South Pole has only marine birds, penguins. The fauna of Alpine Tundra varies with the type of vegetation.

THE POND ECOSYSTEM

A pond is a good example of a small self-sufficient and self-regulating ecosystem. Location, size, depth and substratum of a pond influence the biology of pond ecosystem. The components of the systems are as follows:

Abiotic components

Temperature, light, water, and several inorganic and organic substances like CO2, O, N, PO, Ca, S, and carbohydrates, proteins and lipids make abiotic components. Some proportions of

nutrients are in solution state but most of them are present stored in particulate matter as well as in living organisms. The amount of minerals present at any time in the physical environment of the pond is called standing state.

Biotic components

These include:

a) Producers

They are green plants and photosynthetic bacteria categorized into two types:

i) Macrophytes

Ceratophyllum, Hydrilla, Utricularia, Vallisneria, Jussiaea, Nitella, Wolfia, Lemna, Spirodella, Pistia, Eichhornia, Azolla, Salvinia, Trapa, Typha, Marsilea, etc. are included in this category. This may be classified further into submerged, free floating and amphibious plants.

ii) Phytoplanktons

These are minute floating or suspended lower plants belong to some algae and flagellates. Ulothrix, Spirogyra, Oedogonium, Chlamydomonas, Zygnema, Volvox, Pandorina, Cosmarium, Scendesmus, Closterium, Anabaena, Pediastrum, Microcystis, diatoms, etc. are common algal phytoplanktons.

b) Consumers

These are as follows:

i) Primary consumers

(a) Zooplankton comprises ciliates, flagellates, other protozoans, small crustacean like Copepods and Daphnia, etc. These animals drift with the water current and are found along with phytoplankton upon which they feed. (b) Benthos or bottom forms comprise the bottom dwelling animals, e.g., annelids and mollusks which feed on plants directly or on plant remains at the bottom.

ii) Secondary consumers

These are the carnivores which feed on the herbivores, e.g. insects and fish.

iii) Tertiary consumers

These are some large fish as game fish that feed on the smaller fish.

c) Decomposers (or microconsumers)

Several bacteria, fungi (Aspergillus, Cephalosporium, Pythium, etc.) and actinomycetes represent the group.

THE OCEAN (MARINE) ECOSYSTEM

The oceans of the world cover approximately 36,10,00,000 km2, i.e. about 71% of the earth's surface. Atlantic, Pacific, Indian, Arctic and Antarctic are the main oceans of the world. The ocean represents a very large and stable ecosystem. The main components of the ocean ecosystem are as follows:

Abiotic components

Marine environment, as compared with fresh water, appears to be more stable in chemical composition due to being saline (35 parts of salts by weight per 1000 parts of water, while salinity of fresh water is less than 0.5%), and moreover other physico-chemical factors such as dissolved oxygen content, light and temperature are also different. About 27% is NaCl; most of the rest consists of Ca, Mg, and K salts. Water is strongly buffered. The concentration of dissolved nutrients is low and constitutes an important limiting factor to determine the size of marine populations. Waves of various kinds and tides prevail there. Like ponds and lakes, ocean show distinct zonation.

Biotic components

This category includes phytoplanktons and larger marine plants. The former group includes diatoms and dinoflagillates. The latter group includes sea weeds (algae) belonging to chlorophyceae, phaeophyceae and rhodophyceae; and angiosperms. Ruppia, Zostera, Posidonia, Halophila, Enhalus, etc. are true marine angiosperms while various species of Rhizophora, Avicennia, Sonneratia, Carapa, Aegiceros, etc., represent the mangrove complex-tidal woodlands

a) Consumers

These are heterotrophic macroconsumers, being dependent for their nutrition on the primary producers. These are:

i) Primary consumers

The herbivores that feed directly on producers are chiefly crustaceans, mollusks, fish, etc.

ii) Secondary consumers

Carnivorous fishes, such as Herring, Shad, Mackerel, etc. are included in this group.

iii) Tertiary consumers

Fishes like Cod, Haddock, etc. are the tertiary or top consumers.

b) Decomposers

They are chiefly bacteria and some fungi which participate actively in decomposition of dead organic matter.

ESTUARINE ECOSYSTEM

An estuary is a semiclosed coastal body of water that has a free connection with sea. It is strongly affected by tidal action, and within it sea water is mixed with fresh water from land drainage. River mouths, coastal bays, tidal marshes and bodies of water behind barrier beaches are some of the examples. Estuaries are generally productive because of water flow subsidises an abundant of nutrients. The chief biotic components of estuarine ecosystem are as follows:

a) Producers

Macrophytes- marsh grasses, sea weeds, sea grasses, benthic algae and phytoplankton.

b) Consumers

Oysters, crabs, several kinds of shrimp and many commercial sport fish.

CORAL REEF ECOSYSTEM

A coral reef represents one of the most beautiful and well adapted ecosystems to be found in the world. Coral reefs are made up of calcareous skeletal remains and secretion of corals and certain algae. They are confined largely to the warm waters of the Pacific and Indian oceans. A few coral reefs also occur elsewhere. The reef-building corals grow best in waters having an average annual temperature of about 24°C at a depth of about 40-50 metres. They can survive neither sudden temperature changes nor prolonged exposure to temperature below 18°C. They also require for their growth rocky floor and sunlit water having normal salinity of 35g I-1. They cannot grow in fresh or turbid waters or on highly saline lagoons.

Reef structures are built around islands and volcanic peaks by coral and other lime-secreting minute animals. Corals build protective shells of calcium carbonate around their bodies, which

after their death, sink and accumulate on the sea bottom. Coral families usually produce forms that resemble branching trees or shrubs. In due course, the inner-spaces between the branching coralline structures are filled up by the deposition of calcium carbonate either by lime-secreting organisms or by debris brought by sea waves. Apart from polyps (corals), a number of organisms and plants such as calcareous algae, bryozoans, molluscs and microscopic protozoans (foraminifera) take part in building coral reefs.

Microecosystem

These are little self-contained worlds, in bottles or other containers that simulate in miniature the nature of ecosystems. Completely closed microecosystems (or microcosms) that require only light energy are very difficult to have on a small scale. Experimental microcosms usually vary from partially closed systems having outlets and inlets only for gaseous exchange with the atmosphere to very open systems involving assemblages of organisms maintained in various kinds of chemostates and turbidostates with regulated flux of both nutrients and organisms. Well-designed microcosms may exhibit most of the basic functions and trophic structures of an ecosystem, except the reduction in variety and size of constituent components. Microcosms are suitable for the study of nature and functions of the ecosystems in laboratory.

11.3.14 Spacecraft as an ecosystem

During space travel for a short journey, such as a few orbits around the earth, man does not require to take along with him a self-sustaining ecosystem since sufficient oxygen and food can be stored in the capsule to last for a short time. However, for a long journey involving a number of astronauts, such as an expedition to one of the planets he must devise some self-contained system so as to get at least minimum requirements, necessary for his smooth working and survival, as in nature. Such a self-contained space-craft must include all four of the basic components producers, consumers, decomposers, and abiotic components in such proportion and diversity as to maintain a stable environment capable of adjusting to the incoming solar radiation as do the earth's ecosystems. A small capsule with a few components might function outside the biosphere for a short time, but a larger, more diverse system would be more stable and safer for a longer time. Engineers and environmentologists associated with such a planning, however, could not able to decide as yet on the size and composition of self-contained system that might function completely independent of other ecosystems during a long space journey.