ECOLOGY

This is the scientific study of the relationships of organisms with each other and their environment. Environment is the immediate surrounding of an organism.

IMPORTANCE OF STUDYING ECOLOGY

- It gives the scientific foundations for understanding agriculture, forestry and fisheries.
- It gives the basis for predicting, preventing and remedying pollution.
- It helps us to understand the likely consequences of massive environmental intervention, as in the construction of dams or diversion of rivers.
- It also provides the rationale underlying biological conservation.

TERMS USED IN ECOLOGY

Population: a group of organisms of the same species occupying a defined area and usually isolated to some degree from other similar groups.

Community: Any group of organisms belonging to a number of different species but co- exist in the same habitat or area and interact through trophic and spatial relationships.

Ecosystem: A community of organisms and their physical environment interacting as an ecological unit. Different ecosystems together form the biosphere.

Biosphere/ecosphere: This includes all organisms living within a relatively narrow sphere (land, water and air) and the earth's surface.

The biosphere is divided in to two major regions i.e. **aquatic regions** made up of fresh water (lakes, ponds, rivers, streams and wetlands), marine water (oceans and seas) and estuaries. And the **terrestrial regions** made up of the soil (land mass) and the atmosphere.

Biomes: These are large ecological areas on the biosphere with distinctive plant and animal groups which are adapted to that particular environment e.g. tropical rain forests, tundra regions, hot and dry desert regions, cold deserts and temperate regions.

Habitats: A specific locality in the biome where an organism normally lives within the environment with set physical conditions that support specific organisms e.g. leaf litter for earthworms, intestines of man for tapeworms, ponds for frogs, kitchen for cockroaches, etc.

Ecological niche: This is the role and position any species has within its habitat, ant its interactions with living and non – living environment. It describes how an organism meets its needs for food, shelter, survival and reproduction. There are two types of ecological niche

- **Realized niche** – occurs in the presence of predators, competitors and parasites limiting the habitat and roles performed by an organism. It is smaller in size.
- **Fundamental niche** – occurs in the absence of predators, competitors and parasites allowing an organism experience a larger habitat and perform a variety of roles.

ECOSYSTEMS

This is a natural unit of environment composed of living (biotic) and non – living (abiotic) components whose interactions lead to a self – sustaining system. They include the water/aquatic ecosystems and land/terrestrial ecosystems.

THE MAJOR COMPONENTS OF AN ECOSYSTEM

There are two main components of the ecosystem namely abiotic and biotic components:

Abiotic/non – living components:
These are physical and chemical factors that influence organisms on land and aquatic ecosystems.
Examples:
- Climatic factor like temperature, light, wind, humidity and rainfall.
- Soil/edaphic factors like soil pH, soil air, inorganic particles, soil water, organic matter (dead organism matter (DOM) and living organisms), soil temperature, etc.
- Topography
- Other physical factors such as fire, wave action etc.

Biotic/living components
These are living factors (plants, animals and decomposers) that affect the survival and distribution of an organism.

ENERGY FLOW THROUGH AN ECOSYSTEM
The study of energy flow through ecosystems is called **energetics**.
The sun is the primary source of energy in the ecosystem. Light energy is trapped by photosynthetic organisms (green plants, algae and some bacteria) and converted in to chemical energy during photosynthesis. Energy is then transferred from one feeding level to another through feeding relationships like food chains or food webs. Most of the energy from the sun is radiated to the atmosphere leaving only 5 – 10% for the producers to make use of. Along the food chain, only a small portion of the available energy is transferred from one feeding level to another. Much energy is lost as heat during sweating and excretion, respiration, egestion and some remains locked up in indigestible parts of the plants like cellulose or bones, hooves, hair, skin etc. in animals.

Note
The number of organisms decreases at each successive feeding level because of the great energy losses, so the energy left in organisms is little to support large numbers of top consumers, limiting the length of the food chain (not exceeding 5 trophic levels).

TROPHIC/ECOLOGICAL EFFICIENCY
This is the percentage of energy at one trophic level that is converted in to organic substances at the next trophic level. **Productivity** in ecosystem is the amount of organic material manufactured by organisms. It can be measured using methods like harvest crop; through oxygen consumed during photosynthesis and rate of consumption or use of raw materials.
It can be divided in to:
Gross productivity: The total amount of energy and organic matter stored in an organism over a period of time.
Net productivity: The amount of energy and organic matter stored in an organism that is passed on to the next trophic level.
Primary productivity: The amount of energy and organic material stored in primary producers. It is measured in mass per unit area per unit time (kg/m^2/year).
Gross primary productivity (GPP): The initial amount of energy incorporated in to primary producers during photosynthesis.
Net primary productivity (NPP): the amount of energy transferred from primary producers to primary consumers/ the net gain of organic material in photosynthesis after allowing the losses due to respiration. Therefore: **NPP = GPP – assimilation (respiration and metabolism).**

Secondary productivity (SP): the amount of energy incorporated in to the body of consumers. It is also known as gross secondary productivity (GSP).
Net secondary productivity (NSP): the amount of energy that can successfully be transferred from one consumer to another.

Note
Carnivores have a higher SP than herbivores because;
- Diet of carnivores is rich in proteins, easily digestible and therefore absorbed efficiently, allowing little energy to be lost. Herbivores have their diet consisting of mainly plant materials which are not easily digested.
- Carnivores do not have symbiotic microbes to consume part of the energy of their diet in digestive tracts.
- Their faeces contain much less undigested material.

Endotherms have high NSP because energy from absorbed food is used in replace of the lost heat to their surrounding in order to maintain a constant body temperature, unlike exotherms that depend mostly on behavioral means to maintain their body temperature.

FOOD CHAINS

These are linear sequences of energy flow from producers through a series of organisms in which there is a repeated eating and being eaten. There are two types of food chains; the grazing and detritus food chains.

GRAZER FOOD CHAIN

This starts with autotrophs (producers) or green plants which convert carbon dioxide and water in to chemical compounds. It contains the following trophic levels:
Producers
These are autotrophic organisms such as green plants, algae and blue – green bacteria. Microscopic algae and blue – green bacteria are the main producers in aquatic ecosystems and are called **phytoplanktons**, and in terrestrial ecosystems, larger plants dominate e.g. grasses and trees.
Primary consumers
These feed on producers. They are the herbivores. On land, herbivores include insects, reptiles, birds and mammals. In aquatic ecosystems, herbivores include crustaceans, molluscs and protozoans, collectively called **zooplanktons**.
Secondary consumers
These feed on primary consumers. They are the flesh eaters or carnivores e.g. birds of prey like eagles, kite lions, cheetahs, tigers, hyenas, snakes, big fish etc.
Tertiary consumers
These feed on both primary and secondary consumers.
Secondary and tertiary consumers may be
- Predators which hunt capture and kill their prey.
- Carrion feeders which feed on corpses like vultures.
- Parasites which do not eat their prey but feed off the host organism while it continues to live.

Two examples of **predator** food chains are given below.
Plant (e.g. Leaves) $\longrightarrow$ slug $\longrightarrow$ frog $\longrightarrow$ grass snake $\longrightarrow$ stoat.
Rosebush sap $\longrightarrow$ aphid $\longrightarrow$ lady bird $\longrightarrow$ spider $\longrightarrow$ insectivorous birds $\longrightarrow$ hawk.
Here, carnivores become larger and fewer in numbers at each successive trophic level.

Parasite food chains are different in that the parasites get smaller at successive trophic levels and increases in number.

Grazer food chains can be grass lands or water bodies

E.g. Grass → Millipedes → Toads → Snakes → Hawks

Green algae → haplochromics → tilapia → king fisher.

DETRITUS FOOD CHAIN

This is a food chain in which most primary production is decomposed or consumed as detritus (fragments of dead decaying organic matter). It also exists in both aquatic and terrestrial habitats.

The first trophic level is occupied by a decomposing organic matter.

Examples

Leaf litter → earthworms → blackbird → sparrow hawk

Dead animal → blow flies → common frog → grass snake

Tree log → woodlice → toad → python

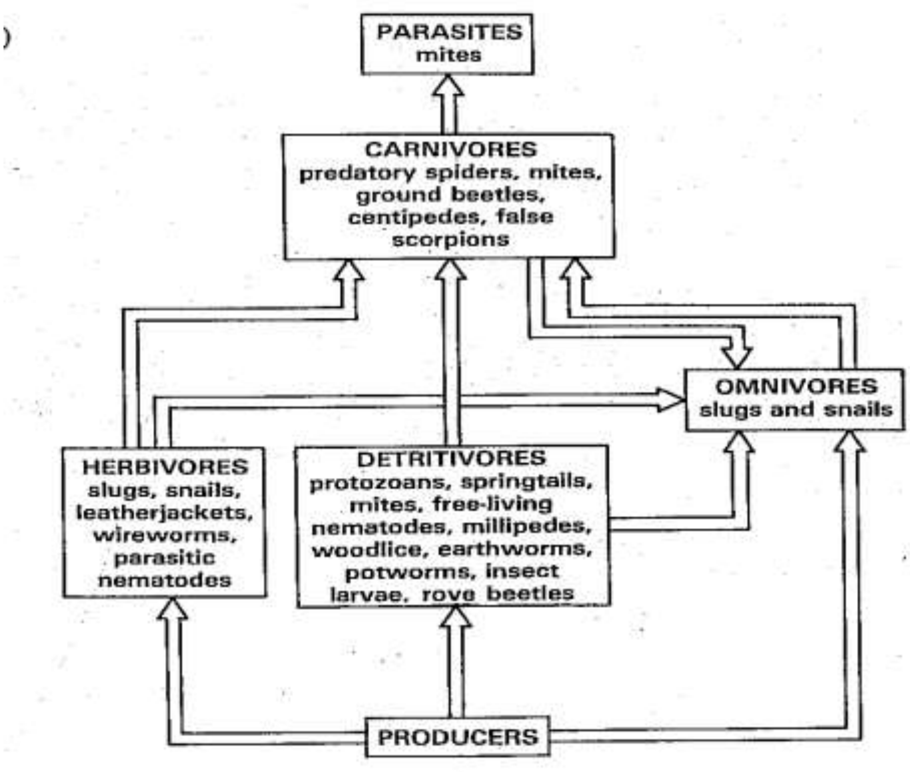
Importance of decomposition

- It enables dead bodies to be disposed off which if left would accumulate everywhere.
- Recycles nutrients to be used by other organisms.
- Unlocks trapped energy in the body of dead organisms.

FOOD WEBS

These are complex nutritional interrelationships that illustrate alternative food sources and predator for each organism. A food web is made up of several food chains.

Examples of a food web



Note

- The arrow points to the organism eating another.
- Removal of one organism from the food web usually causes its destruction, following decreases and increases in the population of certain organisms. E.g. when insect larvae are removed, plants (producers) increase in number because of reduced consumption while centipede (carnivore) and slugs (omnivore) reduce in number because of starvation and death due to reduced food resource. This in turn increases the number of herbivores due to less predation.

ECOLOGICAL PYRAMIDS

These are histograms that provide information about feeding/trophic levels in ecosystems. Ecological pyramids help to compare different ecosystems, seasonal variation within a particular ecosystem and change in an ecosystem.

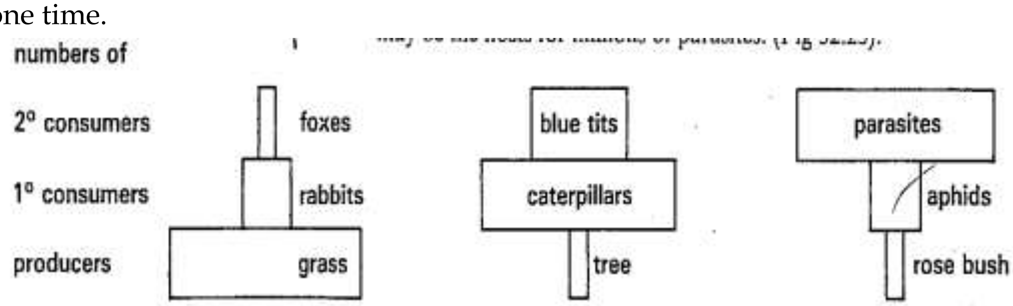
There are three types of pyramids: pyramid of numbers, pyramid of biomass and pyramid of energy.

Note

Length of a given bar is proportional to the number, energy and biomass at a given trophic level in a given area.

PYRAMID OF NUMBERS

This is a histogram representing the number of different organisms at each trophic level in an ecosystem at any one time.



Note

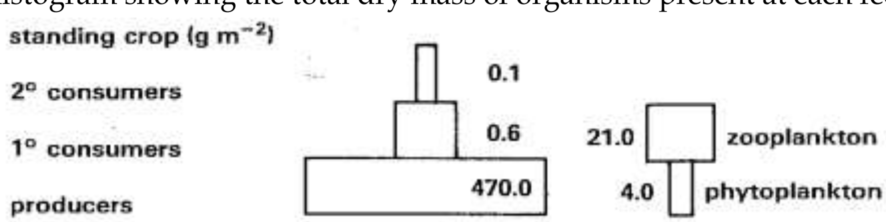
- As a pyramid is ascended, the number of organisms decreases but the size of each individual increases.
- In some cases, the consumers may be more than the producers e.g. in a parasitic food chain, inverted pyramids B and C are obtained because parasites progressively become smaller and many along a food chain.

Limitations of pyramid of numbers

- Drawing the pyramid accurately to scale may be difficult.
- Pyramids may be inverted.
- The trophic level of an organism may be difficult to ascertain.
- The young forms of species may have a different diet from adults hence their number not considered.

PYRAMID OF BIOMASS

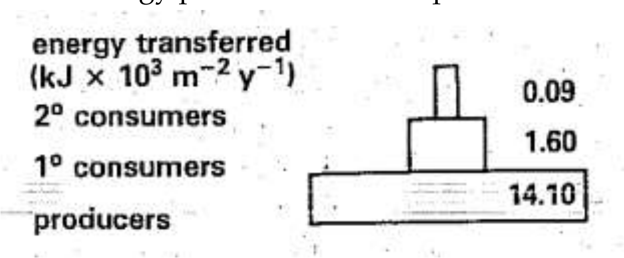
This is a histogram showing the total dry mass of organisms present at each feeding level at a particular time.



Pyramids of biomass reduce the possibility of forming inverted pyramids because its construction depends on biomass of organisms.
Inverted pyramids of biomass represent an aquatic ecosystem because diatoms (phytoplanktons) have a lower biomass but with higher productive rates, therefore capable of supporting a larger biomass of zooplanktons.

Limitations of pyramids of biomass
- Do not allow for exchange in biomass at different times of the year e.g. deciduous trees have larger biomass in summer than in winter when they shed off leaves.
- Impossible to measure exactly biomass of the organisms in an ecosystem, because the sample used may not be true representation of the whole population
- Results may not be accurate e.g. where killing is not allowed, the results are obtained by estimating the fresh mass.
- Do not take in to account the rate at which biomass accumulates e.g. a mature tree has a larger biomass which increases every year.

PYRAMID OF ENERGY
This is a histogram showing the total amount of energy present at each trophic/feeding level. They show how much energy passes from one trophic level to the next.



Advantages
- It compares productivity because time factor is incorporated.
- Biomass may not be equivalent to energy value e.g. 1g of fat has more kilojoules than 1g of cellulose or lignin.
- No inverted pyramids are obtained because of the automatic degradation of energy quality.
- The solar input of energy may be included as an extra rectangle at the base.

However, obtaining the necessary data required in constructing the pyramids of energy is difficult.

GENERAL PROBLEMS OF ECOLOGICAL PYRAMIDS
1. Identifying an organism's trophic level is difficult because many organisms feed at several trophic levels.
2. Assigning all plant material to the producer level seems inappropriate because many plant organs such as tubers, fruits and seeds are plant products rather than primary producing photosynthetic organs.
3. DOM is omitted from pyramid diagrams yet 80% of all energy fixed by producers is not eaten by consumers but by detritivores or is used by decomposers.

BIOGEOCHEMICAL CYCLES

These are processes by which chemical compounds of a particular element that constitutes living matter are transferred between organisms (biotic phase) and non – living environment (abiotic phase). They include nitrogen cycle, carbon cycle and hydrogen/water/hydrological cycle.

THE CARBON CYCLE

The main carbon source for living organisms is carbon dioxide present at 0.036% by volume in the atmosphere or dissolved in surface waters.

Carbon fixation involves the reduction of carbon dioxide to large organic substances/ molecules during photosynthesis and chemosynthesis by green plants, algae and bacteria. During aerobic respiration by all organisms, carbon dioxide is returned to the atmosphere or dissolved in water.

Over millions of years, buried deposits of dead plant debris and bacteria are compressed between layers of sediment to form carbon – containing fossil fuels e.g. coal, oil and natural gases due to anaerobic environment e.g. in waterlogged soils which when burnt release carbon dioxide in to air.

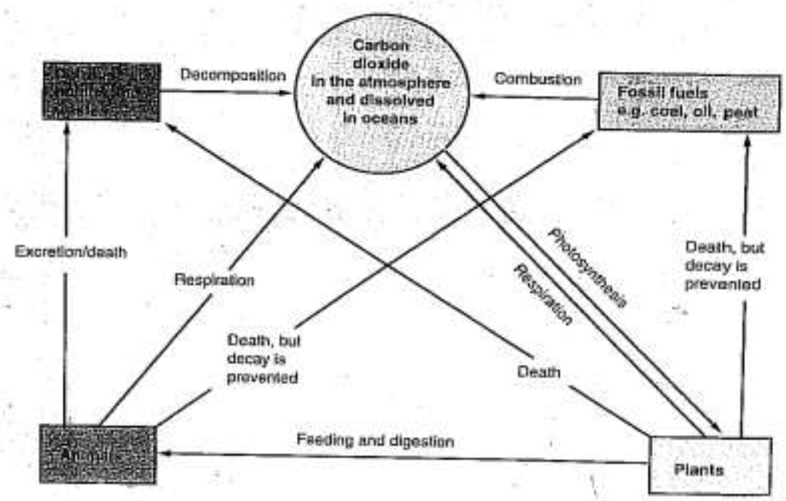
In aquatic ecosystems, carbon dioxide may remain dissolved, be utilized by photosynthesis or react with water to form carbonate and hydrogen carbonate ions. As water warms, more dissolved carbon dioxide returns to the atmosphere.

In marine ecosystems, some organisms take up dissolved carbon dioxide molecules, carbonate and hydrogen carbonate ions which react with calcium ions to form calcium carbonate to build their shells and skeletons.

When the animals with calcium carbonate in shells and skeletons die and drift in to deep bottom sediments of oceans, immense pressure there causes limestone and chalk to form after a very long period of time.

Weathering process releases a small percentage of carbon dioxide from limestone to the atmosphere.

Summary



Effect of human activity on carbon cycle

- Deforestation increases carbon dioxide in the atmosphere.
- Afforestation/ reforestation decreases carbon dioxide in the atmosphere.
- Burning of fossil fuels like coal, petroleum oil, etc. and wood increases carbon dioxide in the atmosphere.

THE NITROGEN CYCLE

Nitrogen is the most abundant element at 78% by volume in the atmosphere. However, nitrogen cannot be absorbed and metabolized directly by multicellular plants and animals.

Atmospheric electrical discharges in the form of **lightening** cause nitrogen and oxygen in the atmosphere to react and produce oxides of nitrogen which dissolve in rain water and fall to the ground as weakly acidic solutions.

Nitrogen fixation occurs when the nitrogen in soil is reduced to ammonium ions catalyzed by Haber process, nitrogen – fixing bacteria e.g. azotobacter, clostridium and rhizobium.

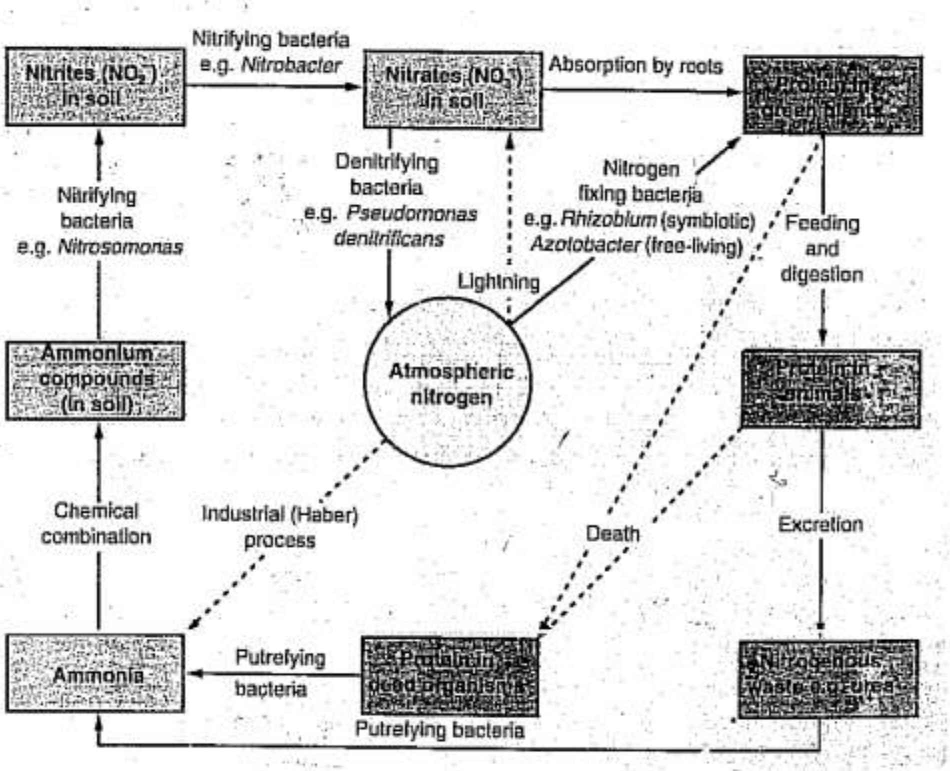
Nitrification occurs when ammonium compounds in the soil are converted first to nitrite ions) highly toxic to plants) by nitrosomonas bacteria and later to nitrate ions by nitrobacter and nitricoccus bacteria.

Ammonification (putrefaction) occurs when decomposers e.g. saprophytic bacteria and fungi convert nitrogen – rich organic compounds, wastes like urea and dead bodies of organisms in to ammonia and ammonium – containing salts.

Assimilation occurs when inorganic ammonia, ammonium and nitrate ions are absorbed by plant roots to make nucleic acids, amino acids and proteins.

Denitrification occurs when mostly anaerobic bacteria e.g. *Pseudomonas denitrificans* and *thiobacillus denitrificans* in waterlogged soil and deep in ocean, lake and swamp bottoms convert ammonia and ammonium ins back in to nitrites and nitrate ions, and then in to nitrogen gas and oxygen. Nitrogen is released in to the atmosphere while oxygen is used for respiration by these bacteria.

Summary



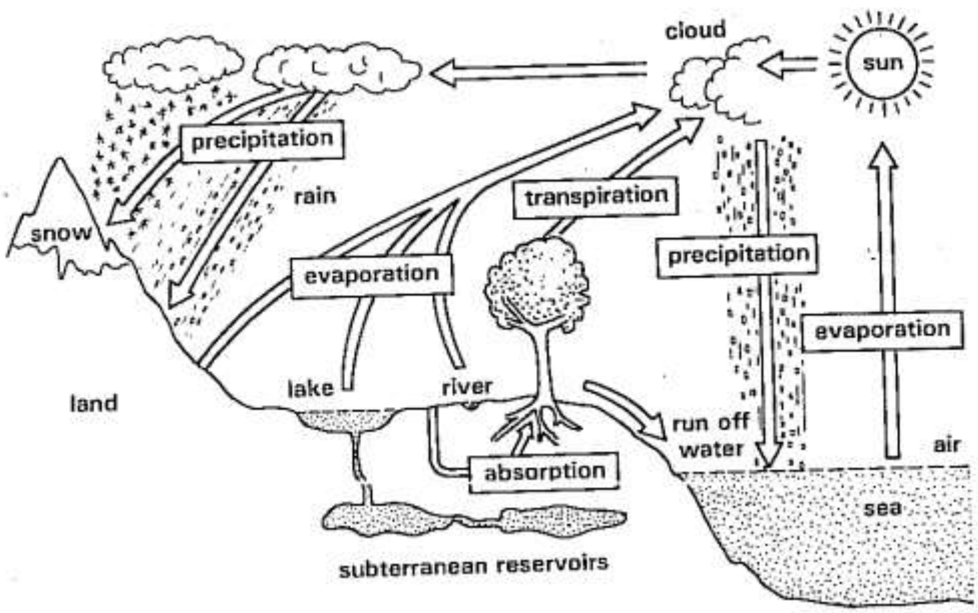
Effect of human activity on nitrogen cycle

- Burning of fuels form nitric oxides (N_2O) which reacts with atmospheric oxygen to form NO_2 that reacts with water to form acid rain.
- The inorganic fertilizers applied to soils are acted up on by anaerobic bacteria to release nitrous oxide in to the atmosphere, where it depletes ozone and contribute to green – house effect.
- Nitrogen is removed from top soil when nitrogen – rich crops are harvested, irrigating crops and burning or clearing grasslands and forests before planting crops.
- Adding nitrogen compounds to aquatic ecosystems e.g. sewage algal blooming which upon death, their decomposition causes oxygen shortage resulting in to death of aerobic organics e.g. some fish.
- The accelerated deposition of acidic nitrogen – containing compounds e.g. nitrogen dioxide and nitric acid on to terrestrial ecosystems stimulates growth of weeds, which out compete other plants that cannot take up nitrogen efficiently.

THE HYDROLOGICAL CYCLE

The oceans are the major reservoirs for the hydrological cycle, containing 97% of all water on Earth. Evaporation from the oceans and subsequent condensation and precipitation is the source of all fresh water for terrestrial and fresh water organisms. Fresh water may rapidly evaporate in to the atmosphere or returns to the oceans via surface run – off and river flow. Some precipitation especially in areas of vegetation may percolate and soak in to the underlying soils and enter longer – term storage as ground water. Fresh water may also be stored as ice for long periods in icecaps and glaciers of polar and mountain areas.

Summary



FACTORS AFFECTING ENVIRONMENTS AND HABITATS: DISTRIBUTION OF ORGANISMS

Both abiotic and biotic factors together with combined factors like soil types, fire and others influence the distribution of organisms.

ABIOTIC FACTORS

Temperature

Fluctuations in temperature in lakes, seas and oceans are relatively small because water has a high specific heat capacity. Radiant heat from the sun does not penetrate water very far, so the temperature of deep waters is fairly low (2-3^{o}C) but constant. This is suitable for ectothermic creatures.

Extremes of temperature occur on land. On the fringes of polar areas, the air temperature is always below freezing point. Only lichens, mosses, a few flowering plants and one or two endothermic animals such as penguins and polar bears can tolerate such conditions

In desert areas, the daytime temperature is very high and causes water to evaporate very quickly. Xerophytic plants such as cacti, insects and a few mammals like camels which can tolerate desiccation are distributed here.

Water

The extent to which an organism is dependent on an abundant water supply depends on its requirements and its ability to conserve it in adverse conditions. Organisms living in dry habitat generally have good water conservation

Light

This is essential for all green plants and photosynthetic bacteria and for all animals dependent on the plants. Plants have numerous adaptations for obtaining optimum illumination.

Humidity

This is important it can affect the rate at which water evaporates from the surface of an organism, which in influences its ability to withstand drought.

Wind and air currents

This particularly applies to plants. Only plants with strong root systems and tough stems can live in exposed places where winds are fierce. Wind also affects the evaporation rate and is instrumental in the dispersal of spores and seeds.

pH

This influences the distribution of plants in soil and fresh water. Some plants thrive in acidic conditions, others in neutral or alkaline conditions. Most are highly sensitive to change in pH.

Mineral salts and trace elements

These particularly affect the distribution of plants in the soil. Plants living in soil deficient in a particular element must have special methods of obtaining it. Many ions, when in high concentration are toxic to particular plant species and this limit their distribution ranges.

Water currents particularly in rivers and streams

Only organisms capable of stemming or avoiding strong currents can survive in the open water. Animals incapable of actively swimming generally live under stones or in burrows and crevices in the bark.

Salinity

The importance of this is seen in the sharp distinction between marine and fresh – water species. It also influences the distribution of estuarine animals. These have special physiological or behavioral adaptations for withstanding the daily fluctuations in salinity that accompany the tidal rhythms.

Wave action

This particularly affects organisms living in the intertidal zone. To survive periodic buffering by waves, and exposure to air, special adaptations are required. These include the sessile habit of animals like limpets and anemones, burrowing by shrimps and sand hopers, and the firm attachment to rocks and general toughness of sea weeds such as focus. Species lacking suitable adaptations cannot occur in exposed situations.

Topography

Minor topographical differences such as illumination, temperature, moisture etc. are importance in influencing the distribution of organisms.

Background

The distribution of organisms whose shade or coloration is such that they are camouflaged when viewed against a particular background is related to the general texture and pattern of the environment. There are many cases of protective camouflage, particularly amongst insects, amphibians and reptiles.

Qns. Describe the ecological effects of fire.

BIOTIC FACTORS

These factors arise in organisms that interact with each other and include diseases, competition, parasitism, pollution, pollination and dispersal, antibiosis, mimicry and human influence.

1. **Human influence**

Of all living organisms, humans exert most influence on the distribution and survival of other species through a number of activities like pollution, deforestation, farming, construction etc.
Man is also a predator, hunting down many animals to a point of their extinction.
Pollination and dispersal
Pollination is an ecological interaction because plants and animals interact with each other. Insects transfer pollen grains from the anther to stigma. Dispersal of seeds and fruits introduces new plants to new habitats and this minimizes competition among species. Both interactions between the flowering plants and animals like insects, birds and bats may be highly elaborate and species specific.
The co – evolution ensures that the distribution of the plants with their pollination or agents of dispersal are related. **Co – evolution** is a long term evolutionary adjustment of two or more groups of organisms that facilitate those organisms living with one another.

2. **Antibiosis**

This is the secretion of chemical substances by organisms in to their surrounding that may be repellant to members of the same of different species. There are two types of antibiosis that occur;

- **Intraspecific antibiosis**: the secretion of chemical substances that affect members of the same species. E.g. male rabbits secrete pheromones from their submandibular salivary gland that is used to mark territory as a warning to other bucks that the territory is occupied.
- **Interspecific antibiosis**: the secretion of chemical substances that affect members of different species. E.g. penicillium secretes penicillin that kills or prevents bacterial growth.

3. Mutualism

This is an interspecific association in which both organism benefit. Examples include lichens (alga and fungus), rhizobium and root nodules, etc.

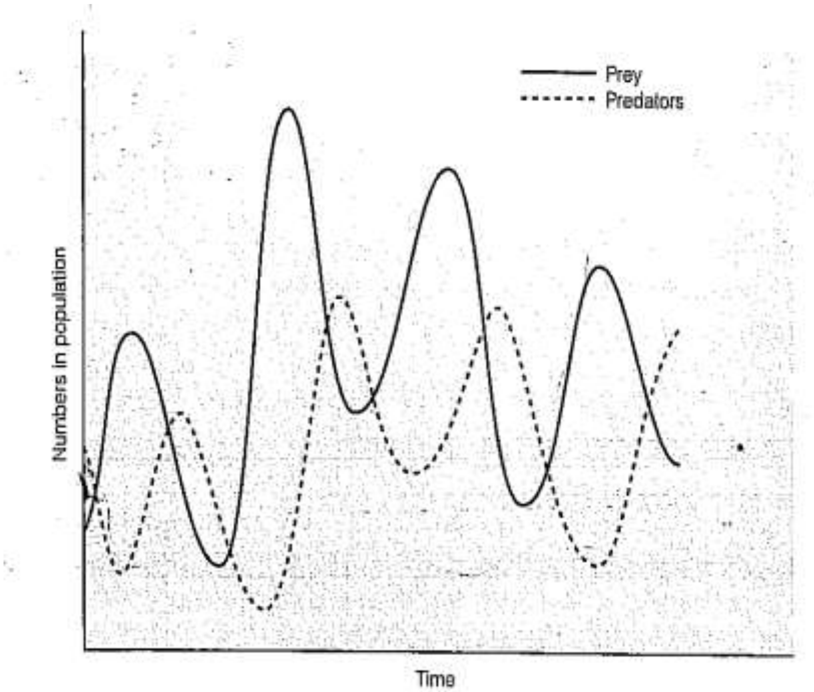
4. Commensalism

This is an association between organisms of different species in which one benefits while the other neither benefits nor is harmed. E.g. cow and white egrets, epiphytes and host plants.

5. Predator – prey relationships

Predation is the relationship whereby members of one species (the predators) feed on all or part of a living organism of another species (the prey). Therefore predators are only found where there is prey e.g. herbivores are found where there is suitable plant material.

A predator – prey interaction in ecosystem



Description

Initially, the population of the prey is higher than the population of the predators. Within a short period of time, both populations of prey and predator increase rapidly. The population of the prey reaches a maximum earlier than that of the predator. As the prey population decreases rapidly, the predator population continues to increase gradually for a short time to a maximum then also decreases rapidly. As the predator population continues to decrease, the prey population starts to increase rapidly followed by a rapid increase in predator population. The cycle is repeated.

Explanation

At the beginning, there are more preys than predators to provide food to the predators. When the population of predators is low, they get enough food and few preys are eaten so the both increase rapidly. The large number of preys provides food to predators, so they reproduce fast and increase in number. The increased predator population eats many preys and the prey population crashes. The decrease in prey numbers causes the predators to starve and even their reproduction reduces, so the population of predators crashes. Finally, the very low predator numbers allows the prey population to recover, causing the cycle to start again.

Evolutionary significance of predator – prey interaction

Predators usually eliminate the unfit (aged, sick and weak). This gives the remaining prey access to the available food supply and also improves their genetic stock hence enhances the chances of reproductive success and longtime survival, thus passing on their good traits to their off springs which improve their evolution.

How are the predators suited to capturing prey?

Have keen eyes for locating prey e.g. Wolves, lions; praying mantis, chameleon have cryptic coloration/ camouflage that enable them to walk to prey unnoticed; nocturnal predators e.g. Bats have highly developed sense for detecting sound made by prey; some snakes which have glands to secrete poison (venom) which the fangs inject in to prey to immobilize it; web spinning spiders use their silky cobwebs to catch small sized ground walking or flying insects; ant – lions lay traps by making pits in the ground where prey falls; some have a soft pad at the bottom of their feet so that they are not easily detected as they walk towards prey; some have stinging cells which paralyze their prey e.g. sea anemones; have long and sharp canines which pierce and kill prey; well-developed limbs which increase the speed of locomotion to chase and capture prey.

How are prey species suited to avoid predation?

Ability to run, swim or fly faster; possession of highly developed sense of sight or smell alerting the presence of predators; possession of protective shells e.g. in tortoise and snails for rolling in to armour – plated roll; possess spines to prick the predators e.g. porcupine; in some lizards, the tail breaks off when attacked giving the animal time to escape; some prey camouflage by changing colour e.g. chameleon or having deceptive colours that blend with the back ground; mimicrying; living in groups e.g. schools of fish, herds of antelopes, flocks of birds; some prey scare predators by puffing up e.g. blowfish or spreading wings e.g. peacock; the flesh of some slow – moving fish is poisonous e.g. porcupine fish; some prey secrete poisonous or repellant substance e.g. scorpions, caterpillars, some grass hopers, culex mosquito eggs; the electric fish (cat fish) produces high voltage discharge of up to 350V that shocks any predators that makes contact with it.

Predation:-

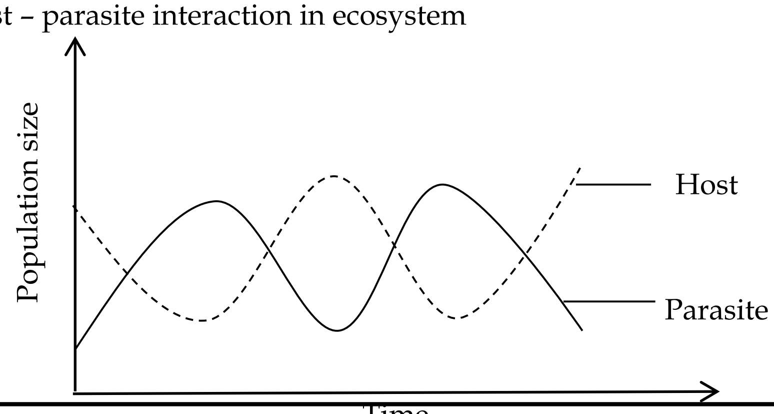
- Determines distribution and abundance of the prey because an increase in the number of predators results in to decrease in the number of prey; predators will always be found in places of their potential prey.
- Leads to dispersal of animals since it involves movement of animals from one place to another. This reduces competition.
- Is a biological control method

6. Host –parasite relationships

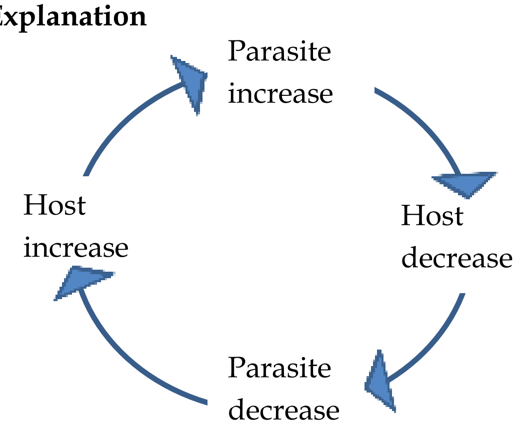
Parasitism is an association in which an organism called parasite obtains part or all its nutrients from the body of another organism of different species called host. The parasite is usually smaller than its host in size. Parasites do not usually kill their hosts, but the host suffers harm. Many parasites live permanently on (ectoparasites) or in (endoparasites) their hosts while some visit their hosts only to feed.

Some parasites are **facultative** i.e. live on or in the host for some time e.g. pythium (a fungus) that causes damping off seedlings, on killing the seedlings, lives as a saprobe on their dead remains; and others are **obligate** i.e. live on or in the host for their entire life.

A host – parasite interaction in ecosystem



Explanation



7. Competition

This is a relationship where two individuals of the same or different species struggle to obtain resources which are in limited supply. E.g. plants compete for light, carbon dioxide, water, mineral, pollinators and sites for spore and seeds to germinate while animals compete for food, mates, breeding sites and shelter from predators.
There are two types of competition i.e. intraspecific and interspecific competition.

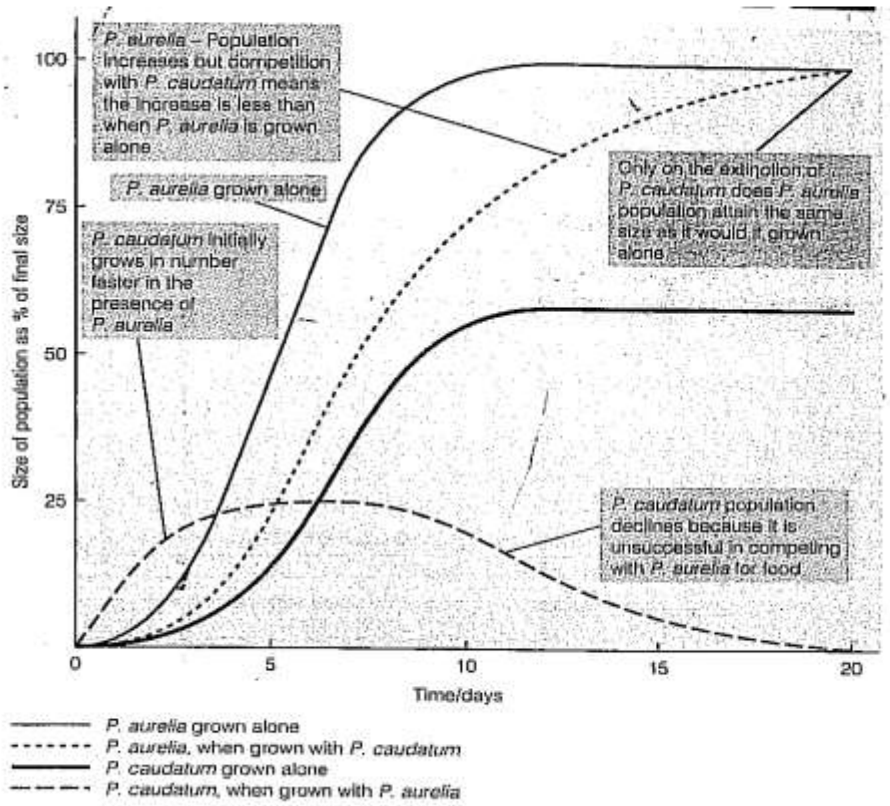
Intraspecific competition:
This is the competition between members of the same species for the same resources. It tends to have a stabilizing influence on population size. If the population gets too big, intraspecific competition increases so the population falls again. If the population gets too small, intraspecific competition decreases, so the population increases again.

Interspecific competition:
This is the competition between members of two or more different species for the same resources.
According to **Gauze's competitive exclusion principle** "no two species can occupy the same ecological niche."
Examples

a) Two species of flour beetles, *Tribolium castenum* and *T. confusum* were kept in the laboratory in bottle of flour acting as a habitat and providing food for them, under variable temperature conditions (24^{0}C and 34^{0}C) and humid conditions (70% RH and 30%RH)

Observation
At high temperatures and in high humid conditions, *T. castenum* succeeded, while at low temperature and very dry conditions, *T. confusum* did better.
Whatever the conditions, only one of the species eventually survived.

b) Two species of *Paramecium aurelia* and *P. caudatum* were grown separately in the cultures and then later cultured together.



Observation

When cultured separately, each species has a maximum population, only coming almost constant with time due to presence of toxic wastes which can poison paramecium; heat generated during respiration may kill some paramecium, decrease in food resources.

When the two species are cultured together, *P. aurelia* gets competitive advantage over *P. caudatum* and after several days, *P caudatum* gradually decreases and later decreases rapidly until it is excluded, hence competitive exclusion principle. *P. caudatum* therefore goes to extinction.

Competitive advantages of *P. aurelia* are:

- high rate of reproduction
- high growth rate
- good nutrient absorptive/ greater efficiency in obtaining food
- being small, it requires less food hence can easily survive

RESOURCE PARTITIONING

This is the specialization by different species to make use of different resources. **Or** is the dividing up of the scarce resources so that species with similar needs use them at different times in different ways or in different places. Resource partitioning decreases competition between two species leading to increased niche specialization and a more stable community structure.

Examples of resource partitioning

- When living in the same area, lions prey mostly on larger animals while leopards on smaller animals.
- Hawks and owls feed on similar prey but hawks hunt during day and owls hunt at night.

- Each of the five species of common warblers (insect – eating birds) minimize competition with the other by spending at least half its feeding time in a different part of tree branches, some hunt at the extreme top, others at the lower portion, some midway, etc. consuming different insect species.
- Eagle species feed at different times of the day.
- Specialization of morphology and behaviours for different foods such as finches of Galapagos island have modified for picking up insects, drilling holes, cracking nuts and tearing flesh.
- Drought tolerant grasses with shallow fibrous roots grow near the soil surface to absorb moisture, plants with unbranched and long tap root system grow in deeper soil while those with a tap root system that branches to the top soil and below the roots of other species grow where soil is continuously moist.

COMMUNITY ECOLOGY

A community is a group of interacting organisms or species populations living together in a particular place. It represents the biotic part of an ecosystem. The scientific study of the community ecology is called **synecology**. Examples of communities include: **woodlands** made up of many different niches and microhabitats and supplies many different food chains. Synecology deals with succession and climax community.

ECOLOGICAL SUCCESSION

This is a long – term directional change in the composition of a community from its origin to its climax through a number of stages brought about by the actions of organisms themselves. It is a process by which plants and animal communities in a given area change gradually over time becoming replaced by different and more complex communities.

Pioneers are first sets of organisms to occupy the area, collectively such organisms constitute the pioneers community.

Complete successions are called **sere/seral stages**. **Hydrosere** is succession in aquatic environment; **halosere** is succession in salty environment; **xerosere** is succession in dry environments and **lithosere** is succession on rocky surfaces.

The first seral stage has pioneers and the final stage is a **climax community**. A climax community is a final stable community at the end of succession. It is characterized by diverse species, complex feeding relationships and progressive increase in biomass.

Types of succession

There are two types of succession i.e. Primary and secondary succession

Primary succession

This is the gradual change in species composition of an area that has never had any vegetation growing on it. It occurs on bare rocks, newly cooled lava, newly created shallow pond, sand dunes, abandoned highways or parking yards.

During primary succession, lichens and mosses as **colonizers** attach to bare rocks and start forming soil by trapping wind – blown soil particles, producing tiny bits of organic matter and secreting mild acids that slowly breakdown the rock by chemical weathering. Alternate heating and cooling also cause breakdown of rocks.

As patches of soil build up and spread, eventually the pioneer species are replaced by the early successional plants like small grasses and ferns, as pioneer plants whose seeds and spores respectively germinate after arriving by wind or in droppings of birds. Some of their roots penetrate and break rocks in to soil particles and death and decay of small grasses and ferns increases nutrients to the soil.

After a long period of time, the soil becomes deep, moist and fertile enough to support the growth of mid successional plant species like herbs, large grasses, low shrubs and small trees that need a lot of sunlight.
Late successional plant species e.g. trees that tolerate shade later replace the mid successional plant species. Unless natural or human processes disturb the area, a complex forest remains as a climax community.

Secondary succession

This is the gradual change in species composition in an area where the natural community of organisms has been disturbed, removed or destroyed by some soil or bottom sediment remains. It occurs on abandoned farmlands, burnt or cut forests, heavily polluted streams, flooded land.
Due to some soil or sediment present, vegetation usually begins to germinate within a few weeks. Seeds and spores can be present in the soil and can be carried from nearby plants by wind, birds and insects. The ground may contain resistant plants/ vegetative organs of the colonizing plants that survived the changes.

POPULATION ECOLOGY

A population is a group of organisms of one species occupying a particular place and usually isolated to some extent from other similar groups by geography or topography. Population studies (autecology) are concerned with forms of the growth, maintenance and decline of species populations.
The study of how and why population size changes over time is called **population dynamics**.

Terms used in population studies
Population size: The number of individuals in a population.
Population density: The total number of organisms of a species per unit area (land) or per unit volume (water).
Population growth: A change in the number of individuals (increase – positive or decrease – negative).
Population growth rate: The change in number of individuals per unit time.
Birth rate (natality): The number of new individuals produced by one organism per unit time (humans: per year).
Death rate (mortality): The number of individuals dying per unit time per unit of population (humans: number of deaths per 1000 people per year).
Carrying capacity: The maximum number of individuals of a given species that can be sustained indefinitely in a given area of land or volume of water.
Age structure/distribution: The proportion of individuals of each age in a population i.e. the young age – age group before reproduction; middle age – reproductive age and old age – age after reproductive stage.
Environmental resistance: All the environmental factors acting jointly to limit the growth of population.
Biotic potential: The maximum rate at which the members of a given population can reproduce given unlimited resources and favorable environmental conditions.
Immigration: Movement of individuals in to a population from neighbouring populations.
Emigration: departure of individuals from a population.
Population distribution/dispersion: The way how organisms are distributed in a habitat including uniform distribution, clumped distribution and random distribution.

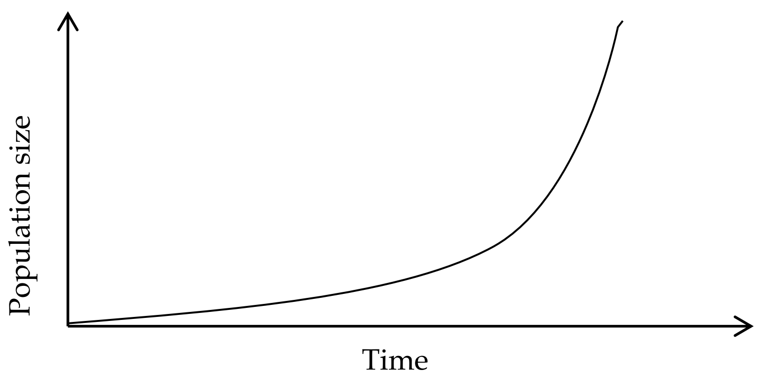
POPULATION GROWTH AND GROWTH CURVES/PATTERNS

Population growth is the change in the number of individuals.
The population grows when natality is greater than mortality, immigration is greater than emigration.
On addition, the size of population increase will be determined by the reproductive potential of the organisms and by environmental resistance. Reproductive/biotic potential varies according to the age structure of a population and influenced by male: female ratio.

Environmental resistance, both biotic and abiotic act to prevent the maximum reproductive potential from being reached. It includes external factors such as predation, food supply, heat, light and space, and internal regulatory mechanisms such as intraspecific competition and behavioral adaptation.
The balance between biotic potential and environmental resistance defines the carrying capacity for a particular organism with a given set of environmental resources.

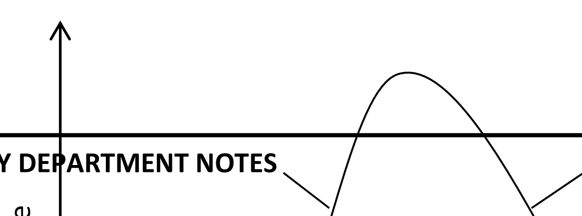
Population growth curves include exponential population growth (J – shaped), logistic population growth curve (sigmoid/S – shaped)

J – Shaped curve
This describes a situation in which after the initial establishment phase (lag phase), population growth continues in an exponential form until stopped abruptly as environmental resistance becomes suddenly effective. However, this is rare in nature because of limiting factors.



Description
Number of individuals/population is small; their number gradually increases with time along AB. Later, the population size increases rapidly/sharply/drastically with time along CB.
Explanation
Initially, the number of individuals increases gradually with time because the population size is small, thus few reproducing individuals, reproducing individuals are scattered with in the environment, some may not have reached reproductive ages, organisms are still getting used to their environment.
Later on, the number of individuals increases rapidly because many individuals have now reached reproductive age and number of reproducing individuals now gets bigger.

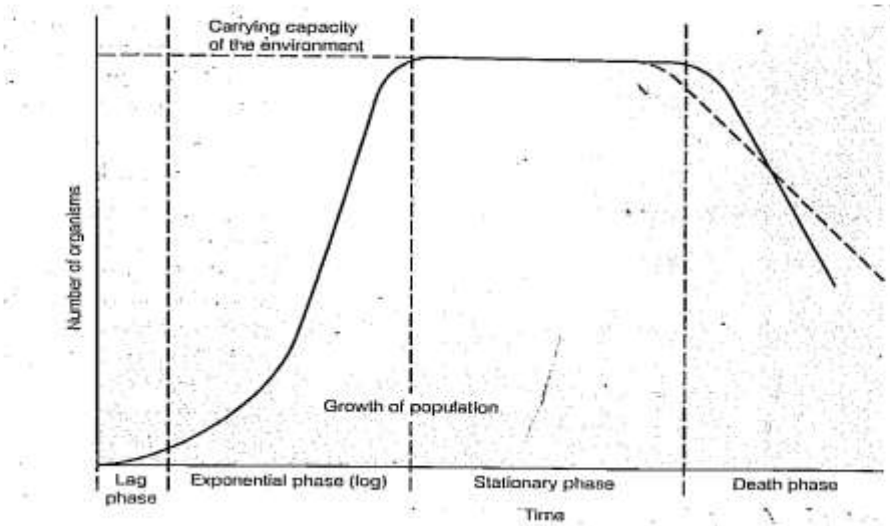
These population growth curves occur until the crash occurs. The crash may be triggered by seasonality or the end of a breeding phase, either of the organisms itself or an important prey species, seed production or human intervention like using insecticides. Following the crash, such populations show a fluctuating recovery pattern to give the "**boom** and **burst**" cycle. E.g. in some insect species and associated with algae blooms as shown below.



Boom Burst

S – Shaped curve

This describes a situation in which in a new environment, the population density of an organism increases slowly initially, then proceeds faster to a maximum (carrying capacity) and then levels off. The population then fluctuates slightly above and below the carrying capacity and then declines with time.



Explanation

Lag phase

There is gradual population growth. Because little growth while organisms start synthesizing appropriate enzymes for new conditions. Because due to small population, individuals may rarely meet so few chances of mating, long gestation so few births. Organisms are getting used to conditions in the environment.

Log (Exponential) phase

There is rapid population growth rate. Because no factors limiting growth. Food resources are discovered and exploited. There is ample space. Organisms have reached reproductive stage. Competition is low. Birth rates are greater than death rates.

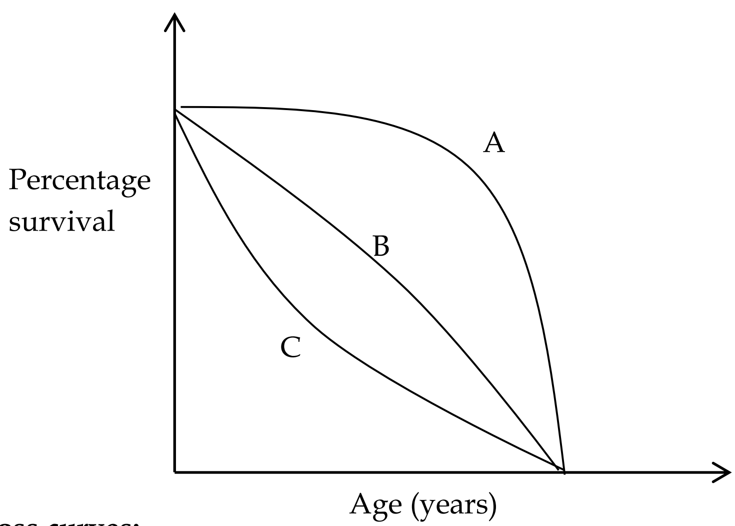
Stationary phase

By this time, the population size is stable and does not increase further. There is a limit to which any habitat can support a population. This is called a habitat's carrying capacity. The key factors here are density dependent factors such as the amount of nutrients and supply of oxygen. Shortage of space, nutrients and oxygen prevent any further increase in the density of the population, accumulation of toxic waste products, intraspecific competition, predation, etc. This is known as environmental resistance. Natality is equal to mortality.

Death phase
At this stage, the carrying capacity of the environment has declined. It is unable to support such a high density of organism and they begin to die. They may die of starvation, a shortage of oxygen or waste products may be present in toxic amounts.

HOW POPULATION DENSITY AFFECTS POPULATION GROWTH
These include density dependent factors and density independent factors.
Density dependent factors are those factors whose effectiveness depends on number of individuals present in a unit space. The more individuals there are in the population, the greater the percentage of population that dies or fails to reproduce. These include diseases, predation, competition for food, parasitism, pollution (accumulation of wastes) etc.
Density independent factors are those factors whose effectiveness is not related to the density of the population. Any change in the factor affects the same proportion of the population regardless of population density. They include temperature, rainfall, light, floods, soil nutrients, fires, drought, hurricanes and habitat destruction, pesticide spraying. They are mainly abiotic factors.

SURVIVORSHIP
This is the percentage of an original population that survives to a given age. The percentage of individuals that die before reaching reproductive age is called pre – reproductive mortality, this affects population size.
Survivorship curve is a graph which shows the number or percentage of surviving individuals of each age group of a population for a particular species. Each species has its own survivorship curves, as shown below.



A – Late loss curves:
These occur in humans, elephants, rhinoceroses, mountain sheep, annual crops such as wheat, where all the plants in a given field survive well early in life and then senescence occurs simultaneously.
Such organisms have stable populations close to the carrying capacity of the environment. They produce few young ones which are cared for until reproductive age, thus reducing juvenile mortality and therefore enabling high survivorship to a certain age, then high mortality at later age in life.

B – Early loss curves:

These curves occur in population with a high mortality rate early in life such as in mountain sheep or for humans in a country in which starvation and diseases are prevalent. It also occurs in annual plants, most invertebrates and most bony fish species with a high intrinsic rate of increase.
They produce many offspring which are poorly cared for resulting in to high juvenile mortality.
There is high survivorship once the surviving young reach certain age and size.

C – Constant loss curves:
These occur in many song birds, lizards, small mammals and hydra in which there is a constant mortality rate throughout life (50% per unit time), thus a steadily declining survivorship curve.
There is an equal chance of dying at all ages.
These organisms face a fairly constant threat from starvation, predation and disease throughout their lives

Survivor ship curves;
- Enable determination of mortality rates of individuals of different ages and hence determine at which age they are most vulnerable.
- Enable identification of factors causing death at different ages so as to plan regulation of population size.

DETERMINATION OF POPULATION SIZE OF ORGANISMS
Population size of organisms is determined by the following methods; total count; counting by sampling.

1. TOTAL COUNT
This is the physical counting of every individual of a population in a specified area of ground. It is effective for large animals living in unconcealed/ exposed habitats. It includes direct counting method, aerial photography, drive and count method and strip census method.

a) Direct counting method: This is used to determine population of large mobile animals such as deer, lions, wood pigeons and bats as they leave their roost, and sessile or slow – moving animals. It gives a quick estimate of the population.
b) Aerial photography method: This is used to obtain the population size of large mammals and sea birds which congregate in open spaces by direct counting using low flying aircrafts. It is also quick but expensive.

2. COUNTING BY SAMPLING
This is when the number of organisms is determined in several sample plots that represent a known fraction of the total area under investigation from which estimation of the total population size of the whole area is made by simple calculation. It includes quadrat method, removal method, capture mark release recapture method (Lincoln Index)

a) Quadrat method:

This is suitable for slow moving animals and grass.
The metallic/plastic/wooden frame of area 1m^2 is randomly thrown several times in an area under instigation. All individuals within a quadrat are counted each time. Population density is expressed as the average figure per m^2. Total population is obtained by multiplying the average with the total area under investigation.
This method helps to determine:
Species density: This is the number of individuals of a given species in a given area. It is obtained by counting the number of organisms in randomly thrown quadrats.
Species frequency: This is a measure of the probability of finding a given species with any one throw of a quadrat in a given area. E.g. if the species occurs once in every 10 quadrats, it has a frequency of 10%.

Species cover: This is a measure of the proportion of ground occupied by the species and gives an estimate of the area covered by the species as a percentage of the total area. It is obtained either by observing the species covering the ground at a number of random point or by use of a pin frame.

b) Removal method

This is suitable for estimating numbers of small organisms e.g. insects within a known area of grassland or volume of water.

Using a net, the number of animals captured is recorded and the animal kept. This procedure is repeated 3 times and the gradually reducing numbers recorded. A graph is plotted of number of animals captured per sample against the cumulative number of animals captured.

By extrapolating the line of the graph to the point at which no further animals would be captured (that is number in sample = 0), the total population may be estimated.

c) Capture – mark – release – recapture method

This method is used on highly mobile animals like fish, rats, birds, insects etc.

Traps are setup randomly over the study area. After sometime, the traps are observed for any captures made, a count made for all organisms captured in this first occasion, noted as $\mathbf{N_1}$. They are all marked using a suitable label or tag e.g. placing an Aluminium disc on the ear of a mammal (rat). These animals are then released back to their natural environment. After allowing sufficient time for the population to mix thoroughly, the traps are set up again all over the study area. A count is made of all animals captured on the second catch noted as $\mathbf{N_2}$. A count of how many animals captured on the second catch have marks/labels is made, i.e. Those that are recaptured noted as $\mathbf{N_3}$.

The estimated total population P of animals in the area is then estimated using the Lincoln Index formula as follows: $P = \frac{\boldsymbol{N1 \times N2}}{\boldsymbol{N3}}$

Assumptions made in this method

- Organisms mix randomly within the population.
- The time allowed for random mixing is enough.
- Changes in population size due to immigration, emigration, death and birth are negligible.
- The movement of organisms is restricted geographically.
- There is even dispersing of organisms within the study area.
- The mark does not hinder the movement of organisms or make them conspicuous to predators.

Limitations of the method

- It is only reliable when the organisms 'range of movement is restricted and defined.
- Animals often move in groups whose members recognize one another and avoid mixing with those of other groups.
- Many animals have particular localities where they confine, so the marked animals may not spread widely.
- Loss of marked individuals reduces those recaptured and this causes inaccuracy.
- The label may psychologically or physically disturb the organism.

REGULATION OF POPULATION SIZE

Population size is naturally maintained at their normal carrying capacity depending on the resources in a given habitat. This depends on the density controlled factors e.g. food, pests, diseases, predators, etc.
The following methods are used in population control, biological control methods and chemical method.

Biological control method (BCM)

This is the regulation of pest species or weeds using their nature enemies called **control agents** e.g. natural predators, parasites and pathogens. Examples: using cats to eat rats, using beetles to feed on the water hyacinths on L. victoria, placing fish in ponds to eat larvae of mosquitoes.
Biological control method can be used to control vector population, control of parasites, control of pathogens (viruses and bacteria), control of some plants e.g. weeds, and control of pests.

Steps involved in using BCM

- Identification of the pest and tracing its origin where it came from
- Investigating the original site of the pest, its natural predators i.e. pathogen or parasite.
- Testing the potential control agent under careful quarantine to ensure its specificity.
- Mass culturing of the control agent.
- Development of the most effective distribution/ release method for the control agent.

Advantages of using BCM

- It is very specific to target organism.
- No danger of environmental pollution
- Control agent may become useful food materials for other organisms.
- No extinction of target organism but marinated in carrying capacity.
- No pest resistance and resurgence.
- Biomagnificatioon and bioaccumulation do not occur.

Problems of BCM

- Pests are not fully eliminated.
- Control agent can change prey.
- Pest replacement may occur.
- Waste pollution especially in aquatic habitats.
- There may need to control the agent of predator, parasite or pathogen in case of their population explosion.

Chemical method

This involves the use of chemical substances by humans to eradicate harmful organisms. The methods are named according to the target organisms e.g. herbicides kill weeds. Insecticides kill insects, fungicides kill fungi.

Properties of an ideal pesticide

- Should be biodegradable/non – persistent so that toxic products are not left in or on crop plants.
- Should be specific so that only one pest species is killed.
- Should not accumulate either in specific parts of an organism so as it passes along food chains.
- Should effectively control the pest under field growing conditions.
- Should be easy to apply at the correct dosage.

Problems of using chemicals

- Accidental misuse of toxic chemicals results in death of humans and domestic animals.
- Many chemicals are non – specific/ are broad – spectrum pesticides, this leads to **pest resurgence**, when numbers of the pest after treatment increase to more than before the treatment. This is because the pesticide not only kills the pest but also the predators of the pest.
- Pest resistance occurs i.e. genetic variation enables a few individuals in the pest population to survive and may quickly reproduce.
- There is **pest replacement** since most crops are susceptible to attack by more than one pest species and the pesticide may be more deadly to one species than another. Elimination of one species allows another species to ensure major pest proportions.
- **Bioaccumulation** where some molecules of the pesticides are stored in specific organs or tissues at levels higher than would be expected and **biological magnification**, the pesticide getting more concentrated as it passes along the food chains and webs may occur.

NATURAL RESOURCES

These are materials that are not made by man but obtained from the environment to meet human needs and wants. While some resources are directly available for use e.g. solar energy, fresh air, wind, fresh surface water, fertile soil, and wild edible plants, others become available after processing has been done e.g. petroleum, metallic elements like iron, ground water, modern crops, etc.

TYPES OF NATURAL RESOURCES

Perpetual resources

These are resources that are replaced (renewed) continuously on human time scale e.g. solar energy, wind, tides.

Renewable resources

These are resources that are replenished (replaced) fairly rapidly through natural process as long as the usage is not faster than the replacement e.g. fresh water, fresh air, fertile soil, animals and plants (forests, grasslands, etc.).

Non – renewable resources

These are resources that exist in a fixed quantity or stock in the earth's crust. On the shorter human time scale, they are depleted much faster than they are formed e.g. fossil fuels, metallic and non – metallic minerals, etc.

POLLUTION

This is the release of substances or energy in to the environment in such quantities and for such duration that they cause harm to organisms or their environment. Such substances or energy are called **pollutants** e.g. noise, heat and radiations, many chemical compound, elements and excretory products affecting air, water and land.

CATEGORIES OF POLLUTANTS

1. Degradable/ non – persistent pollutants

These are pollutants that are broken down completely or reduced to acceptable levels by natural physical, chemical and biological processes.

Biodegradation is the breakdown of complex chemical pollutants in to simpler chemicals by organisms such as bacteria and fungi e.g. sewage is a biodegradable pollutant.

2. Slowly degradable/ persistent pollutants

These are pollutants that take a longer time to degrade e.g. DDT, an insecticide and plastics e.g. plastic bags.

3. Non – degradable pollutants

These are pollutants that cannot be broken down by natural processes e.g. the toxic elements such as lead, mercury, arsenic, etc.

TYPES OF POLLUTION

AIR POLLUTION

The important atmospheric pollutants include gases like chlorofluorocarbons (CFCs), Sulphur dioxide, hydrocarbons and oxides of nitrogen (NOx), natural gases such as carbon dioxide, dust, noise, waste heat, radioactivity and electromagnetic pulses.

Forms of air pollution

Greenhouse effect

This s caused by carbon dioxide from burning large amounts of fossil fuels and large scale deforestation.

Carbon dioxide is transparent to incoming short – wave radiations from the sun, but absorbs strongly the long – wave radiation which the earth re – radiates in to space. Carbon dioxide thus traps outgoing radiations, warming the lower atmosphere which in turn radiates back energy to the surface of the earth. Thus carbon dioxide gas acts like a glass of large green house covering the earth. This causes **global warming**, the observed global temperature 32^0C above those that would occur.

The effect of global warming include

- Rise in sea level due to melting of polar ice and thermal expansion of sea, this causes floods on sea shores.
- Altered temperature gradients cause cyclones and heavy rains as water evaporates quickly.
- Species migration causing pests/diseases extend their ranges.
- Reduced crop yields due to drier weather.
- Increased crop yield because of more rainfall and longer growing seasons in some regions.
- Extinction of some animal and plant species.
- Increased death of human population
- Increases wild fires in areas where the climate becomes drier.

Acid rain

The acid gases like Sulphur dioxide and oxides of nitrogen are produced by burning fossil fuels, incomplete combustion of these fuels also releases hydrocarbons and ammonia.

These oxides react with water in the clouds/ atmosphere to form solutions of sulphurous and nitrous acid which produce and precipitate in rain and snow.

Acid rain has the following effects

- Hydrogen ions in the soil are displaced in to run off water by the sulphate ions from sulphuric acid, causing formation of soft exoskeleton, which results in to death of invertebrates.
- Aluminium ions are displaced from soil by sulphate ions in to water where it interferes with gill functioning causing fish deaths.
- Aluminium ions displaced are also toxic when absorbed by plants and Mycorrhizae.
- The leaching action of acid rain removes calcium and magnesium ions from soil causing poor formation of middle lamella and chlorophyll in leaves.
- Contributes to humans' respiratory diseases such as bronchitis and asthma.
- Can leach toxic metals such as lead and copper from water pipes in to drinking water.
- Damages statues and buildings.

- Decreases atmosphere visibility, mostly because of sulphate particle.
- Promotes the growth of acid – loving mosses that can kill trees.
- Loss of fish population when pH lowers below 4.5.

Ozone depletion

Ozone is produced high in the atmosphere by the action of sunlight on oxygen molecules. This provides a thermal blanket and radiation shield to the earth. Oxygen and ozone absorb most short – wave radiations which harm organism, through damaging their genetic material, and causing skin cancer.

Ozone is depleted by CFCs, chemicals including CCl_4 and chloroform used as solvents, aerosol propellants and refrigerator coolants. They are not readily broken down in the atmosphere and contribute to increased greenhouse warming. Eventually, they diffuse in to the stratosphere. High in the atmosphere, they are broken down by sunlight, releasing chlorine and fluorine. These react with ozone and break it down in to oxygen faster than it can be reformed from oxygen in to ozone.

WATER POLLUTION

The major components of water pollution include sewage discharge in to rivers, eutrophication, thermal pollution and oil pollution.

Sewage discharge in to rivers

Sewage is liquid waste composed of faeces, urine, water, detergents and other substances from industries and or homes carried through pipes called sewers.

Discharge of untreated sewage in to rivers cause an immediate change in both the biotic and abiotic components due to specific chemical pollutants e.g. heavy metals like cadmium from industrial processes and pesticides from agriculture.

Eutrophication

This is the nutrient enrichment of land waters with nitrogen and phosphorous run – off from fertilizers used in intensive agriculture and discharge of phosphate – rich sewage effluents.

Nitrates and phosphates limit primary productivity in aquatic ecosystems; this favors an increase in rapidly growing competitive planktonic species. Since consumer organisms delay to increase in number in response to environmental change, not all the increased primary production is eaten by the consumer organisms. Instead the excess material enters the decomposition pathway. Breakdown to simple inorganic nutrients of the decomposing matter is an oxygen – demanding process.

This thus reduces the dissolved oxygen levels below those necessary for the successful growth and reproduction of other species. This result in to death of fish and other species and their subsequent decomposition can impose a further oxygen demand, making the situation increasingly worse.

Effects of eutrophication

- Species diversity decreases and the dominant biota change
- Plant, algal and animal biomass increase.
- Turbidity of water increases.
- Rates of sedimentation increases, shortening the life span of the lake.
- Anoxic conditions may develop.
- Stratification, when the water forms layers with different temperatures.
- Decreased biological oxygen demand (BOD) for aerobes.

- Water may be injurious to health.
- The amenity value of the water decreases.
- Increased vegetation impedes water flow and navigation.

Thermal pollution

It occurs in rivers and coastal areas. It arises from the use of water as a coolant in industrial processes such as in electricity generating plants. Water discharging from electricity stations may be warmer than that taken in.

Warm water has lower dissolved oxygen content than cold water. At the same time, the increased warmth raises the metabolic rate of organisms in the water and thus increases their oxygen demand.

When the difference in temperature is large, significant changes are caused such as migratory species such as salmon and trout are prevented from returning to spawning sites.

Oil pollution

This occurs in marine and coastal environments due to damage of oil tanker ships through collision, explosion or wrecking, seepage from offshore installations and flushing of tanker holds.

Effects of oil pollution

- Crude oil kills sea weeds, molluscs and crustaceans when washed on to rocky shores.
- Oil spills affect marine mammals, when their fur is oiled.
- Oil penetrates and mats the plumage of fish – eating birds making flight impossible.
- Heat insulation is lost and the birds may also die of hypothermia.
- Buoyancy of water is also reduced causing birds to drown.
- Shades phytoplankton restricting light penetration and thus reduces photosynthesis.

Treating and preventing oil pollution

- Bacterial decomposition, aided by wind and waves action.
- Use of dispersants accelerates breakup of oil slicks.
- Use of floating booms to prevent slicks from reaching sensitive shore lines.
- Burning heavy oil residues (where feasible).
- Collection of oil and pumping it back in to special collection ships.
- Spraying on to oil slicks naturally occurring bacteria such as pseudomonas that can digest oil.
- Use of new specifically designed oil spill cleaners that are less toxic and more biodegradable than those used previously.

CONSERVATION

Conservation maintains the biosphere. It means taking action to avoid species decline and extinction and permanent detrimental changes to the environment.

TERMS USED IN CONSERVATION

Extinction: This is the total loss of an organism species from a habitat. It is caused by overhunting, pollution, widespread use of pesticides, habitat fragmentation and loss, and agricultural intensification.

Biodiversity: This is the variety of species on earth.

Rare species: Species with small populations either restricted geographically with localized habitats or with widely scattered individuals.

Vulnerable species: These are species under threat of actually declining in number or species which have been seriously depleted in the past and have not yet recovered.

Endangered species: Species with low population numbers that are in considerable danger of becoming extinct.
Extinct species: Species which cannot be found in areas they recently inhabited nor in other likely habitats.
Keystone species: Species on which many other organisms depend e.g. elephants in ecology of African savannah are a keystone species.

IMPORTANCE OF CONSERVATION

They include ethical, utilitarian, aesthetic and ecological or scientific reasons.

- **Ethical reasons** include cultural traditions, religious beliefs, political persuasion and other concepts that assert that all living species have a right to co- exist. No right to cause them extinct or to diminish the quantity of life of any organism.
- **Aesthetic reasons** include humans deriving pleasure from natural environment and the presence of other organisms. Nature permeates art, design, literature and music and influences our recreational pursuits.
- **Utilitarian reasons** include wildlife contributing to the immediate needs e.g. agriculture, forestry and fisheries, and crop benefits. Here we use pollinating insects and beneficial predators in pest control, many plant species have important medical uses, animal studies have enabled understanding and treating human diseases more effectively, numerous industrial processes depend on plant and animal materials, and microorganisms.
- **Ecological reasons** include our well – being, being maintained by a fully functional biosphere. Conservation helps to prevent pollution, acidification, eutrophication, deforestation, desertification which lead to loss of vegetation cover causing soil erosion, lead to siltation of rivers and coasts and may change rainfall and climate patterns.

HOW TO PREVENT EXTINCTION OF SPECIES

- Protecting and restoring habitats.
- Establishing national game parks, natural reserves and similar protected areas.
- Controlling and reducing the impact of modern intensive agriculture.
- Reducing the use of bio – poisons such as pesticides.
- Restricting trade in endangered species.
- Providing refuges and assisted breeding programmes for endangered species e.g. in zoos and botanic gardens.
- Establishing sperm banks and seed stores to maintain the full range of genetic diversity of species.

HOW CONSERVATION CAN BE DONE

- Botanic gardens: Plants are best conserved in situ, i.e. where they grow naturally including their pollinators, symbionts, competitors and predators.
- Seed banks: These are convenient and space – saving methods of conserving germ plasma e.g. storing food crops and their wild relatives and endangered wild species.
- Cryopreservation: This involves storage of cells from embryos and shoot tips of plants in liquid nitrogen at -195^{0}C. This stops all metabolic processes and preserves materials if mechanical failure of the storage system occurs.
- Field gene banks: These are permanent living plant collections made through growing small plots or strips of each variety of a particular species.
- Zoos: These are collections of animals for curiosity's sake through captive breeding to preserve genetic stocks of threatened species so that they are re-introduced in to the wild when conditions permit.

- Waste management and recycling.
- Sustainable use of plant and animal resources.
- New sources of energy.