ECOLOGY

Ecology is the study of the relationship between living organisms and the environment or surrounding.

The living organisms are the flora and fauna. Ecological studies can be directly towards a particular organism or a single species, communities or an ecosystem. The word ecology originates from a Greek word 'oikos' meaning a home. Two types of ecological studies namely autecology and synecology are commonly carried out.

Autecology is the study of the relationship between a single species and the environment in relation to its environment.

Synecology is the study of the relationship between communities or different populations of organisms in a given environment i.e. the study of the relationship between all plants and animals in a particular area to the environment.

Description of ecological terms

1. **Species**
   This is a group of organisms or individuals capable of interbreeding to produce fertile off springs.
2. **Population**
   This is a group of organisms or individuals of the same species which occupy a particular area or habitat at the same point and time. The population size of a given species changes with time and changes in environmental factors.
3. **Habitat**
   This is a place or physical area where the organism or species lives in an ecosystem.
4. **Community**
   This refers to all populations that occupy a particular area at a given time. This implies that all plants, animals and fungi in a particular area form a community therefore a community is a group of plants and animals of different species living together in a certain environment i.e. plant and animal community.
5. **Ecological niche**
   Refers to the particular part of the habitat where an organism lives, its feeding habits and how it interacts with other organisms in the habitat in terms of the role it plays and the total environmental factors affecting the organism in the ecosystem.
6. **Ecosystem**
   An ecosystem is an ecological unit consisting of a community of living organisms and its physical environment. Such a unit will consist of plants, animals and micro-organisms as well as non-living components like water, soil, air and light. Or
   An ecosystem refers to the interaction between living organisms and non-living components of the environment or habitat to form a self-supporting system e.g. in a pond or aquatic ecosystem. It consists of phytoplanktons, saprophytes, zooplanktons as the biotic component (living) whose interaction with dead decaying organic matter or recycle for self-sustainability.
7. **Biosphere**
   This is part of the earth inhabited by living organisms. The biosphere comprises of terrestrial and aquatic ecosystem.
   The biosphere is subdivided into bio-geographical regions each inhabited by destructive species of plants and animals that are favored by unique conditions of such areas.
   Bio-geographical regions are also subdivided into particular areas called 'biomass/biomes'.
   Biome refers to a large recognizable community formed as a result of interaction between regional climates with regional/biotic e.g. tropical rain forests, tropical savanna, desert, temperate region. The biome is divided into zones e.g. forests biome forms the ground level and canopy. The lake forms the limnetic zone, littoral zone, benthos and profundal zone, each zone supporting a particular type of organisms.
   Ecotones are boundary zone between two biomes or ecosystem where one merges into the other.

The structure of the ecosystem (Components of the ecosystem)

It consists of:

1. **Biotic component:**
   These are the components which interact between the different living organisms e.g. competition, predation, symbiosis. Also they are called density dependent factors.
2. **Abiotic factors (density independent factors)**
   These are factors affecting the population regardless of the number of individuals within e.g. temperature changes, natural catastrophes like foods, storms, volcanicity, fire, earth quake, drought, etc.
3. **Edaphic factors**
   The soil directly influences plant growth and indirectly the animal population e.g. soil texture, soil pH, air, humus, salts, water, etc.
4. **Climatic factors (density dependent)**
   E.g. light, water/rain fall, wind/air, relative humidity, temperature.

The biotic part includes producers, primary consumers (first level carnivores), tertiary consumers (higher carnivores), decomposers, detritivores, etc.

Functions taking place in the ecosystem

- Recycling of matter i.e. nitrogen cycle, carbon cycle, etc.
- Energy flow/transfer from producers, consumers and decomposers.
- Food interactions/food chain and water.
- Development and evolution of species of organisms (death due to competition and resistance due to competition/survival for the fittest).
- Population control/dynamics/cybernetic of the population.
- Succession.

POPULATION, POPULATION GROWTH AND POPULATION GROWTH CURVES

1. Population density is the number of organisms per unit of space/area.
2. Population size: is the number of organisms of the same species sharing the same habitat at a certain time. Population size change as a result of natality, mortality, migration in and out of the population.

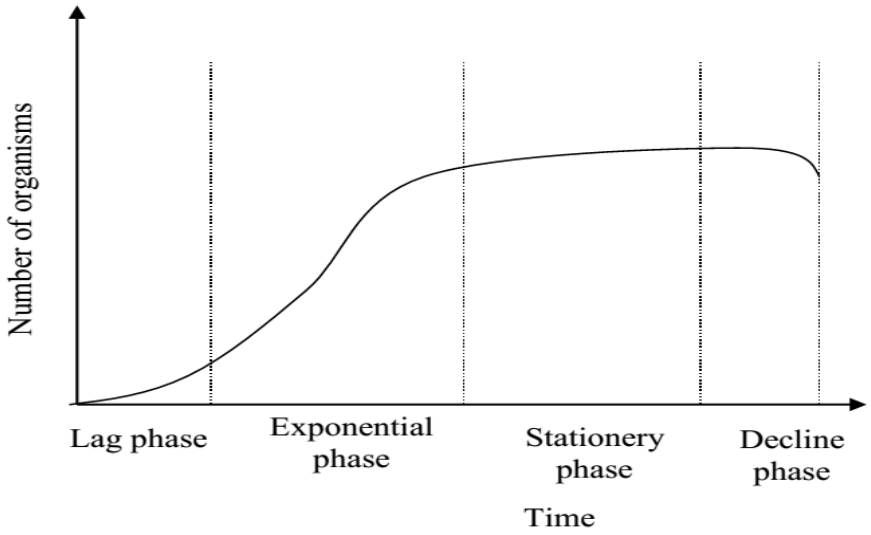
Types of population

1. **Open population**
   This is the one in which density changes as a result of the interaction of mortality, natality, migration and emigration. It occurs in a natural environment.
2. **Closed population/cultured populations**
   This is one in which density changes are the result of natality and mortality with neither food nor wastes being allowed to enter or leave the given environment. It occurs in laboratory settings and game reserves/cultured populations.

Population growth

Natural populations start with small size and gradually increases to a climax/carrying capacity where it is no longer growing/increasing. At this point the population undergoes a number of changes as a result of the changes in the environmental factors.

Population growth curve of organism in a given habitat (sigmoid curve)



1. **Lag phase:**
   This is the period of low growth rate because the reproducing organisms are few and the members are still adjusting to the environmental conditions. There is plenty supply of nutrients, space, oxygen and low or few wastes. At this point the decrease in the population is directly proportional to the group members/individuals that are reproducing.
2. **Exponential/log phase:**
   This is the phase of fast increase in the population/increased rate of growth because the individuals are used to the environment, majority have reached their reproductive potential and there is no limiting factors such as food, space, oxygen hence the organisms are able to grow and reproduce at fast rate.
3. **Stationery phase:**
   This is also called the equilibrium stage. This occurs as a result of low growth rate. The birth rate decreases while the death rate increases as a result of shortage of food nutrients, over-crowding, accumulation of toxic waste products, predation and competition for the above resources amongst the death rate and birth rate are equal and the population size becomes stable or attains its climax which is called the stationery phase or the carrying capacity of the population.

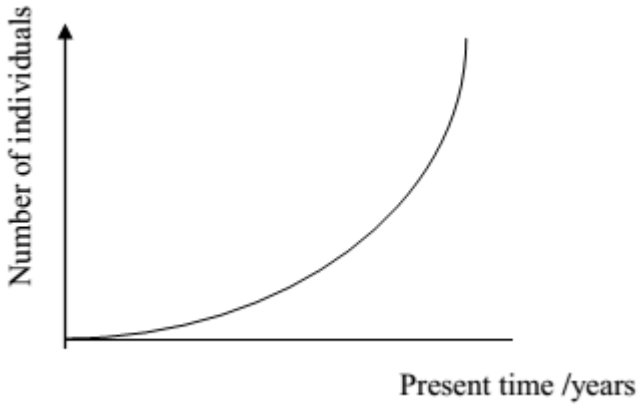
Carrying capacity of a population refers to the maximum number of the individuals of a population which the resources in a particular environment can support maximally at a given time. At carrying capacity, changes in environmental factors such as food supply decline/reduced rainfall fluctuation in temperature or an outbreak of epidemics, temperature, etc. results in an increased death rate which over powers the birth rate hence leading to a fall in the population. This is known as a decline phase.

Types of growth curves

There are two basic forms, i.e. J-shaped growth curve and S-shaped (sigmoid) growth curve.
The above curves where there is a log phase, exponential, stationery and declining phase describes a sigmoid curve as a result of changes in both density dependent and density independent factors.

J-shaped growth curves

This describes a situation in which after the lag phase/population growth continues in an exponential form until when it stops abruptly and due to environmental resistance, such growth is density dependent. The crash (abrupt stoppage) may be caused by factors like seasonality i.e. end of breeding season of the organism or of prey species. The crash may also be due to human interaction like application of insecticides to control pests, herbicides to control weeds.



Examples

1. Bidens pilosa (black jack)
2. If cats totally fed on prey/rats. The removal of prey results in the crash of the predator/cat population.

Factors that influence population growth size

Collectively the factors which limit population growth are termed as environmental resistance and are grouped into two.

1. **Density dependent (biotic) factors**
   These include diseases, competition for food, light, shelter, etc. assume there is a fixed food supply available for the organisms, the larger the population, the less the food available for each individual hence the slower the growth rate of the organism. However, a small population can expand more rapidly or exponentially.
2. **Density independent (abiotic) factors**
   These affect the population regardless of the number of individuals within the community such as temperature, natural calamities, etc.
3. **Edaphic factors**
   These are soil factors such as;
   i) **Texture:**
   This is the proportion of soil particles (sand, silt, clay). It influences the water holding capacity of the soil which in turn influences the number of individuals in a population since plants need water for growth.
   ii) **Humus:**
   These are the dead remains and decaying organic matter of living organisms. It acts as sponge in retaining water as so to break up and hence humus decomposes to release minerals which add nutrients to the soil enabling the plant number to increase in habitat.
   iii) **Air:**
   Oxygen is required by roots in the soil and most soil animals. Therefore well aerated soils support a number population/community. Water logged soils are due to compacted soil particles like clay has less air which leads to anaerobic conditions and hence cause death of most aerobic plants, animals and fungi hence reducing their population.
   iv) **Water:**
   Water is an important metabolic and a medium of transfer of gametes/dispersal of fruits/seeds thus its availability supports the growth of populations. This explains the presence of xerophytes and halophytes (normal soils) and hydrophytes (aquatic).
   v) **Mineral/inorganic salts:**

Different species of organisms (plants) require different mineral salts and their qualities and so the distribution and number of any population is pH influence the type of plants in a particular area. It also affects the physical properties and uptake of the mineral salts hence affects growth. Some plants require alkaline soils yet others acidic soils.

vi) Soil organisms:

These are the macro-organisms/population of organisms which influence aeration, drainage tunnels and also soften soil thus exposing the mineral content to plants.

Saprophytes/bacteria/fungi break down plant tissue and dead animals to release humus or mineral salts.

The symbiotic association in the soil such as root nodule bacteria and plant roots enable fixation of gases/nitrogen in the soil for proper plant growth.

4. Climatic factors

i) Light: this affects the population growth and the distribution of organisms move so the plants. It is essential for photosynthesis, chlorophyll formation, stomatal opening, hence gaseous exchange, phototropism, flowering stimulants, seed germination, broadness of leaves and ripening of fruits. In animals it enables hibernation, vision and migration.

ii) Water/rain fall

iii) Air and wind: wind brings about changes in the weather and it directly affects the organisms.
In plants it enables seed and spore dispersal.
It affects the rate of transpiration.
It determines the distribution of many plant species.
Because of wind, plants have strong deep roots.
Wind also enables mixing of nutrients and pollutants in water.

iv) Humidity: affects transpiration rates in plants, number of stomata in the leaves and rate of evaporation in animals more so the small invertebrates like earth worms, snails hence distribution of plant and animal populations.

v) Temperature: it's vital because it affects the enzymes in plants and animals. It also enables fruit ripening, transpiration rate, wilting of leaves. In animals it affects humidity and available water in the habitat which factors affect the distribution of organisms.

Other factors include:

- Man's activities like immigration, pollution, drainage.
- Epidemic out break/diseases.
- Predators.
- Migrations in and out.
- Accumulation of toxic substances.

Assignment: read and make notes about the following

- Estimation of population
- Energy flow/trophic levels, biome
- Succession both terrestrial and adequate
- Aquatic ecology
- Pollution, pests, pests control measure and effect on environment.

5. Biotic factors (interactions within the population)

This is the way how organisms deal with each other in their habitats and the relationship influence their distribution and abundance in the habitat. The interactions could be positive of negative.

The negative interactions enables the growth rate of individuals affected by the presence of related organisms or species to decline as a result of over predation, competition, parasitism, symbiosis, mutualism, commensalism.

POPULATION GROWTH AND SURVIVORSHIP CURVES

POPULATION GROWTH

Population grows and declines in size. The size of population increase is determined by the reproductive potential of the concerned organism and by environmental resistance.

The biotic potential/reproductive potential is the maximum number of off springs that can be produced by a species under ideal conditions or is the rate of reproduction given unlimited environmental resources.

Factors affecting biotic potential

- Off spring; the maximum number of off springs per birth.
- Capacity for survival; the chances the organisms' off springs will reach reproductive age.
- Procreation; the number of time per year the organisms reproduces.
- Maturity; the age at which reproduction begins.
- Male to female ratios in the population.
- Age structure; age at which reproduction is high e.g. in man is 45, chances of producing become minimal.

Factors hindering biotic potential

- Loss of food.
- Increased predator population.
- High pollution in the environment.
- Fire out break; destroys organisms, breeding sites, nest, eggs, slow moving organisms.
- Man's activities of man e.g. encroaching on swamps, wet lands, forests, road construction(separates ecosystems)
- Diseases, parasites and pests.

Environmental resistance

Refers to the sum total of limiting factors, both biotic and abiotic which affect together to prevent the biotic potential from being obtained or all the factors that tend to reduce population numbers, such as predation, food supply, heat, light, space, regulatory mechanisms like intraspecific competition and behavioral adaptation.

Mac Arthur and Wilson (1967) estimated population growth using the logistics equation i.e.

Population increase = Biotic potential (reproduction per individual) X No. of individuals X Relationship between carrying capacity and resources available

$$I = \frac{rN(K-N)}{K} \quad \text{Or} \quad rN(1-N/K = dN/dt$$

For sigmoid growth curve

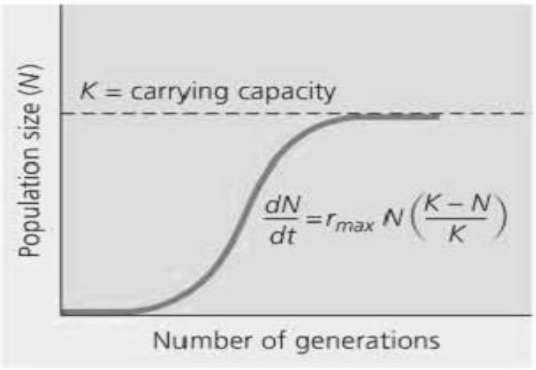
Where:

t- Time
r- biotic potential/maximum rate of increase of the population
N- No. of individuals in the population
K- Carrying capacity
I- population change

Where the population is low, the I value is close to NVR

When the population increase and resources become depleted, I decrease sharply to zero where N=K.

The Logistic Growth Model According to the logistic equation $dN/dt = r_{max}N(K - N)/K$, growth levels off as population size approaches the carrying capacity.



K and r population strategies

Most natural population fall between two extremes called r-selected and K-selected population as were used in the equation for population growth.

Note: r-species/r-strategists species produce rapidly and have a high value of r.

Characteristics of r-selected populations

- They are found in habitat/environments which undergo many changes.
- The individuals are small in size.
- Have a short life span i.e. they attain reproductive potential very early.
- Have a high mortality rate not density dependent.
- Reproduce at a high rate.
- Off springs grow rapidly with little parental care provided.
- Favourable conditions favour rapid explosion of population growth hence no or less competition. Thus selection pressure in such species favours high reproduction rate and short generation.
- A sudden environmental change results in a massive number of deaths. But their rapid birth rate and short life span favour the ability to adapt to a changing habitat e.g. insects, seeds, spores, bacteria, annual plants, paramecium.
- They are opportunist pioneer species of new and disturbed habitats. Migration and dispersal are key factors of their strategy.

K-selected populations

These are associated with specific habitat conditions or fairly stable environmental conditions with fewer fluctuations, relatively undistributed habitats and ever the changes of the seasons are regular and predictable and where competitive ability rather than reproductive speed is a major survival attribute/factor. They tend to be more typical of the later stages of succession and such species are not very adapted to recover from population densities significantly below their equilibrium level (K-value or carrying capacity).

Characteristics of K-selected population

- Reproduce slowly (low fecundity, long generation time) therefore low value of r.
- Reproduction rate is sensitive to population density, rising rapidly if density falls.
- Population size stays close to equilibrium level determined by K.
- Species are persistent in a given area.
- Disperse slowly
- Large in size e.g. woody stems and large roots if plants.
- Individuals live long
- Habitats stable and long lived (forests for monkeys).
- Good competitors

- Many become dominant.
- Less resistant to changes in environmental conditions e.g. butterflies, birds, humans and trees.

Assignment: ***compare r-selected and K-selected populations (see table in BS page 411).***

SURVIVORSHIP CURVES

For any population size to remain consistent at least two off springs from each male and female pair on average must survive to reproductive age.

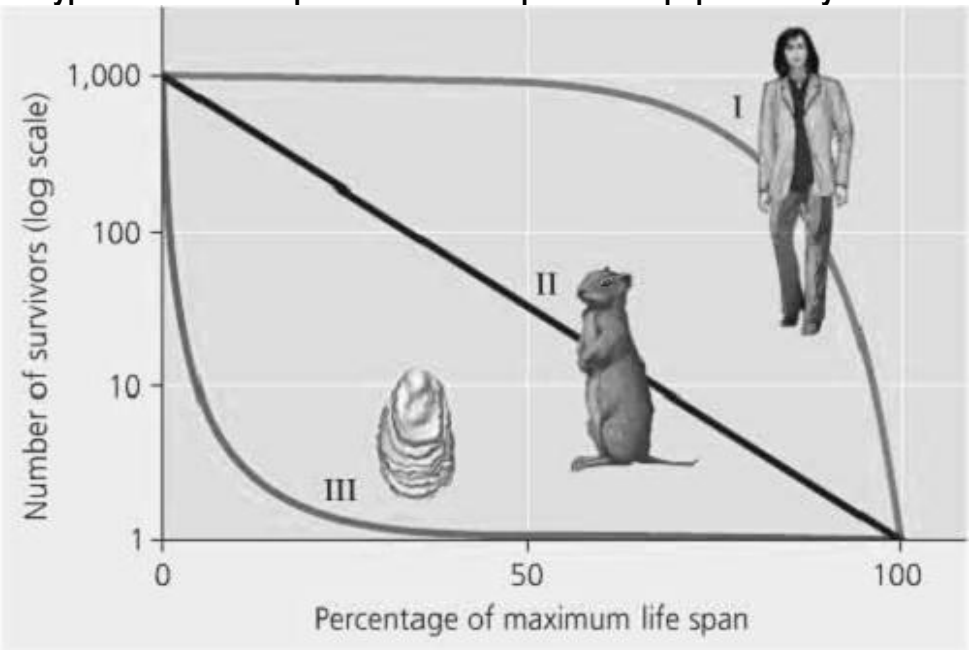
The percentage of individuals that die before reaching reproductive age pre-reproductive mortality (infant mortality) is a major factor determining population size.

A survivorship curve

This is a curve showing the number of individuals who survive per thousand of population through each phase of life. It shows the effect of mortality and natality among age groups under environmental conditions.

Note: different species have different characteristic survivorship outcomes depending on their pre-reproductive mortality.

Types of survivorship curves/different patterns of population dynamics



Curve I: shows the ideal curve for a population where ageing (senescence) is the major factor affecting mortality. Once ageing begins, there is an increased number of death occurring mainly due to reduced resistance to environmental factors and carrying capacity. The deviations are due to lower infant mortality and accidents. In human, it's characteristic of industrialized countries like U.S and U.K where life expectancy is about 75 years because high standards of medicine and nutrition are maintained.

Annual crop plants e.g. wheat also exhibit curve I where all the plants in a given field senesce at the same time.

Curve III: shows a population with a high mortality rate early in life/infant. Survival of individuals increases with time. In humans it's characteristic of undeveloped countries where infant mortality is higher due to poor medication, sanitation and nutrition.

Question: ***which population I and III would need the highest reproductive rate to maintain a stable population?***

It is population III because a high percentage of individuals would die before reproductive age is reached. Population I would have to combine its high survival rate with low reproductive rate to maintain a stable population size.

ESTIMATING POPULATION DENSITY

Population size can be estimated in various ways which include;
Direct counting/census method
Quadrat method
Transect method
Capture-mark release recapture method (the Lincoln index)
Pitfall method
Sweep net method

Census/direct counting

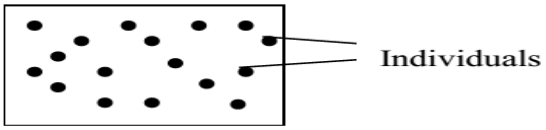
This method can be used for determining the population for almost all organisms. The organisms are seen and counted and their population is recorded. It's the most accurate method at determining population size.

DISTRIBUTION OF ORGANISMS (POPULATION DISPERSION)

Dispersion refers to the structure/distribution of individuals or organisms within an area.
Dispersal mechanism of the population supplements natality and mortality in shaping population growth form and density.
There are 3 forms of dispersion:

1. **Random dispersion/distribution**

This is relatively rare in nature. It occurs where the environment is very uniform in terms of resources and there is no tendency of organisms to aggregate. There is equal and even distribution of resources. There is low or no competition.

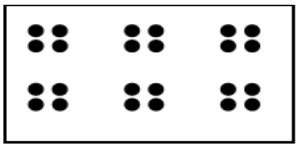


2. **Clumped distribution/aggregate/clustered**

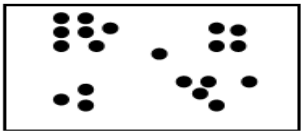
It's the naturally occurring type of distribution where individuals tend to aggregate at a particular point on the habitat. It's due to;

i) Distribution of resources that are not regularly distributed due to climate and soil factors.
ii) Social behaviour like termites and bees have division of labour among members, animals that live in colonies like buffalos, baboons, monkeys, etc. clumps could be irregular or regularly distributed.

Regular pattern:

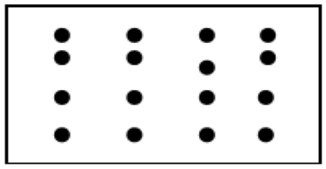


Irregular pattern or random:



3. **Uniform/regular distribution**

This occurs where intraspecific competition is severe. However, man artificially can induce it through agricultural practices e.g. planting of seeds.



Many communities are dominated by clumped patterns of distribution for several reasons:

i) Effects of parent plant i.e. seeds may not be dispersed far from the parent plant hence plant seedlings are usually found near the parent plant.
ii) Distribution of environmental factors. These are not uniform for all areas.
iii) Species interrelations i.e. a species may be depending on another directly e.g. epiphytes.
Animals exhibit dispersion in form of territorial behaviours. A territory is a defined area owned by a group of animals/family and defended against other members of the same species.
iv) Natural barriers like rivers and rift valley restrict animals in particular areas e.g. bush backs, chimps and elephants.

Importance of dispersion in animals

- Individuals acquire a home/nest/habitat within which they can live and breed.
- Individuals are spread out such that resources like food, breeding grounds become enough.
- Chances of obtaining a mate is increased since males attract females into their territories.
- Natural barriers like rivers and rift valleys restrict animals in particular areas e.g. bush backs, chimps and elephants.
- Reduces distances moved away from home to search for food, mate, etc. this saves energy, time and prevents exposure to predators.

Note: dispersal is the movement of individuals/organisms or their seeds, parts into or out of the population or habitat to a different locality/area.

Importance of dispersal

- New or depopulated areas are colonized.
- It increases the rate of gene exchange/gene mixing between populations via mating.
- It may prevent extinction and or speed up population growth.

Population Histograms

Population growth curves only show how populations change over time but don't tell or show the age distribution of the members. The population histograms show or represent population of an organism in terms of its age structure and the proportion of males and females at a specific instant in time (sex ratios).

Age distribution/structures

It's the proportion of the individuals of different ages in their population. It is an important factor because it influences mortality and natality. It's determined by:

i) Observing the teeth and bones of organisms.
ii) Observing horns, claws, rings and scales, etc. depending on different types of animals or organisms or plants. E.g. some animals or organisms show annual increment in rings e.g. scales in fish and horns in cattle.
iii) In invertebrates and some vertebrates, weight and size are used to determine the age of an individual.

Types of ecological ages

1. Pre-reproductive age; represent organisms that are below the reproductive age (between 1-14 years).
2. Reproductive age; shows organisms of the population able to mate or reproduce.
3. Post-reproductive age; represent members that are old enough to reproduce e.g. 65+ years in humans.

The relation duration/time of each one age varies with different species. Age structure is studied using the age sex graph or population pyramids. It deals with relationships in number between males and females of age groupings.

INTERACTION WITHIN THE POPULATIONS

COMPETITION

Within a population, individuals compete with each other for food, water, mineral salts, territory, shelter, mates, resting sites, etc. therefore competition is the interaction that occurs between two or more organisms, populations or species that share resources.

Types of competitions

1. Interspecific competition; is competition among individuals from other species for resources.
2. Intraspecific competition; is competition among individuals of the same species for essential resources.

The closer the ecological niches of the competing organism, the fierce are the competition.

Co-existence between two species which compete is impossible. To avoid severe/stiff competition and extinction the two different species occupy different ecological niches. This is called competitive exclusion principle.

It states that, "no two organisms can occupy the same ecological niche when they compete for the same resources. If they did so, one would become extinct or will be out-competed thus becomes extinct."

Organisms develop structural features and behavioral patterns to enable them succeed in the exploitation of natural resources.

The successful organism has a faster rate of reproduction and a higher tolerance to waste materials e.g. seedlings in forests show rapid growth due to competition to gain access to sunlight for photosynthesis.

Consequences of competition

- Weak competitors are eliminated or extinction of species or migration.
- It results in feeding habits/feed on food nutrients which they used not to feed on.
- It affects pollination between certain plants and specific insects.
- Gene loss or change in gene frequency.

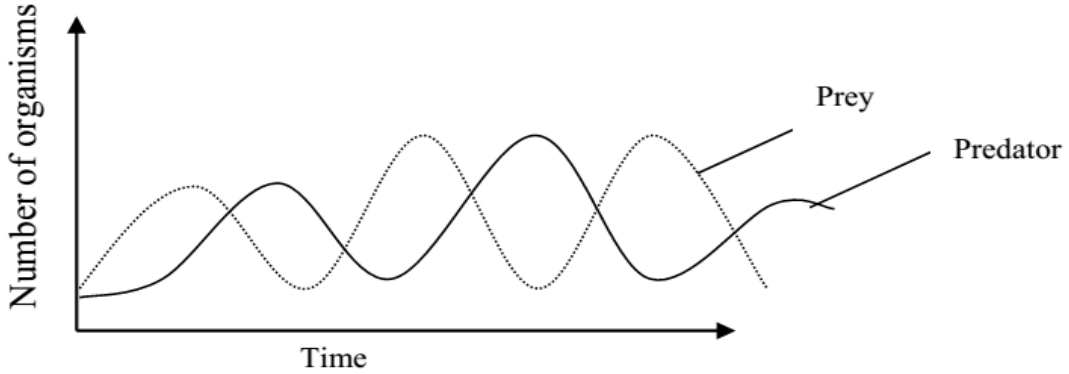
PREDATION

Predation is a feeding relationship where one organism of a given species, the predator, hunt, kill and feeds on another, the prey of another species. The growth and decline of the population of such organisms depend on the number of each group in an ecosystem. Initially prey population grows at a faster rate than the predator. The predators feed on the prey, thus increasing in production.

A reduced prey population triggers off competition for density dependent factors like food, space, mates among the increased predator population and also increased accumulation of wastes. These will check the increase in predator population hence predator number will start to decrease in number due to starvation.

When predator populations decrease, prey will reproduce and multiply in number and increase. Therefore, large numbers of preys provide food and therefore food becomes available. Thus the population of prey and predator affects each other which bring about fluctuation in the growth of their populations.

Graph showing relationship between predator-prey populations



Note: normally the numbers of predators tend to lag behind than those of prey because predators being larger have a slower rate of increase.

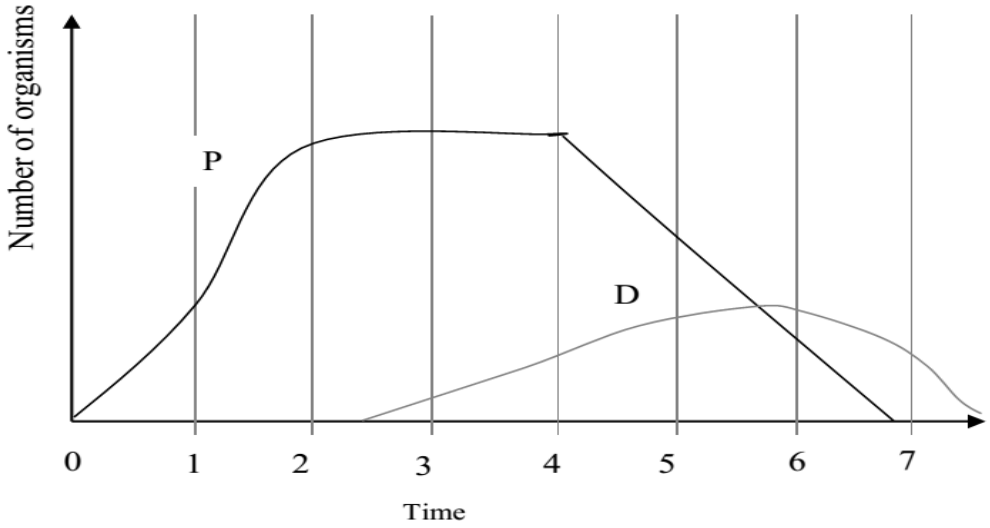
Importance of predation

Predation maintains populations within the carrying capacity of their habitats and lessens the sudden explosion of prey species within a population.

Predation is a mechanism by which excess animal productivity is re distributed by conversion to other animal tissues at higher trophic levels.

EXAMPLES

1. *The graph below show the relationship between a predator, Didium (D) and prey, paramecium (P) in a culture medium.*



Description:

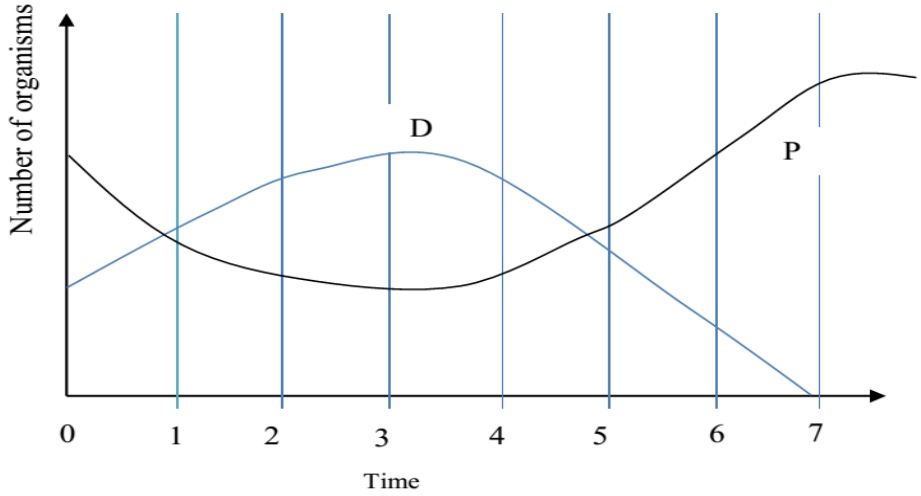
Paramecium increases gradually on the first day, then steeply increases up to the 2nd day, becomes constant up to the 4th to the 6th then gradually decreases to zero on the 7th day.

Didium increases gradually after 2 ½ days, they reach a maximum then remains constant up to the third day it gradually declines to the fifth day, remains consistent up to the 6th day and declines to zero gradually.

Explanation:

Once introduced in the paramecium culture, Didium feeds on and reduces the number of paramecium and it multiplies, increases in number and reaches a maximum, the Didium feeds on paramecium until it gets extinct. Didium starves to extinction.

2.



Description:

Number of paramecium declines gradually to the 3rd day and then increases gradually up to day 5 then steeply increases up to the 7th day then remains constant up to the 9th day/end.
Didium increases gradually in the 1st day, then increases gradually to day 2 then declines gradually to the 5th day and more gradually decline to zero on day 6.

Explanation:

The Didium feeds on paramecium and multiplies in number. The paramecium is then reduced to a number that can support the Didium which then starves and paramecium which survives increases up to starvation point/carrying capacity/plateau/equilibrium point.

ECOLOGICAL SUCCESSIONS

A community is a group of interacting populations living in a given area and represents the living part of an ecosystem. Its functions are energy flow and cycling of nutrients. The structure of a community is always built up over a period of time until a stable climax community is established. Ecosystems are dynamic constantly changing in response to both physical and biological factors.
Ecological succession is a gradual change in community composition from the initial colonization of an area/habitat to establishing a relatively stable community. Or
Ecological succession is a fairly orderly process of changes of communities in a region or an area. It involves replacement in the course of time of the dominant species within a given area by other species. Or
It's the establishment of a sequence of different communities in a particular area over a period of time.
Communities succeed each other in an orderly sequence in which such successive stage i.e. it's dependent on the one that precede it.
Succession progresses gradually from a small number of colonizing species known as seres or seral stages (i.e. communities that replace one another in a given area are called seres. These temporary consists the seral stages/seral communities).
Each sere has its own community of organisms until the terminal relatively stable and final stage community called climax community.
The climax community comprises of dominant or several co-dominant species which refers to species with the greatest collective biomass/productivity and physical size of individuals in a given area after some time (years).
At climax community the net productivity/biomass tends to remain constant but dependent on species number and population size.

Types of succession

1. Primary succession
2. Secondary succession

Primary succession

It occurs during the colonization of uninhabited area or where no new life previously existed e.g. volcanic islands, bare rocks, sand dunes, lake shore, river banks, bare pavements, bare soil surface, dry area devoid of vegetation, ponds, swamps.

An example of succession on a rock:

On a bare rock/bare pavement several seral stages are identified, lichens (algae and fungi) are the pioneer community to be established first.
They are able to utilize the low moisture, nutrients, and ions on rock surface. The hyphae of the fungi penetrate the tiny pores on the rock providing a firm attachment and absorbing inorganic nutrients from the rock while the algae provide food since it is photosynthetic.
Bacteria and fungi also aided by weathering loosen rock surface by the process of rock decay. Their decaying bodies (algae/fungi and bacteria) add humus to the loosen rocks to form sedimentary soils.

The loosen rock is now able to be inhabitable by the drought resistance second colonizers to support plant life of rhizoids on humus/traps the tiny organic and inorganic debris and water/moisture and further loosen the rock surfaces.

Also death of some moss plants add nutrients to the soil due to decay by saprophytic organisms, more soil is formed to support the germination of seeds/grass of the large colonizing angiosperms/vascular plants. Small animals like insects, molasses, earth worms, and rodents break down rocks. The herb seeds germinate to replace proceeding growths and they in turn provide suitable conditions for large woody shrubs to begin to grow in the newly fertile formed soils.

Eventually as a thicker layer of soils develops, shrubs get replaced by deciduous trees with deeper roots that penetrate crevices/cracks. The seeds of the trees become germinated/grow in the created suitable conditions by their parents' previous plants and animal colonizers and the mature forest community develops which becomes self-sustaining.

Note:

As the number of tree species increase, there is increased modification of the micro climates in the habitat e.g. shade increases, making light demanding shrubs to disappear and are replaced by light tolerant species of trees. The tolerant species of trees finally form the climax vegetation. The savanna grass land and forest ecosystems are the dominant terrestrial ecosystems.

Summary:

Pioneer species → animals (mosses) → herbaceous perennials (herbs) → shrubs → tree → forest

Secondary succession

This is the establishment of communities on areas/habitats previously occupied by developed communities but has been disrupted in some ways such as burnt farm, playground fire cleared, forests destroyed by natural disaster like hurricanes, drought, volcanic eruption, floods, human activities like fires, cultivation, fire, overgrazing.

Such areas have seeds/spores, organs of vegetative reproduction/propagation rhizomes and abundant nutrients in soil to support life. The successions are called secondary seres. E.g. fires from lightening burn plants stable community living a bare ground. The ground layer plants are killed, the heat destroys hollow roots/seeds and animals burnt in soil.

Often the first green plants on a burnt wood ash are the mosses that form an extensive green carpet. Within carpet the seeds of herbaceous and woody plants germinate. A new herbaceous layer grows, forming the grasses and followed by shrubs and trees. Each dominant plant community has associated dominant animal population within it. The climax community persists for a long time until when factors that favour that favour invasion of better adapted forms of organisms set in.

The climax vegetation makes efficient use of resources of the community ensuring indefinite self-sufficiency i.e. a community maintaining itself.

A similar secondary succession takes a short time to reach climax community. This is because the soil is already formed and supports growth of a wide range of plants immediately.

Note:

Both primary and secondary succession is affected by the animal (fauna) and flora (plants) of the surrounding environment/areas through dispersal and migration.

Characteristics of a succession process

- A pioneer community which is quite simple in biomass content and composition.
- A series of intermediate stages/seres
- Increasing biomass/productivity and species biodiversity
- Ends into a stable community which is in equilibrium with its environment called the climax community.

Factors affecting the number and diversity of species reaching an area/colonization

- Geographical barriers like mountain ranges/ river/lake/rift valley.
- Ecological barriers like unfavourable habitats separating areas of favourable habitats.

- Distance over which dispersal must operate
- Size and nature of invasion areas

BIOMASS

This refers to the dry weight of organism(s) at a trophic level. The biomass at the time of sampling or given movement in time is called the standing biomass or standing crop biomass.

The process or trend of succession on a bare rock or bare pavement or bare soil surface or dry area is devoid of vegetation.

On bare rock the first organisms to colonize the area are lichen/bacteria/fungi aided by weathering loosens rock by the process of rock decay. Their dead bodies add humus to the loosen rock enabling algae growth. The invertebrates invade and feed on them. When these organisms die and decompose and their metabolic wastes cause rock weathering leading to soil formation. Mosses/liverwort would then come in including insects that feed on them. Other plants with better roots like ferns and animals like earth worms, molluscs, amphibians, birds, reptiles and mammals comes in. Evergreen plants with deeper roots like vascular grasses, shrubs and trees and then come in animals which finally form a climax community.

Note:

The biomass of climax community is higher also in cleared forest than in developing community, e.g. algae growing on a concrete. This is so because a formerly cleared forest has the soil substratum rich in organic matter/nutrients on which woody species can grow very fast accumulating organic matter. However on a rock/concrete/non-decomposable blocks little or no nutrients are obtained slow growth occurs so less accumulation of organic matter or biomass occurs. The algae are small in size contributing less organic matter.

So trees have a higher biomass since they accumulate it over a long time period compared to the small algae.

POLLUTION

This is the contamination of the environment by discharge of substances/pollutants of energy in quantities that affect the well-being of organisms in their habitats. To be a habitat, the substance has to be harmful to life.

Types of pollution

1. Air pollution
2. Water pollution
3. Soil/terrestrial pollution

Water pollution

Water is a habitat for aquatic life. Most aquatic life respires aerobically and so requires oxygen from their environment. Any change in the amount of oxygen in the water can severely/seriously affect the suitability of water as a habitat.

The main water pollutants are;

- Untreated sewage
- Fertilizers (leach from near farm land)
- Pesticides/herbicides
- Heat from industries

Sewage

Sewage is any water borne waste from domestic/industry including faeces, nitrogenous wastes, detergents, garbage, dirty water discharged in a water body. Discharge in water body of untreated sewage, fertilizers (nitrogen compounds and phosphates) decompose causing excessive enrichment of nutrients like ammonium, nitrates, phosphates, etc. this leads to eutrophication that encourages rapid algae growth/phytoplankton.

Eutrophication

This is the addition of nutrients to water bodies which encourages blooming/proliferation of algae, fungi and other aquatic plants. The human activities that cause eutrophication are;

- Discharge of untreated sewage into water bodies/industrial wastes
- Use of fertilizers which later wash into water bodies

Effects of eutrophication

i) Algal bloom reduces light penetration into the water body, so algae and other photosynthetic plants in the deeper regions of the water body are unable to photosynthesize leading to death of aquatic plant species.
ii) Algae decays and increased decomposition reduces oxygen level in water leading to death of other aerobic aquatic organisms since nitrifying bacteria uses oxygen in breakdown of ammonium compounds to nitrates by saprophytes.
iii) Also sewage exposes aquatic organisms to their predation due to poor visibility.
iv) The process of decomposition also depletes the water off oxygen leading to increased biochemical oxygen demand (B.O.D).
v) Such water is unsuitable for drinking and cause irritation to the skin. They also cause diseases to man like cholera and typhoid.
vi) Due to anaerobic activity and decomposition the water becomes alkaline due to high concentration of ammonia.

Eutrophication is greatly accelerated by thermal pollution because heat increasing the rate of decomposition that bring about a higher oxygen demand into aquatic environment.

TYPES OF ECOSYSTEMS

There are two major types of ecosystem, namely;

1. Terrestrial/land ecosystem
2. Aquatic ecosystem

Each of the two can further be grouped into several habitats.

AQUATIC ECOSYSTEMS

Aquatic ecosystems support a great diversity of life forms. Water occupies 50% of the earth's surface. Water provides a more constant and protective environment than land (desiccation, less affected by sudden and drastic changes in physical and chemical conditions, some change due to climatic or seasonal variation). It provides support and dissolved oxygen and nutrients to aquatic organisms.

Aquatic ecosystems are classified as the following depending on the concentration of salts they contain;

- Fresh water ecosystem
- Marine ecosystems
- Estuarine ecosystem

FRESH WATER ECOSYSTEM

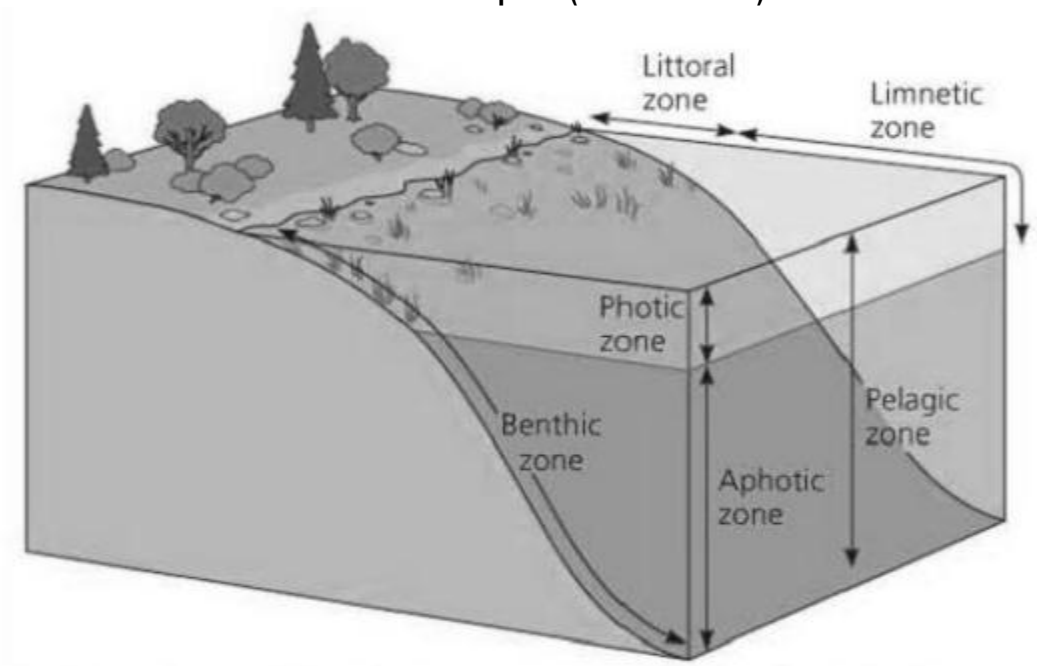
Fresh water habitats occupy a small portion of the earth's surface as compared to marine and terrestrial habitats. However, fresh water habitats are of great importance to man for the following reasons:

- Cheapest source of water for domestic and industrial use
- Provide the cheapest waste disposal systems
- Habour various animals

Fresh water habitats can be classified into:

1) Lotic (running water bodies) e.g. rivers and streams
2) Lentic (standing water bodies) e.g. pond, lake and swamps

Structure of a lake/pond (Lake Zonation)



Note: The lake environment (lake zonation) is generally classified on the basis of three physical criteria: light penetration (photic and aphotic zones), distance from shore and water depth (littoral and limnetic zones), and whether it is open water (pelagic zone) or bottom (benthic zone).

i) **Littoral zone:** shallow water region with high light penetration. It has the highest productivity due to high carbon dioxide/oxygen and suitable temperatures.

ii) **Limnetic zone:** it's the open water zone to the depth of effective light penetration. The community here includes phytoplankton, floating insects and algae. Like littoral zone, productivity/net productivity is highest because of high effective light penetration, more dissolved gases, high temperatures at the surface and turbulence due to the high air content/wind so high photosynthesis. Dissolved nitrogen is fixed by nitrogen fixing bacteria and blue-green algae to make proteins. Dissolved carbon dioxide formed carbonic acid which results in formation of H^+, HCO_3^- and CO_3^{2-}.

iii) **Profundal zone:** receives little or no light. Light penetration decreases with depth and also net productivity decreases with depth.

iv) **Benthic zone:** this is the bottom most, receives no light at all, no dissolved gases, aerobic bacteria exists so little productivity. The productivity is due to water currents which tend to mix the upper layers with bottom layer and photosynthesis and chemosynthesis bacteria exist.

Ecological classification of fresh water organisms

Organisms in water can be classified depending on their life form which is based on their mode of life. The following terms are used:

1. **Neuston:**
   These are organisms resting or swimming on the surface of water. Such organisms may be supported by the surface film or cling to the surface film from beneath or swim in the upper waters. Examples include pond skaters, air breathing diving beetles, water boat men, floating plants like duck weed, bladder work, etc.
2. **Plankton (floating):**
   This is a mass of floating small plants (phytoplankton) and animals (zooplankton) whose movements and distribution are more or less dependent on currents. Their powers of locomotion are restricted to small vertical movements or to catching prey. Examples include arolia, Pistoia, water burg, tadpole, etc.
3. **Nekton:**

These are free-swimming organisms that can swim against water currents. Some of them are small e.g. swimming insects while others are large e.g. bony fish, amphibians, etc.

4. **Benthos:**

These are organisms attached or resting on the bottom or living in the bottom sediments. Most of them feed on fresh water organisms in ponds and lakes. They may also be classified depending on the sub habitat they occupy. Three zones are generally evident;

i) **Littoral zone:**
This is the shallow-water region with light penetration to the bottom. Such a zone is typically occupied by plants in natural ponds and lakes.

ii) **Limnetic zone:**
This is the open water zone to the depth of effective light penetration. The community in this zone is composed of plankton, nekton and sometimes Neuston. In shallow ponds, this zone is absent. The total illuminated depth including the littoral and limnetic zone is referred to as the euphotic zone.

iii) **Profundal:**
This is the bottom and deep water area which is beyond the depth of effective light penetration. This zone is often absent in ponds.

Factors affecting productivity of the lake

- Temperature
- Nutrient availability
- Salinity
- Water current
- Pollution

Warm temperature provide optimum medium for aquatic organisms distribution as well as enzymes involved in photosynthesis.

Cool temperature of bottom water inactivate enzyme and affect distribution of phytoplankton thus reduced productivity.

Availability of nutrients in water due to decomposition of organic matter like sewage, dead organisms and fertilizers washed off from farm and water would lead to algal blooming or eutrophication of phytoplanktons. This would instead increase productivity since phytoplanktons are many.

Man's activities that harm the environment. With the recent increase in the human population, there has been over exploitation of natural resources.

Several human activities which directly destroy the environments are:

1. **Deforestation;** forests are important for:

Have most species and diverse wild life communities. Their destruction will lead to extinction of numerous species and less of genetic variety and potential resources.

Forests protect the soil. Deforestation leads to soil erosion, clear water supply are destroyed and silting of reservoirs.

Timber harvest, poles, food, fuel, honey, fruits and herbs

Forests catch large amounts of rain and release the water slowly into streams and rivers. Their destruction cause floods in areas down-hill.

Forests release large amounts of oxygen and absorb carbon dioxide (lock it up) during photosynthesis. Deforestation has led to increased global carbon dioxide hence causing global warming.

Forests influence the amount and frequency of rain fall received in an area.

2. **Poor agricultural methods:**

These include Monoculture, shifting cultivation, use of artificial fertilizers and pesticides. Excess fertilizers and pesticides leads to eutrophication of water bodies giving rise to build up of toxic by-products by

leaching and draining. Pesticides/herbicides/fungicides draining away from fields enter water ways are connected through the food chain. This leads to poisoning of top carnivores.

3. **Poor methods of mining;** such as open cast mining destroy habitats. Mineral elements mined cause destruction of the environment around the mine. Heavy metals like lead and mercury drain into water bodies causing severe destruction of aquatic fauna, poison water for human consumption; sulphides destroy vegetation altering the structure of plant and animal communities.
4. **Urbanization/human settlement;** e.g. aggregation of people, food and water supply, garbage disposal.
5. **Fires;** burning of fossil fuel
6. Cement manufacture

Limiting factors in fresh water ecosystems

Limiting factors restrict the distribution of living organisms hence preventing the colonization of otherwise favourable environment. The most important limiting factors in fresh waters are:

1. **Temperature:**
   Water has several unique thermal properties. Although temperature is less variable, it is a major limiting factor. Aquatic organisms have narrow tolerance. Temperature changes produce characteristic patterns of circulation which greatly influence aquatic life.
2. **Light penetration:**
   Penetration of light is often limited by suspended materials (turbidity). This restricts the photosynthesis zone. Plants cannot survive below the compensation level. Light penetration can be measured using a ***Secchi disc***. It consists of a white disc that is lowered from the surface until it just disappears from view. This ranges to about 40 cm in very clear waters.
3. **Water currents:**
   Currents determine the distribution of vital gases, salts and small organisms. Water current is a limiting factor in fast flowing streams and on shores when it prevents colonization by weak swimming organisms.
4. **Dissolved gasses:**
   Gases from the atmosphere dissolve in water at the surface. However, some gases are more soluble than the others. E.g. oxygen is 30 times less abundant in water than in air.
   This limits the distribution of living organisms. The diffusion of dissolved gases through deep layers of water is very slow. In some places currents and wave action aid the diffusion, but in still waters, very little oxygen is transferred to lower levels. Once the little oxygen available is used up by decomposers, the effects may be disastrous to the whole community.
   Dissolved nitrogen is used by nitrogen fixing bacteria and blue-green algae in the manufacture of proteins.
   Effects of carbon dioxide are complex due to the formation of carbonic acid to form H^+ HCO_3^- and CO_3^{2-} ions. These combine with other dissolved substances in the water.
5. **Dissolved salts:**
   Fresh water ecosystems show a considerable variation in salt content. This depends on the minerals present in drainage water from the surrounding land mass and activities of living organisms. Deposition of nutrients in water is known as eutrophication.
   Nitrate and phosphate are the most limiting factors in fresh water ecosystems e.g. phosphorous is a limiting factor because the ratio of P to other elements in organisms is greater than the ratio in the primary sources of the biological elements. K, Ca, S and Mg may also act as limiting factors.

Biological classification of lakes

Biological classification of lake ecosystems depends on the circulation rates of inorganic plant nutrients in the lake. Three major types are recognized:

1. **Eutrophic lakes:** These are with waters relatively rich in plant nutrients.

Characteristics

- Have high surface area to volume ratio hence easy circulation
- They are relatively shallow with gentle slopping banks which can support wide belts of marginal vegetation (wide littoral zone).
- Have relatively high phosphates and nitrates, i.e. they are very productive.
- Due to emergent and submerged plants plus a lot of phytoplanktons, upper layers are rich in oxygen. The bottom layers are low in oxygen concentration since it is continuously being used for bacterial decomposition e.g. Lake Kyoga.

2. Oligotrophic lakes:

These are with low plant nutrients and they are highly oxygenated.

Characteristics

- They have low surface area to volume ratio, hence limited circulation.
- They are deep with steep rock sides.
- Waters are low in plant nutrient but highly oxygenated.
- Neither have extensive marginal vegetation nor organic bottom deposits which results in their low productivity e.g. Lake Tanganyika.

3. Dystrophic lakes

These have brown water where the bottom deposits of such lakes consist of unrotten organic matter which accumulates as heat. Productivity of such lakes is very low.

THE POND ECOSYSTEM

The pond ecosystem is complex and is affected by several environmental conditions. The living organism and the nonliving environment are inseparable and the following can be recognized:

i) **Abiotic substances:**
These include basic inorganic and organic compounds e.g. water, CO_2, O_2, Ca, N, P, soil, etc. A small portion of the vital nutrients is in soil and available to organisms but much larger portion is held in the bottom sediments and in the organisms themselves. The rate of release of nutrients from the solids, solar input and other environmental factors determine the productivity of the entire ecosystem.

ii) **Producer organisms:**
There are two major types only; Rooted or large floating plants growing in shallow water e.g. papyrus and Phytoplankton distributed throughout the pond as deep as limnetic zone.
Note: in deep ponds and lakes, phytoplankton is much more important than rooted vegetable in the production of the basic food from the ecosystem (algal blooms)

iii) **Macro organisms:**
These include animals like insect larvae, crustacea, fish, etc. primary consumers feed on plants or plant remains e.g. zooplankton and benthos (molasses).
Secondary consumers e.g. predaceous insects and fish feed on primary or secondary consumers.
Detritivores e.g. worms, larvae and rotifers consume organic matter from upper layers.

iv) **Saprotrophic organisms:**
Aquatic bacteria, flagellates and fungi are distributed throughout the ponds, but are abundant at the bottom where plant and animal organic matter accumulates.
Dead organisms are rapidly broken down by detritus feeding organisms and microorganisms and their nutrients are released for re-use.

TERRESTRIAL ECOSYSTEMS

Regional climates interact with regional biota and substrate to produce large recognizable community units called biomass. A biome is identical with a major 'plant formation' but it is a total community unit in which both animals and plants are considered. The six major biomass of Africa include:

- Tropical rain forest
- Tropical savanna and grass land
- Desert
- Sahel region (semi-desert)
- Mountain forests
- Temperate region

The above form the major terrestrial ecosystems.

Tropical rain forest ecosystem

This is characterized by high temperatures of 25^0C and 35^0C and a high monthly rain fall distributed over 10 months of the year i.e. 200 and 400 cm^3 of rain fall annually. They are dominated by broad leaved evergreen trees which occupy low altitude zones near the equator (amazon, Congo, Malaysia, etc.).

Seasonal changes in breeding and other activities of plants and animals in a tropical rain forest are largely related to variations in rain fall and to a certain extent temperature.

Forest communities are well structured and contain specific plant and animal populations that interact in a complex fashion.

Trees in the forest form three layers (stratification):

Emergent layer:

This consists of scattered, very tall emergent trees (80-100m) that project above the general level. They have wide spread, umbrella shaped crowns and huge buttresses. Examples are the Chlorophora excelsa (Mvule), mahogany, mbizia, etc.

Canopy layer:

This forms a continuous evergreen carpet 50-80m tall. The crowns of such trees are small compared to the emergent and buttresses are narrow.

Understoney layer:

This includes relatively short trees 1-1, 20-40m tall and young trees of the emergent and canopy layers. Ferns e.g. platycerium spp is common as an epiphyte high on trees. Other epiphytic plants include figs and orchids.

Ground layer:

This includes shrubs, herbs, lianas, shade loving plants with broad leaves and thallophytes e.g. lichen, mosses, liverworts and shade loving animals.

A much large proportion of animals live in the upper layers of the vegetation. These include birds, mammals, amphibians and others. Some animals are ground dwellers e.g. ants, butterflies, moths, snakes and other reptiles.

Tropical rain forests are rich in flora and fauna species e.g. a six square mile area can contain 20,000 species of insects. A tropical rain forest is the only major vegetation type which does not burn i.e. fire is not an ecological factor.

Variation in environmental factors (temperature, light, moisture) caused by the stratifications creates micro-habitat conditions.

The ground layer receives light of low intensity approximately 10% of the total value received by the emergent. Ground layer plants are therefore adapted to such conditions.

The shade effect of the canopy layer cuts off the sun's rays, thus relatively lower temperatures are experienced in the lower layers.

Moisture is influenced by temperature as it increases rates of evaporation and transpiration. Underground plants are in a region of lower rates of evaporation and transpiration than those above them.

Crowded leaves on the upper layer of tree branches act as wind breaks so the interior of the forest is not windy. The relative humidity inside is relatively constant to the upper layers.

Adaptations

- Emergent and canopy layer trees prevent excessive transpiration by having leathery surface and adequate deposits of cuticle.
- Plants of the undergrowth have large thin leaves.
- Animals on the ground use the soil for protection against extreme condition.
- Arboreal animals possess special features that enable them to climb e.g. specialized feet in squirrels and the monkeys' prehensile tails.
- Some animals use camouflage for protection against predators.

GRASS LAND ECOSYSTEM

Tropical savanna (grassland with scattered trees or clumps of trees) forms the grassland ecosystem in Africa. Grasslands are characterized by hot weather with a moderate temperature range. Rainfall is about $120cm^3$ per annum which falls in one period, followed by a long period of drought.

Grassland ecosystems are dominated by grasses such as guinea grass, elephant grass, spear grass, and palms.

Animals include a variety of numerous hooted mammals e.g. antelopes, elephants, zebra, giraffes which graze or browse on the vegetation. Others include predators like lions, cheetahs, scavengers like hyenas, jackals and culture insects most abundant during the dry season which include grasshoppers, termites, ants and locusts. Reptiles are abundant during the dry season and these include snakes, lizards, chameleons, tortoise, etc.

In the savanna grassland ecosystem, seasons are determined by rainfall. Other two factors include herbivore and fire. Trees and grass present must be resultant to drought and fire. This explains why the number of species in the vegetation is not large.

Grazing mammals are important in determining the flora composition of the community. Some species of grasses and other plants are more sensible to grazing pressure than others.

During the dry season, fire is a major ecological factor. It destroys non-resistant plant species like grasses but it also stimulates those with underground parts to grow. Trees develop a dense and shady canopy and grasses grow to high heights during the short rainy season.

Adaptations

- Savanna trees grow long tap roots and develop thick barks which enable them to survive the long dry season and resists fires. They have umbrella shaped canopies which shade the ground and limit loss of soil moisture. The leaves have thick surfaces which minimize the loss of water by transpiration.
- Grasses have durable roots which remain underground when the tops have been burnt away after a fire. They sprout again with the onset of the first rains in the following year.
- Animals usually migrate and hibernate.

Fire as an ecological factor

Factors that control the effectiveness of fire

i) **Kind and amount of fuel:**
Tall grasses produce much fire more than heavily grazed areas. However, forest fires are more vigorous than grass fires and they cause much more destruction. This is due to the amount of fuel that takes time to be completely burned.

ii) **Weather conditions:**
During the rainy season fires do not spread very far and become wild but in a dry season fires are more wild, strong and destructive.

iii) **Topography:**
Fires are fastest uphill and slowest downhill therefore the effect of fire on soil is greatest on fires downhill rather than uphill.

iv) **Frequency of burning:**

Continued burning has a more permanent destructive effect. It does not only destroy vegetation cover but kills soil and fauna.

v) **Direction of fire:**

Back fire burning against the wind direction is more severe on the soil than forward fire burning with the wind direction.

Advantages of fires

- It breaks seed dormancy due to hard seed coat leading to fast germination.
- It increases recycling of nutrients in an ecosystem.
- It is used in selective weeding.
- It controls pests and diseases.
- It improves on herbage in an area.
- It improves on light penetration leading to rapid under growth in the forest.
- It improves on the visibility of the prey to predators by burning the vegetation cover down.

Disadvantages of fire

- It destroys the habitat of animals which may cause extinction of some animals.
- It causes air pollution
- It destroys green plants which are producers of the community.
- It destroys animals in the ecosystem.
- It increases predation due to improved visibility.
- It leads to loss of some nutrients from the soil by decomposition e.g. humus and nitrates.

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"You can have anything you want-if you want it badly enough. You can be anything you want to be, have anything you desire, accomplish anything you set out to accomplish-if you will hold to that desire with singleness of purpose" Robert Collier.