ECOLOGY

Ecology is the study of living organisms in relation to their environment i.e. the study of interactions between living things and their environment.

The organisms and the environment depend on each other for resources plants e.g. plants need carbon dioxide and water to manufacture food for animals to feed on.

Terms used in ecology

Environment: This refers to the immediate surroundings of an organism.

Habitat: This is the place in the environment where an organism lives.

Biosphere: This is the surface of the earth where life exists

Ecological niche: This is the role/ status played by an organism within the community.

This refers to the specific mode of life of an organism within its habitat.

Ecosystem: This is the natural unit consisting of biotic and abiotic components interacting to produce a stable system.

Biotic components are the living components while abiotic components are the non-living components.

Community: This refers to the populations of plants and animals living together in a common environment.

The individuals of the population within the community interact with each other and with the abiotic components of the environment.

Species: This is a group of organisms capable of interbreeding and producing viable offspring.

Habitat

Classification of habitats:

These are classified into two; aquatic habitats and terrestrial habitats.

a) Aquatic habitats:

These are the habitats in water. They include;

i) Fresh water habitats. These include rivers and lakes. Inhabitants include protozoans (amoeba), fish, aquatic plants such as algae and papyrus.

ii) Marine (salty) water habitats. These are ones which are found in seas, oceans and swamps. Inhabitants include sea anemones, sea weeds, whales, fish, etc.

b) Terrestrial habitats:

These are habitats on land. They include;

i) Forests where the inhabitants are include birds, insects, fungi, monkeys, etc.

ii) Savanna where inhabitants include birds, grazers, insects, grasses, etc.

iii) Desert where the inhabitants include hardy droughts resistant species like xerophytes, cactus, euphorbia, camels, etc.

iv) Underground where inhabitants include termites, burrowing mammals, and earth worms, etc.

Environment

An organism in an environment is surrounded different things. Therefore, the environment is divided into two;

i) Physical environment
ii) Living environment

1. Physical environment (abiotic)

- This is composed of all the non-living factors which directly or indirectly limit or favor the growth and distribution of a species in the environment.
- The physical environment determines the survival, distribution and productivity of a species.

a) Climate

Climate affects the following; temperature, water and humidity, light, wind and air currents.

i) Temperature

- This varies in terms of latitude, and relief of an area.
- Temperature affects the biochemical processes in living organisms bringing about physiological or behavioral processes e.g. aquatic animals hibernate in adverse cold temperatures while land animals estivate during adverse high temperatures.

ii) Water (Rain fall)

- Water is a very essential requirement for both plants and animals and its supply determines its requirement and its ability to be consumed e.g. plants in dry habitats have deeper roots while some have wider stems for storage of water, and others have a higher osmotic potential.
- Therefore, the micro-climate which is the immediate weather conditions surrounding an organism determines its life style.

iii) Humidity

This is the amount of water vapor in the atmosphere. It affects the rate of evaporation from the surface of the organisms which in turn influences their ability to withstand drought.

iv) Light

This is very essential for all green plants and photosynthetic bacteria which in turn are very important for survival of all animals which depend on green plants for food.

v) Wind and air currents

Wind can affect organisms such as plants whereby plants with strong roots can survive in exposed places where wind speed is fierce while those plants with weak roots will die. However, average winds and air currents are very important in the dispersal of seeds.

vi) Topography

Topography means the altitude, slopping and steepness of a place. These aspects of a place affect the distribution of organisms.

E.g. with high altitude, temperature decreases, wind speed becomes greater, atmospheric pressure is lowered and there is more rainfall.

vii) Edaphic factors

These are factors associated with soil in terms of;

- Soil pH
- Drainage
- Water retention
- Humus content
- Number of living organisms
- Mineral salts, e.t.c

A soil deficient in one of these factors may deter the growth and survival of certain organisms, and only the organisms adapted will survive.

Living Environment (Biotic components)

The living components of the ecosystem consist of producers, consumers, predators, parasites, competitors and man.

1) Producers.

These are the green plants.

They fix the sun's energy into the ecosystem in form of organic compounds made by photosynthesis.

All other organisms depend on producers for food.

2) Consumers.

These are organisms which depend on other organisms for food i.e. they depend on producers, therefore feed heterotrophically.

Levels of consumers:

i) Primary consumers

These are organisms that feed on green plants directly i.e. herbivores e.g. grazers, grasshoppers, etc.

ii) Secondary consumers

These are organisms which feed on herbivores (i.e. carnivores) e.g. members of the cat family feed on antelopes, birds, insects, etc.

iii) Tertiary consumers

These are organisms which feed on secondary consumers e.g. vultures on other birds.

iv) Decomposers

There organisms which feed on dead bodies of plants and animals e.g. bacteria and fungi.

Decomposers are important because they bring about decay in organisms which is essential for recycling of nutrients for reuse by the plants.

If decomposers are absent, materials would accumulate in the environment and no nutrients would be recycled.

FEEDING RELATIONSHIPS

In nature, organisms depend on others for food.

Food Chain

These are linear relationships which show how members in an ecosystem depend on each other for food.

It involves the flow of energy from the sun to the producers through a series of organisms at different **trophic levels.**

A trophic level refers to a given feeding level of an organism in the food chain, i.e. producer, primary consumer, secondary consumer and tertiary consumer.

Examples of food chains

These food chains have the first trophic level occupied by either green plants, or algae and the second level by herbivore.

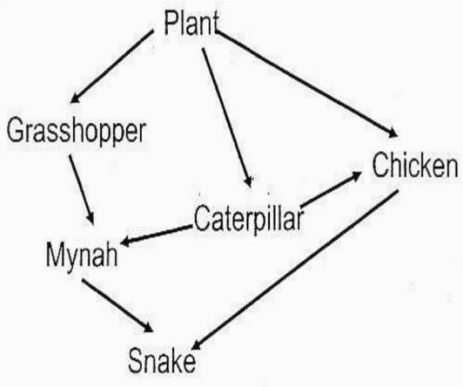
i) Grass → Grasshopper → hen →human being
ii) Grass → grasshopper →lizard→ snake→ hawk
iii) Phytoplankton →zooplanktons →small fish →big fish →crocodile

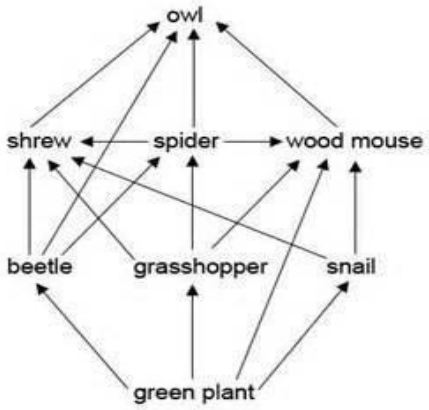
These types of food chain have their first trophic levels occupied by detritus

i) Leaf litter → earthworms→ birds → hawk
ii) Dead animal → blow fly maggots → frog → snake

Food web

This is a complex nutritional interrelationship that illustrates alternative food sources and predator for each organism. In a food web, there are several food chains.





Practice questions:

1) *Construct a food web using the following organisms: phytoplanktons, mosquito larvae, small fish, large fish, and crocodiles.*
2) *(a) With reference to a **named** ecosystem, what is meant by the following terms;*

i) Energy flow
ii) Trophic levels
iii) Food web.

(b). Discuss the interactions between the living and nonliving components of such an ecosystem.

(c) What is an ecosystem?

NB. Techniques used in constructing food webs and food chains:

- Direct observation of organisms as it feeds so as to establish the organisms prey.
- Examination of stomach content through dissecting the animals' stomach.
- Faecal method; observation of faecal materials egested by an animal.
- Use of radioactive tracers to label the environment from which organisms obtain their food and then trace them in the organisms gut.

Ecological pyramids

- An ecological pyramid is a graphical representation of food chains in an ecosystem.
- An ecological pyramid is constructed from a food chain because it shows the different energy levels.
- The producers are at the base then the successive trophic levels come one after another.

Types of ecological pyramids

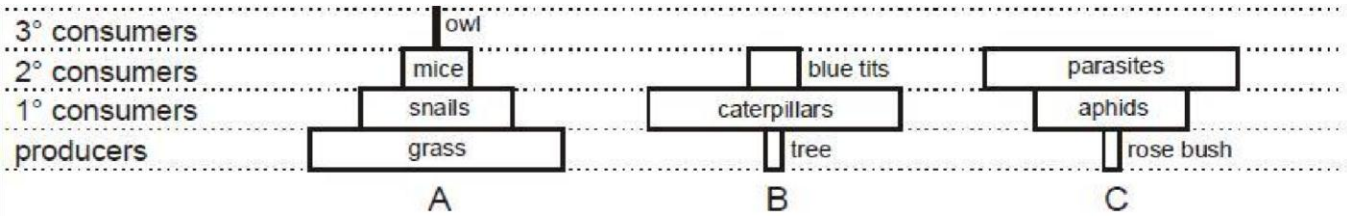
i) Pyramid of numbers
ii) Pyramid of biomass
iii) Pyramid of energy

NB: Decomposers are excluded from an ecological pyramid because;

i) Pyramid of numbers:

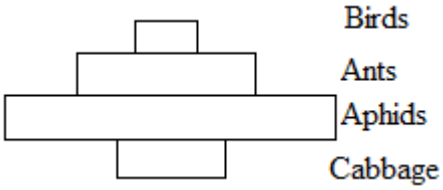
This is a diagrammatic representation showing the number of organisms at different trophic levels in a food chain.

The length of the bars represents the relative abundance of organisms

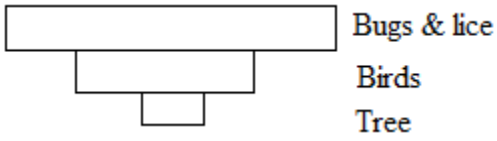


NB. Most ecological pyramids of numbers are always upright. However, in some cases, they may be inverted e.g.

a) Where a cabbage plant is supporting a large number of aphids; which also support a few ants; which in turn support a few birds

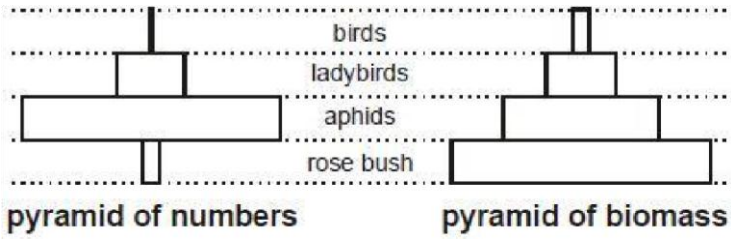


b) Where a single tree supports a number of herbivorous birds which in turn support numerous parasites e.g. bugs and lice



ii) Pyramid of biomass

- This is a diagrammatic representation of the biomass of organisms at each trophic level at a particular time.
- Biomass is the weight of the living matter in the organism measured by either living weight or dry mass.



NB. The biomass increases at each successive trophic level.

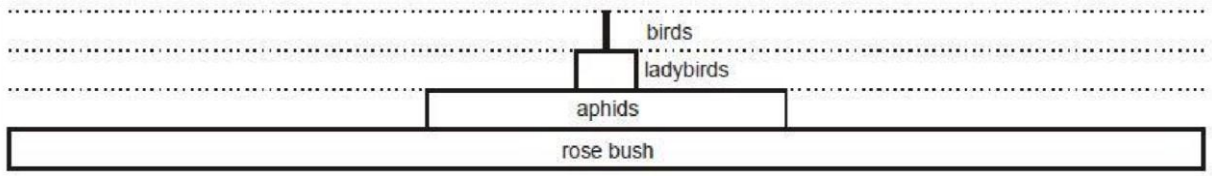
iii) Pyramid of energy

This is the best way of representing relationships and ecological productivity between organisms in different trophic levels.

It is a histogram showing the energy content of the organisms at each trophic level. At each trophic level, the energy is lost as heat during;

- Respiration
- Egestion
- Death
- Decomposition

NB. The energy decreases as it is transferred from one trophic level to another. Therefore, the pyramid of energy is always upright.



ASSOCIATIONS AMONG ORGANISMS

In nature, organisms tend to relate in their ecosystems.

Types of feeding associations

They are mainly two;

i) Intraspecific associations
ii) Interspecific associations

Intraspecific associations

These are associations among organisms of the same species. Examples include;

- Social insects (termites, bees, etc.)
- Territoriality e.g. in Uganda Kob where males defend others in the territory

Interspecific associations

These are associations among organisms of different species and they include;

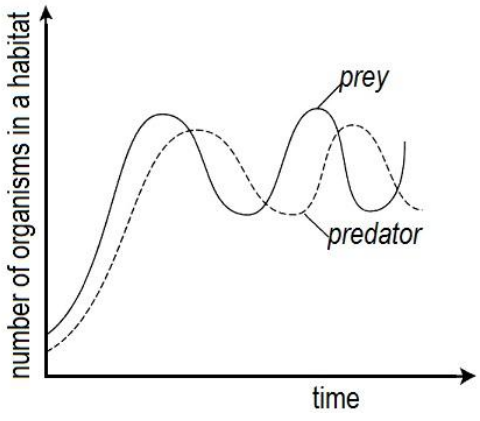
i) Predation.
ii) Symbiosis

Predation

This is a relationship whereby members of one species (the predator) 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 is an animal that feeds on another live organism. **A prey** is the live organism that is fed on by the predator.

The graph showing the predator-prey relationship



Description:

Initially, the population of the prey is higher that the population of the predator.

Within a short time, both populations of prey and predator increase rapidly.

The population of the prey reaches a maximum earlier than the predator population.

As the prey population decreases rapidly, the predator population continues to increase gradually for a short time to a maximum after which it 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 prey than predator to provide food to the predators.

When the predator population is low, they get enough food and few preys are eaten so they both increase rapidly.

The large number of preys provides food to predators, so they reproduce fast and increase in numbers. 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 predator numbers crash.
Finally, the very low number of predators allows the prey population to recover, causing the cycle to start again.

How predators are suited for capturing prey

- They have keen eyes for locating prey e.g. wolves, African lions hunt in groups.
- 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 into prey to immobilize it (prey).
- Web-spinning spiders use their silky cob webs to catch small sized ground walking or flying insects.
- Some have soft pads 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.

Significance of Predation

i) Determines distribution and abundance of the prey because:
   - An increase in the number of predators results into decrease in the number of prey.
   - Predators will always be found in places of their potential prey.

ii) Predation leads to dispersal of animals which reduces competition since it involves movement of animals from place to place.

iii) Predation is a biological control method.

How prey species are 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 into armor-plated ball.
- ✓ Possession of spines like in porcupines or thorns (cacti and rose-bushes) for pricking predators.
- ✓ In some lizards tails break off when attacked, giving the animal enough time to escape.
- ✓ Other preys gain some protection by living in large groups e.g. schools of fish, herd of antelope, 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 preys secrete poisonous or repellant substances e.g. scorpions, caterpillars, some grasshoppers and Culex mosquito eggs

- ✓ The electric fish Malapterurus (a cat fish) produces high voltage discharge that shocks any predator that makes contact with it.
- ✓ Other preys employ alarm signals and calls e.g. ants, various fish, small birds and mammals.
- ✓ Group defense occurring among those that live and feed in herds like the Buffalos.
- ✓ Some prey species discourage predators by secreting chemicals that are poisonous (e.g. oleander plants), irritating (e.g. bombardier beetles), foul smelling (e.g. stinkbugs and skunk cabbages) or bad tasting (e.g. monarch butterflies and buttercups).
- ✓ Some species gain protection to avoid predation by mimicking (looking and acting like) other species that are distasteful to the predator.

Symbiosis

Symbiosis (from Greek, *sumbíōsis*, "living together", from *sún*, "together", and bíōsis, "living") is any type of a close and long-term biological interaction between two different biological organisms, be it ***mutualistic, commensalistic***, or ***parasitic***. The organisms, each termed a **symbiont**, may be of the same or of different species. It can also be defined as "the living together of unlike organisms".

(The term was subject to a century-long debate about whether it should specifically denote mutualism, as in lichens. Biologists have now abandoned that restriction).

Symbiosis can be ***obligatory***; which means that one or more of the symbionts entirely depend on each other for survival, or ***facultative*** (optional); when they can generally live independently.

When one organism lives on the surface of another, such as head lice on humans, it is called ***ectosymbiosis***; when one partner lives inside the tissues of another, such as *Symbiodinium* within coral, it is termed ***endosymbiosis.***

Forms of symbiotic relationships

i) Commensalism:

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

ii) Mutualism:

This is an interspecific association in which both organisms benefit.

Examples include.

- Cellulose digesting bacteria in the gut of ruminants such as goats, cattle and sheep. Ruminants obtain sugars and amino acids while bacteria obtains shelter and food.
- Leguminous plants e.g. clover and nitrogen fixing bacteria (rhizobium). The plants obtain nitrates while bacteria obtains shelter, sugars and vitamins.
- Mycorrhiza (fungus and root of higher plants) .
- Lichens; algae and fungus. Algae carries out photosynthesis providing nutrients to the fungus while the algae is protected by the fungi from intense sunlight and desiccation, minerals absorbed by the fungus are also passed onto the algae.

iii) Parasitism:

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 (ecto parasites) or in their hosts (endo parasite) while some visit their hosts only to feed.
Some parasites are **facultative**, live on or in the host for some time e.g. Pythium (a fungus) that causes damping of seedlings, on killing the seedlings, lives as a saprophyte on their dead remains and others are obligate (live on or in the host for their entire lives)

Characteristics of parasitism

- The parasite and the host are of different species
- Parasites are usually smaller than their hosts
- The host suffers harm from the association
- The parasite gains both nourishment and protection from the host

Feeding methods of parasites

i) Sucking:
- This is employed by parasites that depend on body fluids like blood and tissue fluid.
- They include ticks, lice, tape worms, etc.

ii) Absorption:
- These feed on nutrients from digested food
- Absorption occurs over the body surface of parasites
- They include ascaris, liver flukes, etc.

Adaptations of parasites for their life

For a parasite to be successful in its way of life, it needs adaptations to overcome challenges;

Challenge	Nature of parasite	Adaptation
Finding/ reaching the host	Endo and ectoparasites	• Use of vectors to find and reach the host • Occupying strategic places where they can be picked up by vectors or hosts e.g. in food
Attaching on to the host	Ecto and endoparasites	• The ecto parasites have claws and teeth for attachment • The endo parasites have suckers and hooks for attaching inside organs
Entering the host	Endoparasites	• Piercing organs and cutting plates such as in hook worms
Protection from the host	Endo and ecto parasites	• Camouflage through resembling the body color of the host by ecto parasites • Production of mucus to protect themselves against digestion by enzymes secreted by host in endoparasites

Reproduction	Endo and ecto parasites	• Most have short life cycles • Produce very many offspring • Use of both sexual and asexual reproduction by some parasites
Surviving adverse conditions	Endo and ecto parasites	• Most are able to suspend development for some time when the conditions are not favorable e.g. bladder worms in taenia, cysts in bacteria and protozoans.

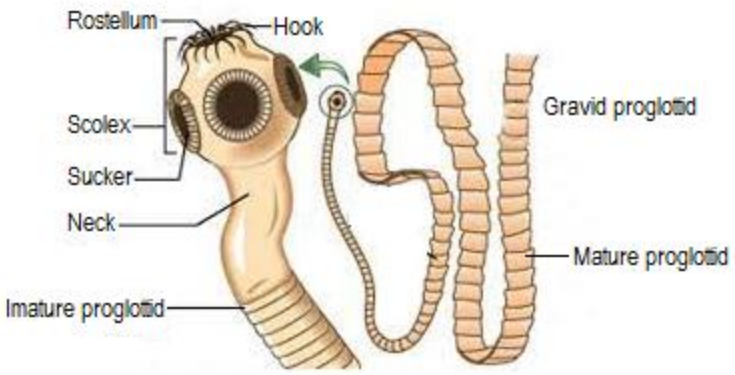
Parasites and disease in man

Many different parasites are responsible for diseases and disorders in man. They include;

i) **Tape worm**(*Taenia spp*)

- The tape worm belongs to the phylum Platyhelminthes.
- Its body is shaped like a tape; consisting of the head (scolex) and a series of segments (proglottids).
- The proglottids are bisexual and are the means for faster propagation.
- They are consistently produced behind the head
- They constantly detach from the end, and leave the body with feces.

Structure:



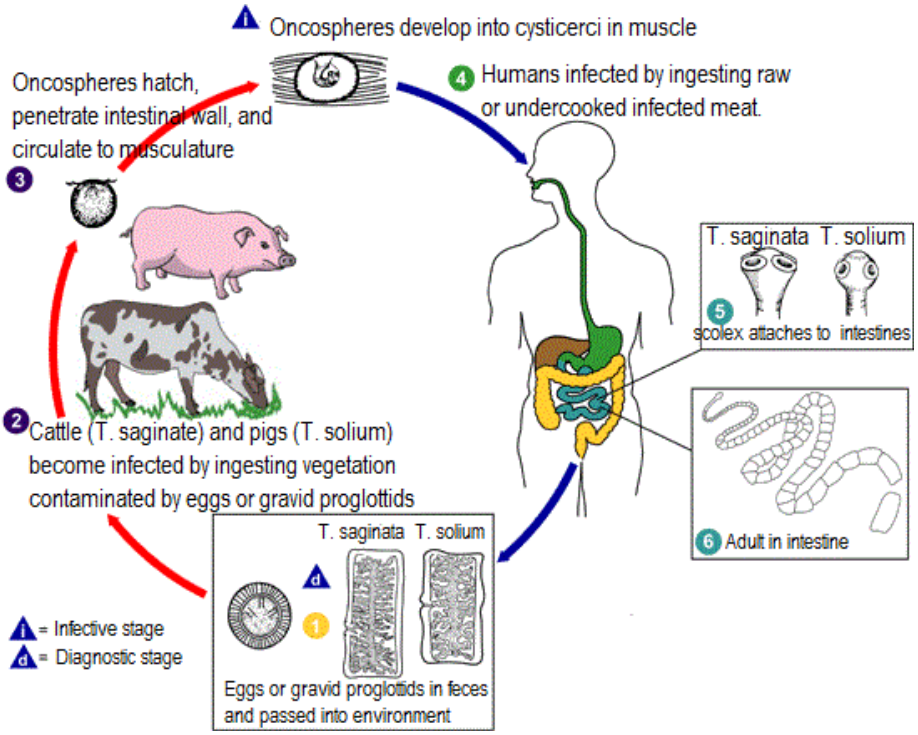
Way of life:

- The tape worm lives by absorbing digested food from the ileum.
- They attach themselves from the walls of the ileum by means of suckers.
- They protect themselves from digestion by the host's enzymes by secreting on to themselves a mucus lining.

Life cycle of a tape worm

- Mature proglottids at the end of the tape worm containing eggs break off and are released with faeces.
- They are picked up from grass by a pig or a cow, the eggs develop from the stomach into an embryo.
- The embryo has 6 hooks which it uses to burrow into the wall of the intestines, and into the blood stream.
- Further development occurs in the muscles; after about 3 months, they develop into bladder worms.

- The bladder worms are persistent and resistant i.e. they can remain in this form for a long period of time; and if uncooked or half cooked beef or pork from such an infected animal is eaten by man, the bladder worms enter the intestines and develop into a tape worm.



Effects of tape worm infection

- Blocking the intestines by the tape worm unfoldings.
- Constipation
- Loss of weight as they feed on the host's digested food

Control of tape worms

- Proper disposal of faeces
- Proper cooking of meat
- Meat inspection to declare infected meat and unfit for consumption
- Treatment of patients using drugs

ii) Plasmodium

- This causes a disease called malaria.
- The parasite is transmitted by female anopheles mosquitoes which introduces into the host's blood stream as it sucks blood.
- The parasites multiply from the liver and red blood cells, killing them.

Adaptations of mosquitoes as parasites

✓ Have wings for fast flight or fast movement.
✓ They feed at night when the host is a sleep or less alert.

- ✓ They are light therefore land on the host without being noticed or felt.
- ✓ They have an anticoagulant in saliva which prevents clotting of blood as they suck.
- ✓ They are highly sensitive to carbon dioxide respired by the host to easily locate the host.
- ✓ They are sensitive to heat produced by the host to easily locate the host.
- ✓ They have piercing/sharp stylets for piercing through the skin.
- ✓ They have sucking mouth parts for sucking blood.
- ✓ They have salivary tubes for introducing saliva containing parasites into the host.

iii) Schistosomiasis (bilharzia)

This is a disease caused by the blood fluke which belongs to phylum Platyhelminthes. The parasite is found in fresh water and is spread through taking water contaminated with its larvae but it can also penetrate the skin.

Adaptations of schistosoma (the blood fluke)

- It has two hosts, thus enhancing its survival.
- It has ability to penetrate the skin.
- It can tolerate low oxygen concentration in the host's tissues.
- It has suckers for attachment to avoid being dislodged from the host s body.
- It produces larval forms in snails hence making it difficult to eradicate.
- It lays many eggs increasing its chances of survival.
- Adult worms secrete chemicals which protect them from the host s immune reaction.

Control and treatment

- Proper disposal of faeces and urine.
- Treat or boil drinking water.
- Avoid swimming, bathing in water infested with snails.
- Avoid walking barefooted in swampy water.
- Spray fresh water bodies with molluscicides to kill snails.
- Provide medical treatment to infected persons.
- Full treatment of sewage before its discharge to destroy eggs.

iv) **The tick:**

The tick is an arthropod in class Arachnida. It is an external parasite and feeds by sucking up the host s blood. While feeding, ticks transmit certain diseases. Some ticks carry a virus responsible for tick fever in man.

Adaptations of the tick to a parasitic mode of life

- It has a dull coloured body for camouflage
- It has a hooked rostrum for piercing and sucking blood from the host and also for firm attachment to the host.
- Its body is dorsal ventrally flattened for camouflage.
- Its body is covered with a hard cuticle for protection from physical injuries.

- Its body is segmented for flexibility
- Has 8 Legs for walking
- The limbs are jointed for flexibility.
- The legs have pointed claws for clinging to the host's body so that they are not dislodged.

Summary of adaptations of parasites

- Some parasites have hooks for attachment to the host e.g. the tape worm.
- Some have suckers for attachment to the host e.g. the blood fluke and the tape worm.
- Some ectoparasites have claws for attachment to the host e.g. the tick
- Some ectoparasites like the tick have body colour resembling that of the host for camouflage
- Some parasites secrete mucus to protect them against digestion by the host's enzymes.
- Some parasites secrete substances to neutralize the hosts
- Some parasites have dorsal ventrally flattened bodies in order to reduce the distance across which materials diffuse.
- Some parasites have body surfaces that are permeable to nutrients.
- Some have long, folded bodies to increase surface area for diffusion of nutrients.
- Some parasites have more than one host to increase chances of survival
- Some produce many young ones thus increasing their chances of survival.
- Many are able to suspend development for some time when conditions are not favourable e.g. as bladder worms in tape worm.
- Some parasites are hermaphroditic and can carry out self-fertilization.
- Some are adapted to live in conditions of low oxygen supply e.g. the tape worm.
- Some blood feeding parasites like the mosquito can produce anti-coagulants.

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.

Community/ecological succession is the progressive (gradual) change in the composition of a community of organisms towards a complex stable one.

It is a gradual process where one community of organisms replaces another.

It occurs in a way that one community modifies the environment so that the conditions are ideal for the next community.

Types of ecological successions

i) Primary succession
ii) Secondary succession

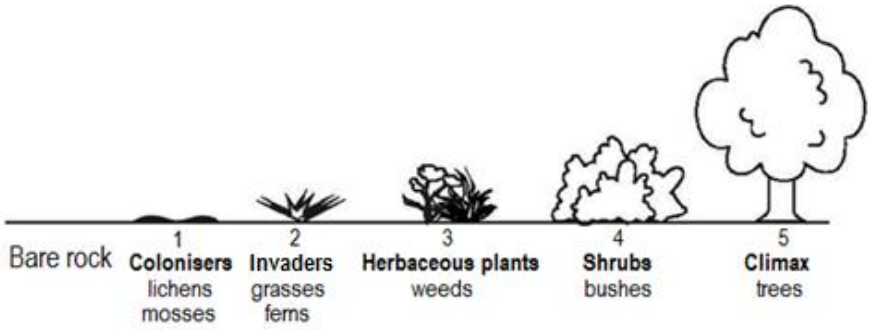
1. Primary succession:

This is the succession which starts from a bare ground. It occurs on bare rocks exposed by erosion, newly cooled lava, newly created shallow ponds, sand dunes, abandoned highway or parking yard.
The bare ground may result from;

- Landslides, volcanic eruption, exposure of rocks by erosion and alluvial deposition
- Man's activities which lead to excavation of the soil e.g. agriculture, settlement, recreation, etc.

In such cases, new communities become established gradually following several periods of succession until a final community is established.

An illustration of primary succession on land



Stages of primary succession

It involves;

- Colonization
- Invasion
- Stabilization

Colonization:

- This begins with the arrival of the first organisms (the pioneers).
- The pioneers are usually very simple organisms that can survive in hard conditions of a bare area i.e. extremes of heat, light, dryness and windy conditions.
- The organisms include lichens (on land) and algae (in water).

Invasion:

- The invaders include mosses, herbs and weeds.
- They rot and add humus to the bare area.

Stabilization:

The organisms which form this stage are the grasses, shrubs.

Climax:

- This is usually formed a forest community.
- The forest community makes the climax community.

Examples of primary succession

a) On a bare ground

Lichens (pioneers) → mosses → herbs → grasses → shrubs → Trees (forest) (climax community)

b) In water

Phytoplanktons (pioneers) → large algae → water weeds → swampy vegetation → papyrus swamp → forest (climax community).

2. **Secondary succession**:

This is the gradual change in species composition of an area where the natural community of organisms has been disturbed, removed or destroyed but some soil or bottom sediment remained.

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 even contain resistant plants/vegetative organs of the colonizing plants that survived the changes.

CHANGES IN POPULATION

A population is the total number of number of individuals of the same species living together in the habitat at a given period of time.

Characteristics of a population

A population can be defined in terms of its;

- Density
- Age structure
- Dispersion
- Birth rates and (Natality rate) and death rates

a) Age structure:

- This is the way in which members of different age groups are represented in an area.
- Death varies with the age structure of a population

b) Population Dispersion:

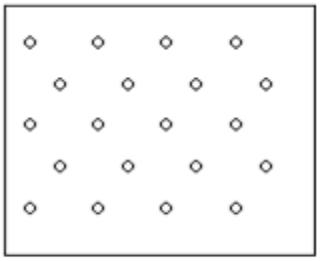
This is the spatial pattern or distribution of individuals of a population relative to one another within the area.

There are three (3) types of dispersions namely;

i) Regular/uniform dispersion
ii) Random/scattered dispersion
iii) Clumped/aggregate/clustered dispersion

Regular Dispersion:

This is where individuals are evenly distributed i.e. more or less equidistant from each other.



Uniform

This kind of dispersion is very rare in natural communities but may be found where resources are thinly but evenly spread.

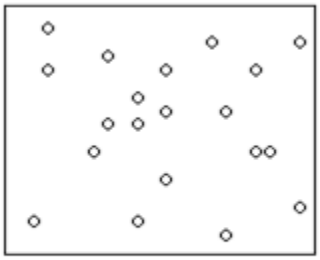
It is commonly found in:

- Animals demarcating and defending their territories which is common in some birds and bears.
- Individuals of similar species which are aggressive or antagonistic to each other which is common in many carnivores.
- Plants and animals managed by humans e.g. planted crops in a garden or an artificial forest.

Random Dispersion:

In this kind of dispersion, there is no definite relationship between the position of individuals and their neighbors

The organisms are randomly distributed in the environment and therefore, there is no tendency to aggregate.



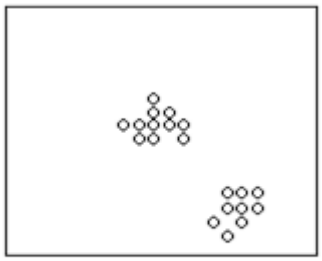
Random

It is as a result of plentiful resources which are scattered in the environment.

It is also common in distribution patterns of humans.

Aggregate (clumped) Dispersion:

This is the most common in nature where clumps may result from or may be found in areas where resource and environmental factors that are favorable are concentrated at certain points.



Clumped

It can be found where;

- There is self-dispersal of seeds
- There is territorial behavior i.e. organisms live in defended areas
- There is aggregate behavior i.e. organisms live in herds
- Resources are being concentrated at one point e.g. weaver birds living on the same tree
- Species defend one another so that they exist together

c) Population Density:

This is the number of individuals present per unit space at a given time. The unit area for terrestrial organisms may be considered as per square meter ($/m^2$) while for aquatic organisms, it is the unit volume i.e. per cubic meter ($/m^3$).

Factors affecting population density

Population density is affected by;

i) **Mortality:**

This refers to the death of individuals per unit time and it is expressed as a percentage or as per 1000 individuals in humans.

It can be determined in infants or in other age groups of the population;

$$\boldsymbol{Infant\ mortality\ rate} = \frac{number\ of\ infant\ deaths}{\boldsymbol{number\ of\ live\ births}} \boldsymbol{x1000}$$

ii) Natality (birth rate):

This is the production of new offspring sexually or asexually to give rise to live individuals. It can be determined as crude birth rate (CBR);

$$CBR = \frac{number\ of\ in\ a\ year}{total\ population\ that\ year}$$

Birth rates are determined by the fertility rate of that population;

$$Fertility\ rate = \frac{number\ of\ live\ births}{number\ of\ women\ between\ ages\ 15-45\ years} x1000$$

It is expressed as a percentage per 1000 individuals in the human population

iii) Migration rate

This is the rate at which individuals migrate into (immigration) and out (emigration) of the population.

Estimation of Population Density of Organisms

To study the details of a population, or how the distribution of the members of a population is influenced some factors, it is necessary to estimate the population size.

In order to count the number of individuals in a population per unit area (density) taking small areas of the big area (samples) is necessary. This is called **Sampling.** It involves use of different methods depending on some factors.

Factors to consider while choosing a suitable sampling method

- The size of organisms to be counted
- The nature of vegetation
- Topography
- The nature of habitat of the organism i.e. aquatic or terrestrial
- Behavior of the organism i.e. is it aggressive; nocturnal; does it fly; is it slow moving or fast moving; the social structure; growth habit; feeding habit, etc.
- Resources available such as apparatus, money e.g. for hiring aircrafts which is very expensive.
- Does the organism live in an open or concealed place
- The environmental conditions of the area e.g. does the area experience frequent rainfall or it is not suitable to use pit falls to trap soil dwelling organisms.
- The size of the area should be investigated and the time available.

Methods of sampling

1) Direct Counting:

In this method, one moves through the study area along a predetermined path as he/she is counting the animal type of his/her interest.

A low flying aircraft can also be used to cover a wider area and in case the animals are aggressive.

In both cases, several counts are made and an average taken to get a good estimate.

The population density is given as numbers per unit area.

Suitability:

- This method is suitable for large animals living in unconcealed habitats e.g. elephants, antelopes, etc.
- It is also suitable for animals living in herds e.g. buffalos

2) Aerial Photography:

In this method, photographs are taken from a low flying aircraft usually on scale, over the study area.

The photographic film is developed; and the animals of one's interest are counted (excluding those which are not of one's interest).

The population density is estimated in terms of numbers per unit area.

Suitability:

- This method is suitable for large animals living in unconcealed habitats.

3) Capture Mark Recapture Method (The Lincoln Index)

This method was discovered by a scientist called Lincoln.

Procedure

- Suitable traps are laid at random in the area
- After a short period of time, a count is made for all animals captured
- The captured animals are marked with a permanent, easily recognized mark before they are released back into the environment
- The traps are laid again at random in the area.
- After a given period of time, another count is made for all those animals captured in the second trapping. Animals that bear a mark (from the first capture i.e. recaptured) are also counted and their number noted
- The total population is estimated using the formula;
  - $P = {}^{NxM}/_{R}$ where P = total estimated population
  - N = number of individuals caught; counted and marked in the first capture
  - M = number of individuals in the second capture
  - R = number of marked individuals in the second capture (recaptured)

Assumptions considered when using the method

However, the method is carried out on the following assumptions;

- Animals first captured mix freely in their habitat
- There is no death birth in the study population for the period of study
- No migration of individuals takes place during the study period

NB. Due to the many assumptions, this method does not give accurate population sizes

4) The Quadrat Method:

The quadrat may be in form of a frame or it may be fixed on the ground using pegs along which a rope is tied to enclose organisms inside.

The quadrat frame is a frame which may be metallic or wooden forming a square of known area (e.g. $0.5m^2$ or $1.0m^3$)

Procedure:

- For a uniform habitat, the quadrat is thrown randomly i.e., without bias over one shoulder in the area and the number of individuals of one's interest enclosed are counted.
- Several quadrats are thrown and an average is taken.
- The population of the area is got by multiplying the average number of animals or plants in the quadrat by the total area of the habitat under study.

Suitability:

- This method is suitable for sampling a habitat with short vegetation e.g. grassland and small slow moving there in.

Example:

An ecologist threw 5 quadrats of $1m^2$ at random. He obtained 3, 7, 1, 0, and 9 plants of a given species.

Given that the area of study is $5000m^2$, estimate the population of plant species in the area.

Solution

$$Average\ population\ of\ quadrats = \frac{\mathbf{3 + 7 + 1 + 0 + 9}}{\mathbf{5}}$$

$$Estimated\ population = 4x500 = 2000\ plants$$

Population growth patterns

Population grows when:

- Natality is greater than mortality.
- Immigration is greater than emigration.

Population growth may form a curve which is either:

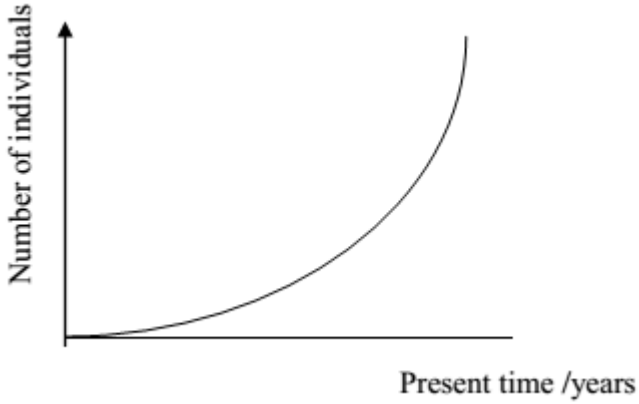
- Exponential population growth curve (J-shaped).
- Logistic population growth curve (Sigmoid/S-shaped).

Exponential population growth (J-shaped curve)

It is a theoretical population growth curve in which the population growth rate increases with time indefinitely.

Population growth starts out slowly and then proceeds faster and faster as the population increases.

It occurs when resources are unlimited and the population can grow at its intrinsic rate of growth (rate at which a population would grow if it had unlimited resources). However this is rare in nature because of limiting factors (environmental resistance).



Description:

Number of individuals (population) is small; their number increases gradually/slowly with time.

Later the population size increases rapidly/sharply/drastically with time.

Explanation:

Initially, the number of individuals increases gradually with time because the population size is small, thus few reproducing individuals, reproducing individuals are scattered within the environment, some may not have reached reproductive age, organisms are still getting used to their environment.

Later on, number of individuals increases rapidly because many individuals have now reached reproductive age and number of reproducing individuals now gets bigger.

Logistic population growth curve sigmoid/s-shaped)

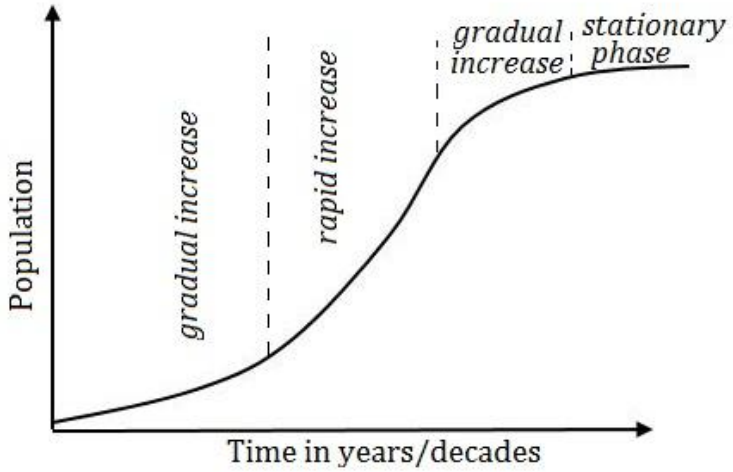
Population growth starts out slowly and then proceeds faster to a maximum (carrying capacity) and then levels off.

Population then fluctuates slightly above and below the carrying capacity with time.

The population stabilizes at or near the carrying capacity (K) of its environment due to environmental resistance (any factors that may prevent a population from increasing as expected e.g. predation, parasitism, and accumulation of toxic substances).

The actual factors responsible for the shape of each phase depend on the ecosystem, and this can be illustrated by considering two contrasting examples: **yeast** in a flask (reproducing asexually), and **rabbits** in a field (reproducing sexually).

Sigmoid curve of growth of population (S curve)



Description (phase)	Yeast in a flask	Rabbits in grassland
Initial gradual increase.	Little growth while yeast starts synthesizing appropriate enzymes for new conditions. Slow growth because cells are getting used to conditions in the environment	Little growth due to small population. Individuals may rarely meet, so less mating. Slow growth because of few reproducing individuals
Rapid increase	Rapid growth. No limiting factors since relatively low density	Rapid growth. Few limiting factors since relatively low density.
Gradual increase	Slow growth due to accumulation of toxic waste products (e.g. ethanol) or lack of sugar.	Slow growth due to intraspecific competition for food/territory, predation, etc.

Stationary phase	Population is stable (fluctuates slightly above and below the carrying capacity). Cell death is equivalent to cells formed	Population is stable (fluctuates slightly above and below the carrying capacity). Death rate is equivalent to the birth rate.

How population density affects population growth

i) **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.

ii) **Density independent factors,** are those 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 e.g. clearing a forest or fishing in a wetland, pesticide spraying. They are mainly abiotic factors.

Microbial growth

Micro-organisms (microbes), such as bacteria, fungi and protozoa are found around us. Many are harmless but some cause disease to man, plants and animals, and said to be pathogenic. Others are responsible for food spoilage.

Requirements for growth of microbes

- Nutrients
- Moisture
- Adequate temperature

Characteristics of microbes

- They have the ability to reproduce sexually and asexually, and can reach great numbers in a very short period of time if the environment is favourable
- They can also survive in unfavorable conditions as cysts, spores, etc.
- Under unfavorable conditions, reproduction and development are suspended for some time.

Note:

i) Microbes can be grown in the laboratory. This is called culturing.
ii) Most cultures are prepared using agar.
iii) In such controlled medium conditions, growth of microbes exhibits a sigmoid growth curve.

Effects of microbial growth

The effects are unpleasant and are usually as a result of spoilage and disease
They include;

- Some cause plant and animal diseases e.g. rusts, mosaics, ringworm, etc.
- Some cause spoilage of fresh fruits e.g. fungi
- Others cause spoilage of fresh food e.g. milk and its products, meat etc.

Microbial growth control

It is necessary to control microbial growth especially for those microbes which cause diseases and those which cause food spoilage.

Methods of microbial control

i) Temperature control:
- High temperatures destroy microbes. This can be done by boiling such as drinking water.
- On the other hand, very low temperatures inactivate microbes. Low temperatures can be induced by refrigeration.

ii) Drying

This involves removal of moisture from a food substance by sun drying, smoking, etc. It can guard food against mainly fungi and bacteria.

iii) Sterilization:

This involves keeping medical apparatus, food utensils and any other equipment which is likely to be a medium for microbial growth free from microbes. This can be done by use of heat, chemicals, ultra violet (UV) light, etc.

iv) Use of antimicrobials:

These are chemical substances which prevent the growth or kill micro-organisms. They include fungicides against fungi, antibiotics e.g. penicillin against fungi, etc.

HUMANS AND NATURAL ENVIRONMENT

The environment refers to the immediate surroundings of an organism.

The environment is composed of many things most of which are useful to man. These are termed as natural resources.

Man has modified the environment through;
- Agriculture, deforestation, swamp reclamation, reforestation and urbanization
- Spread of pests and diseases
- Mismanagement of chemicals such as insecticides, molluscides, acaricides which cause water, land and air pollution
- Use of explosives which contain chlorofluoro carbon (CFCs) compounds. These have destroyed the ozone layer leading to global warming
- Loss of habitats leading to extinction of some species of organisms

Natural resources

Natural resources are the materials which are nature given in the environment which are useful to the human being.

Types of natural resources

i) Renewable natural resources:

These are used continuously if allowed to regenerate e.g. Forests, wild life, fish, Soil, air etc.

ii) Non-renewable natural resources:

These are exhaustible and once used, they cannot be regenerated e.g. minerals, and fossil fuels.

iii) Inexhaustible resources:

These are not exhausted and they are always present in abundance e.g. air, water, sunlight, etc.

Conservation of natural resources

Conservation refers to the sustainable use of resources to avoid extinction and exhaustion. Land is usually set aside for conservation purposes all over the world in form of national parks, game reserves, sanctuary, etc.

Reasons for conserving natural resources

- Commercial values whereby when animals become abundant, they can be cropped and their meat and skins sold to generate income.
- Recreation e.g. those who hunt fish for sport
- For preservation of genetic diversity
- To avoid extinction of endangered species; Any species whose population or habitat has become so small that it may be gone forever if not given adequate protection is considered to be endangered.
- For ethical values whereby wild life is protected for further generation and because of certain people's beliefs, certain plants and animals are protected
- For aesthetic values especially for beauty e.g. people go to national parks to photograph animals
- For scientific research e.g. the rhesus monkeys which have helped in understanding many viral diseases.
- For educational purposes through wildlife clubs of Uganda
- It creates an international understanding between the hosts and the guests who come to view wildlife
- It is used to fulfill international obligations such as UNESCO whereby the entire wildlife should be conserved
- For employment purposes in national parks and other conservation areas

Forestry

Importance of forests:

- Trees improve on soil fertility through the influence of leaf fall which are acted on by saprophytic bacteria and fungi leading to the formation of humus.
- Trees check on water run-off and act as wind breaks hence preventing soil erosion.
- They modify the climate and act as a habitat for organisms which are important components of an ecosystem.
- They provide food for many animals e.g. monkeys, butterflies, bees, etc.
- Trees give support to other plants especially the epiphytes
- Trees purify the environment by removing carbon dioxide and adding oxygen to the atmosphere during photosynthesis.

- They influence the hydrological cycle through evapotranspiration which affects the amount of rain received.
- Some trees are luminous in nature; therefore, they add nitrogen to the soil.
- Trees provide timber
- Some trees are for medical purposes
- They attract tourists which is a source of foreign exchange
- It offers employment opportunities in form of forest rangers, guides, etc.
- It provides peaceful healthy environment for picnics
- They are a source of raw of materials for industrial use and promoting culture e.g. the bark cloth.

Problems facing forestry industry

i) Uncontrolled felling of trees for timber
ii) Encroachment for agriculture
iii) Charcoal burning
iv) Uncontrolled bush fires

Conservation of forests

- Afforestation by planting trees where they have not existed
- Reforestation by planting trees where they existed before
- Selective felling i.e. cutting down only mature trees
- Putting up regulations discouraging forest encroachment
- Introduction of firefighting teams to control bush fires

Wild life conservation

This involves application of measures such as:
Enforcing laws against poaching
Game cropping (killing old and weak animals to keep the population at carrying capacity.

Uses of wild life:

- Recreation for game watching
- Source of foreign exchange from tourism
- Source of game meat
- Source of useful products such as skins and hides

Problems associated with wildlife conservation:

- Fires
- Encroachment through grazing and cultivation, recreation, etc
- Poaching
- Hostile animals especially when food supply is insufficient
- Lack of funds for development especially against poaching

Effects of Human Activities on the environment

Of all living organisms, humans exert most influence on the distribution and survival of other species through a multitude of activities like pollution, deforestation, farming, construction etc.

Pollution

It is the release of substances or energy into the external environment in such quantities and for such duration that may cause harm to living organisms or their environment.

Pollutants include; noise, heat and radiation as different forms of energy, many chemical compounds and elements and excretory products.

The parts of external environment affected include air, water and land.

Harm caused by pollutants.

- Disruption of life support systems for living organisms.
- Damage to wild life, human health and property.
- Nuisances such as noise and unpleasant smells, tastes and sights.

Types of pollution

They are: Air pollution, Water pollution, Thermal pollution and soil pollution.

Air pollution

Pollutant	Source(s)	Effects/ consequences	Control measures
1. Carbon monoxide	Motor vehicle exhausts, Incomplete combustion of fossil fuels, tobacco smoking, etc.	• Prevents oxygen usage by blood by forming carboxy-haemoglobin, which may cause death. • Small concentrations cause dizziness and headache	• Efficient combustion of fuels in industry and homes. • Avoid smoking. • Vehicle exhausts gas control.
2. Sulphur dioxide	Combustion of Sulphur containing fuels, oil and coal gas	✓ Causes lung diseases, irritation of eye surface, and asthma resulting into death if in high concentrations. ✓ Forms acid rain which increases soil PH. ✓ Reduces growth of plants and kills lichens.	✓ Use of Sulphur free fuel e.g. natural gas. ✓ Installation of Sulphur dioxide extraction units in industrial chimneys.

Pollutant	Source(s)	Effects/ consequences	Control measures
3. Smoke	✓ House smoke and soot. ✓ Motor vehicle exhausts. ✓ Tobacco smocking. ✓ Incomplete combustion of refuse in incinerators and bonfires.	✓ Causes lung diseases when inhaled. ✓ Sunlight barrier hence reducing photosynthesis. ✓ Stomatal blockage hence reducing photosynthesis. ✓ Damages clothes, cars and buildings hence costly to clean.	✓ Usage of smokeless fuels ✓ Efficient combustion ✓ No smoking ✓ Vehicle exhausts gas control
4. Dust	Solid fuel ash, soil, quarrying, mining, etc.	Lung diseases, stomatal blockage, stunted growth of plants and smog. Smog forms when temperature inversion occurs (layer of warm air traps cool air containing dust and smoke close to the earth's surface)	• Installation of dust precipitators in industrial chimneys. • Efficient combustion. • Wearing of face masks by factory workers.
5. Carbon dioxide:	Motor vehicle exhausts and combustion of fossil fuels	Increased carbon dioxide causes greenhouse effect (the warming up of the earth's atmosphere as a result of the blanket of carbon dioxide, preventing escape of solar radiation higher into space).	Planting more green plants, reduction in combustion of fossil fuels by relying on alternative sources of energy e.g. solar energy.
6. Noise:	Discos, road traffic, running engines, machines, aero planes, firearms, etc.	• Hearing impairment • Total deafness. • Nervous disorders	• Effect laws against excessive noise. • Put on ear muffs and plugs while in very noisy areas.
7. Radioactive leakage.	Nuclear weapons and nuclear power fuels.	Ionizing radiation causes cancer	Nuclear power controls

Greenhouse effect and global warming

Greenhouse effect is a description of the condition which results when greenhouse gases i.e. gases in the troposphere (atmosphere's inner most layer extending about 17km above sea level) like carbon dioxide, water vapor, methane and nitrous oxide allow mostly visible light, some infrared radiation and

ultraviolent radiation from the sun to pass through the troposphere to the earth, which transforms this solar energy to longer-wave lengths-infrared radiation (heat) which then rises into the atmosphere. Molecules of greenhouse gases absorb and emit this heat into the troposphere as even longer-wave-length infrared radiation, which causes a warming effect of the earth's surface and air.
The tropospheric gases act like a glass of large green house surrounding the earth.
Global warming is the observed average global temperature rise of 0.8^0C since 1900 as a result of the enhanced natural greenhouse effect.

The origins of greenhouse gases are:

- Combustion of fossil fuels by motor engines and industries releases carbon dioxide and methane into the troposphere.
- Deforestation and clearing of grasslands reduces the uptake of carbon dioxide in photosynthesis.
- Ruminant fermentation produces methane, which is released into troposphere.
- Use of aerosol propellants which contain CFCs that are 105 times worse than carbon dioxide as greenhouse gases.
- Cultivation of rice in swamps and muddy fields causes anaerobic fermentation which produces methane.
- Use of inorganic fertilizers cause the release of nitrous oxide.

Effects of global warming

✓ Rise in sea level due to melting of polar ice and thermal expansion of seas.
✓ Altered temperature gradients cause cyclones and heavy rains as water evaporates quicker.
✓ Species migration which are likely to cause pests/diseases to extend their ranges.
✓ Reduced cropped fields due to drier weather.
✓ Increased crop yields because of more rainfall and longer growing seasons in some regions.
✓ Flooding low-lying islands and coastal cities.
✓ Extinction of some animal and plant species.
✓ Increased death of human population.
✓ Greatly increased wild fires in areas where the climate becomes drier.

Water pollution

Sewage discharge into rivers

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

Effects of untreated sewage discharge into rivers

Discharge of untreated sewage into a river has an immediate effect on the aquatic environment, causing many changes in both the **abiotic** and **biotic components**. Some of these changes are due to specific chemical pollutants (e.g. heavy metals such as cadmium from industrial processes, and pesticides from agriculture) with the effects varying according to the chemicals present in the discharge.

Addition of inorganic chemicals, plant nutrients and sediments into lakes.

Pollutant	Examples	Main sources	Harmful effects
Plant nutrients	Nitrate (NO_3^-), phosphate (PO_43-) and ammonium (NH_4^+) ions. The nutrient enrichment of water bodies is termed ***eutrophication***	• Raw sewage discharge, detergents and other chemical release from industries. • Leaching of inorganic fertilizers e.g. NPK from farmland.	• Rapid growth of algae and green protists (algal bloom). • Reduces light penetration in water leading to death and decay of algae, which depletes water of dissolved oxygen, killing fish and other aerobic animals. • Excessive levels of NO_3^- if drank in water lowers the oxygen carrying capacity of blood and kill unborn children and infants **("blue baby syndrome").**
Sediment	Soil and silt	Land erosion	✓ Can cause turbidity/cloudiness in water; light penetration is reduced therefore reduce photosynthesis. ✓ Settle and destroy feeding and spawning grounds of fish. ✓ Clog and fill water bodies, shortening their lifespan. ✓ Disrupt aquatic ecosystems. ✓ Carry pesticides, bacteria and other harmful substances into water.
Inorganic chemicals	• Acids. • Compounds of toxic metals like lead (Pb), mercury (Hg), arsenic (As) and selenium (Se). • Salts e.g. NaCl in ocean water	Surface runoff, industrial effluents and household cleaners	• Drinking water becomes unusable for drinking and irrigation • Lead and Arsenic damage the nervous system, liver and kidneys • They harm fish and other aquatic life • They lower crop yields • They accelerate corrosion of metals exposed to such water.

Soil pollution and land degradation

Soil pollution can occur due to various direct and indirect ways which include:

- Dumping of industrial wastes.
- Excess use of agrochemicals in the form of pesticides and fertilizers.
- Dumping of discarded wastes like paper, food and plastics.
- By air pollution like acid rain.
- By water pollution like pollutants finding their way to soil.

Soil pollutants and their effects

Pollutants	Effect
Pesticides, herbicides and fertilizers	• Cause death of microorganisms, animals and certain plants. • Affect soil fertility. • Several non-biodegradable by-products find their way to animals and man through food chain and have serious long term damaging effects. Some may be cancerous.
Excretory products of organisms and digested sewage sludge used as manure.	Number of pathogens present in the wastes contaminate the soil. Cause health hazards for man and domestic animals.
Salts of iron, lead, copper, mercury, arsenic.	Toxic to both plants and animals.
Discarded food, paper, carcasses, Aluminium and plastics.	Damage the landscape and also affect the flora and fauna.

Control of soil pollution

i) Construction of transfer stations at different points in a city for bulk transfer of refuse to discharge sites to speed up removal.
ii) Materials like paper, glass and plastics should be recycled to decrease the volume of refuse and to conserve the natural resources.
iii) Use of chemical fertilizers should be reduced. Bio fertilizers and manure should be used in their place.
iv) Instead of pesticides, biological control of pests be used where possible.

Land degradation

Land degradation is the reduction or loss in the productive capacity of the land and loss of the biological or economic productivity and complexity resulting from natural processes, land uses or other human activities and habitation patterns.

Causes of land degradation

i) Soil erosion

It can be due to natural causes like floods, high wind, ocean waves and glaciers or due to man-made activities like over grazing, felling of trees, monoculture, over cropping or improper tilling.

A grass cover is an excellent binding material that stops the soil erosion. Ploughing loosens the soil and increases erosion. Soil erosion is high in Bududa, Kasese and Bundibugyo where the terrain is mountainous.

ii) Deforestation

All over the world, forests are being destroyed or degraded as a result of human activities. When forests disappear, so do the soils on which they stood and the peoples and species which lived in them. Firewood, on which many people depend is scares in most developing countries and is

becoming scarcer as forests fall.

Deforestation is responsible for between a quarter and a third of CO_2 humanity has added to the atmosphere to date, increasing the risk of global warming.

iii) Shifting cultivation

The end