S5 BIOLOGY

POPULATION AND NATURAL RESOURCES.

Population is a group of organisms of the same species occupying a particular place at a given period of time, a population is usually isolated to some extent from other similar groups by geographical barriers.

Properties/characteristics of any given population.

(i) **Population size**: is the number of individual organisms of the same species living in an area at a given period of time.

(ii) **Density*:*** Is the number of individuals per unit area of the living space.

(iii) **Mortality rate:** Is the number of individuals which die within a population in a given area at a given period of time.

(iv) **Birth rate/natality:** Is the number of individuals born reproduced within a population in a given area at a given period of time.

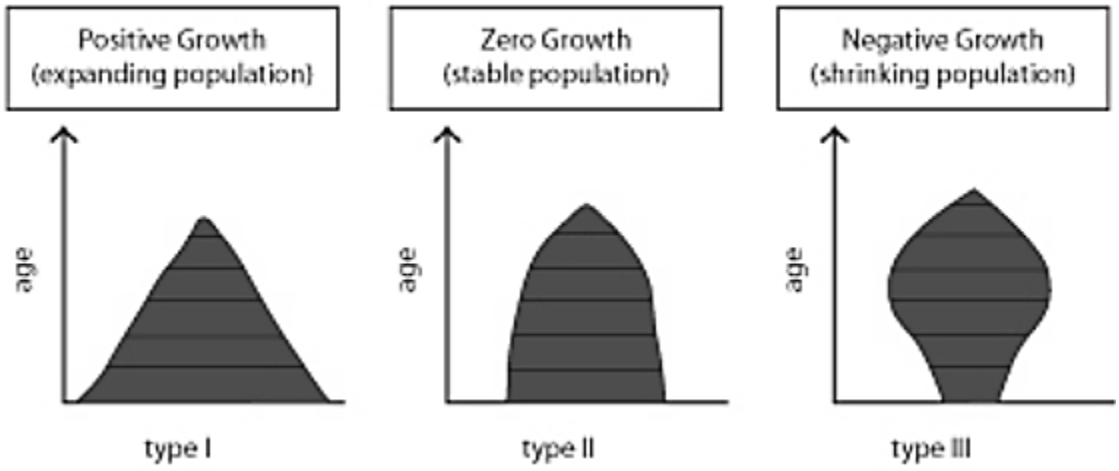
(v) **Fecundity:** Is the reproductive capacity of individual female species.

In mammals the birth rate is used to measure the fecundity. And therefore the size of a population is regulated by,

- Balance between its fecundity and its mortality.
- Migration rate, these include, Immigration, this is where individuals join or enter into a population from neighbouring areas and Emigration, this is where individuals depart or leave a population.

(vi) **Age distribution or age structure.**

It refers to the proportional distribution of individuals of various ages in a given area. It gives information about the future trends of a population growth.



Age structures can reveal a population's health.

Type I, with most individuals below reproductive age, often indicates a growing population.

Type II, with roughly equal proportions of the population at each age level, indicates a stable population.

Type III, with more individuals at (or above!) reproductive age than young, describes a declining population.

(vii) Biotic potential

Is the maximum rate at which members of the species can reproduce with unlimited resources and under an ideal environmental condition. Biotic potential varies according to age structure of the population and is influenced by male to female ratio. Full potential is never realized. The difference between actual rate of increase and biotic potential reflects environmental resistance.

(viii) Growth form: It refers to the variation of a population size with time.

(ix) Carrying capacity: Is the maximum number of individuals that can be supported or sustained by available natural resources in an environment.

(x) Dispersion (Distribution): Is the pattern of spacing among individuals within the boundaries of the population.

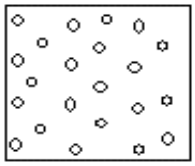
Dispersion is divided into three types, dispersion or distribution is divided into,

- Random distribution.
- Uniform or Regular distribution.
- Clumped or clustered distribution.

TYPES OF DISTRIBUTION/DISPERSION.

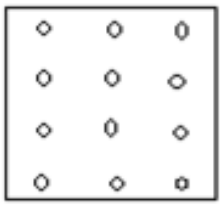
(i) ***Random* dispersion (unpredictable spacing):** the position of each individual is independent of other individuals. This pattern occurs in the absence of strong attractions or repulsions among individuals of a population or where key physical or chemical factors are relatively homogeneous across the study area. For example, plants established by windblown seeds, such as dandelions, may be randomly distributed in a fairly consistent habitat.

Random distribution.



(ii) **Regular or uniform dispersion:** May result from direct interactions between individuals in the population. For example, some plants secrete chemicals that inhibit the germination and growth of nearby individuals that could compete for resources. Animals often exhibit uniform dispersion as a result of antagonistic social interactions, such as territoriality the defense of a bounded physical space against encroachment by other individuals.

Regular/uniform distribution.



NOTE:

Random and clumped distributions are quite rare in a population for the reasons that, environment is not usually uniform in terms of availability of resources, there is not intense competition.

Advantages of random and uniform distribution.

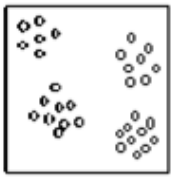
- Competition for natural resources like food, mates, space among the organisms is reduced.
- Prevents spread of diseases since the organisms are not overcrowded.
- Leads to maximum utilization of resources in the habitat since wide range of habitats are occupied.

Disadvantages of random and uniform distribution.

- The organisms may lack group protection against their predators.
- The organisms somehow far apart, reducing chances of locating mates.
- Plants are not properly protected from strong winds.

(iii) **Clumped or clustered distribution:** Consists of individuals aggregated in patches e.g. Plants and fungi are often dumped where soil conditions and other environmental factors favor germination and growth, Insects and salamanders may be clumped under the same log because of the higher humidity there. Clumping of animals may also be associated with mating behavior.

Clumped/clustered distribution.



This form of dispersion is quite common because of the following,

- Resources are clustered in nature or rarely uniform.
- Social interactions are common resulting in social groups.
- Some reproductive patterns favour clumping for example vegetative propagation in plants, the young animals remain with their parents for long among animals.

Advantages of clumped distribution.

- Both the adult and young organisms are offered better defence and protections against predators.
- Plants are quite close and can resist strong winds.
- There are better chances of locating mates.

Disadvantages.

- Increases competition for resources.
- Increase spread of diseases.
- There is little utilization of natural resources since small range of habitat is occupied.

POPULATION GROWTH AND CHANGES IN POPULATION.

Population growth is the measure of change in a population. The change can either be positive when the number of organisms increase and negative change when the number of organisms decrease. There is no change in population growth when the number of the organisms remained constant.

Population growth rate is the change in the number of individuals per unit time.
Many environmental factors determine the size of a population by affecting,
• Birth rate; Number of births or number of adults in a population.
• Death rate: Number of deaths in a population.
• Immigration: The amount or number of individuals moving or entering into the population.
• Emmigration: The amount or number of individuals moving out or leaving a population.

- ❖ In favourable conditions the population grows if,

Number of births + number of immigrants is greater than number of deaths + number of emigrants.

- ❖ In unfavourable conditions, the population will decrease if,

Number of births + number of immigrants is less than number of deaths + number of emigrants.

Importance of population growth and population size of different organisms in ecosystem.

- ➢ To construct food webs, food chains, pyramid of numbers, pyramid of Biomass and energy.
- ➢ To be able to understand the existing food relationships within the habitats. The predator and prey organisms are easily identified.
- ➢ To realize population changes overtime or seasons, so as to understand the way populations are affected by various environmental factors.
- ➢ It determines the population of the pests, to help in designation of control methods and rapid prevention of its spread.
- ➢ To determine the carrying capacity of a habitat of different populations so as to maintain ecologically balanced habitats.
- ➢ For management of national parks, game parks, game reserves and forest reserves to enable plans for cropping programmes.
- ➢ To be able to value wild life reserves (national parks) and design or alter boundaries of various conservation areas.

FACTORS THAT AFFECT OR INFLUENCE SIZE OF POPULATIONS IN AN ECOSYSTEM.

These factors are divided into two broad categories, the density dependent and density independent factors.

(a) Density dependent factors that influence size of population.

Density dependent factors: are those factors of the environment whose effectiveness in controlling the size of population depends on the number of individuals or organisms per unit area (population size). These factors are usually biotic and they include the following,

(i) ***Competition for Resources;***

In a crowded population, increasing population density intensifies competition for declining nutrients and other resources, resulting in a lower birth rate due to reproductive failures and death causing decline in the size of the population. Plenty of resources such as food reduces competition and thus favours reproduction and increase in population size and lack of food and water leads

(ii) ***Diseases and pests.***

Where there is a large number of individuals crowded together diseases spread rapidly and cause deaths, reducing the population and where there is no overcrowding of individuals, diseases are rare and population increases.

(iii) ***Accumulation of toxic wastes.***

In laboratory cultures of microorganisms, metabolic by-products which may be toxic wastes accumulate as the populations grow, poisoning the organisms within this limited, artificial environment, toxic wastes can cause death of some organisms and reduce their population size. Non-toxic environment provides favourable condition for growth of organism and the size of population increase.

(iv) ***Predation.***

Where the number of predators are few or individuals have the ability to avoid predators, the population size increase. While a decline in the size of population is caused by large population size of predators or individuals lack ability to avoid predators.

(v) ***Availability of space/shelter.***

This includes breeding sites. It determines protection of organisms from hostile environmental conditions, determining their survival. Plenty of suitable space increases population size. While, lack of suitable space or in adequate space decreases population size.

(vi) ***Reproductive or Biotic potential.***

High biotic potential increases size population of organisms, while low Biotic potential decreases the population size of organisms in an ecosystem. Large size of reproducing individuals in a population will increase size of population; few reproducing individuals in a population will maintain low population size.

(vii) ***Stress factors /psychological factors.***

These include stress factors arising from overcrowding. It leads to abnormal behaviours that may lead to reproductive failures, low food intake, decreasing population size. Absence of stress conditions increase size of population.

(viii) ***Territorial behaviour/territoriality.***

It occurs among wide range of animals such as certain fish, reptiles, birds, mammals and social insects where a male or both male and female animals demarcate an area which they defend against members of the same species. Territoriality limit size of a population within the territory more than outside it.

(b) Density independent factors that influence size of population.

Density independent factors are those factors whose effectiveness in controlling size of population does not depend on the number of individuals or organisms per unit area. These factors are usually abiotic and they include,

(i) ***Availability of light.***

Sufficient light intensity provides light energy for photosynthesis and favours the growth of plant population. This causes increase in the population size of the plants (primary producers). The

animals feed on these plants, they reproduce rapidly and their population size too increases. Inadequacy of light or its absence limit plant population.

(ii) Availability of oxygen.

Oxygen is utilized by aerobic organisms for respiration, its presence in sufficient amounts favours growth of aerobic organisms, hence growth of population size of these aerobic organisms and its absence or insufficient amounts limits size of populations, especially in aquatic organisms.

(iii) ***Climatic conditions*** such as, temperature, relative humidity, salinity, wind.

When favourable increase growth of plants and survival of animals, hence leads to increase in size of population size and when these climatic conditions are not favourable lowers survival of organisms, hence decrease population size.

(iv) ***Catastrophies*** such as fire, storms, and floods

These may lead to sudden mass deaths of organisms, reducing size of population. In absence of such Catastrophies population size remain increasing.

(v) ***Edaphic factors***, these are soil factors such as soil temperature, pH, air, water content, mineral and organic matter. When favourable favour plants growth and activities of micro-organisms, increasing the size of population and when unfavorable will decrease the size of population.

(vi) ***Pollution***, high levels of any kind of pollution will limit the population size of organisms compared to low level or no pollution of the ecosystem.

(vii) ***Topography.*** It influences local climate and soil factors.

The main topographic factor is altitude. Higher altitudes are associated with lower average temperatures, higher precipitation, increased wind speed, lower atmospheric pressures, more intense radiations, these lower growth rate and support smaller size of population than lower altitudes. Mountains are climatic barriers to dispersal and migration, limiting increase in population size.

Population grows and declines in characteristic ways. The size of population increase is determined generally by the reproductive potential (Biotic potential) and environmental resistance.

Maximum Biotic potential (Reproductive potential) of an organism is the rate of reproduction given unlimited environmental resources.

Environmental resistance is both biotic and abiotic factors that together prevent the maximum reproductive potential to be achieved and as such limit growth of a population. They include external factors such as shortage of food, water or oxygen, lack of light, presence of predators and parasites, lack of shelter (space), excessive heat, intraspecific competition and behavioural adaptations.

The balance between biotic potential and environmental resistance determines the ***carrying capacity*** for particular population.

CARRYING CAPACITY.

Carrying capacity is the maximum number of individuals that can be supported or sustained using the available natural resource in an environment.

Factors that determine carrying capacity of the environment.

- Food shortage.
- Increased predation.
- Overcrowding.
- Competition.

Conditions that may cause carrying capacity to be exceeded.

- Removal, death or absence of predators in an area.
- Abundant food supply.
- Favourable climatic or weather conditions.
- Adequate space/shelter/breeding sites.
- High Biotic potential.
- Low mortality rate.

Environmental indicators for a population that has exceeded its carrying capacity.

- Destruction of vegetation, rapid environmental degradation.
- Extinction of some species of organisms.
- Accumulation of wastes.
- Increased rate of emigration. Rate of emigration exceeds immigration.
- Death rate exceeds birth rate.

POPULATION GROWTH CURVES.

These are graphs which show the trends of population growth over a period of time. There are two types of growth curves,

- J-shaped growth curve.
- S-shaped or Sigmoid growth curve.

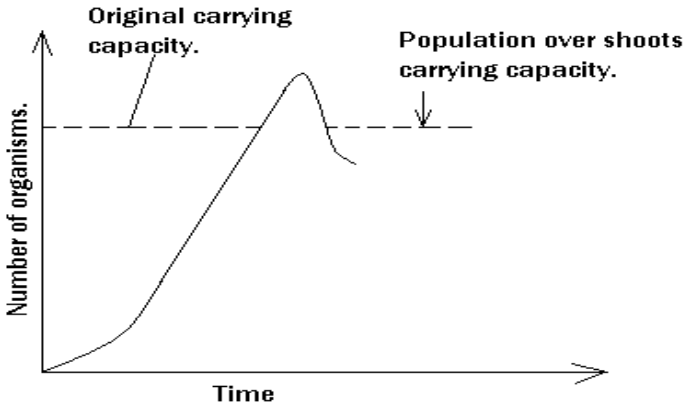
J-SHAPED GROWTH CURVE.

It describes a situation where organisms better adapt in the initial lag phase, then the population size increase rapidly during the exponential phase that it exceeds the carrying capacity then population growth suddenly stops and declines, population crash occurs. The populations that show this type of growth curve is referred as **boom and bust populations**. Its growth is regulated by density independent factors. Overpopulation can damage the environment leading to a new lower carrying capacity. After the crash the population fluctuates around the new carrying capacity.

The abrupt stop (population crash) may be caused by,

- Application of pesticides or insecticides to control an insect pest.
- Harsh environmental conditions.
- End of breeding season.
- End of particular stage in the life cycle of some organisms.

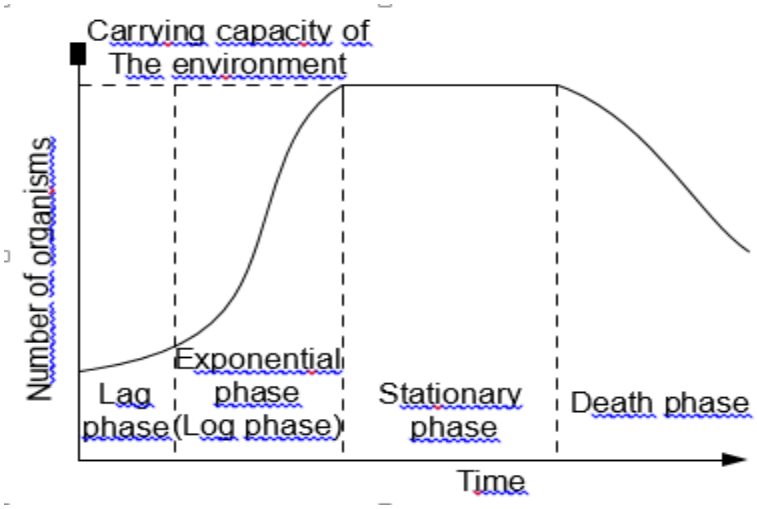
J-SHAPED GROWTH CURVE.



THE SIGMOID GROWTH CURVE.

The type of population that exhibits the sigmoid growth curve has population growth controlled by the density dependent factors. It is associated with a population living in an area with limited resources.

S-SHAPED SIGMOID GROWTH CURVE.



DESCRIPTION OF THE SHAPE OF THE GRAPH.

Initially the number of individuals in a population increase gradually and then the increase become drastic/rapid, but as it is approaching the carrying capacity, the number of the individuals in the population begin to increase slowly until it reached maximum, after which it remained constant for a while and gradually decrease.

EXPLANATION OF THE GRAPH.

(i) Lag phase.

Population increase slowly because there are fewer reproducing individuals and they are widely dispersed. In some cases, the organisms are not fully adapted to the environmental conditions, only the few individuals start to reproduce.

(ii) Exponential phase.

Population increase or grow drastically/rapidly/steeply/fast. This is because there are more individuals reproducing, there is no environmental resistance, food and space are sufficient, there

is no competition for the available natural resources such as food, shelter, water, oxygen, light and biotic potential is higher and hence the natality, or birth rate exceeds mortality rate. In some cases, the organisms have adapted to the environmental conditions which is more favourable to the organism.

(iii) Decelerating phase.

The population increase slowly/gradually until it reaches maximum. This is because the environmental resistance sets in like shortage for food, space, resulting into increased competition, death rate increases exceeding the birth rate.

(iv) Stable phase/ constant phase.

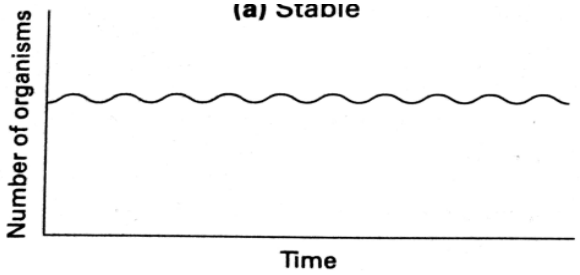
The population of the individuals remains constant. In this case the population has reached its carrying capacity. The birth rate and the death rate exactly balance each other resulting in equilibrium.

(v) Declining phase.

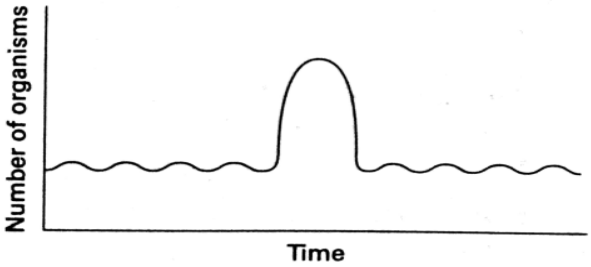
The population rapidly/steeply declines or decreases. This is because the environmental resistance at its maximum. There is intense overcrowding, more competition for food, space, oxygen, etc. occurs, there occurs production and accumulation of toxic wastes from the organisms, reproduction potential rapidly declines, death rate exceeds the birth rate.

Growth curves that occur in natural environments include

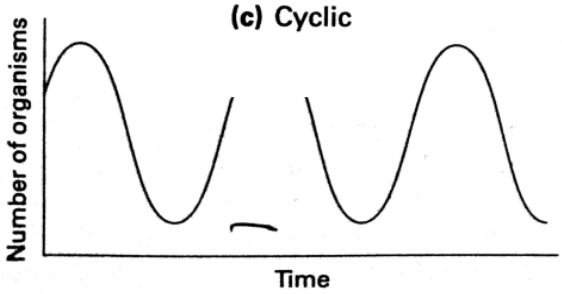
(i) **Stable population growth curve:** the population size remains relatively constant, fluctuating slightly over a long period of time e.g. trees in a well-established woodland



(ii) **Irruptive population growth curve:** the population size usually hovers about a mean, but occasionally increase dramatically to overshoot the carrying capacity. The overshoot is usually followed by an equally dramatic decline e.g. some algal populations in freshwater habitats. When conditions become particularly favourable an algal bloom occurs.



(iii) **Cyclic populations growth curve:** the population size increases and decreases in a regular cyclic manner e.g. lemmings with a high reproductive potential.



Predator and prey populations are therefore regulated by ***a negative feedback mechanism*** that keeps the populations balanced at levels that the environment can support.

The role of negative feedback mechanism in control of population size of organisms.

Feedback mechanisms: Are systems that detect a change in the level or amounts of a particular parameter from the norm or normal levels, then the system is stimulated or triggered to bring into action corrective processes or regulatory processes. In negative feedback mechanisms, a change in the amounts of the parameter about the norm or set point, triggers processes that will bring the amounts or the levels of the parameter back to norm.

Regulation of population size of most organisms in an ecosystem is by negative feedback mechanism, which maintains size of population at the carrying capacity (the Norm) with minimum oscillations or deviations. When the population size increases far beyond or above the carrying capacity, environmental resistance or environmental stress factors set in, like competition for scarce natural resources such as food, space, mates. Other stress factors such as accumulation of own toxic wastes, starvations also occur, resulting into death of some organisms. The population size declines back to normal. And when the population size decreases below the normal, the environmental stress factors are removed, encouraging population growth and the size of the population increases back to norm.

However, human population cannot be regulated by negative feedback mechanisms. This is due the following reasons,

- Modern methods of food production have led to production of plenty of food hence deaths due to hunger have been minimized.
- Manufacture of drugs has minimized deaths due to diseases and other pathogenic infections.
- Improved standards of living such as good hygiene, people tend to live longer.
- Use of contraceptives or birth control methods has controlled abnormal rise in human population.

METHODS/TECHNIQUES OF ESTIMATING POPULATION SIZE IN AN ECOSYSTEM.

Factors determining the methods employed in estimation of population size of organisms.

(i) Size of the area under investigation

(ii) Nature of vegetation.

(iii) Topography or terrain.
(iv) Size of organisms to be counted.
(v) Behaviour of the organism or its social structure and activities.
(vi) Nature of the habitat whether terrestrial or aquatic, concealed or non-concealed habitat.
(vii) Resources available for example, apparatus, money etc.

The methods used to estimate the size of a population is divided into two categories,

- Total count methods.
- Sampling methods.

1. TOTAL COUNT METHODS.

This method involves physical count of all the organisms in an area under study. In this method, the whole area is searched, all organisms are counted and it should give absolute number of organisms in the whole area. These methods include the following,

- Direct observation.
- Aerial photography.
- Removal methods.

(a) DIRECT OBSERVATION.

This involves direct counting of all the animals in the whole area of study. The total number of the animals observed and counted is recorded.

It is applied to sessile, slow moving animals and also applied to many larger mobile organisms that do not live in concealed areas such as deer, lions, wood pigeons and bats as they leave their roost.

Direct observation methods is further divided into,

(i) Drive and Count methods.

Procedure:

a number of people drive animals into a particular spot with in the study area and counting is done. The figure obtained represents the total population size of the study area. The population density may be calculated as:

$$\textbf{Population density} = \frac{\textbf{Total number of animals of a particular species under study}}{\textbf{Area of study area}}$$

This is one of the most accurate methods of population determination that have the following characteristics:-

- large organisms that can be seen
- those that live in herds especially within open grasslands
- the organisms must be friendly to the one counting
- the organisms must be slow moving

Advantages of the method

- It reduces the chances of counting the same animals more than once.
- It is a fairly quick and easy method for animals which live in herds.

Disadvantages/ challenges / weaknesses of the method.

- It involves disturbance of the animals which may make them aggressive.
- It can't be applied on aggressive animals.
- It is difficult to apply on animals which do not live in herds.
- It is difficult to apply on fast moving animals

(ii) Strip census.

In this method, animals are counted along paths while walking or in a vehicle. Population density is determined as number of individuals per unit area of the strips. It is applied to large animals which live in non-concealed areas.

Advantages.

- It is quick.
- It is comparatively cheaper than aerial photography.

Disadvantages.

- The animals may be scared away by the passing vehicles or even by the presence of the human beings thus may not be counted at all.
- Some animals avoid the paths and therefore may not be counted.
- Very many counts must be conducted in order to get reliable information.
- Some of the animals are too mobile and are likely to be counted twice.

(iii) *Direct counting using a low flying air crafts.*

This method involves physical counting of all the animals within the study area. It is applied to large animals living in non-concealed habitats for example, Lions, Buffaloes, Rhinos, giraffes and elephants.

Procedure

- The study area of known dimensions within the park is surveyed using a low flying light air craft,
- A low flying light air craft is flown along a transect and animals along the transect are counted.
- The air craft then flies back along another adjacent transect and counting continues until the whole area sampled is covered.
- Several such counting are carried out and an average is determined,
- The product of the average count and the total area of the study area gives the estimated size of population of the organisms in numbers per unit area.

Advantages.

- Is a very quick method of estimating population
- It can be done concurrently with other studies for example studying feeding habits.
- It can be applied in some aggressive animals like lions since it has minimum risks of the researcher being attacked.
- It is less tiresome and not laborious.
- It reduces the chances of counting the same animals more than once since it very organized.

Disadvantages.

- It is very expensive since it involves expensive equipment like air-crafts.

- The air craft may scare away the animals which may go into hiding and end up not being counted.
- It is difficult to apply on animals that live in concealed habitats.
- It can be applied to very small animals since they may not be seen from a distance.
- It's operation can be affected by bad weather or poor climatic conditions for example when the weather is misty or foggy.

(b) AERIAL PHOTOGRAPHY.

This method is also applied to larger animals which live in non-concealed habitats,

Procedure.

- The area of the park of known dimensions is surveyed with low flying light air craft
- The animals in places within the study area where they are present in groups or herds are photographed
- Their number is counted from the developed photographs
- Repeat the process of photography and counting animals from the developed photographs at regular intervals of time over a given period of time,
- The average number of animals counted from photographs is obtained, then the product of the average count and the total area gives the number of the individuals per unit area.

Note: The advantages and the disadvantages of this method is the same as those for direct counting using a low flying air craft.

(c) REMOVAL METHOD.

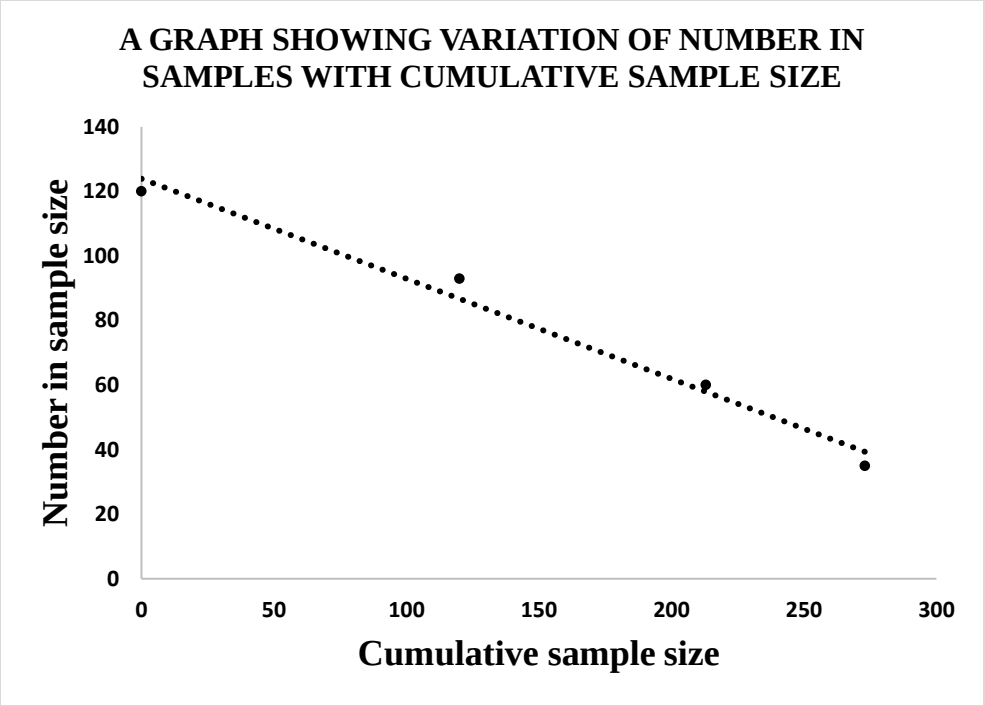
It suitable to estimate numbers of small organisms, particularly insects within a known area of grassland or volume of water.

Procedure

- Using a sweep net, the number of animals captured is recorded and the animals kept.
- This procedure is repeated three times and the gradually reducing numbers recorded.
- A graph is plotted of number of animals captured per sample against the previous cumulative number of animals captured.
- By extrapolating the line of the graph to the point at which no further animals would be captured i.e. number in the sample = 0, this gives the total population estimated

e.g.

Sample	Number in sample	Cumulative sample size
1.	120	0
2.	93	120
3.	60	213
4.	35	273



The estimated population size is equal to the cumulative sample size when the number in sample is zero (0), according to the graph = 350 individuals.

2. SAMPLING METHODS OF ESTIMATING SIZE OF A POPULATION.

Is the random determination of the number or distribution of organisms within a population. In this method, only part of the area is surveyed, only a few organisms within the study area are counted but bias should be avoided and every organism must have equal chances of being chosen in the sample, which must be large and the total number of organisms in the whole area is calculated or estimated from the sampled plots. These methods include,

- Capture-mark release recapture method.
- Quadrat method.
- Use of line transect/Belt transect.

(a) CAPTURE, MARK, RELEASE AND RECAPTURE METHOD.

This method is suitable to determining population of animals which are small, mobile, fast moving, live in concealed habitats and they can easily be tagged or marked, examples include, arthropods, fish, small mammals and birds.

Procedure

Traps are set up randomly within an area and a number of animals are captured.

The animals are marked for instance arthropods may be marked on their back with non-toxic dabs of paint, fish can have tags attached to their opercula, mammals may have tags clipped to their ears and birds can have their legs ringed.

The number of the marked animals recorded is **labeled N_1** and then they are all released back into the population and given sufficient time to mix freely in the population.

After a period of time, the raps are set up again randomly in the area and the animals are captured for the second time and the number of the animals captured for the second time is **labeled as N_2**, at the same time the number of the animals captured and marked (recaptured animals) is **labeled N_3**.

The size of the population size is estimated is determined using Lincoln index as,

Estimated population $= \frac{\left(\begin{matrix}Total\ No.of\ individuals \\ in\ the\ first\ sample(N1)\end{matrix}\right) x \left(\begin{matrix}Total\ number\ of\ individuals \\ in\ second\ sample(N2)\end{matrix}\right)}{Number\ of\ marked\ individuals\ recaptured\ (N3)}$

Assumption of the capture mark release recapture method.

- Organisms mix randomly within the population.
- Sufficient time must elapse between capture and recapture to allow random mixing. The less mobile the species of animals the longer the time lapse must be.
- It is only applicable to populations whose movement is restricted geographically.
- Organisms disperse evenly within the geographical area of the population.
- Changes in population size as a result of immigration, emigration, births and deaths are negligible.
- Marking does not hinder the movements of the organisms or make them conspicuous to predators or death of the animals.
- The population of the marked to unmarked individuals in the second sample is the same as the proportion of marked to unmarked individuals in the whole population.
- Every marked animal has the same probability of surviving the sampling period.
- Every animal captured, marked and released have the same or equal probability of being recaptured.

Precautions to be taken.

(i) The marks should not be harmful to the animals.
(ii) The marks or the tags used should not expose animals to the predators.
(iii) Sufficient time should elapse between the first and second capture.
(iv) The mark is permanent.

Trial question

In an attempt to estimate the number of trout in a small lake, 625 trout were netted, marked and released. One week later 873 trout were netted and of these 129 had been marked. What was the estimated size of the population?

(b) QUADRAT METHOD.

A quadrat is a metal or wooden frame with one metre sides. It encloses an area of $1m^2$, however, larger quadrats marked on ground by either ropes or suitable materials may also be used. It is a random sampling method.

This method is suitable to estimate population size of plant species and sessile organisms or very slow moving organisms.

Procedure

- Survey the area under study and establish its size in square metres, then a quadrate of known square meters i.e. $1m^2$ is thrown at random on an area marked randomly
- The number of enclosed organisms are counted, such of these of throws are carried out several times.
- An average of these counts is taken and the population size is estimated by determining the product of the average count taken and total square meter of the area under study.

Size of population = *Average number of animals in $1m^2$ Quadrat* **X** *Total square metre of area under study*

Example:

If 5 quadrats of $1m^2$ show number of certain plant species as 1^{st} quadrat = 3, 2^{nd} quadrat = 7, 3^{rd} = 2, 4^{th} = 4, 5^{th} = 4 respectively, if the total area under study = $500m^2$. The size of population can be estimated as follows,

Total number of plants = 20 plant species.

Number per quadrat = $\frac{20}{5}$

= 4 plant species.

Therefore $1m^2$ quadrats = 4 plant species.

$500m^2$ = 4 x 500

Estimated population = 2000 plant species.

The quadrat method provides means of studying three aspects of species,

(i) Species density.

This is the number of individuals of a given species in a given area. It is obtained by counting the number of organisms in randomly thrown quadrats.

(ii) Species frequency.

This is a measure of the probability or chance of finding a given species within any one throw of a quadrat in a given area. This is obtained by recording the presence or absence of the species in a randomly thrown quadrat.

(iii) Species cover.

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

Advantages of using quadrat methods.

- It is cheap method to carry out since it does not require many expensive types of equipment to use.
- The aspect of species density makes this method accurate enabling different areas and different species to be compared.
- Species density provides an absolute measure of abundance of species in an area.
- The aspect of Species frequency is easy and quick to conduct.

- It can be applied in large ecosystem such as woodland.

Disadvantages.

- It is time consuming like in determination of species density.
- In determining species frequency, the quadrat size, plant size and spatial distribution affect the results.
- It is slow and tedious like in determining species cover.
- It can only be efficiently applied in estimating population size of plants species.

(c) Transect method

This method is divided into two types:

- Line transect method
- Belt transect method

(i) Line transect

This can be used to estimate the population of plants.

Procedure

- Survey the area under study to establish its size in square metres.
- A tape or string is stretched along given dimension within the study area using two poles.
- The plants touching or beneath the tape or string are counted or the plant species touching or beneath the tape or string are recorded.
- Several counts are made, and an average of such counts is taken,
- The population size (quantitative data) can then be estimated by multiplying average number of organisms counted along the dimension by the total area of study.

$$\textbf{Total population} = \left(\begin{matrix}\textbf{Average number of organisms}\\ \textbf{counted along the dimension}\end{matrix}\right) X \left(\begin{matrix}\textbf{Total area of}\\ \textbf{study area}\end{matrix}\right)$$

This method is useful to study changes in plant species in an area (Qualitative data).

(ii) Belt transect

This is a strip of chosen width through the habitat, made by setting up two parallel strings called twines (line transects) tied across a habitat by help of pegs. The areas between the strings are belts which can be divided into small squares. Organisms within the belts are recorded. This method can be applied for both plants and animals in larger area of study.

In belt transect method, both a quadrat and a line transect can be used. The type of a transect to use depends on the following factors,

- Qualitative and quantitative nature of the investigation.
- Degree of accuracy required.
- Nature of organisms present.
- Size of the area to be investigated.
- Time available.

Over a short distance a line transects is used and over a longer distance the species present every metre or any other suitable distance is recorded. Height variations recorded along line or belt transects produce a profile of transect known as profile transect.
NOTE: State advantages and disadvantages of using line transects.

METHODS FOR ESTIMATING POPULATION GROWTH OF MICRO-ORGANISMS.
When estimating the population growth of micro-organisms such as, bacteria, fungi, and yeasts, it can be done by directly counting the number of cells or by indirectly measuring some indications of the number of cells such as the cloudiness of the solution, or production of the gas. There are two types of cell counts and these are,

- Viable counts.
- Total counts.

VIABLE COUNTS.
Is the total number of living cells only. Viable counts can be made using spread plates, pour plates and haemocytometry. For example the effectiveness of pasteurization milk in killing certain bacteria could be measured by making viable counts before and after pasteurization.

(i) SPREAD PLATES.
A known small volume of sample is added to the nutrient agar in a Petri-dish. The medium containing the sample with bacteria is incubated for a period of few days i.e. two days. Each bacterium grows into a single colony. The number of visible colonies is counted. The number of bacteria is estimated as the number of bacteria in original added sample is equal to the number of colonies after incubation. This method is applied to determine the number of bacteria in a sample of milk. This method relies on the assumption that each bacterium will grow into a single colony.
Precautions to be taken

- The original sample added should not have too few or too many bacteria.
- The lids of the Petri-dishes should not be removed during counting.
- It is usual to prepare dilution series to obtain an ideal number of bacteria. So that only a suitable dilution can be used to improve accuracy and reliability.

Limitations of this method

- Some bacteria form chains or groups. For example, streptococci. Each group gives rise to a colony which may be wrongly counted as a single bacterium.
- If more than one type of bacterium is present as in soil, milk or water sample, conditions will not favour all types equally, some types of bacterium will grow more rapidly than others. This will give a variable numbers of visible colonies

(ii) POUR PLATES.
It is similar in principle to spread plating, but the sample is mixed with the nutrient agar before it sets so the colonies are spread throughout the medium instead of growing only on the surface.
(iii) USE OF HAEMOCYTOMETER/HAEMOCYTOMETRY.
This is the viable counts of yeast cells using a haemocytometer and methylene blue.

TOTAL COUNT.

This is the total number of living and dead cells. The number of bacteria or yeast cells in a liquid culture such as a broth culture can be counted directly using a haemocytometer which a king of a microscope. The technique is called haemocytometry. This method is easier for yeast cells because the cells are larger. With bacteria, an oil immersion lens is required.

HAEMOCYTOMETRY METHOD FOR ESTIMATING POPULATION SIZE/ GROWTH OF MICRO-ORGANISMS.

A haemocytometer slide is obtained. Counting grid is put into the surface of the slide. A cover slip is placed and to ensure close enough contact between slide and cover-slip, the cover slip is pressed down firmly either side of the counting chamber, the cover slip is moved slightly until coloured lines appear on either sides of the cover slip. The liquid sample in the pipette is applied on one side of the cover slip and drawn under the cover-slip by capillary action. The slide is left for 20 to 30 minutes to allow the cells to settle, making counting easier. The microscope is focused on the grid and the number of cells in the entire grid or represented sample is counted. Where cells lie in the boundary, they are judged as in the square to avoid counting half cells. The grid or the counting chamber consists of small squares. Each small square is a known area and the depth of liquid below the cover slip is constant (usually 0.02mm or 0.1mm). The volume of each square is determined. The total area for the grid is $1mm^2$. If the gap between cover slip and the grid is 0.02mm, the total volume above the grid is therefore $1 \times 0.02 = 0.02mm^3$ then the number of cells in a given volume is counted. (note $1000mm^3 = 1cm^3$ and $1000cm^3 = 1dm^3$ (1litre)

With yeast, methylene blue stains is added, this stains dead cells blue and living cells remain colourless or very pale blue. For yeast cells, the best method is to count the increase in number of yeast cells on a daily basis i.e. number of yeast cells/cm^3 of culture solution. And the final results represented as graph of daily increase in yeast cells (log no./cm^3) against time (days).

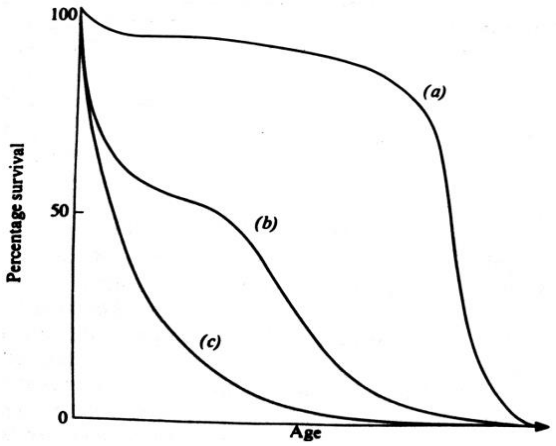
SURVIVORSHIP CURVES.

These are graphs showing the numbers of individuals which survive per 1000 of the population through each phase of life. They are constructed by tracking a group of individuals born around the same time (a cohort) from birth until the last one has died, and recording each individual's age at death. The percentage of the cohort surviving is plotted at each age. So all survivorship curves start at 100% and finish at 0%, but have different shapes in between. Survivorship curves allow us to calculate life expectancy – the mean lifespan of a cohort – by simply reading off the age at which 50% survive. Survivorship curves correlate with strategies species use to adapt to various environments.

$$\textbf{Percentage survival} = \frac{\textbf{Numbers of survivors}}{\textbf{Number in original population}} \textbf{X 100}$$

Different organisms have characteristic survivorship curves, some examples are shown in the graph below.

A GRAPH SHOWING SURVIVORSHIP CURVES.



EXPLANATION OF THE CURVES.

Type I curve (a): species showing this type have a long life expectancy, with low infant mortality and most of the cohort dying in old age. Type I curves are shown by large organisms e.g. humans in relatively stable environments, have few offspring but there is a high investment in parental care.

In organisms exhibiting type I, senescence is the major factor affecting mortality. An example is a human population in modern industrialized country in which the standards of medicine and nutrition are maintained and so most people live to old age. But the life expectancy cannot be prolonged beyond 75 years of age. The initial gradual decrease of the curve is due to the infant mortality. The drastic decrease of the curve can be due to the following,

- Accidental deaths i.e deaths through car accidents, etc.
- Senescence (ageing). Is the general decline in the normal physiological functions of the body systems (declining vigour) with increasing age beyond maturity, resulting eventually into death of the organisms.

The immediate cause of the senescence are, reduced resistance to external factors such as diseases, others causes include, mistakes in protein synthesis, degeneration of cells, in-efficient homeostasis, auto immunity. Auto-immunity is where old people produce anti-bodies against their own antigens.

Organisms in the population would combine their high survival rate with low reproductive rate to maintain a stable population.

Type II curve(b) : species have intermediate life expectancy and a roughly constant death rate regardless of age. Type II curves are shown by animals that are equally susceptible to predation or disease at any age, such as small mammals e.g. squirrels (rodents), many birds, some lizards, annual plants and many asexual species. They are also shown by human societies facing a serious epidemic or population with a high mortality rate early in life like for humans in a country in which starvation and diseases are prevalent.

In this case, the population would need a higher reproductive rate to maintain a stable population since high percentage of individuals would die before reproductive age is reached.

Type III curve (c): species showing this have a short life expectancy, high death rates among offspring; relatively few survive to old age. Most long-lived plants, most marine invertebrates and many fish. Parents invest most of the reproductive energy in high numbers of offspring to offset the high death rates, and little or no energy remains for parental care.

NOTE: Minor variations in survivorship curves may occur within species due to sexual differences, for example in humans female life expectancy is slightly greater than for males.

NATURAL RESOURCES.

Natural resources are useful materials to man provided naturally by the environment. Examples of natural resources include, Forests, Water bodies, fishes, oil, minerals, mountains, soil, sun, air, wild life, coal, natural gas.

TYPES OF NATURAL RESOURCES.

These are,

- Renewable natural resources.
- Non-renewable natural resources.
- Non-exhaustible resources.

(i) Renewable natural resources.

These are resources when used or destroyed may be replaced if proper conservation measures are applied. So, they are replaceable and can be used continuously. Examples of such resources include forests, soil, water, fishes, wild life etc.

(ii) Non-renewable natural resources.

These are resources when once used or destroyed cannot be replaced. So, they are irreplaceable resources. Examples of natural resources include coal, oil, natural gas and minerals.

(iii)Non-exhaustible resources.

These are not exhaustible in life. They are always available in abundance. These include, water, air (wind) and sun.

CONSERVATION OF NATURAL RESOURCES.

Conservation is defined as the action taken to avoid species decline, extinction and any permanent detrimental change to the environment. The aims of conservation are:-

- ❖ To preserve and promote habitats and wild life
- ❖ To ensure that natural resources are used in a way that provides a sustainable yield.

REASONS FOR CONSERVATION OF NATURAL RESOURCES

(i) Ethical reasons.

It is morally wrong to destroy ecosystem or to allow species to become extinct. So, it is right to conserve the diversity of life and the environment so as to pass it onto the future generations the way they were inherited.

(ii) Aesthetic Reasons.

Conserving the wild life for the pleasure it provides to humans. This is to encourage eco-tourism, this is the tourism based on visiting natural environments, promoting art, design, literature and recreation.

(iii) Utilitarian Reasons.

This is where Biological resources are conserved for their usefulness or economic values. Wild life supplies human community with food, medicines and many industrial products.

Medicines obtained from wild plants include quinine and codeine, those obtained from animals include snake venom used as anticoagulants and anaesthetics.

They can also contribute for our needs in agriculture, forestry and fisheries. We make use of pollinating insects and use of predators in pest control.

(iv) Ecological/ scientific Reasons.

For the wellbeing of humans that depend on maintenance of a fully functional Biosphere. For instance maintaining stable biochemical cycles which can only be disrupted by extinction of some species, such disruption can affect negatively human lives. For example loss of vegetation cover can cause soil erosion, siltation of rivers and coasts and may even result in changes in rainfall and climate patterns.

IMPORTANCE AND CONSERVATION OF NATURAL RESOURCES

(i) SOIL

Importance

- In agriculture for growing of plants and rearing of animals.
- Habitat for soil micro-organisms for example earthworms, bacteria, etc.
- For settlement.
- For mining for example sand, clay and other minerals.
- Source of nutrients for plants for example minerals like calcium, nitrogen, magnesium, iron, iodine etc.
- Source of raw materials for example rocks for glass and ceramics industries

SOIL MANAGEMENT TECHNIQUES AND CONSERVATION METHODS.

(i) Crop rotation.

Farming methods where different crop plants are grown in a field in regular rotation. This method prevent, destructs cycles of pests and parasites to any crop species, minimizes the risk of depleting the soil of nutrients and water, where legumes are used in the rotation, nitrogen fixing bacteria in their root nodules add to soil erosion.

(ii) Tillage.

This is the mechanical turning of the soil by ploughing. It suppresses the growth of weeds and promotes a good drainage and soil structure.

(iii) Liming.

This is the addition of agricultural lime to the soil. Lime is a mixture of calcium hydroxide (slaked lime), calcium oxide (Quick lime) and Calcium carbonate (limestone). Liming increases soil pH, neutralizing acidic soils and promoting clumping of soil particles, thus improving soil structure.
Note: Liming adds carbon dioxide into the atmosphere and may cause global warming.

(iv) Addition of organic matter.

This involves addition of substances such as manures, straw and sewage sludge. This promotes humus formation, improving soil structure, and promoting plant growth. Organic fertilizers are also usually more difficult to handle, use and apply onto the soil, they take longer time to have an effect and their compositions are variable and therefore not easy to determine the right amounts or dose, this makes them unreliable.

(v) Addition of inorganic fertilizer/Artificial fertilizers.

It involves addition of granules, pellets or liquid containing one or more inorganic nutrients such as nitrogen, phosphorus and potassium.

Advantages of inorganic fertilizers

- Their actions are quick.
- Easy to use and apply.
- Are reliable, effective and efficient.
- Promote fast plant growth when used appropriately.

Disadvantages

- Heavy use may destroy soil structure, texture and increase soil acidity or pH.
- They can run off into rivers and lakes or leaching into aquatic environment may cause Eutrophication and algal blooms. This causes death of aquatic plants and their decay leads to oxygen deficiency in water.
- Heavy use destroys beneficial soil micro-organisms.
- They may also damage plants, burning or scorching them.

(vi) Practicing terracing, contour ploughing and mulching as good agricultural practices to prevent soil erosion.

(vii) Building dams across streams to reduce the speed of flowing water, preventing soil erosion.

(viii) Establishment of permanent grass lands and wood lands where growth of other useful crops are not possible.

Soil management and conservation is to achieve the following,

- to maintain or improve soil structure.
- To reduce soil erosion.
- To maintain or improve soil fertility.
- To control pests and diseases.

(ii) WATER USE AND CONSERVATION.

Water bodies include lakes, rivers, streams, swamps, wells, seas and oceans.

USES OF WATER BODIES.

- Habitat for fish and other aquatic plants (phytoplanktons) and aquatic animals (Zooplanktons).
- Sources of water for domestic and industrial use.
- For recreation purposes for example swimming, sports and fishing.
- Minning for example minning salt, soda ash and fish.
- Climatic control like in convectional rainfall formation.

WATER CONSERVATION METHODS.

- Restoration of streams and rivers.
- Dumping of untreated sewage and industrial wastes into rivers, lakes be avoided to prevent water pollution.
- Mulching and replacement of the vegetative blanket to retain soil moisture.
- Construction of dams which act as water stores or reservoirs.
- Correct ploughing and cultivation methods.

(iii) Wild life use and conservation methods.

Wild life refers to wild animals and plants.

Uses of wild animals (fauna)

- For tourist attractions.
- Provides hides and skins.
- Means of transport for example horses, elephants, camels, donkey etc.
- Source of food, they provide meat.
- Source of income for example from game cropping and hunting.
- Some are pollinators like the bees, improving crop yields.
- Provide carbon dioxide to green plants.

Conservation methods.

- Legislation. Institute laws against encroachment and poaching and the laws must be state enforced.
- Practicing ***game cropping***. It is the scientific killing of game animals to keep the population at the carrying capacity level.
- Prevent deforestation.
- Restoration of natural habitats.
- Increasing state national parks to protect many wild life from extinction.

Uses of wild plants (flora)

- Source of medicine for example quinine is got from specific wild plant materials.
- Provides food inform of many fruits and roots of some plants. Nectar and pollen can be collected by insects and used for manufacture of honey.
- Habitat for many insects.
- Photosynthesis by these plants removes excess carbon dioxide from the atmosphere, minimizing global warming.

- Biological control agents. Some plant species control population of mosquitoes and tsetseflies.

Conservation methods.

- Prevent over grazing.
- Prevent land, water and air pollution.
- Prevent deforestation.
- Institute legislation that will regulate collection of wild plants and their products such as flowers.
- Use of botanical gardens and seed banks to keep plants that are endangered.
- Controlled fire out breaks.

(iv) FOREST USE AND CONSERVATION METHODS.

Uses of forest.

- Nutrient recycling.
- Provision of fuel for example fire wood for domestic and industrial uses.
- Catch large amounts of rainfall, are useful for rain formation.
- Habitat for many animals and plants.
- Increase soil fertility by adding organic matter into the soil.
- Are wind breakers.
- Prevent soil erosion by reducing speed of water and wind.
- Tropical forests provide humans with anti-cancer and anti-malarial drugs.
- Trees in the forest are photosynthetic utilizing the excess carbon dioxide in the atmosphere, so prevents occurrence of global warming.
- Prevents sound pollution by absorption of loud and bad sounds.
- Used for recreation purposes.

Mis-use of forests can occur due to,

- Un-controlled felling of trees.
- Encroachment for agricultural purposes and settlement.
- Charcoal burning.
- Un-controlled fire.

Conservation methods.

- Re-afforestation, this is planting of trees where they have been before.
- Afforestation, is the planting of trees where they have never been before.
- Selective felling (cutting) of trees.
- By imposing regulations which discourage forest encroachment.

(v) Fisheries, uses and conservation.

Fish are renewable resource. These are resources which with proper management can be used again and again because they are constantly replaced.

Fish are found in rivers, lakes, seas and oceans. Fish are not evenly distributed in lakes, seas etc. Fish feed on phytoplanktons and therefore fish are most abundant where phytoplankton

productivity is highest. Most oceans have a low concentration of nutrients at the surface, so phytoplanktons and fish population are low at the surface. There are two zones in the oceans where nutrient concentration and fish population is high,

(i) Where wind and currents cause water close to the sea bed to rise. The upwelling carries nutrients into waters high up where there is sufficient light to support photosynthesis. This region is known as up welling zone.

(ii) Shallow sea above continental shelves. In this area the concentration of nutrients are high, the water is shallow, the bottom sediments are disturbed by heavy storms to permit nutrients rise up, this zone is also fed by rivers carrying nutrient rich sediment that comes from natural erosion and human activities.

Uses of fish

- Source of protein food to humans and other animals.
- Provide carbon dioxide to phytoplanktons.
- Source of medicine for example cod-liver oil, hypochromis species of fish for treatment of measles in children.
- Used for sports and recreation purposes.

Fish are renewable resource and therefore be replaced. However, over fishing can cause depletion of the species of fish.

Effects of over fishing on ecosystem.

- Reduces the population size of adult fish and limits their distribution.
- The population structure of fish is changed, the population size of younger and smaller fish become greater than those of adults.
- It disrupts food webs by causing increase in plankton population following removal of fish as their predators.
- Population of other animals that feed on planktons may increase.
- The population of fish predators may fall drastically.
- It may result in extinction of fish.

CONSERVATION METHODS OF FISH.

(i) Fish must not be caught faster than the fish stocks can replenish themselves, a phenomenon referred to as sustainable yield.

The largest amount of a naturally renewable resource that can be regularly harvested without causing a decline in stock of that resource is called maximum sustainable yield. The maximum sustainable yield is maintained when,

• The growth rate of the resource is at its highest and when the harvest is at the correct level to keep the population at its optimal size.

(ii) Regulations must be made to prevent over fishing or to allow over fished stocks t recover. So, the following measures must be considered,

• ***Quota system of fishing:*** This is where the amount of fish that each country is allowed to catch be specified.

• ***Minimum mesh sizes****:* Ideally mesh size should be large enough to allow small, fast-growing, immature fish to pass through. These fish can then reach maturity, spawn and help replenish fish stocks.
• ***Closed seasons:*** This is the season of the year where fishing is not allowed, usually during the breeding season of a particular fish species.
• ***Exclusion zones:*** Designated areas in which fishing is banned completely.
(iii) Practicing fish farming. The deliberate cultivation of fish and shell fish so as to meet the high demands for fish.
(iv) To prevent discharge of untreated sewage and toxic industrial wastes into the rivers, lakes, seas to avoid occurrence of Eutrophication and algal blooms.

BIODIVERSITY/SPECIES DIVERSITY.

Biodiversity is defined as the variety of species on earth or the richness of the natural world. It includes ecosystem complexity, genetic variation, biochemical diversity and species richness.

Measurement of biodiversity

Species richness: Refers to the number of species present in a habitat. On its own, this is not usually a very clear indicator of the richness of a habitat.

Species diversity index: this is the most commonly used measure of biodiversity, it is calculated using the number of species present (species richness) and the abundance of each species. This can be calculated using **Simpson species diversity index (D)** which is one of the several mathematical formulae for calculating species diversity index.

$$\mathbf{D}=\frac{\boldsymbol{N(N-1)}}{\sum \boldsymbol{n(n-1)}}$$

Where,
D is the diversity index.
N is the total number of individuals of all species found.
n is the total number of individuals belonging to a particular species.
$\sum$ is the sum of, for all the individual species present in a habitat.

The species index can be related to the abiotic harshness of an environment for example during different stages of ecological succession or the level of pollution in an ecosystem. Generally, the species diversity is greater in habitats in which abiotic conditions are less demanding or in which pollution levels are lower.

LIMITATIONS OF THE SIMPSON SPECIES INDEX.

- It does not take into account the differences in sizes of the individuals.
- It is difficult to apply in determining the species index for plants because it is not always easy to decide what constitutes a plant.
- Some species index are based on biomass and do not depend on identifying individual species.

NOTE: The Simpson species diversity index is sometimes used as an indicator of ecological stability, the assumption being that the greater the diversity, the greater the stability. But stability of an ecosystem is defined in many other ways such as,

- ***Resistance***. The ability of an ecosystem to resist a change following a disturbance.
- ***Resilience***. The ability of the ecosystem to return to its original state after being changed.
- ***Local stability***. The tendency of a community to return to its original state after small disturbance.
- ***Global stability***. The tendency of a community to return to its original state after a large disturbance.

Each of these types of stability is sometimes but not always related to species diversity.
In ecological terms, a more complex community leads to a more stable ecosystem. Complex ecosystems with high species diversity were assumed to be more stable.

CONSERVATION OF GENETIC BIO-DIVERSITY.
Human activities and pressures have caused extinction of many species and put other organisms at the risk of extinction.
Extinction is the death of the only surviving member of a particular species in a population, resulting into the species being completely wiped out of the areas they recently inhabited and cannot be found in other likely habitats anywhere on the biosphere.
To prevent extinction of species, there is need to identify species of organisms at the risk of extinction. Four categories of risks must be identified.

(i) **Rare species**.

Are species of organisms with small populations either with widely scattered individuals or species restricted geographically with localized habitats. These species may become rarer but not under immediate threat of extinction.

(ii) **Vulnerable species**.

Species that have been seriously depleted in the past and have not yet recovered or species threatened with declining numbers or actually declining in numbers because of overexploitation, extensive destruction of habitats or some other environmental disturbance.

(iii) **Endangered species**.

Are species with population numbers so low that they are considered in danger of becoming extinct if the cause of their decline continues operating.

(iv) **Extinct species**.

Are species that have all died or perished and cannot be found in areas they recently inhabited nor be found in other likely habitats.

CAUSES OF EXTINCTION OR WHY ORGANISMS BECOME ENDANGERED.

(i) Natural selection. This is where organisms which are genetically better adapted survive and replace less adapted of other species.

(ii) Habitat destruction. Man's activities such as deforestation, industrial and agricultural development destroys natural habitats, sources of food, breeding sites for many species of organisms causing massive deaths.
(iii) Hunting and poaching for various reasons for example crocodiles for their skin, elephants for ivory, whale for oil and rhinoceros for their horns, on a large scale such activities can result into drastic decline in numbers of these affected species of organisms.
(iv) Pollution by extensive use of pesticides and other poisonous chemicals, Bioaccumulation of these toxic chemicals results in to massive destruction of many species of organisms along the food chains.
(v) Urban development.
(vi) Global warming.
(vii) Interspecific competition.
(viii) Bush burning.
(ix) Disruption of food chains by elimination of particular food sources in an ecological habitat.
(x) Increased predation.

CONSERVATION METHODS FOR PREVENTION OF EXTINCTION AND PRESEVATION OF ENDANGERED SPECIES.

(i) Protecting and restoring natural habitats or create new ones through mowing, grazing or burning to halt succession.
(ii) Restricting urban and industrial development
(iii) Establishing game parks, nature reserves, national parks and similar protected areas.
(iv) Practicing improved and nature friendly methods of agriculture and controlling impacts of modern intensive agriculture.
(v) Reduce use of pesticides.
(vi) Legally protecting endangered species
(vii) Restrict trade in endangered species.
(viii) Providing good breeding programmes for endangered species in zoos and botanic gardens.
(ix) Establish sperm banks and seed stores to maintain the full range of genetic diversity of species.
(x) Removal of animals from habitats threatened by man or natural disasters such as floods and resettled in more secure habitats.
(xi) Prohibiting the release of non-native animals and plants into an area
(xii) Ecological study of threatened habitats and careful analysis of all natural habitats in a way that permits conservation of maximum number of specie
(xiii) Controlling pollution, especially in sensitive environments in which species are at a risk of extinction.
(xiv) Recycling materials such as paper, glass bottles and clothes
(xv) Limiting exploitation of renewable resources to sustainable yields