NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF SCIENCE AND TECHNOLOGY

COURSE CODE: ESM 426

COURSE TITLE: BIOGEOGRAPHY

BIOGEOGRAPHY

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MODULE 1

THE ECOSYSTEM CONCEPT

Introduction

In this introductory lecture, I shall introduce you to the concept of the ecosystem which is very fundamental to the study and understanding of Biogeography and ecology. This discussion lay the foundation for other topics in this course.

Aim

To ensure full understanding of the ecosystem concept.

Objectives

At the end of this discussion, the student should be able to:

i. **Define the ecosystem concept**
ii. **Understand the structure of the ecosystem**
iii. **Identify different levels of organization in the biosphere**
iv. **Identify the components of the ecosystem and some of their characteristics**

The first basic (fundamental) biological concept to the study of Biogeography is the Ecosystem concept. The term ecosystem was first proposed by the British Ecologist A.G. Tansley in 1935.

The definition of the term ecosystem which is most appealing to us as Biogeographers is that given by E.P. Odum (1971) Odum defines the Ecosystem "as any area of nature that includes living organisms and non-living substances interacting to produce an exchange of materials between the living and non-living parts". In terms of structure, the ecosystem consists of 2 major parts:

(i) Physical, inorganic on abiotic part consisting of climate, soil, topography. The physical investment sets the character of the ecosystem

(ii) Biological, organic a Biotic part – made up of living things. This biotic part is made up of 3 major components

(a) producers – these are the green plants which available to fix radiant energy and convert it to chemical energy. This unique ability of green plant places it in a key position within the ecosystem

(b) consumers – These are the organisms animals which consume plants and animals.

(c) Decomposers in microconsumers or saprotropths – these are microorganisms chiefly bacteria and fungi, which act on dead bodies of plants and animals and break down their complex, absorbs some of the decomposition products, and release inorganic nutrients that are usable by the producers together with organic substances which may provide energy sources to be inhibitory or stimulatory to other biotic components.

The producers , consumers and decomposers together consist the living weight or bounces of the ecosystem biomass or standing crop in the total amount of all because of 2 major interactions – complementarity and balance of competition be no one species suffers or gains more than the other in any competition.

Ecosystems vary in size and can be studied at any scale. Ecosystems also vary continuously over space so that it is often difficult to define the spatial limits (boundaries) of Ecosystems. This is due to gradual and continuous variations in the physical environment.

Usually, there are transition zones across which ecosystems tend to merge into each other. These transaction zones are known as Ecotones. For example the mangrove forest is a transitional between the fresh water and salt water biocycles.

The ecosystem is the basic functional unit of study in ecology and biogeography. This is because it includes both living organisms and physical environment each influencing the properties of the other.

Within an ecosystem, all the living things are living in harmony because

(i) they can tolerate each other

(ii) they are inter-dependent

The concept of the ecosystem is of importance in biogeeographical thoughts because of its value, in emphasizing integrating relationships, interdependence and causal relationships among the various components of the national environment.

The ecosystem is also the level of biological organization most suitable as an analytical technique in biogeographical studies.

The ecosystem is a valuable concept by which we try to understand the nature and functions of the biosphere.

An ecosystem in a steady state is self-regulating. This property of self-regulation is technically termed Homestasis

Ecosystem in a steady static is relatively stable over time.

Finally, it has capacity for adaptation.

Conclusion

The ecosystem concept is basic to biogeographical and ecological studies. The concept integrates all the components of the natural environment including man. In nature, ecosystems vary in size and can be studied at any scale. Ecosystems also vary continuously over space so that it is often difficult to define the spatial limits (boundaries) of ecosystems. It is a valuable concept for studying and understanding the components and functioning of the biosphere.

References:
1. Tivy, J.: Biogeography: A Study of Plants in the Ecosphere, Oliver & Boyd, 1977
2. Molles, M.C.Jr.: Ecology: Concepts & Applications, McGraw Hill, 4th.Edition, 2008
3. Simmons, I.G.: Biogeography: Natural and Cultural, Edward Arnold, London, 1979
3. Tivy, J.and O'Hare, G: Human Impact on the Ecosystem, Oliver&Boyd, 1981

MODULE 1UNIT 1

STRATEGY OF ECOSYSTEM DEVELOPMENT

Introduction

This topic introduces the student to how natural ecosystems develop in geographic space. It identifies and discusses the different types of development, the various factors and processes involved.

Aim

This topic aims to enlighten the student about process of ecosystem development

Objectives

At the end of this discussion, the student should be able to:

i. **define ecological succession**

ii. **identify the different types of succession**

iii. **identify the various stages of ecological succession and the various factors involved**

The process of ecosystem development or ecological succession is an orderly process of community development which involves changes in community structure and composition over time. Through continuous replacement of one group of plants and animals by another other partly or completely. The process often results from changes and alteration in the physical environment brought about by the living organisms. The physical environment may however determine the form, the rate of change and the extent to which the development can go. The process usually ends with a relatively stable ecosystem which is in equilibrium with the physical environment.

Any particular sequence or serves of communities replacing one another in terms in a given habitat is called a sere. The relatively transitory communities are variously called seral or developmental stages while the complete sequence from bare soil to a final relatively stable forest or savanna or grassland is called a primary sere or pressure.

Ecological succession usually starts on freshly exposed sites such as land, volcanic ash, filled-up lakes etc.

The site is first colonized by simple quickly growing plants which make little demands on the soil. The pioneer plants modify the physical environment and improve the soil for other incoming plants and animals. Herbaceous plants usually come before woody ones. Woody species of trees overshadow the pioneer plants by cutting off light to the undergrowth. These earlier trees may also be stappessed and replaced by bigger and shade-bearing species.

Several communities continue to succeed one another in the way until the lobtat is finally occupied and dominated by the largest and biggest lied trees. This final biotic community which has achieved maximum biomass possible and is relatively stable over time is known as the climax community.

As the ecosystem development and more spreads are added so that there is species enrichment and increased structural complexity.

Ecological succession starting on a rock or dry musical soil is known as xerosere while that beginning order water or on permanently wet soil is known as hydrosere.

MODULE 1 UNIT2

Climax Concept and Ecosystem Stability

A succession added up with a biotic community in which the species perpetuate themselves through the climax such a community is referred to as the climax community

Species composition remains the same over a big period of time.

The climax stage is indeed a stage of relative and static.

The species of plants and animals within that community are in a state of dynamic balance with one another.

The climax can also be interpreted from a functional point of view to other words, the climax stage can be looked at in terms of relationship between Gross production and respiration.

In the early stages of succession, it is necessary that grass production is considerably higher than respiration. This is the only way in which the community can grow. As the climax stage in approached, the gap between gross production and respiration narrows down. At the stage of climax, there is a balance between grass production and respiration. This conforms to the concept of steady state of ecological system in which input and output balances.

Many theories have been proposed to explain the nature, composition and factors most important in determining the climax. F.E. Clements believes that within a given region, all succession will and up with the same type of climax which is climatically determined regardless of whether the succession starts in water or on the rock or land. The idea is known as the monoclimax hypothesis. Although this hypothesis is convincing because of its simplicity but its validity had been called to question by later investigators.

It is now known that differences in soil, rock-type, relief, ground drainage can all lead to variations in climax community even in the same climatic regions. In other words, within a given climatic climax, there are several climaxes which are related to various local conditions such as soil, relief and topography. This is the polyclimax hypothesis. According to this hypothesis the climatic climax is a mosaic of smaller climaxes that are related to local conditions.

Climax related to soil is known as Edaphic climax, that which is related to relief in Physiographic climax. The climax that living organisms in an ecosystem. The biomass of an ecosystem is related to a no. of factors. Most important of these are (a) the type of organisms (b) the nature of the surrounding environment (climate and soil in particular) to the section of the year (d) stage of development (e) nature of human activities

The balance is achieved in conditioned by activities of animals and as constant growing in known as biotic climax. A fire climax or plagoclimax may be produced in an area that is exposed to frequent fires particularly in dry climates. In such communities subjected to periodic burning or controlled by fire, species that are not fire resistant (fire-tenders) are eliminated while fire-resistant species predominate.

MODULE 1 UNIT 3

Concepts of ecosystem Stability and Fragility

Stability is one of the most important features of ecosystem regulation. Stability is the inherent capacity of an ecosystem to maintain relatively constant state in terms of its species, composition, biomass and productivity, with minor fluctuations around the steady (equilibrium) state, and to return to its steady state fairly rapidly after internal or external disturbance.

Although it was originally believed that the stability of an ecosystem is dependent on change number of species as a high degree of structural complexity, it is now, however known that there is no consistent causal relationship between stability and diversity and that ecosystem complexity may in certain orientation more act to reduce stability. In other words, in some cases, more complex ecosystem tropical ecological) may be less able to withstand the assaults of human than simpler ones (e.g. temperate).

A related concept is that of fragile. Fragility is the ease with which an ecosystem can be disrupted. The concept of fragility is an aspect of ecosystem regulation more replaced to human activities.

Fragility is dependent on two factors

(i) the ability of an ecosystem to prevent and maintain itself in the face of disturbance caused by weather or climate, chemical features, organisms or man. This is known as the Relative resilience of the ecosystem.

(ii) the ability of an ecosystem to maintain itself inspite of disturbance will be determined by (a) that extent to which the ecosystem can deviate from the equilibrium point before total disruption or replacement by another system. This is its amplitude. (b) how fast the ecosystem can recover from disturbances. This is its elasticity.

The relatively resilience of an ecosystem will depend on the weakest component or link within the ecosystem.

(2) Fragility is a less dependent on the type of disturbance in terms of intensity a duration to which the ecosystem is adopted. While different ecosystems cannot withstand minor disturbance, other ecosystems require periodic disturbance to perpetrate themselves. (Example is the Northern boreal forest which required periodic fire to reverse self-imposer climatic a soil condition inimical to the germination of their sun seed and create light conditions necessary for rapid seedling growth)

Man, through his various activities often disturb natural ecosystems. In fact, there are few areas of the earth's surface which have not been affected directly or indirectly by man's activities.

MODULE 1 UNIT 4

Fragile and Resilient (Durable) Ecosystem

Fragile ecosystems are those which are delicately balanced and easily vulnerable to disturbances. They are usually those with a high proportion of their nutrient and energy store in the above-ground biomass, those on young, unstable soils; those with limited area content of islands.

The most fragile of the ecosystems in the world is the tropical rainforest. Its high vulnerability to disturbance is related to (i) presence of several species with low populations, low seed production and poor dispersed capabilities.

A large proportion of the biomass is above ground biomass because of the shallow root system. In other words, almost the entire energy nutrient pool is concentrated above ground.

An example of a fragile ecosystem on young, unstable soil the arctic tundra ecosystem. The ecosystem, unlike the tropical raining forest is very young and comparatively simple in its fragility is due to its small number of plants and more particularly soil species, the wide fluctuations of its bird and mammal populations.

Its fragility is however more related to the soil conditions then with the nature of the biomass. This is use and soil levels, except the surface layer remain fragile all year round. Rates of biologically production and decomposition are characteristically low.

Island ecosystems are also fragile. An island ecosystem is one which is surrounded by a different habitat, in which its species will find it difficult to survive a foil to survive and which is a wide enough to form an effective barrow to migration.

Oceanic islands are particularly more vulnerable to human disturbance. Their relative fragility is due to their small size, the violation and distract to mainland, small number of species and ecosystem simplicity.

MODULE 1 UNIT 5

Resilient (Durable) Ecosystem

Resilient ecosystems are more durable and robust in the face of environmental and human induced disturbance, able to persist under difficult conditions and recover more rapidly from stresses.

Resilience is dependent on the strongest component or link in the ecosystem. Resilience is balanced by (i) a wide range of tolerance and adaptations by organisms to environmental stresses e.g. and diserts; (a) a large proportion of biomass located below the ground as a types of perennial herbaceous vegetations and (3) a continual supply of energy and nutrients into the ecosystem as in existences.

Examples of a resilient ecosystem is the arid desert,

Although the arid desert has the smallest business and the lowest biological productivity of all land ecosystems, it is one of the most resilient and aggressive ecosystems.

The resilience is due to its adaptation for survival in a particular difficult and useful environment, its soil conditions and the ability of plant and animal life to survive in often extreme and prolonged drought. The desert soil can, to a greater or lesser extent act to temporally water store by strong water at a depth of 22cm at which direct evaporation of water is less effective. The ability of plants and animals to survive drought is more important for the resilience of the ecosystem as a whole.

The semi-Natural permanent grassland is an example of a resilient ecosystem dependent on high durable below-ground biomass. The root system guarantees is a continual supply of organic matter to the soil. This supply of organic matter to the soil makes the bleak earth, (chernozem) of grass lands particularly cost temperate climates (semi- arid prairies and step as and particularly much and efficient nutrients store. This underlines the grasslands ability to recover after heavy use or after destruction of surface biomass.

The estuary (semi-enclosed body of water which has force connection with the open sea and is affected by tidal action) is an example of a potentially relevant ecosystem in terms of continual input of nutrients. The estuary environment is however a biologically difficult and plentiful environment because of the physicist instability and the extreme range of variations in environmental condition.

References:

1. Tivy, J.: Biogeography: A Study of Plants in the Ecosphere, Oliver & Boyd, 1977
2. Molles, M.C.Jr.: Ecology: Concepts & Applications, McGraw Hill, 4th.Edition, 2008
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MODULE 2

Energy Flow in the Ecosystem

One of the 2 major ways in which the ecosystem function is through the flow of energy. Energy flow is the also the first major link between the components parts of the ecosystem.

This flow of energy from the solar to the earth system is the basis of life and all ecological systems in the earth surface.

There are various sources of energy for the ecosystem but the most important of all is the energy from the sun supplying over 97% of total energy used in the ecosystem.

Geothermal energy – from inside the earth's const. It is important in areas of volcanic activity

Cosmic Energy-from outer space and the amount is very small. It is important in mountainous areas

Solar energy is the most important form of energy. The temperature of the sum is estimated at 6000^{o}C and is therefore able to give off lots of energy in form of electromagnetic waves. The energy from the sum reaches the outer edge of the atmosphere at a constant rate of 2cd per sq.cm. per minute. Then value is known as the solar constant. Only about 67% (1.34 cal per sq. cm/minute) of the amount may however reach the earth's surface.

Part of the energy reaching the earth's surface is fixed by green plants to manufacture highly complex organic substances from simple inorganic substances. The complex organic substances provide the food energy necessary not only for the growth of plants but for the maintenance of all other forms of life on earth.

This process is known as photosynthesis.

$$6CO_2+2H_2O + 673kcal \longrightarrow C_6H_{12}O_6 + 6O_2+6H_2O$$

The chemical energy produced is stored in the form of organic matter by the autotrophs.

The entire process by which radiant energy is forced and eventually converted into organic matter is referred to as Biological Production. Because this production is at the level of autotrophs (green plants), it is referred to as primary Biological Production. Since the time element is involved in the process of biological production, it is usually measured in terms of the role at which it is taking place. Thus, the term Primary Productivity is used to refer to the rate of primary production.

The total amount of potential food energy produced by green plants is known as Gross Primary Production. Its rate of production is known as Gross Primary Productivity. The plant uses part of this energy for its metabolic processes by breaking down chemical energy during respiration. The amount left after respiration is stored in plant to build to plants body and which eventually provides food for animals. The amount of energy left after respiration is known as Not Primary Productivity or Not Assimilation'. The living weight for an organism such as plant is referred to as BIOMASS

The energy that is stored in plant tissues is passed from the plant-eating animals or herbivores to the meat consumers or carnivores and eventually to decomposers such as bacteria and fungi which act on dead bodies of plants and animals to release nutrients. The process of food energy transfer from the plants through a series of organisms with respected eating and being eaten is referred to as the food chain.

In the transfer from one level to another, a large amount of the energy is lost such that there is rapid shrinkage of the original food energy stored by plants. As a result, the shorter the food chain, the greater the amount of energy available. In fact, food chains can rarely be composed of more than four or five levels or links.

There are two basic types of food chain.

(i) The grazing food chain which state from green plants to herbivores and on to carnivores

(ii) The detritus food chain which goes from dead organic matter to micro-organisms and then to detritus feeding organisms and their predators

Since feeding relationships are inn reality not a simple and one type of plant may provide food for several different types of animals, food chains are always interconnected with one another to form the food web.

Each stage in the food chain is referred to as Trophic level

Trophic level 1 (T1) is usually the level of the producers or autotrphs

Tropic level 2 (T2) is the level of Herbivores which consume plants

Trophic level 3 (T3) is the level of the carnivores which consume herbivores e.g. wolf

Tropic level (T4) is the level of Top carnivores which consume other carnivores e.g. Lion

Trophic level 5(T5) is the level of micro-organisms referred to as decomposers.

A food chain may contain two to 5 trophic levels man as an omnivores can be placed in the herbivore on carnivore level.

Two important laws help to explain energy flow. These are 1st and 2nd laws of open system thermodynamics. First is the law of conservation of energy states the energy may be altered from one form to another but it is neither created nor destroyed. Inputs = output

Some law states that no process involving energy transformation with a spontaneously occur unless the energy is first degraded from concentrated to its dispersal form.

In the words before energy conversation can take place the energy must first be broken down to its elements and the new form synthethesized

In the process of degradation of energy, there is some dissipation of energy. This dissipation of energy is referred to as Entropy. Entropy is a state of losing energy or a measure of disorder. It is not an amount or quantity of energy. As a result of entropy, the energy available to the ecosystem decreases during the food chain.

Apart from respiration, there are other ways by which energy is lost along the food chain.

i. Energy taken in but not utilized – NU
ii. Energy not assimilated-NA

The efficiency of the various tropic levels in converting energy is a very important issue in energy flow. It is this possible, using certain parameters, to indicate the efficiencies of energy conversion in the ecosystem. These parameters, particularly ratios between energy flow at different levels of the food chain expressed as percentages are referred to as Ecological Efficiencies

There are various types of ecological efficiencies. Two of these are

(i) Efficiency of energy fixation by Autotrophs – this is calculated by expressing gross primary production as percentage of incident solar radiation.

$$= \frac{\text{Gross Pri Production}}{\text{Energy incident}} \times 100$$

On the global level, the efficiency of energy fixation is about 1%. In some part of the ocean, the efficiency may be as long as 0.18%

Assimilation Efficiency of Autotrophs i.e. how much energy remains after respiration

$$\text{Assimilation} = 100 - \frac{\text{Energy loss than respiration}}{\text{Gross Primary Production}} \times 100$$

The ratio of energy utilization between one trophic level and another is also of ecological interest.

We can compare energy intake in one level with another using:

$$\frac{It}{It-1} \times 100 \quad \text{e.g. Trophic level z : } \frac{It(z)}{It} \times 100$$

$$\text{Trophic level 3: } \frac{It3}{It3-1} \times 100$$

Assimilation efficiency in one level can also be compared with another. $\frac{At}{At-1} \times 100$

Flow of energy in the ecosystem can also be shown with the use of ecological pyramids. The pyramids however provide a static picture of a dynamic process of energy flow.

There are 3 main types:

1. pyramid of numbers
2. pyramid of biomass
3. pyramid of energy

In pyramid of numbers, the number of organisms is simply counted and pyramids are constructed on the basis to the total number of organisms at a level.

The pyramid of biomass is constructed on the basis of organic matter in each trophic level.

In pyramid of energy………

References:

1. Tivy, J.: Biogeography: A Study of Plants in the Ecosphere, Oliver & Boyd, 1977
2. Molles, M.C.Jr.: Ecology: Concepts & Applications, McGraw Hill, 4^{th}.Edition, 2008
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MODULE 3

POPULATION AND COMMUNITY ECOLOGY

Introduction

This topic introduces the student to the structure and functioning of ecological populations and communities. The various attributes of population and individuals composing them shall be discussed. The will also be introduced

Aside from energy flow, nutrient cycling and environmental factors, the group of organisms and their interaction constitute one other major control in the ecosystem

Each ecosystem is made up of groups of plants and animals often referred to as biotic communities. A biotic community is any group of populations of plants and animals living in a given area or habitat.

The biotic community is the living component of the ecosystem and functions as an organized unit.

The biotic community concept emphasizes that all the diverse forms of life live together in an orderly manner as interacting and interdependent organisms rather than as independent entities.

Within each biotic community not all organisms are of equal importance in determining the form and activities of the entire community. Certain species often exerts the major controlling influence as a result of their numerical strength, size, production etc. Such species or group of species which largely control energy flow, nutrient cycling and strongly affect the environment of all other species are known as ecological dominants. For example, trees because of their size and longevity are the ecological dominants in the forest ecosystem.

Each community is made up of smaller, homogenous units referred to as species population.

The species population is a collective group of individual organisms (plant or animal) occupying a given area.

Members of this same species population usually have the same external appearance, are able to interbreed among themselves and have the same ecological requirements.

In other words, there is a certain probability that certain species will occur together.

The species population has individual as well as collective characteristic or biological attributes. In other words, a population has characteristics it shares with its component organisms and also characteristics which are unique to the group as a whole. For example, the population just like each organisms grows, reproduces and maintain itself while such characteristics as birth rate, death rate are applicable only to the group.

Thus, a species population in regarded as a real entity in nature because it possesses characteristics which are additional to the characteristics of the individuals composing it.

Some of these characteristics include:

Population size, population density, natality (birth rate), mortality (death rate), growth rate or form, age distribution or age-sex structure.

Population size: This is determined by carrying out a census or total count of all the individual organisms in the population. Unfortunately, total count may sometimes be problematic especially when dealing with animals which are not fixed in space. So very often, a sampling of the population is done and the total population is estimated from the sample.

Sampling may be done on two ways:

(i) Numerical sampling i.e. controlling of numbers within a defined part of the community

(ii) Biomass sampling in which we estimate the dry matter weight of organisms

Numerical sampling is valuable where the individuals do not vary much in size. However, where the individuals vary greatly in size, the biomass sampling is better.

Population Density: This involves the consideration of area of space occupied by the species population. It is generally expressed as the number of individuals or population biomass per unit area or volume.

A distinction is usually made between crude population density and ecological population density.

In crude population density, we consider the total land area irrespective of inhabitable or habitable parts.

In ecological population density, we consider only the habitats areas i.e. the part that can be actually colonized by the organisms of the total land area.

Population density is important in that it determines the extent to which the population would affect the habitat

More important than the population density is the way the population is changing over time. In other words, the change of size within the population over time. In monitoring change in population size, indices of relative abundance are used.

One such parameter is

Growth Rate of Population: This is the number of individuals added to the population per unit time. It is usually calculated by dividing the population increase by the change in time (time elapsed).

Growth Rate = $\frac{\Delta N}{\Delta t}$

Then can be expressed in graphical form

DRAWING

The shape of the wave gives an idea or measure of growth. The steeper the slope, the higher the growth rate

Specific growth rate is obtained when the change in population per time is related or divided by the original population i.e. number of organisms initially present.

Specific growth rate is the number of organisms added per unit time per individual organism

Specific growth rate = $\frac{\Delta N}{\frac{\Delta t}{N}}$ *or* $\frac{\Delta N}{N\Delta t}$ *or* $\Delta N / (N\Delta t)$

Specific growth rate is useful when populations of different sizes are being compared.

The growth rate of a population is influenced to a great extent by Natality and Mortality

Natality is the inherent ability of a population to produce new individuals and hence increase Natality is determined by the number of new individuals produced per unit time.

Absolute Natality Rate = $\frac{\Delta Nn}{\Delta t}$ ΔNn = new individuals

If we divide by the original population we get specific natality $\frac{\Delta N}{\frac{\Delta t}{N}}$ *or* $\frac{\Delta N}{N\Delta t}$

Specific Natality is the number of new individuals per unit time per unit of population.

It should be noted that although the same notations may be used for both natality rate and population growth rate, the two are different because ΔN present different values in the two situations

In Natality, ΔNn = new individuals added

Natality rate can never be negative, it is either positive or zero.

Growth rate ΔN represents the net increase or decrease in the population. The net increase or decrease results not only from natality but from mortality, emigration, immigration. Thus, growth rate may be either negative, zero or positive. this is because the population may be either decreasing, standing still or increasing

Natality can be expressed in two ways:

iv. Potential or maximum natality

v. Actual or realized or ecological natality

Potential or maximum natality is the maximum production of new individuals that is theoretically possible to achieve under ideal conditions i.e. when no limit is imposed by ecological factors.

Potential or maximum natality is important in that it provides a standard against which the actual natality can be measured. Secondly, it is used for predicting the possible rate of increase in the population.

Mortality refers to death of individual organisms within a population. It is measured in terms of the numbers of individuals in a given period i.e. death per unit time.

Potential mortality is the minimum number of deaths possible theoretically under ideal conditions. In other words, under the best conditions, death could still occur as a result of old age-which….

Actual or Ecological mortality is the actual number of deaths under prevailing conditions.

Specific mortality is the percentage of the initial population dying within a given time.

Since mortality is known to vary greatly with age particularly in higher organisms, it is possible compile relate mortality to age groups by compiling a life table.

Since we are often more interested, in organisms that survive, it is sometime more practical to express mortality in terms of reciprocal survival rate.

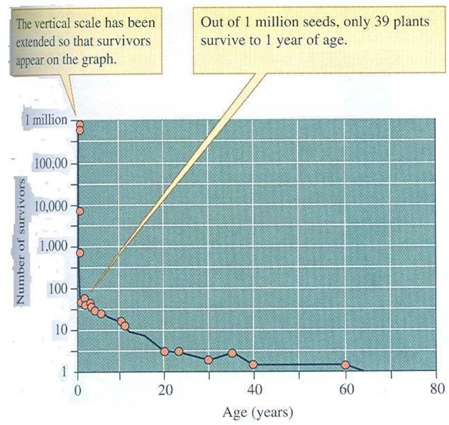
Survival rate can be expressed in a graphical form showing number of survivors per 1000 against age group to give Survivorship curves

Survivorship curves are of three types.

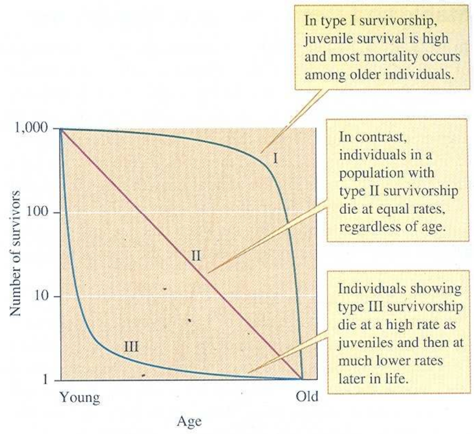
(i) Highly convex curve which is characteristic of species such as the Dall sheep, in which population mortality rate is low until near the end of the life span (in adult) e.g. man.

(ii) Highly concave curve in which mortality is high in the young stages of oysters and oak trees

(iii) A diagonal straight line showing a nearly constant age-specific survival rate. This is however very rare in nature



A high rate of mortality among the young of a perennial plant, *cleome droserifolia* (data from Hegazy 1990).



Three types of survivorship curves.

To allow comparisons to other studies, number of Dall sheep surviving and dying within each year of life is converted to numbers per 1,000 births.

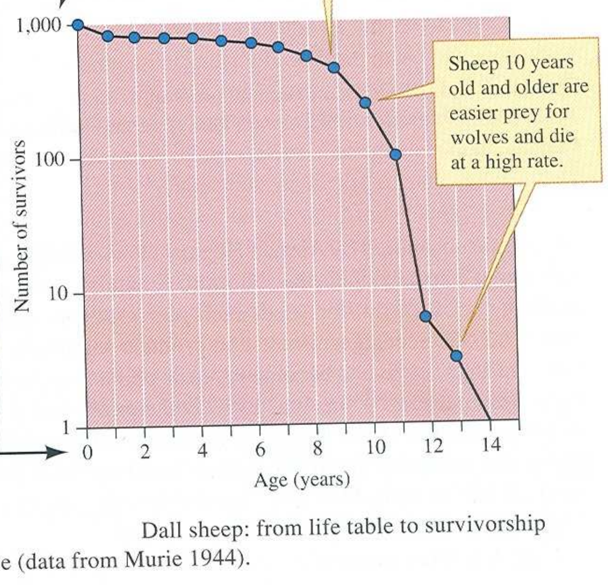
Subtracting number of deaths from number alive at the beginning of each year gives the number alive at the beginning of the next year.

Age (years)	Number of survivors at beginning of year	Number of deaths during year
0–1	1,000	199
1–2	801	12
2–3	789	13
3–4	776	12
4–5	764	30
5–6	734	46
6–7	688	48
7–8	640	69
8–9	571	132
9-10	439	187
10–11	252	156
11– 12	96	90
12–13	6	3
13–14	3	3
14–15	0	

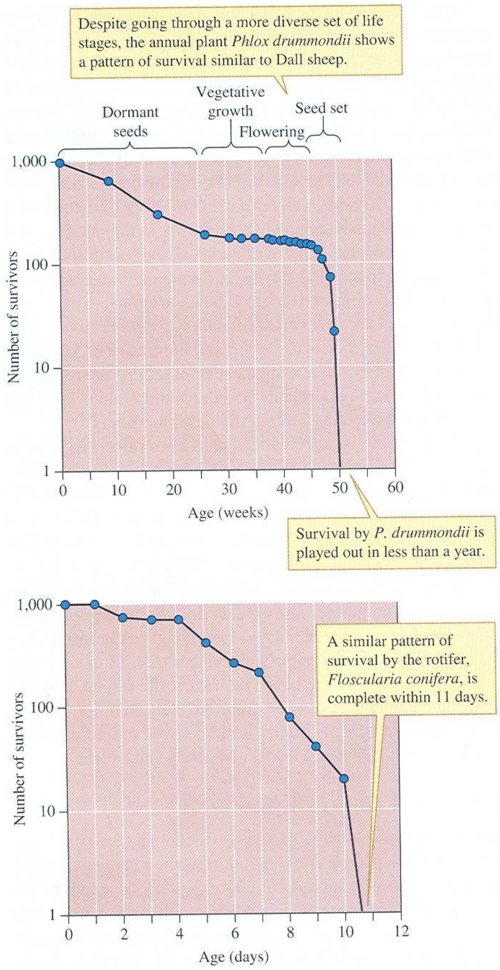
1,000–199
801–12
789–13
etc.

Plotting age on the x-axis and number of survivors on the y-axis creates a survivorship curve.

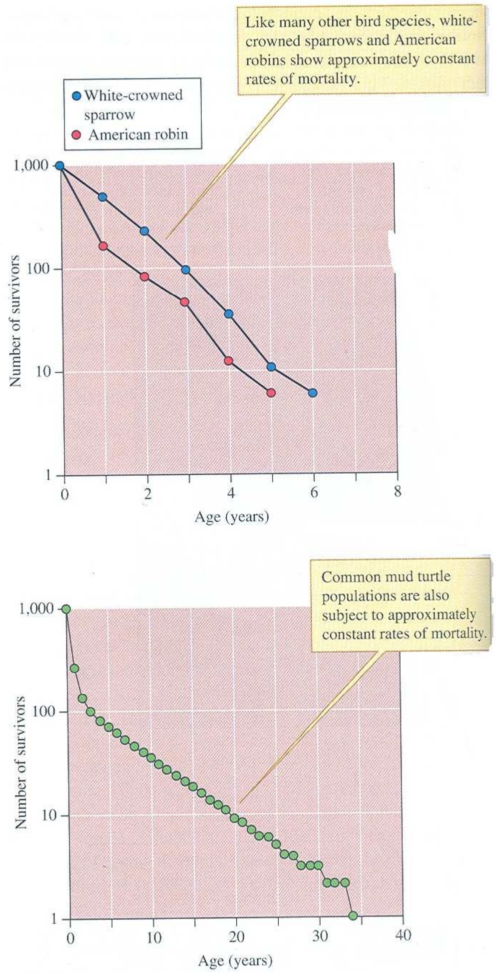
Dall sheep surviving their first year of life have a high probability of surviving to about age 9.



Dall sheep: from life table to survivorship curve (data from Murie 1944).



High rates of survival among the young and middle-aged in plant and rotifer populations (data from Deevey 1947, *bottom*, Leverich and Levin 1979, *top*).



Constant rates of survival (data from Deevey 1947, Baker, Mewaldt, and Stewart 1981, Frazer, Gibbons, and Greene 1991).

Life tables and survivorship curves help to determine life expectancy. Life expectancy is about 45-47 years in Nigeria.

Population Age Structure – Age distribution in any population in an important factor which influences birth and death rates. The ratio of the various age groups may indicate the current reproductive status of the population.

A large proportion of young individuals indicates a rapidly growing or expanding population while a large proportion of old individual indicates a declining population.

Ecologically speaking, there are 3 important types of ages. These are:

Stable age distribution may be determined using life stable data knowledge of its specific growth rate.

1. Pre-reproductive age
2. Reproductive age
3. Post-reproductive age

The age structure of a population can be shown in form of a polygon or age pyramid. In constructing an age pyramid, the percentage or number of individuals in the different age classes are shown by the relative widths of successive horizontal bars.

There are three hypothetical pyramids

(a) a broad-based pyramid which indicates a high proportion of young individuals

(b) a bell-shaped polygon showing a moderate proportion of young to old

(c) an un-shaped figure indicating a low percentage of young individuals.

There are 2 opposing factors controlling the growth of population:

1. Inherent ability to grow

The maximum growth rate of a population under ideal conditions is known as “Biotic or Reproductive Potential. At that rate, growth rate is as high as possible and death rate is a low as possible. It is however very rare for a population to achieve its biotic potential because of an opposing force. This opposing force is

2. iInherent capacity for death

The capacity for death is caused by the regulatory effects of the physical forces of the physical environment. This inherent capacity for death is caused by the sum total of environmental limiting factors which prevents the biotic potential from being realized. These environmental limiting factors are collectively referred to as Environmental Resistance.

In addition to the two opposing forces mentioned earlier there are other factors which influence and control the growth of population. These are

(i) Population dispersal or dispersal of organisms

(ii) Competition between organisms

Dispersal of population is the movement of individuals or their propagules (e.g. seeds, spores, larvae etc) into or out of the population or population area. Dispersal is influenced by barrows and ………

There are 3 types of dispersal of population

(a) Immigration –one way inward movement of organism into a population

(b) Emigration – one way outward movement of organism

(c) Migration – this implies a rhythmic or periodic in and out movement of organisms.

Competition exists in all ecosystems. It may be between plants, between animals or between plants and animals

Competition between organisms can take 2 forms:

Intraspecific competition – this is competition between members of the same species

Intraspecific competition – may occur in the form of a direct competition between large numbers of organisms. In the process, the weakest are eliminated and the strongest survive. This type of competition often results out of a need to conserve available resources. Secondly, intraspecific competition may cause as a result of struggle for space. This is common among higher animals while forest trees compete for space.

Individuals or family groups of veritable and hypher invertebrates commonly try to confine their activities to a definite area known as Home Range. If the home range is actively defended against any intruder, the home range becomes a Territory. The act or habit of defending the home range or area of activities of an organism is known as Territorially. Territorially often arises out of the need to have more specific or isolation. Many animals particularly vertebrates and certain anthropoles whose reproductive behaviour patterns involve nest building, egg laying, and core and protects of the young for example, birds practice it during their breedy season.

In higher animals, territorially is often achieved through behaviour pattern while in line plants and animals it is chemical.

Isolation which results from territoriality reduces competition helps to conserve energy during critical periods and prevents over crowding and it also helps to prevent exhaustion of food supply i.e. the case of animals or nutrients or light in the case of plants.

Interspecific competition – this is usually most intense between closely related speices who are in the same genus. Interspecific is the active demand by 2 or more species at the same trophic level for a resource that is actually or potentially limited.

Interspecific competition is best explained and understood in terms of ecological niche. Every organism has a role to play in the ecosystem and this role determines the status of the organism.

Ecological Niche to the functional role or status of an organism or species within an ecosystem

(i) the physical space occupied by an organism – spatial or holistic niche.

(ii) Functional role in the community – the trophic nioche

(iii) Its position (status) in environmental gradient of ……..

Broadly speaking, the ecological niche of an organism ….. is not only on where it lives but also on how it transforms energy, behaves, responds to and modifies it physical and …….. and how it is affected by other species.

The concept of ecological niche is most useful when attempting to quantitatively differentiate between different species or the same species at different locations.

Organisms that have the same similar ecological niches in different geographical regions are known as ecological equivalents.

Interspecific competition therefore implies that different species can have identical ecological niches.

Interspecific competition can have positive or negative effects on organism within a population.

Negative Interactions include:

(i) Parasiticism (b) prediation (c) Ahtibiotics or allelopathy

In the first 2, one organism feeds on another.

In parasitism, a smaller organism is feeding on a bigger one while predation refers to the feeding of large organism in smaller ones.

Antibiosis is a situation in which one population produces substances or chemicals which are harmful to a competing population. Allelopathy is used to describe such a situation in plant communities.

Positive Interaction include

Commensalism (b) proto-corporation (c) mutualism

Commensalism is a type of interaction in which one population benefits and dominates while the other is not adversely affected. Commensalism is a simple type of positive interaction and perhaps represents the first step toward the development of beneficial relations. It is common between sessile plants and animals on the one hand and motile organisms on the other. An example is when oysters provide shelter for small crabs.

Proto-cooperation- when both organisms benefit more or less equally but the relationship is not obligatory. An example is when concentrates provide protection for crabs while the coelenterates are transported about by the crab. In the type of relationship, neither organism is completely dependent on the other.

Mutualism or Obligate Symbiosis – in the type of relationship, both organisms benefit and organisms are completely dependent on each other. Mutualism is most likely to develop between organisms with widely different requirements. The most important example of mutualism is that between autotrophs and heterotrophs.

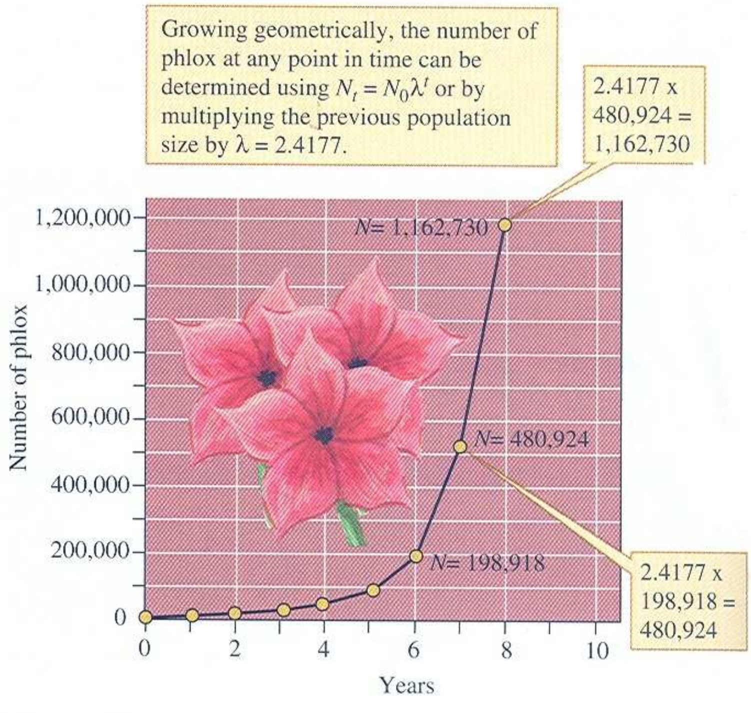
Population Growth form

As a result of the interplay of the factors of the environment and interaction between organisms, every species population develops a characteristic pattern of increase. This characteristic growth pattern is known as Growth form.

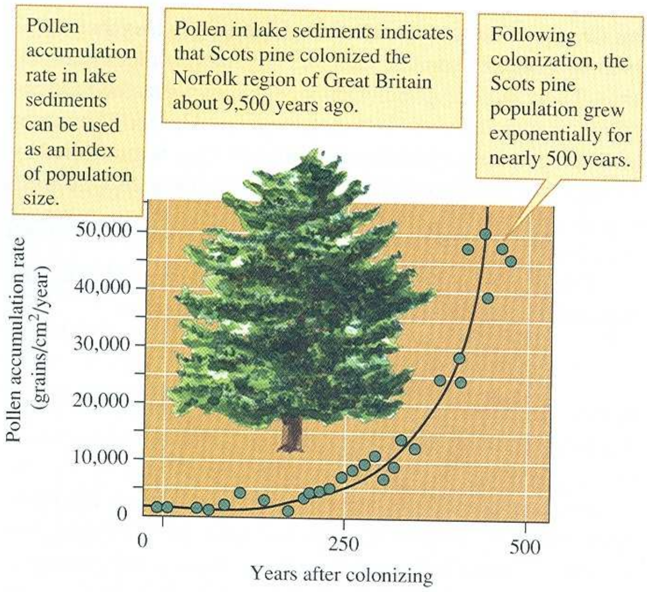
Biologists recognize 2 basis growth forms.

a. J – shaped growth form (b) S-shaped growth form

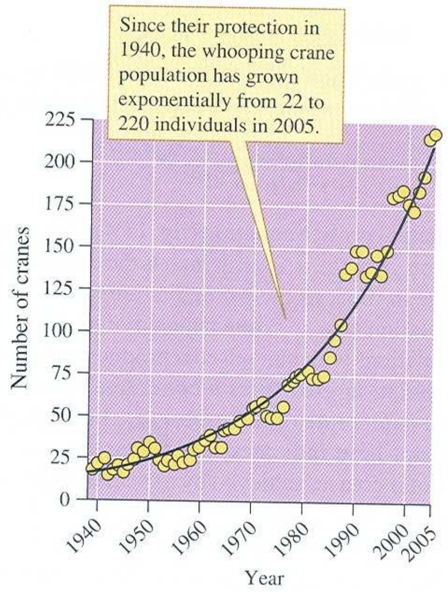
In J-shaped form, population increases rapidly and then stops suddenly as environmental resistance sets in. Although this is not a common growth form, some insects and micro-organisms are known to have the J-shaped growth form.



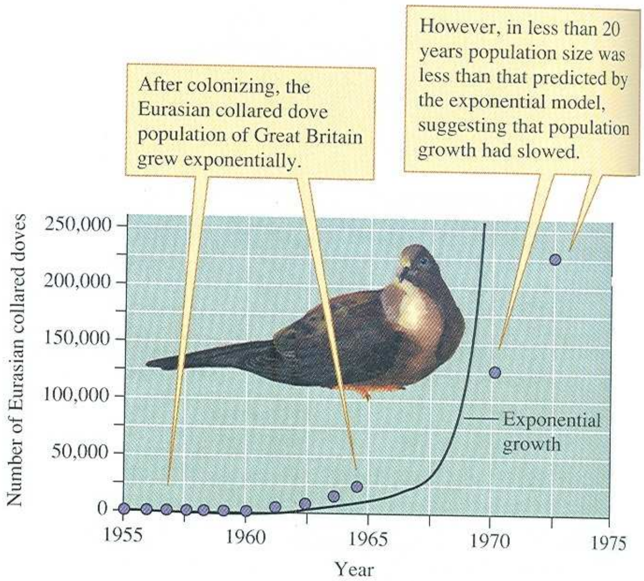
Geometric growth by a hypothetical population of *Phlox drummondii*.



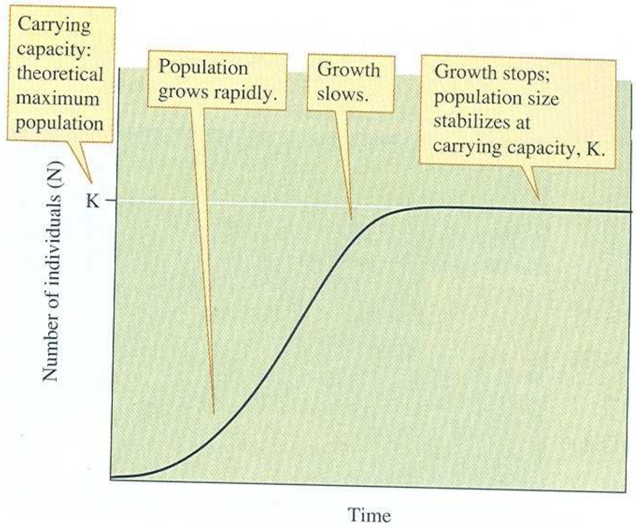
Exponential growth of a colonizing population of Scots pine, *Pinus sylvestris* (data from Bennett 1983).



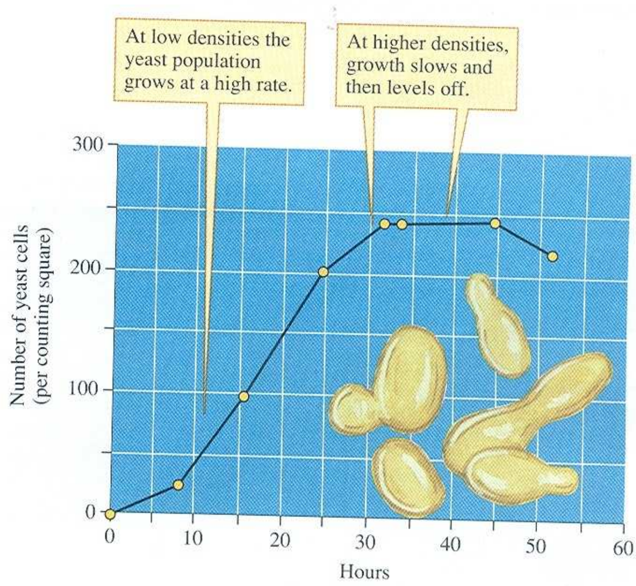
Hunting and habitat destruction reduced the whooping crane, which is endemic to North America, to a single natural population. Protection and intensive management of this population has led to its dramatic recovery (data from USGS 2005, USFWS Whooping Crane Coordinator).



Exponential growth of the Eurasian collared dove population of Great Britain (data from Hengeveld 1988).



Sigmoidal, or logistic, population growth results from environmental limitation on population size.



Sigmoidal growth by a population of the yeast *Saccharomyces cerevisiae* (data from Gause 1934).

In S-shaped, the population grows slowly at the initial stage until the threshold is reached. This initial stage is known as establishment or positive acceleration phase. There is rapid increase after the threshold and the stage is known as Logarithmic phase. The population increases until a point is reached when the resources available are just sufficient for the size of population. At that point the population is said to have reached its carry capacity beyond the point, population growth declines gradually. This is the Negative acceleration phase. The population later attains its equilibrium level

MODULE 4

THE FOREST ECOSYSTEM

INTRODUCTION

This lecture discusses characteristic structural and functional attributes of the most extensive terrestrial ecosystems in the world. We shall discuss the general characteristics of the forest ecosystem and then focus on the distinguishing characteristics of forest ecosystems in tropical and temperate environments.

OBJECTIVES

At the end of this lecture, the students should be able to:

1. **Identify the geographic distribution of forest ecosystem and the factors responsible**
2. **Identify and describe the sub-divisions of forest ecosystem**
3. **Describe the differences in the structural and functional characteristics of the different forest types.**
4. **Have some idea about energy flow and nutrient cycle in the forest ecosystem**
5. **Explain why trees are the dominant plant species in the forest ecosystem and why forests are difficult to regenerate.**

The forest ecosystem is the most extensive, most complex and also the most biologically productive of all terrestrial ecosystems in the world. Although the forests on the earth's surface have been reduced to almost half their original extent, they still cover on area greater than that of the world's agricultural lands. This is because they are able to occur over a wider ranger of ecological conditions than any other type of vegetation.

Also more than any other ecosystem, it exerts a very great influence on the atmosphere and the soil. The forest is able to create its own microclimate.

Forest are dominated by woody plants and of the woody plants, the trees are by far the most important. In fact, ecologically trees dominate forests. Trees are also the most important economically because for the various uses to which they can be put and their products particularly timber.

Two important characteristics, which also distinguish them from other types of plants, account for the dominance of trees. These are (1) size (more particularly height), (ii) longevity. The life-span of a large number of tree species greatly exceeds that of most living organisms including man. In fact, the age of some existing oaks has been estimated at 1,500 years while some Californian redwoods at 3,000 years more. However, unlike some other plant forms, trees are very difficult to regenerate.

In terms of structure, forest ecosystems are characteristically stratified or layered – this stratification is both above ground surface and also below ground surface.

The forest ecosystem is also characterized by large biomass. In fact, it produces the largest biomass per acre. Relatively speaking, the plant biomass is by far greater than animal biomass and this plant biomass is made up mostly of tree layers. Although, the animal biomass is smaller, there is a greater diversity of species. The greater diversity of animal species is attributed to the many micro-habitats in the forest ecosystem.

Of all the animals in the forest ecosystem, the insects are the most numerous and also the most important. This is because the insects occupy not only the tree layer but also more, importantly the litter layer. They therefore, constitute a very important link in the nutrient cycle within the forest ecosystem.

Because of the large plant biomass, the forest ecosystem is very efficient in fixing and utilizing radiant energy. Therefore, biological productivity is very high in the forest ecosystem. Another important factor contributing to the high productivity is that the trees have very extensive root systems, therefore they are able to obtain water and nutrients from a large volume of soil. Generally speaking, trees are capable of exploiting a greater depth and volume of soil than herbaceous and smaller perennial woody plants.

The nutrient cycle in the forest ecosystem is also very efficient part of this efficiency is due to the fact that the trees take a lot of nutrients from the soil and store them in their bodies. Therefore, the nutrients are not available for leaching from the soil. The trees in return supply a large quantity of litter to the soil.

In the tropical areas, this litter is rapidly decomposed and is it doesn't accumulate much on the soil surface. By contrast therefore, the litter tends to accumulate on the soil surface.

Although the trees supply a great deal of litter to the soil this organic matter concentrated on the top layer of soil in most of the nutrient cycling in the forest ecosystem takes place between vegetation and the narrow top layer of the soil. Therefore, most soils under-forests are infertile below the top rich humus layer.

The nutrient cycle in the forest ecosystem has a number of implications for the way we make use of forest lands. In the first instance, when trees are removed from the forest a great deal of the nutrient capita of the forest is being removed. This is particularly so in the tropics where forest removal also reduce the ability of land to hold and recycle nutrients in the face of high year round temperatures and heavy rainfall. Therefore, if trees are removed at a rate faster than they are regenerated, the soil under the forest is deprived of a major source of nutrients and the soil fertility diminishes.

Secondly, under a forest ecosystem, the organic matter content of the soil is maintained through litter fall. The removal of trees will deprive the soil of this source of litter. Also, the soil surface is exposed to intense isolation which others the micro-climate – it becomes hotter and more arid. Under these conditions, the organic matter in the soil is rapidly burnt out (decomposed) while evaporation from the soil is increased. The result is that tree regeneration becomes much more difficult. Eventually, forest degradation may set in leading to the destruction of the forest ecosystem.

Although different types of forest may be recognized, the major divisions are:

(i) tropical forests (2) temperate forests

Tropical forests can be sub-divided into tropical rain forests and seasonal tropical forests.

Tropical rainforests – they are broad-leaved evergreen forests which are found in low latitude zone near the equator usually 5oN and S of equator – Tropical rainforests are by far the most massive of all tropical forests. Rainforests occur in three main areas:

(a) the Amazon and Orinoco basins in South America (this is the largest continuous stand of rainforest) and the central American lithmus.

(b) (b) the Congo, Niger and Zambezi basins of central and Western Africa and Madagascar.

(c) The Indo-Malay-Borneo- New Guinea regions.

Although these three areas have similar forest structure and ecology, they differ in the species present.

The rainforest is highly stratified. 5 layers may be recognized. They consist of 3 top layers formed by trees viz- lower tree layer, middle tree layer, upper-tree layer. There are also the shrub layer and the herb layer. The trees of the upper-tree layer are usually the tallest and are called emergent.

Below the soil surface up to a depth of about 50cm we can recognize 3 root layers.

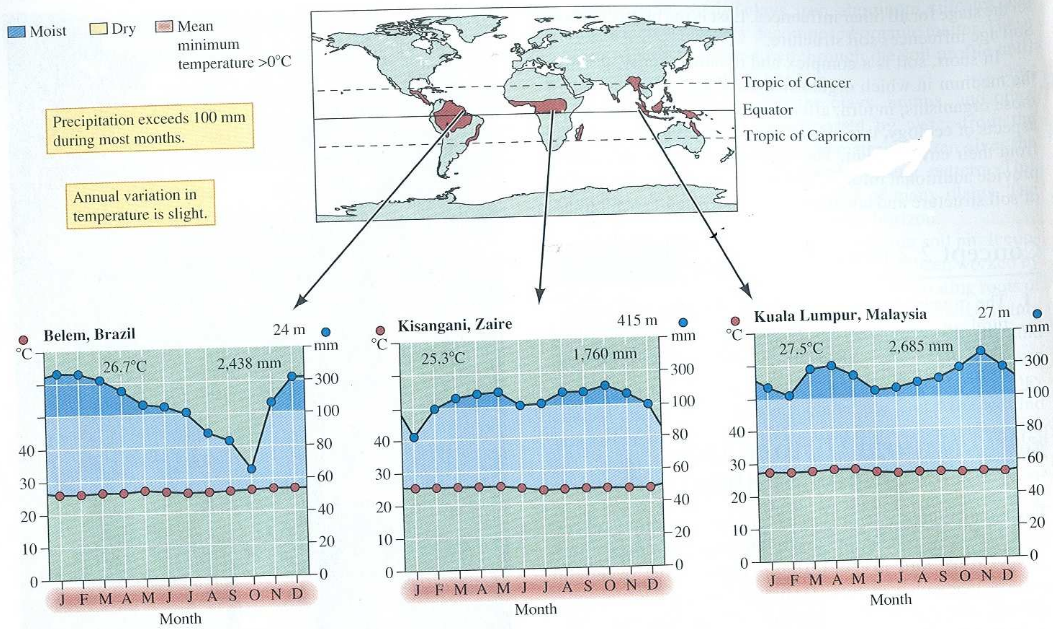
In the tropical rainforest, a very large proportion of animals lives in the upper layers of the vegetation than in temperate forests. The animals of the TRF feed mainly on fruits and termites. One reason why birds are numerous is that a large number of them are herbivores.

Variants of the lowland rainfall are the montane rain forest in mountainous areas of the tropics. The forest becomes progressively lies tall with increasing height.

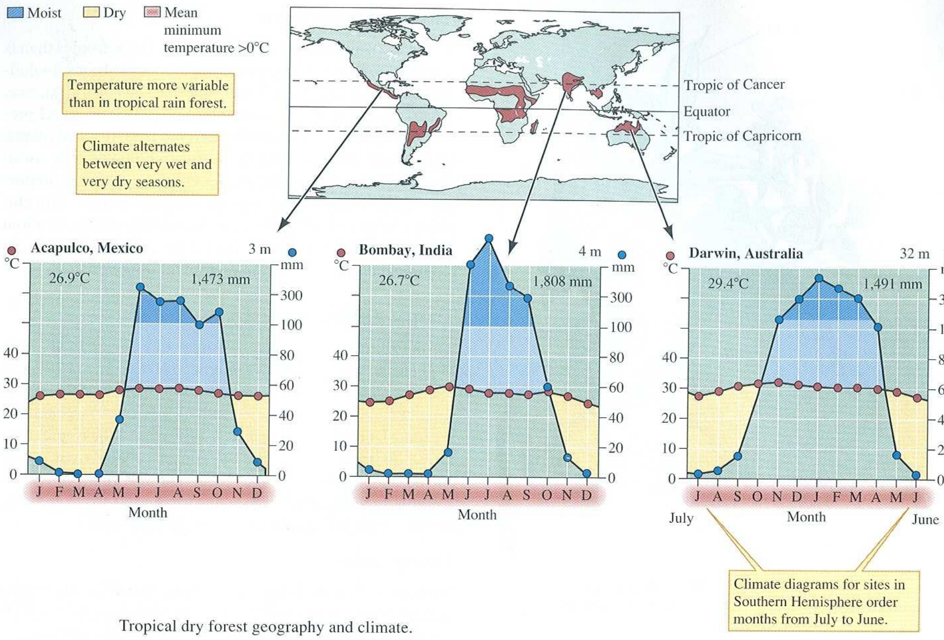
Gallery forests which are found along the banks and flood plains of rivers……..

Seasonal tropical forests are the second type of tropical forests. They may be referred to as Dry forests or Moonsoon forests in India. The key climatic factors is the imperfect distribution of a fairly good total rainfall.

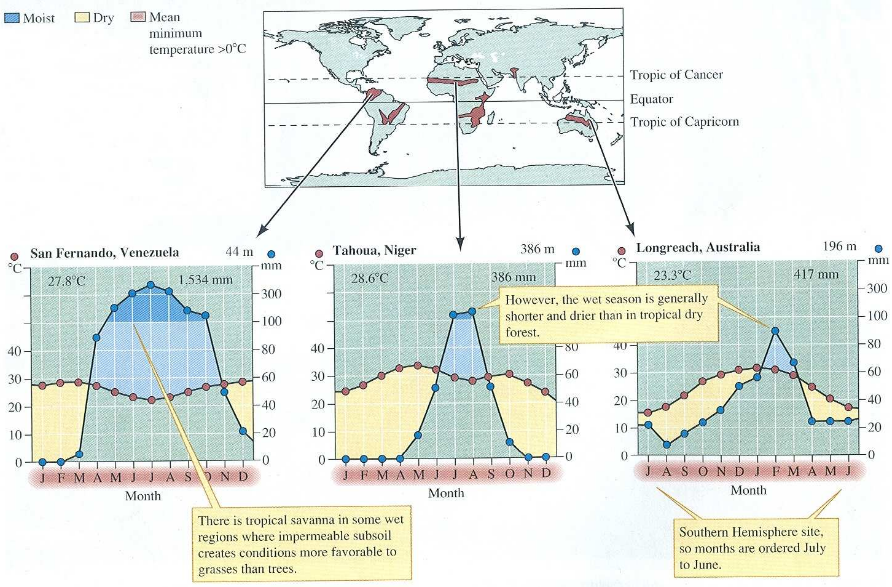
Thus, this forest exists in areas of marked seasonal rainfall and therefore they have a large proportion of deciduous trees which shed their leaves in dry season. One important feature that distinguishes the tropical from the temperate forest is the great diversity of species in the tropical forest. In fact, the variety of life is believed to have reached its peak in the tropical rainforests.



Tropical rain forest geography and climate.



Tropical dry forest geography and climate.



Tropical savanna geography and climate.

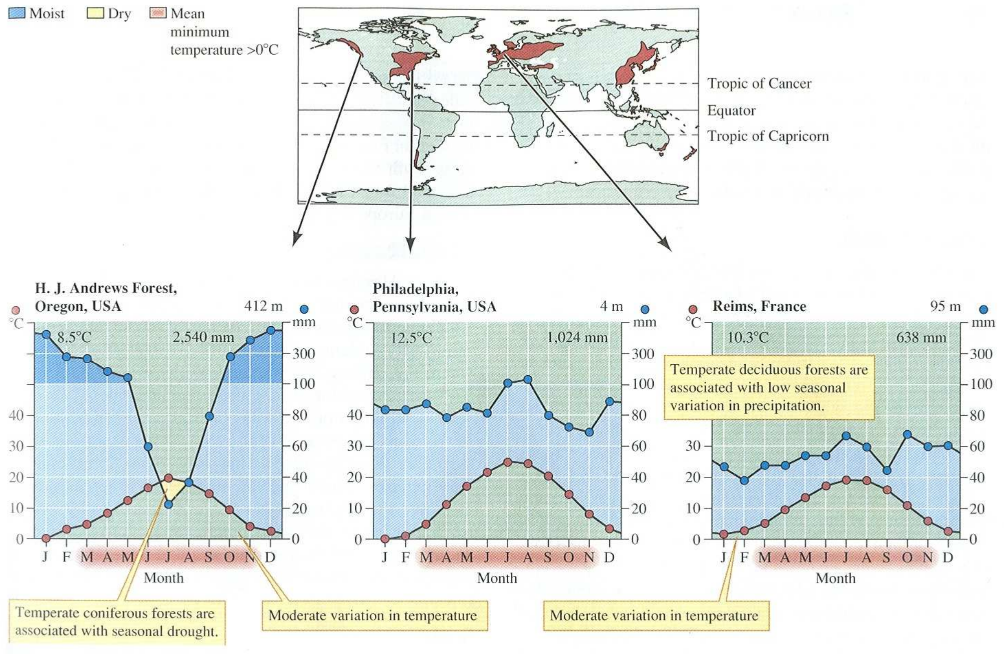
Temperate forests can be subdivided into 3 main types. These are

(i) Temperate rainforests which are found in the western margins of the continents. These are the areas that receive abundant rainfall. The forests contain evergreen oaks particularly cork oaks (valued for their thick barks used for wine bottle corks), eucalyptus forests of Australia and the giant sequoia or redwoods of California. These are some of the tallest trees in the world.

Closely related to the rainforest are the coniferous forests which are found in the continental areas of the same latitude. They are closely related because they have the same conifers.

Second major type of temperate forests is the deciduous forests which are found in the warmer and drier parts of the temperate. They characteristically contain deciduous trees with thick trunks that yields the valuable temperate hardwood. Some of the common species include oak, elm, birch, beech, poplar. In the wetter areas are willow, alder trees. Deciduous forests are found in Britain, northern and western France, Belgium, the Netherlands, Denmark, Western Norway.

Third major type is the mixed forests. It is so-called because it is a mixture of evergreen and deciduous trees most of these mixed forests are transitional between the evergreen and the deciduous forests, therefore they are ecotones.



Temperate forest geography and climate.

CONCLUSION

Climate is the most important singular factor determining the distribution and richness of forest ecosystems. Rainforests are richer than other forest types due to abundance of rainfall and heat. Trees are the ecological dominants on the forest ecosystem as they influence energy flow, nutrient cycling and the environment of other organisms.

Examination – 60%

References:

1. Tivy, J.: Biogeography: A Study of Plants in the Ecosphere, Oliver & Boyd, 1977
2. Molles, M.C.Jr.: Ecology: Concepts & Applications, McGraw Hill, 4th.Edition, 2008
3. Simmons, I.G.: Biogeography: Natural and Cultural, Edward Arnold, London, 1979
3. Tivy, J.and O'Hare, G: Human Impact on the Ecosystem, Oliver&Boyd, 1981

MODULE 5

THE GRASSLAND ECOSYSTEM

INTRODUCTION

This lecture discusses the terrestrial ecosystem that is dominated by grass species. The grassland ecosystem is second only to the forest ecosystem in area extent but far exceeds the forest in economic importance. Its biological productivity is however less than that of the forest ecosystem.

OBJECTIVES

At the end of this discussion, the students should be able to:

1. **Discuss the geographic distribution of grassland ecosystem and the factors influencing their distribution.**
2. **Outline the structural and floristic composition of the grassland ecosystem.**
3. **Differentiate between tropical and temperate grasslands.**
4. **Identify the major differences between forest and grassland ecosystems.**
5. **Outline the factors responsible for the richness of the tropical grassland.**

The grassland ecosystem is dominated by herbaceous plants of which the grass family is by far the most important both ecologically and economically. Indeed, grass dominated ecosystems are second only to forests in extent and far exceed forests in economic importance.

The grass family provides most of man's food supply especially cereals of rice and also provide feed for animals which man consumes.

The total population of grasses is far greater than that of any other family, and members of the grass family are found in almost all types of habitats. This is because of their very wide range of tolerance of environmental conditions which is only exceeded by that of lichens and algae. In addition, they have a very high capacity for reproduction and dispersal. They produce abundant seeds which are readily and widely dispersed by wind because they are small and light. Grasses usually have very large and extensive underground root system and the efficiency with which the root system can take up soil-water and nutrients from a large volume of soil gives the grass species a competitive advantage over other plants that have similar roots.

The density and the rapid rate of growth of their roots and underground stems also make the grasses the most effective colonizers and stabilizers of unconsolidated, mobile sediments.

The grassland ecosystem is usually subdivided into

i. tropical grassland – commonly referred to as Savannas

ii. temperate grassland – Prairie and steppe

The savanna covers about 20% of the total land surface of the earth and are found in all tropical regions. Sizeable tropical savannas occur in Africa, south-America and Australia. Savannas occur under a variety of tropical climates, from those with 500 to 3750 of rain per annum and prolonged dry season.

Tropical grassland differs from temperate grassland in that they have a very high proportion of woody species and a greater diversity of form and habitat. They are also referred to as woodlands.

The savanna vegetation is made up of 2 major components – herb layer and wood layer. The herb layer is usually dominated by a few species of grass. They range in height from 1-5m. Most important grass are Anderopogon, Loudetia, Hyparrhenea and Pennisetum purperium(-elephant grass). All the grasses in the savanna are xeromorphic i.e. they are adapted to seasonal drought.

The woody layer is composed of trees and shrubs. In Africa, baobab trees, acacias and palms are common. On the basis of proportion and distribution of woody plants, different types of savanna can be recognized.

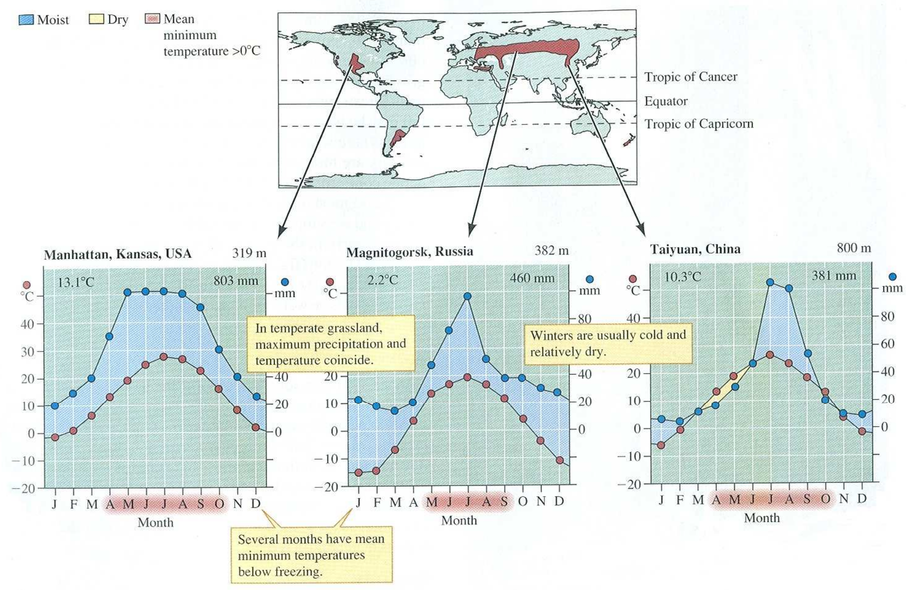
The first type where there is a close canopy of trees is referred to as Woodland

The second type where trees are widely separated is termed Tree Savanna

The third type where there are red trees but shrubs of the same height as grasses is termed Shrub savanna.

The fourth type composed of grass is termed grass savanna.

The temperate grasslands are generally found in the interior of North America, South America, European and Australian continents. Temperate grasslands have only one layer of vegetation but here is a high variety of species. The grasses are also xeromorphic.



Temperate grassland geography and climate.

Some of the important premil species classified according to the height of the above ground parts include

Tall grasses – big bluestem, switchgrass, Indian grass

Mid grasses – little bluestem, needle grass, western wheat grass, June grass, Indian rich grass.

Short grasses – buffalo grass, blue gramma, cheat grass.

The Prairie type of grassland has little or no woody plants whereas the steppe has a fair proportion of woody plants.

The grassland ecosystem has certain characteristics which contrast markedly with those of forest ecosystem.

1. The grassland ecosystem is less massive and less voluminous than the forest ecosystem. In other words, in terms of size, and biomass of vegetation, the grassland ecosystem is not, in massive as the forest ecosystem. For example, a study carried out in the temperate region shows that the biomass of the Prairie is less than 5% of the biomass of the deciduous forest in the same environment.
2. the structure of the grassland ecosystem is much simpler than that of the forest. There is less stratification and less micro-habitats. The species diversity is also much lower than that in the forest. Indeed, the grassland ecosystem is dominated by herbaceous stratum which ready exceeds four to five meters at the period of maximum growth
3. because of its simple structure and its less massive plant biomass than the forest, the grassland ecosystem influence on its physical habitat is much less than that of the forest. In fact in grassland ecosystem extent a much greater effect on the soil than on the atmosphere of the site it occupies. There is thus an absence of a micro-climatically distinct zone between the canopy and the ground since the herbaceous vegetation is virtually lying on the ground.
4. a distinctive feature of the grassland plant community is the high proportion of the total biomass that is contained in the soil. Thus, unlike the forest ecosystem, a very large proportion of the biomass of the grassland ecosystem is below the ground surface (in soil). In fact, in some places as much as 80% of the biomass below the surface, the grassland ecosystem has its greatest effect on soil formation.

Reason for this is the extensive root systems e.g. rhizomes, bulbous and runners. Because of this and unlike in the forest where bulk of the organic matter is supplied by litter, the roots and stems supply the greater proportion of soil organic matter.

The distribution of the animal population is influenced by, and similar to, that of the plant biomass. This is because there is more food under the ground and secondly the grassland vegetation are therefore more exposed and subject to extreme climatic variations than in forests. To protect themselves, most of the animals developed a burrowing habit. Some of these animals are antelope, bison also exhibit flocking and migratory habits which are not common among forest animals. Smaller animals particularly the rodents such as mice, voles, rabbits breed and live below but feed above ground.

5. The productivity of the grassland ecosystem is much less than that of the forest. However, this productivity varies with the proportion of woody plants – the higher the proportion of woody plants the higher the productivity. This is why the savanna is the most biologically productive of all grasslands. This also accounts for the large population of animals which they support an example are East Africa Savannas.
6. Like in all ecosystems, the cycling of materials within the grassland ecosystem is very complex. The energy flow through the grassland ecosystem is very rapid. However a lot of the energy is dissipated by the living organisms. Thus, entropy is very high because the animals expend a great deal of energy through movements. Productivity below the ground surface is also much higher than above the ground surface.

A very important ecological factor of the grassland ecosystem is fire. Sometimes, fire occurs naturally but most of the time it is caused by man and this is because the grassland supports a very important human activity which is grazing.

Fire is used to promote growth of grass. Consequently, in many parts of the world, the grasses are fire-climaxes. The most important animals for grazing include cattle, sheep, goats (Brow..). compared to wild herbivores, the domesticated ones are less efficient in converting energy. A .. of the plants they consume come out in form of faeces – as waste product.

Finally, domesticated herbivores are very selective in the choice of plants they eat.

CONCLUSION

The grass family which dominates the grassland ecosystem provides most of man's food supply especially cereals of rice and also provide feed for animals which man consumes. The grassland ecosystem is therefore of strategic importance in attaining food security.

The very wide range of tolerance of environmental conditions of members of the grass family which is only exceeded by that of lichens and algae and their very high capacity for reproduction and dispersal

ensure that members of the grass family are found in almost all types of habitats.

Post-test questions

Examination – 60%

References:

1. Tivy, J.: Biogeography: A Study of Plants in the Ecosphere, Oliver & Boyd, 1977
2. Molles, M.C.Jr.: Ecology: Concepts & Applications, McGraw Hill, 4th.Edition, 2008
3. Simmons, I.G.: Biogeography: Natural and Cultural, Edward Arnold, London, 1979
3. Tivy, J.and O'Hare, G: Human Impact on the Ecosystem, Oliver&Boyd, 1981

MODULE 6

THE BIOLOGICAL DESERTS

INTRODUCTION

Biological deserts are areas where the plant and animal biomass is very meager and biological productivity is extremely low compared to more fertile areas.

Absolute deserts which are unihabited and completely devoid of any form of life are rare and the only areas which could be described as absolute deserts are those of the central savanna and north Chile where little or no rain falls.

Deserts generally occur in regions receiving less than …. Of rainfall or where rainfall is unevenly distributed.

Low rainfall in deserts may be due to (i) high subtropical pressure in the Sahara and Australian deserts, (2) geographical position in rain shadows as in the western north American deserts or (3) high altitude as in Tibertan, Bolivian or Gobi deserts/

The paucity of life and low productivity in deserts are due to several factors:

(i) Extremely high or low temperatures

(ii) Lack of water – this may be due to the aridity of the climate or excessively perineable parent materials into which waker infilterately rather quickly. Lack pf water may also be due physiologic and physiologic drought. In other words, too much salt in the water may make it unuseful to plants.

(iii) Presence of toxic substances in the soil or air

(iv) Extremely forceful winds

(v) Direct or indirect activities of man, which exceed the range of tolerance of many organisms.

The most extensive deserts are those which are climatically determined either by a scarcity of water or an insufficiency of heat.

There are two types of biological deserts

(a) Hot deserts or Arid lands

(b) Cold deserts or Tundra

Inspite of the marked differences between hot and cold deserts, all biological deserts have certain ecological characteristics in common.

These are

(i) the physical environment is very harsh in both deserts therefore the living organism are highly specialized morphologically and physiologically. For survival, the organism have developed a very high degree of tolerance or adaptation to difficult living conditions

(ii) the vegetation cover is very sparse. In fact absence or extreme sparsity of trees is a generally universal feature of cold and arid deserts. Most of the trees also have low stature with a large amount of its underground.

(iii) Biological productivity is very low due to both low plant biomass and physical limitations to photosynthesis. The animal net primary productivity of true deserts is less than 2000kg/jhectare or a daily rate of less than 2.5cal per m2.

(iv) For these reasons, the available food resources in the deserts are very small and therefore the animal population that can be supported is very low compared to other ecosystems.

The number of trophic levels in desert food chains is also smaller than in richer ecosystem.

(v) The landscape of biological deserts is immature and extremely unstable. In the hot deserts, the action of wind and water and heat-expansion constantly disturb the land surface. In the cold desert, the action of frost, moving ice and the process of slifluction (island movement of saturated material downslope) inhibits the development of horizons in many turdra soils but may involve redistribution or sorting of the soil according to particle size to produce a soil catena or topo-sequence)

As a result of the constant disturbance of the landscape both the soil and vegetation cannot develop to maturity. Soils are skeletal and unctable while vegetable is kept in a stake of protracted immaturity which is not very different the pioneer stages of vegetation development is more favourable areas. The alternation of stable and unstable conditions over a period of time in a single habitat is a well-recognized feature of all desert ecosystem. Furthermore, because of the harsh conditions particularly the deficiency of water and/or heat, this dominant rock weathering process is mechanical.

MODULE 6 UNIT 1

ARID LAND OR HOT DESERTS

Hot deserts are found in the tropics and sub-tropics. They are areas where water deficiency is the master limiting factor. This deficiency of water imposes severe limitation on biological activity and dictates that about plants and animals have a high degree of adaptation. A distinguishing climatic characteristic of arid lands is low seasonal precipitation. As a result, all and regions cannot maintain permanent river flow.

Atmospheric humidity is in while dry and the absence of cloud result in intense isolation during the day and rapid loss of heat by outgoing radiation at night.

Combined with the water deficiency is excessively high temperature throughout the year. Daily temperature maxima of over 60oC have been recorded in hot deserts.

Under these harsh conditions, the survival of plants and animals depends on their ability to

(i) prevent dessication

(ii) keep cool

There are 4 different group of plants found in the hot deserts

(a) Animals and Ephemerals – this account for about 50-60% of desert plant population. They survive by means of Evasion by avoiding drought and growing only where adequate moisture is available. They are able to complete their life cycles within six to eight weeks or average on even within eight to ten days in the case of certain ephemerals.

(b) The desert shrubs – they usually have many branches spreading out from a short basal trunk. They are able to survive by becoming dormant and losing all their leaves and many branches during periods of drought to avoid withering

(c) Succulents – they are the most heat tolerant of all plants. They can withstand temperatures of between 50 and 65oC which will he harmful for other higher plants. Their ability to remain active at such high temperatures is due to the fact that they are able to stare a larger quantities of water in their bodies e.g. calctus.

(d) The microflora e.g. blue green algae, lickens, mosses. These microplants can remain dormant for several years but they respond very quickly when favourable conditions develop.

The ability to germinate and establish the new plant is important to the survival of all desert plants. Thus, ample supply of seeds and efficient means of plant distribution are more important to desert plants then in humid environment.

Arid land vegetation is treeless and the volume and density of plant communities decrease with increasing aridity.

The vegetation cover so discontinuous with a highly characteristic even-spacing in which individual plants are scattered thinly with large bare surfaces in between.

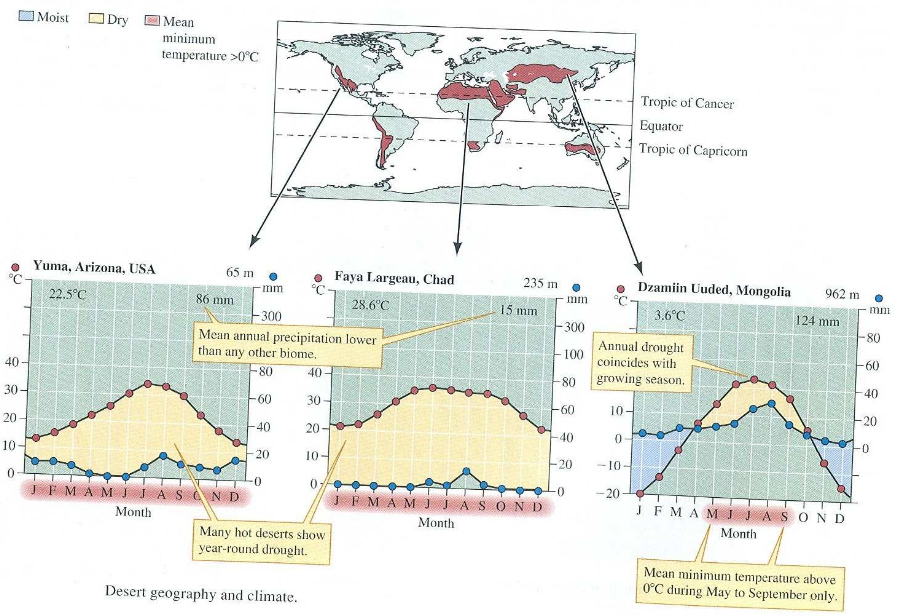
Arid land vegetation is much more complex in composition and structure then that for the turdra.

Desert animals, like the plants, have to contend with the same difficult living conditions. Like in the turdra,m animal species are few but more specialized than in humid environments. They are adapted in various ways to lack of watery excessive heat and limited food supplies. The ability to exist on water contained in the food available and to conserve water from the breakdown of carbohydrates (metabiotic water) by various physiological means as a characteristic of many arid land animals.

Among the animals, the reptiles and insects are the most important in the hot deserts. Most of the reptiles and insects develop impermeable body covering, sparse hairy coat and colony. Some also develop burrowing habits and conserve water by excreting very concentrated urine.

Some mammals also adapt by living solely on dry food while others such the camel can withstand high water losses. For example, camel can go for long periods without water and can endure a loss of water equal to over 25% of its body weight and is able to replace this only by drinking large quantities at irregular intervals. Desert birds are sustained by occasional drink from lows and other sources. As a result birds are most abundant where water or succulent foods are available.

In contrast, most mammals, including man are physiologically very poorly adapted to deserts. They are unable to survive losses of water greater than 12 to 15% of their body weight.



Desert geography and climate.

MODULE 6 UNIT 2

COLD DESERTS OR TUNDRA

The tundra is more or less synonymous with Arctic habitats. The chief limiting factors in the cold desert are the extremely low temperatures and a short growing season of about 60 days. Air temperatures are below zero for at least 7 months of the year while absolute minima below 70oC have been recorded. The short growing season dictated that the plants must complete their development cycle before foster commence.

Because of the low temperatures, higher in soils and rocks are frozen for most of the year. In fact, the ground is permanently frozen a few centimeters below the ground. The permanently frozen deeper soil layer is called permafrost plants only become active when the snow starts to melt and soil temperature reach at least 0oC. The rapid commencement of photosynthesis is a well-known feature of tundra species, particularly evergreen shrubs. Aside from climatic difficulties, two other difficult conditions with which plants have to cope are to permanently frozen ground and intensive frost action. The permafrost limits the effective soil and root development to the few centimeters of the ground. The permafrost is therefore, comparable to the impervious layer or hardpen in tropical soils.

Plants of the tundra have to be adapted to severe water stresses, created and made worse by a characteristically high windforeen. The permafrost prevents water absorption during winter while during winds which accelerates evapo-transpiration makes tundra plants must susceptible to water stress during early summer and the decomposition of litter as a result of retarded bacteria activity. The release and availability of nutrients to this reduced while nitrogen is particularly deficient in most tundra (arctic) san. The soils are skeletal and high mobile as a result alternate freezing and thowing of ice – The vegetation of the tundra is characterized by an absence of trees and a relative paucity of annual plants. The tundra is often described as a wet arctic grassland. The vegetation is composed mostly of mosses, lichens, grasses and sedges. Some of the dwarf woody plants particularly masses and lickens have well-developed underground storage organs. The vegetation cover is more or less discontinuous. The plants are adapted to extremely low temperatures. For example, locheas and mosses can survive most extreme conditions when virtually all other plants have been eliminated. The lichens never freeze however low the temperature and can photosynthesis when the temperature is below 0cC

The tundra animals are limited by the intense winter cold and shortage of food. Life on the ground is made difficult by lack of surface whether while the drainage and the presence of permafrost inhibit life below ground.

Warm-blooded animals in the tundra have wooly coat, thick skin covering which protect them from excessive heat-loss. Such animals as carbohydrates of eurasion, arctic have, musk ox lemming develop migratory habits. These animals and some migratory birds undertake a seasonal migration southwards in the winter and return north during the arctic summer.

The commonest cold-blooded animals are the insects. The insects most are by far the most important of all the animals in terms of population size and in terms of rate of reproduction. The net primary productivity of the tundra in low and this accounts for the small animal population which varies greatly in number and volume from season to seasons. The density of large herbivores (e.g. reindeer) is low which many of the permanent residents are omnivorous. The food webs are Jenny complex while the small number of trophic levels reflect the lack of animal diversity in the tundra. The large scale periodic fluctuations in the population of tundra species e.g. the lemming in an indication of the inherent stability of the tundra ecosystem.

Examination – 60%

References:

1. Tivy, J.: Biogeography: A Study of Plants in the Ecosphere, Oliver & Boyd, 1977
2. Molles, M.C.Jr.: Ecology: Concepts & Applications, McGraw Hill, 4th.Edition, 2008
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MODULE 7

THE MARINE ECOSYSTEM

INTRODUCTION

This chapter discusses the marine ecosystem highlighting the most fundamental differences between life on land and in the sea. The unique characteristics of the marine ecosystem, their causes and implications for organisms are discussed.

OBJECTIVES

At the end of this lecture, the students should be able to:

1. **Understand the unique attributes of the marine ecosystem.**
2. **Why the marine environment provides a more conducive environment for life than land.**
3. **Explain the factors responsible for the salinity of the marine environment and its implications for life.**
4. **Appreciate the sea is an important reservoir of many minerals and substances that are useful to man.**

The most fundamental contrast in the biosphere is that, between the environmental conditions and associated life forms on the land and those in the sea. However, in spite of the fundamental differences in the characteristics and organisms of the two ecosystems, the whole cycle of life and the basic biological processes are the same in both ecosystems. The requirements for life are the same and the maintenance of life in the sea is dependent on the basic process of photosynthesis just as on land. Biological production and distribution in the sea are determined by factors similar to those on land of which radiant energy from the sun in basic.

Although the marine-ecosystem cover over two thirds of the earth's surface and are habitable for most parts, its productivity is far less than that of the land. In fact, the mean net productivity of the total land area. The relatively low productivity of the marine ecosystem is attributable to 2 factors:

(1) the relatively small quantity of such nutrients as potassium, nitrogen and phosphorus available for plant growth in the producing or euphotic zone (within which there is sufficient light for photosynthesis

(2) the higher rate of respiration by microscopic marine plants are compared with the larger land plants. Higher rate of respiration results in lower net biological production

The marine ecosystem both physically and chemically provides a more favourable medium for life than is the land. The environment is also more uniform and most stable in many respects. Water is always available, therefore organism are never in subjected to water stresses. In other words, unlike on land, the problems of dessication are unknown in marine ecosystems.

Secondly, the marine ecosystem contains all the nutrients elements necessary for the maintenance of life. In particular, the two most essential gases – oxygen and carbon dioxide are relatively easily absorbed from the atmosphere and are available in sea-water. They are effectively distributed within the water body by the mixing action of water and the biological processes of photosynthesis, respiration and decomposition regularly ensure than replenration. The marine ecosystem contains about fifty times the concentration of Co_2 in the atmosphere. The o_2 content in far less and is also less evenly distributed in sea-water this than that in deeper water. This is due to the fact that it is in direct contact with the atmosphere and it is also the zone of high photosysnthetic activity which adds oxygen to the surface water.

The marine ecosystem also contained different quantities of many of the minerals found in the earths crust. In fact about 45 elements are known to contribute to the salt content of the sea. This salt content salinity is perhaps the most distinctive characteristic of the marine ecosystem of mineral elements, sodium and chlorine constitute over 80% and are the main determinants of the salinity of sea water. Other important elements available in smaller quantities are magnesium, sulphur, calcium, potassium and bromine salts. The concentration of dissolved nutrients such as nitrates, phosphate is however low.

Salinity and temperature are two of the most important limiting factors in the marine ecosystem. Thus, the ability to successfully adapt to life in saline medium is one of the important features which distinguishes the organism found in the sea from these on land or in fresh water. The average salinity of the marine ecosystem is 35 parts per 1000 or 25% or 3.5 percent while that of the fresh water is less than 0.5%. Salinity increases with increase in temperature due to high rate of evaporation.

The marine plants are less diverse than the land plants. The marine plans are dominated by the most primitive and least specideised algae of which the most obvious are the sea weeds. About 30 species of higher plants which are mainly Angiosperms also constitute a relatively insignificant part of the total marine vegetation. Far more important are the micfro-scopic one-celled organism containing chlorophyll which constitute over 99% of marine vegetation. These microorganism float in the upper layers of the sea and can give a distinct colour to the marine ecosystem due to the very high densities in which they occur – 36 million per cubic meter. These float plants are known as phytoplanktons of which the most important and most numerous members are the diatoms and the dianoflagelates. The basic process of photosynthesis is dependent on the chlorophy-containing diatoms and diamoflagellates whose distribution is restricted to the illuminated cuphotic zone. Their great photosynthetic efficiency make them the dominants of the producer trophic level and accounts for their dominance in the marine ecosystem. The total food supply of the marine ecosystem is based on the phyto-plankton as they are responsible for almost all of the primary biological productivity of the marine ecosystem. The mean annual primary productivity is however about 25 to 50% less than that on land.

The total amount of phytoplankton present in the euphotic zone and its rate of production are highly variable both in time and from one part of the ocean to another. In the tropical areas, adequate light for most of year guarantees continuous production. In the high latitudes and in polar areas, low light intensity and short daily durations of light may completely inhibit plant activity during the whole. The quantities of mineral nutrients particularly nitrates and phosphates available will also influence the productivity of photoplakton even in the presence of maximum-light intensity temperature possible in the euphotic zone. Compared to other essential elements for plant growth, not also and phosphates occur in relatively small and limited quantities. They, therefore constitute an important limiting factor in determining the size of marine populations.

Unlike both land and fresh water ecosystems, the marine ecosystems contain a varied and important group of sessile (fixed) or immobile animals. The plant-plankton provides the bulk of the primary food on which animals in the sea depend. The majority of the animals which feed on the phytoplanktons are among the smallest of marine animals. This is because the microscopic size of the phytoplanktons limits this direct use by large grazing animals therefore large herbivores which feed directly on land plants are non-extent in the sea. The small marine animals are capable of using plant food most efficiently. As a result of this efficient use of plant food and reduced losses, food chains tend to be longer in marine ecosystem than on land.

Secondly, most of the sea such that only a very small grazing animals of the sea such that only a very small proportion of living material are passed as decaying matter to decomposers. In other words, the role of decomposers in the marine food-chain is less important than it is on land. Also, unlike the land, the total animal biomass exceeds that of the plant biomass in the marine ecosystem.

Of the various zooplankton species, the most important are such small crustaceans as the copepods of which the genus calanus in one of the major sources of fish-feed in cooler, northern waters and the larger crustaceans called krill.

There is greater diversity of species in warmer and tropical sea than in cooler waters.

Unlike the phytoplanktons, the distribution and productivity of the zoo-plankton is not directly influence by light.

The zoo-planktons exist virtually in all parts of the marine ecosystem. Their distribution however depends on the availability of plant food.

Other marine animals include the larger bottom-living (benthos) or free-swimming (Nekton animals).

Nekton animals include herring, mackerel, sardines, swordfish while the benthos include clam, snails.

Although the total biomass of the sea greatly exceeds that of the land, the full potential the marine ecosystem is yet to be fully developed. In fact, only about 1% of what man eats come from sea, most of which comes primarily from fish which is at the end of the marine food chains. As a result of their position in the food chain and being secondary on tertiary consumers, they provide only small proportion the primary food produced by phytoplanktons to man. This dependence of fish rather than phytoplankton may be attributed to the higher biomass of marine animals and the fact that the direct harvesting of minute-sized phytoplanktons in extremely difficult and expensive.

Man has been very selective is exploiting marine life by concentrating on those animals whose size and concentration of numbers in particular areas facilitate the greatest exits of catch. Fish is not only the one important source of protein food that is still hunted but also the only important food animal that is not domesticated.

CONCLUSION

The marine ecosystem both physically and chemically provides a more favourable medium for life than is the land.

Unlike both land and fresh water ecosystems, the marine ecosystems contain a varied and important group of sessile (fixed) or immobile animals.

Although the total biomass of the sea greatly exceeds that of the land, the full potential the marine ecosystem is yet to be fully developed. In fact, only about 1% of what man

eats come from sea, most of which comes primarily from fish which is at the end of the marine food chains.

References:

1. Tivy, J.: Biogeography: A Study of Plants in the Ecosphere, Oliver & Boyd, 1977
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Table 7-6. Analysis of Two-species Population Interactions

0 indicates no significant interaction
+ indicates growth, survival, or other population attribute benefited (positive term added to growth equation)
− indicates population growth or other attribute inhibited (negative term added to growth equation)

Type of Interaction*	Species 1	Species 2	General Nature of Interaction
1. Neutralism	0	0	Neither population affects the other
2. Competition: Direct interference type	−	−	Direct inhibition of each species by the other
3. Competition: Resource use type	−	−	Indirect inhibition when common resource is in short supply
4. Amensalism	−	0	Population 1 inhibited, 2 not affected
5. Parasitism	+	−	Population 1, the parasite, generally smaller than 2, the host
6. Predation	+	−	Population 1, the predator, generally larger than 2, the prey
7. Commensalism	+	0	Population 1, the commensal, benefits while 2, the host, is not affected
8. Protocooperation	+	+	Interaction favorable to both but not obligatory
9. Mutualism	+	+	Interaction favorable to both and obligatory

*Types 2 through 6 can be classed as "negative interactions," types 7 through 9 as "positive interactions," and Type 1 is neutral.