LESSON 7. PATTERNS AND TYPES OF DISTRIBUTION OF LIVING ORGANISMS

7.1. Introduction

This topic introduces the patterns and types of distribution of living organisms. The biotic and abiotic facts that influence the patterns and types of distribution are described. The abiotic factors include climate, soil and relief. The biotic interactions include competition, predation and symbiosis. These interactions are discussed and their effects on the living organisms considered.

7.2. The objectives

By the end of the topic, the learner should be able to:

1. Describe the spatial and temporal variations of biotic factors.
2. Explain how abiotic and biotic factors influence the patterns and distribution of living organisms
3. Comment on the effects of historical factors on the distribution of plants in East Africa.
4. Explain the factors that determine the distribution of living organisms.

7.3. Patterns and Distribution of Living Organisms

The distribution of living organisms by spatial patterns and temporal variations is determined by many factors such as historical changes. What is most puzzling is how these organisms have got where they are and how they maintain themselves in the face of perturbations that are part of nature. There are a number of biotic and abiotic factors that are used to explain the past and present patterns of distribution. These are generally biological factors such as adaptation, predation and competition on the one hand and physical factors such as climate, soil and light on the other.

Past sets of controls of distribution range from evolutionary processes to climatic and geological processes. The Pleistocene ice age is the most recent climatic event that has been associated with the expansion and contraction of certain biomes. They have also been

associated with the extinction of the less adapted species. Plate tectonics and continental drift are identified as being responsible for the splitting asunder of a once continuous distribution or as welding it in new patterns. The different patterns of distribution that one can observe on the earth's surface are partly due to a combination of physical factors, which provide an envelope within which the life processes function.

7.4. Spatial and temporal patterns

The distribution of organisms in the biosphere is characterized by lack of uniformity; however, there is no organism that is distributed haphazardly on the earth's surface. A close examination shows that the patterns of distribution are never even. Indeed each species exhibits variations in distribution, both in time and space. Spatial variation in abundance reflects the extent to which the local environment meets the niche requirements of a species. Each species tends to be most abundant where all niche parameters are in favourable range and to be rare or absent where one or more environmental factors are strongly limiting. Living organisms are not haphazardly distributed on the face of the earth; we can therefore identify different patterns of distribution. Generally, at any one place there exist patterns of distribution, which vary in space, called spatial patterns, and those which vary with time called temporal patterns. The spatial patterns, which occur in different aspects of measurements and identification, are a function of species richness or diversity, and continuity or discontinuity. The spatial patterns also are a function of species occurrence.

Spatially, for instance, vegetation is gregarious, i.e. it grows together in groups of various sizes and shapes. This is because plants are immobile and tend to cluster where growth conditions are favourable. Clumpness in vegetation is of ecological importance because it supports the theory of plant associations, what is commonly called plant co-existence. Clumpness is an adaptation mechanism, which plants use to counteract any environmental imbalances. This they achieve by means of morphological, behavioural and physiological properties. By modifying micro climatic conditions, for instance, plants create conditions that are favourable for the invasion of others, which on their own would not be able to succeed. These requirements are not important to faunal population, which can avoid harsh environmental conditions by migration. On the other hand, temporal patterns of distributions are those studied from the point of view of time. In the long term or short term, basic distributions can be seen as periodic or non-periodic and continuous or discontinuous. A good example of this is the occurrence of ephemerals with the onset of rains.

The present trend and the evolutionary history have interacted to produce uneven patterns of distribution. Even in worldwide distribution cosmopolitan organisms do display unevenness. It may be said that unevenness of spatial and temporal distribution is a natural phenomenon. Further, it is a basic characteristic of natural distributions and reflects differences, which exist in the life envelope. Thus, the population factors are far from being evenly distributed. Therefore, unevenness tends to suggest that there are discontinuities in the envelope and that the success of the individual species in occupying a portion in the envelope depends upon its biological adaptation. But the invasion of the open mix by a particular species is equally crucial.

Clearly, variations in the distribution of organisms are a response to variations in physical and biological parameters. Each species, therefore, occupies a limited area, which it is best specialized to exploit. Within a habitat the distribution of a species tends to be characterized by a gradient. If a cross-section is taken, the number of the species in a population decreases, then increases then decreases and eventually disappears along a gradient of population factors. At the margins of this factor, the species population disappears because the individuals cannot be maintained.

Survival in adjacent habitat eventually becomes unbearable because the species is not adapted to the conditions therein. Surrounding habitats act as geographical barriers. The latter have to be crossed for further distribution of the species to occur. Examples of these barriers are terrains, climate, water bodies and landmasses. Barriers have certain interesting characteristics. They may be selective, temporary or permanent in their effects. Mountain barriers, for instance, are not obstacles to flying birds while water bodies are not obstacles to aquatic life.

Mountains provide obstacles to the spreading of plant species in the form of extreme temperatures and long distances to flightless organisms; they provide unfavourable substrate consisting of rocky and shallow soils which cannot support the existence and hence the expansion of certain organisms. Cold and hot climates are barriers to the distribution of warm and cold-blooded organisms, respectively.

Some of the present pattern of distributions cannot easily be explained and are therefore said to be responses to catastrophic or gradual change. These include tectonic processes and climatic changes. They have profound effect, for instance, on the present distribution the world over. Some patterns of plant distribution are at best accidents of history. Some of these accidents led to the wiping out of the less resistant species while others have restricted the distribution of once continuous species to a limited portion. In various places in the world, living organisms have experienced different developmental changes through their evolutionary ways.

Therefore a species flourishes best without any external assistance only within a range of tolerance. The latter is the limit within which a species successfully completes its life cycle freely. This consideration is very important in determining species density and abundance. Within the range, maximum population occurs in the ecological optimum or the optimum range, a zone where survival is most favoured. Organisms occur in great concentrations and perform extremes of the population factor where conditions for survival become unsuitable and finally intolerable. Domestication by man, has to certain extent, modified the concept of range of tolerance. Once he interferes with the dependence of organism on their environment man, through inputs of energy and matter has enabled the existence of cultigens in areas where they could never occupy.

Each species is distributed over a particular area of the biosphere, which is termed its range. Not all ranges are of the same dimensions and their boundaries are determined by a combination of factors.

- A species range represents a response to the physical environment in which all organisms live. The physical environment consists of non-living (abiotic) components such as rock, air and water, which are products of the lithosphere (rock strata), atmosphere (air masses) and hydrosphere (water bodies) of the earth. The lithosphere, atmosphere, and hydrosphere thus impinge upon and contribute significantly to the composition of the biosphere, together with this, they make up the interacting geo system.
- A species range results from competition with other species for essential resources such as food and living space. Each species does not possess a unique range. There is a certain amount of overlap between ranges because each species does not have exclusive use of a particular resource.

- A species range is not only a result of the adaptation of species to its existing environment (animate and inanimate) but also of its evolutionary history. This history usually spans thousands or millions of years and has proceeded against a background of continuous environmental change.

7.4.1. Disjoint Distributions

Continuous distributions of living organisms are anomalous in nature because even the environmental variables that determine them are highly variable. What is discussed as once continuous distribution of certain, organisms that was split by continental drifts and plate tectonics, is therefore questionable. Fossil records on the flora of Africa suggest that neighbouring populations converge during favourable periods but separated at wide intervals when conditions were harsh. The degree of convergence is still questionable. For instance, it may occur in the form of a small strip. However on the local scale, one can talk about the distribution of a species population being continuous.

Naturally, distributions are disjoint. Thus, a species may occur in areas, which are geographically far apart. Unravelling the causes of disjoint distribution is one of the biogeographical problems. Evolutionary disjoints are said to be species which were once widely distributed but were split or made to contract into isolated patches because of climatic changes. The survivors of these species today occur in limited numbers in different continents or on one continent. A good example is the distribution of the African Gorilla.

7.4.2. Endemic Distributions

These are distributions, which are confined to areas of origin or to refugia. Tectonic processes and past climatic changes have been predicated as being responsible for wiping out world vegetation and fauna population. If changes are gradual, some organisms will avoid death and take refuge in suitable habitats. If they are erratic, the organisms will become extinct. The Pleistocene ice age has similar effects in USA and Europe. They wiped out populations of vulnerable species while in southern warmer areas and on mountains on which ice formation was limited some organisms migrated behind retracted ice; others remained confined to refugia probably due to their inability to overcome barriers. Most flora on sea islands or mountain tops have high levels of endemism. On the East African mountains, for instance, the lobelia species on Mt Kenya is endemic. Alternatively, endemism is associated with organisms that have recently evolved and have therefore not had enough time to spread.

Lastly, some endemic species could be on their way to extinction as changes in their habitats have reached such an intolerable state that they cannot compete successfully for soil and space.

7.5. Abiotic Factors and Distribution of Living Organisms

Abundance and distribution are influenced by multiple and interacting environmental variables. The distribution of certain organisms can be explained partly on the basis of the physical environment. These include a number of factors such as climate, soil/edaphic and topography that affect the distribution of living organisms directly or indirectly. The direct effects of these factors are difficult to evaluate but they can be inferred from the response of organisms such as their birth rate, growth rate and reproduction. These physical factors, also known as abiotic factors, are commonly described as the life envelope. They are non selective to the extent that they provide an environment which has to be complete for living organisms. On the other hand, these factors may be seen as selective to the extent that their unevenness in distribution tends to put a threshold to certain organisms. Consequently certain physical factors have limiting effects on the spread of organisms.

7.5.1. Climatic factors

Climate is the single most important factor that plays an overriding role in the distribution of organisms. The climatic factors can further be grouped into: light, temperature, moisture wind/atmospheric conditions and humidity. Solar energy is the driving force behind photosynthesis. Climate leads to temporal variations through its seasonality. Temperature and moisture are the two main limiting factors of life on earth. Potential evapotranspiration, water surplus and deficit delimit the distribution patterns of vegetation types. The latter, for instance determines the abundance and distribution of ephemeral plants in Kenya's semi-arid environment. During the wet season, the fields bloom with abundant life, which declines with the arrival of drought. The long-term effect of change on life processes is best demonstrated by Pleistocene Ice age episodes. During alternating favourable and unfavourable periods, different parts of the world experienced fairly high species enrichment and species enrichment and species improvement respectively. This was due to migration, evolution, reproduction, and extinction processes. The southward and northward movement of vegetation in North America following glacial and interglacial conditions is such an example. Analogic to this pattern is the upward and downward migration of vegetation on the mountains of East Africa.

7.5.1.1. Temperature

There are large differences in temperature across earth's surface due to variation in the quantity of incoming radiation. The unequal distribution of land and sea since the land is subject to a greater temperature range than the ocean. There is seasonal variability in light and temperature conditions due to aspect and topography (altitude). Temperature provides the medium in which chemical reactions and metabolic activities are enacted. Most chemical reactions increase in speed with temperature; thus in areas with extreme temperature conditions, such as very high and very low temperatures, the species decrease in number and variability. For instance as temperature decreases with increasing latitude, the species decrease. In plants, temperature affects the chemical breakdown. For each plant species, there is a minimum and a maximum temperature below and above which chemical reactions cannot take place. There is an optimum temperature (ideal) within which the species have the highest species. Variations in absolute temperature, which influence the physiological functions of plants and animals, are in most cases a result of latitude, altitude and distance from sea. In the tropics, the effect of temperature is of little significance in the distribution of organisms. Most places have high enough temperature. The effect of temperature is best demonstrated in vegetation zonation on mountain areas.

Temperature may influence in life through water availability. High temperature, characteristic of dry regions amounts to increase of water stress. Only organisms that are adapted to such conditions can survive in such environment. Extremely low temperatures are an environment hazard especially in the tropics because it leads to frost formation. Tropical plants have no bracts and stipulates to protect them against frost. Otherwise, the effect of temperature is best demonstrated by high latitude plants, which become dormant during the low temperatures of winter and active during high temperatures of summer. On the average, life processes are best in the temperature range of 4 ^{0}C to 40 ^{0}C a few organisms however, in India, can survive in temperatures below 0 ^{0}C. The effects of temperature are also tied up with those of light. Physiological processes depend upon intensity of light and temperature conditions. Plants for example, have their own optimum in high temperature conditions where they function freely. Processes like photosynthesis depend upon light intensity. The latter is a function of characteristic insulation. In high latitudes, these components affect life processes such as plant growth and flowering.

Correlations may provide only circumstantial evidence and do not necessarily indicate direct causal relationships. The species may be limited not by their inability to tolerate low temperatures, but by competition from other species that are superior competitors in cold climates.

7.5.1.2. Moisture

Moisture is vital in the maintenance of many physiological and chemical processes within plants and animals. There is a zone of high precipitation at equator. Ocean land configuration affects precipitation values: areas far from oceanic moisture are more drier than those, which are Maritime. Biogeographically, what is important is not so much the absolute amount of water, but rather the relationship between the two variables, precipitation and evaporation. It is possible to classify ecosystems according to their moisture relations. Hydrophytes: are plants, which require permanently moist, water logged or even aquatic conditions. Xerophytes are plants adapted to very dry conditions (characteristics of xerophytes cactus, euphorbia, prickly pear, reduction in leaf size, rolled or folded leaves to reduce surface area, hence evaporation, emphasis on growth below ground). Mesophytes are plant species, which are found, on sites with moderate soil moisture levels. Trophophytes: have organisms with which to avoid drought - e.g. long roots. The amount and distribution of rainfall is very important for plant life, and hence animal population. Forest communities characterize sufficient and well-distributed rainfall while tropical savannas characterize light seasonally distributed rainfall. Fauna population in the tropical savannas has to be equipped with certain animal mechanisms. The wildebeest of East Africa, for example are tuned to migrate from Serengeti in Maasai Mara during dry season to avoid competition for food. The problem of water stress for plants is averted by adaptation, which includes the development of thick bark, the shedding of leaves and the replacement of leaves by thorny structures. Water is very important for various physical processes such as photosynthesis and respiration.

7.5.1.3. Solar radiation

Light and temperature are controlled by the latitude through inclination of the sun, the albedo of surface bodies, especially at the local level and aspect. The quantity rather than quality of light is very important in determining the distribution of living organisms. Wavelengths such as ultraviolet and gamma rays are known to affect regions of high altitudes. The plant characteristics that may be observed at 1500m and above in East Africa are a result of high component of ultraviolet light.

The components of a plant association depend on the amount of light received. At the regional scale, equatorial forests have high density compared to temperate or coniferous forests because of their unlimited supplies of energy. Locally, components of a stand of plants are dictated by differences in energy demands. At the lowest levels are the shade tolerant or low light species while at the top canopy are the light lovers or shade intolerants. Accordingly, light amount determines the abundance and diversity of species and their structural variation.

Solar radiation is the fundamental basis of photosynthesis and in the absence of light, even when it is in poor supply as on the floor of a dense forest, the number of species is restricted. Short wave solar radiation reaching the not only determines gross patterns of energy exchange within the biosphere, but certain of its components are also responsible on a more local scale for imposing limits to organic growth. The quantity and quality of light are important, together with the day length or photoperiod. Light varies both spatially and temporally. Spatially, there is variation due to latitude, thus the equator receives more light that the poles. These variations result in differences in the distribution and location of plant life. Light intensity is greatest at the equator. Quality of light varies according to the intercepting surface (vegetation canopies). Light is one of the main factors that determine shape, size of plants, suppression. Competition for light dominates the competition for plant survival. Root development and seedling development also determine the growth of plants. Photosynthesis depends on light variation. Competition for light by species decreases from the equator to the poles. Species adapt to stress conditions through mechanisms such as hibernation, reproduction, migration and feeding habits.

7.5.1.4. Wind

Wind is another climatic factor that affects life processes in different ways and modifies the hydrologic cycle by increasing the rate of evaporation. As a drying power, wind lowers the relative humidity in the vicinity of the leaf surface by removing water vapour. This leads to the creation of a vapour gradient there initiating evaporation in plants. As desiccation increases, the mesophytes are replaced by the xerophytes.

Wind affects coastal areas. It may lead to total or partial destruction of plants. Strong winds are experienced several times during the year in different parts of the country, and are associated with uprooting of trees, tree falls and broken branches. The high latitude and desert areas, there appears low and deformed growth. Wind equipped with particulate is associated

with wind training; a process, which hits plants growth at a certain level, especially where wind direction is constant. All branches except those in the leeward side are destroyed. The effect of wind on the plant community depends on the depth of the roots, wind velocity and frequency of occurrence. Frequent winds in high altitudes are partly accountable for dwarfness in trees.

Wind retards growth by increasing physiological stress on mating cells. In the seacoast dwarfness results from unfavourable internal water conditions, which is aggravated by salt sprays dispersed by wind. The effects of wind on the migration of birds and even of water plants in very interesting but not yet studied properly. Wind facilitates movement and increases the organism's chance of arrival at a new site. Wind can affect plants through soil structure. Frequent wind activities in coastal and desert sand dunes bring about drifts of sand in sites devoid of vegetation. Such unstable sites hamper progressive succession of even simple life forms.

7.5.2. Topographic Factors

As indicated earlier, topographical differences can affect distribution by acting as barriers. Mountain terrains, for instance, can limit the spread of animals and plants by separating potential habitats or by the provision of unfavourable climates and substrate. In East Africa, mountain tops impose a selection effect on distribution by low mean temperature. The current limited distribution of the equatorial rainforest can be explained by altering rainfall conditions through aspect. The south east slopes of Mt Kenya and Mt Kilimanjaro carry abundant life because of high moisture. The drier northward and westward slopes are characterized by scant life. The effects of aspect and light conditions and hence substrate conditions are distinct.

Topography encompasses numerous abiotic factors, although these are often interlinked in a complex manner with other environmental components. The main topographic factor is relief, which induces vertical temperature changes and related climatic adjustments such as humidity variations (decrease of $0.6^{o}C$ for every 100m altitudinal rise) leading to altitudinal zonation. The influence of topography on ecosystem characteristics is often manifested through its interaction with other components of the physical environment. Plants and animals become increasingly restricted to low elevations in the northern hemisphere.

7.5.3. Edaphic factors

Soils are important in determining the pattern and distribution of living organism; they provide the anchor for plants and are the nutrient store upon which plant life is dependent. Soil contains both abiotic and biotic components and provides the vital link between living and non-living phenomena, without which terrestrial ecosystems would not operate. Soils are made of the mineral components and vary in type. The soil texture is the proportion of silt, sand, clay and this determines the degree to which roots penetrate the soil, the water content, and aeration and soil temperature. Sand for example has large pore spaces. This decreases the capillary so that sandy soils cannot hold water. Clay soils have small pore spaces, thus water is easily held. The thin layer found around each soil particle is referred to as hygroscopic water or water of adhesion. This water is bound to the soil particles, and is unavailable to plants. Bound to the water of adhesion is another body of water known as water of cohesion or capillary water. It is the propensity of water to adhere to the surface and get pulled up. The water is loosely held to the soil particles on the water of adhesion. At saturation a soil is wetted and all gravitational water is drained out.

Soil is also the habitat of different fauna. The occurrence of certain plant species depends upon soil conditions. The distribution of cosmopolitan plants depends upon distributed substrate. The occurrence of a plant species in any substrate depends upon its occurrence and ability to grow and successfully compete for opportunities the soil offers. Variations in patterns of distribution can be said to be a response to soil conditions. Soils vary in nutrients and water conditions, grain size and arrangement, and in depth. There is no soil type with uniform conditions. Water logged sites attract grasses while well-drained sites favour the dominance of tall plants. Frequent nutrient shortages in the soil initiate competition among organisms that may lead to the extinction of less aggressive species. Certain distributions can be explained on the basis of soil PH, defined as the level of acidity or alkalinity. Acid soils support oxylophytes while halophytes occur in saline soils.

7.5.4. Geological Factors

Besides the climatic history of an organism's habitat, distribution can also be determined by geological factors. Environmental mode is far from having ways been identical or normal. Most of the processes such as volcanism and mountain building have bursts or peaks that lead to massive killing and extinction of organisms and species. The eruption of volcanoes and the burning from underneath of organisms in East Africa's Rift Valley are such examples.

However, some geological changes have been gradual and "accommodating". The effect of geological history in the distribution of organisms was recognized. It is associated with the origin of Vireroin Biogeography.

Wegner's theory of plate tectonics provided ample evidence for the distribution of similar animals and plants on different continents. His theory supported by that of palaeomagnetism and sea-floor spreading, emphasizes that certain distributions have been passive. The involved organizations have merely been transported across the globe due to constant drifts, which have split the once continuous continents apart and led to new patterns.

Geological processes caused many variations in landforms and subsequent patterns of distribution of plants and animals. The diversity of landforms in East Africa is reflected in its varied climates, which have led to normal diversity in vegetation. The geological processes have caused variations in land and sea sizes leading to differences in habitats for terrestrial and aquatic organisms. The effects of these processes are always confused with those of extra-terrestrial forces such as meteoric impact that led to the disappearance of certain distributions. This period saw the Mesozoic extinction (65million years B.P) in which certain mammals like reptiles were eliminated. The asteroid impact hypothesis of the Pleistocene ice age and the killing of large mammals is another geological episode whose effects can be seen today. From these and other evidences, it appears that the biosphere has not always evolved gradually, but in bursts.

7.6. Biotic Factors and Distribution of Living Organisms

The existence of an organism in a certain area is mostly determined by the nature of the physical environment. The soil and climate, for instance must satisfy at least the minimum requirements for plant growth and reproduction. Certain biotic factors must be present before an organism can occupy a potentially favourable physical habitat. There are factors, which result from the interaction of plants and animals existing under similar conditions. Although most physical habitats may be favourable, only a few are exploited by a number of species. The rest have been avoided because of the organisms' inability to obtain their essential requirements and to maintain themselves successfully along with others.

For organisms occupying a given habitat, there exists an interwoven web for mutual interdependence and interactions that result from different life processes. These relations are

either beneficial to the existence of others or generally detrimental and therefore inhibiting to the existence of others. The habitat of an organism is therefore partly physical and partly biological. Unlike physical factors, biotic factors are more difficult to assess and diverse in occurrence since they are a combination of the action of a wide variety of organisms. The factors are selective in their effects and operate within a given envelop of physical settings. The biotic factors or processes such as routes of dispersal, competition, predation, symbiosis and fire finally determine the overall range of species and their arrangement in the landscape. In this lecture, each of these interactions is discussed and its effect on living organisms considered.

7.6.1. Competition

The struggle for existence between and within species for the insufficient resources available in a habitat is called competition. The competition amongst plants of the same or different species for different resource arises because of economic reason. There is greater demand on resources than there are resources to feed the organisms (supply). The limited area of the environment in between which plants will compete is referred to a niche. The mega vegetation (trees) will face intense competition for resources. It is usually competition for space, space for seedling, water, and light, and soil nutrients. Intense competition amongst seedling will result in varying survival rates, those that compete successfully are said to be more demanding or aggressive. The losers are described as suppressed. The physical conditions of plant growth may be said to be permissive. Biotic factors however, are selective and competitive. All living organisms are faced with one major problem. They have to struggle for the limited earth resources.

Competition can occur between populations of the same species referred to as **intracompetition** or between populations of different species known as **intercompetiton**. The real success of an individual is either type of competition depends upon its requirement, its life form, its vigour and density of growth and its seasonal development. Usually vigorous growth is the most successful. Fast growing plants, for instance, modify micro-climatic conditions thus depressing or excluding the less demanding and less aggressive forms from a habitat.

The influence of factors being competed for varies from one habitat to another. In the arid and semi-arid environments, plants compete for soil and water while in the equatorial rainforest;

stratified plant stands compete for light. Competition for light and food is basically synonymous with competition for space. Competition is mitigated in different ways. A response common in plants is **allelopathy**. This is a short-term chemical response meant to inhibit competition for space. Certain plants eliminate others by producing inhibitive chemicals as leaf leachate or as rhizosphere products. These substances include toxins, which injure plants within reach. Some of the chemical exudates like those released by milky weed and walnuts, inhibit seed germination of competing species.

The ungulates of the East African Savannah mitigate competition for food by seasonal migration. The wildebeest, for instance, migrate from Serengeti plains to Maasai Mara in Kenya. Within the grazing community of the Savannah, the ungulates mitigate competition for forage by feeding at different canopy levels, a phenomenon called **temporal sepa**ration (Cox and Moore, 1986). The buffalo feeds on the leaves of very large grasses, the zebra eats the low protein grass stems, next are the antelopes and wildebeest, which feed on short, trampled grass and lastly are Thomson's gazelle which feed on a broader leaved dicotyledonous plants after most grasses have been reduced. Within a tree canopy, insects and birds avoid competition by the development of specialized microhabitats. This is called **spatial separation** of species.

Competition has a lot of effects in a community or organisms. It does reduce the species range and generally may lead to the elimination of a species, a phenomenon called competitive exclusion. Also it induces development of stratified communities, especially where light is limited. Competition may prevent two species from living together in a habitat, or it may reduce the vigour and therefore, the reproduction rate of certain species. Competition is, therefore associated with the extinction of less aggressive species and the dominance of the more aggressive species under given environmental conditions. Coexistence of the competing species, with time, through evolutionary changes may eventually reduce or remove competition.

7.6.2. Tolerance Limits

In any environment, all organisms have tolerance limits beyond which they cannot exist. Each physical environment factor is operative over a gradient, which affects all organisms present, for example through a range of temperature from low to high. Any organism, which is tolerant of a wide range of conditions, is termed **eurytopic**. An organism, which is tolerant of a

narrow range of conditions, is referred to as **stenotopic**. All organisms function with maximum efficiency over only part of a gradient. Here at its optimum, the organism is able to exist in large numbers, since its ability to compete is at its greatest. Beyond this limit, it suffers physiological stress, so that its reproductive capacity is impaired and smaller numbers can be maintained. The organisms may migrate to more favourable area.

7.6.3. Predation

The distribution of species is affected by another biological factor known as predators. Predators reduce or eliminate species (the prey) by eating them. Predation is the most obvious form of species reduction. By reducing the number of preys, predation reduces the pressures of competition between them. Thus it may allow more species to survive than would be case in the presence of competition alone. Recent studies of natural communities tend to suggest that predators may increase the number of different species in a habitat. So predators broaden the distribution of species rather than confine it.

Despite the debates about predation, there is much yet to be understood. Theoretically, predators reduce prey to a certain size along which its population oscillates through feedback mechanism. An increase in predator population is followed by an increase in the prey eaten and subsequently a reduction in prey population. Below a certain level, the predators find it time consuming to obtain enough prey. This absence of food leads to competition in predators and hence natural ecosystems where predators and preys control themselves to a certain size to avoid impoverishment of either population.

Naturally, predator species depend on more than one prey, an ecological adaptation, in order to reduce pressure on prey and increase chances of a predator reaching its targets. This characteristic applies to certain plants as it does to animals. At a very limited level, predation can be seen as animal interaction, but it also involves carnivorous plants such as Venus flytrap, which catches and digests various insects. The ability as a predator to find and feed on its prey depends upon the rate of energy and matter flow from one trophic level to another. Predators employ various specialized features and behaviour patterns. Hawks, falcons and eagles, for instance have eyesight that enables them to spot prey from a distance. Wolves are able to take larger preys than themselves by hunting in packs while spiders build complex webs to trap moving insects.

Preys do not lend themselves easily to predation. Instead, they are equipped with various avoidance mechanisms such as fast flight or living in habitats with many hiding places; they also have sharp senses to detect the presence of predators. Some species defend themselves against predation by taking unattractive scaring shapes. Blowfish, for instance, inflate to larger size, while cacti have thorns to discourage predation. Some beetles may emit evil smelling gasses to discourage their enemies.

7.6.4. Symbiosis

When two different species exist in close physical contact and benefit from their association the phenomenon is called symbiosis. Literally, symbiosis means living together for mutual advantage. Three types of symbiosis, which can be identified on the basis of energy transfer, are: mutualism, communalism and parasitism. Through ecological associations, the presence of one organism may be dependent on the other.

7.6.4.1. Mutualism

This is a symbiotic relationship from which the two species involved benefit. It is the interaction displayed by Rhizobium bacteria and the root nodules of leguminous plant. Large colonies of bacteria in root nodules fix gaseous nitrogen to available forms such as nitrate and ammonium ions. Thus plants benefit by obtaining available nitrogen, which bacteria have reduced in a habitat. Mutualism is also demonstrated between ants and the acacia of the East Africa Savannah. The former protect the trees from predation and damages by ungulates while the latter provide the insects with food (nectarines) and a habitat.

7.6.4.2. Communalism

This is an association from which one species benefits while the other is neither harmed nor helped. Epiphytes, for instance, use tree trunks to reach upper canopies to get access to sunlight. These so called air plants, take nothing from the tree leaves and do harm or benefit from it.

7.6.4.3. Parasitism

This is a symbiotic association where one species the parasite benefits while the other species the host is harmed. From the host, the parasite takes its nourishment, which can be in form of blood or sap. Parasites can live on the host (ecoparasite) or in the host (endoparasite). Animal plaguing parasite includes lice, ticks and worms. Parasites, which plague plants, include fungi, which cause disease and wheat rust.

7.7. Fire

Fire both natural and human induced affects vegetation. It is possible to consider fire abiotic rather than a biotic environment. Fire is a biotic factor to the extent that its occurrences; duration and intensity depend upon the amount of combustible litter and to the extend that most fires started by man. The contrary is true, to the extent that natural fires depend upon lightning and the fire characteristics depend upon climatic and topographic variations. Fire for instance, is controlled by wind. The latter determines the speed and direction of fire. Other climatic factors like humidity and temperature affect the severity of fire. In the East African Savannah, fires are common during the dry season when weather conditions are favourable and combustible litter in plenty. Concentrating on logistic of fire may not/ suffice; its effect on biota. There is a lot of literature, which has been written on fire in the savannah, and any interested reader may investigate.

Some plants need exposure to fire before germination. Fires result in radical changes in the community structure. Some plants have roots and shoots, which are, fire adapters. Fire is usually an occasional factor in the ecosystem, but one, which in a short time can cause substantial modifications. All independent components of ecosystems are likely to be affected by fire, which becomes particularly drastic if driven by wind. Most natural cause of fire is lightening. Fires cause changes in the composition of vegetation and in soil moisture and nutrient levels. Modifications also occur in microclimates, notably among temperature and light conditions within the vegetation cover, while plant competitors, animal food supplies and habitats are likely to be varied. Fire regarded as most important factor in the origin and development of grassland ecosystem (not necessarily the case). Deliberate burning can be problem, yet exclusion of fire may also lead to a greater incidence of diseases and pests.

Fire increases plant susceptibility to bacterial and fungal attacks by making scars on them. Such plants can easily be damaged by wind or may attract later fires. Fire kills animals on the surface and those in shallow depths. By destroying habitats, it induces the migration of certain organisms. On the contrary, the creation of open sites attracts seed feeders such as birds and rodents and increases the population of shade intolerants. Fire, like biological variables, has a selective effect. Fire occurrence stimulates populations of species, which are fire resistant plants.

7.8. Anthropogenic

Human beings are also biotic factors because they select certain plants and animals over others. This is done through agriculture, intensification of grazing and fire. Domestication of animal affects plants differently by grazing and browsing, which results in selection of species, thus affecting the composition of the natural vegetation. Grazing decreases the variety of species in an area, eliminates grasses, shrubs, and bushes, weakens desirable species, and increases competition, survivors and soil fertility decline. Recreation use of natural area, hunting, vehicles, camping also have an impact on landscapes and environment. The spread of domesticated plants, some useful (maize, potato), some harmful species (hyacinth) has been largely due to anthropogenic activities.

7.9. Time and Ecosystems

A fundamental characteristic of ecosystems is their susceptibility to change with the passage of time. Two kinds of changes take place, each associated with a different time scale: First, ecosystems are modified in a series of stages which cover the lifespan of their component individuals and last for decades or centuries. Second, they are affected by changes, which occur over much longer periods of time, usually measurable in thousands or millions of years, and are a response to alterations in physical environmental conditions together with the evolution of their component species.

7.10. Summary

This lesson discusses the distribution of organisms in the biosphere and the factors that influence them. Indeed, distribution of living organisms is characterized by lack of uniformity; however, there is no organism that is distributed haphazardly on the earth's surface. A close examination shows that the patterns of distribution are never even. Indeed each species exhibits variations in distribution in both space and time. The patterns and distribution of living organisms in an ecosystem are determined by several factors both abiotic and biotic. These patterns are also controlled spatially and vary temporally. The anthropogenic activities have had a great impact on the distribution of living organisms and further reading is recommended.

7.11. Definition of key words

1. **Symbiosis** refers to the relationship between two different species usually for mutual advantage.

2. **Tolerance limits** refers to the environmental gradient within which a species is able to survive. Beyond the limit, the species suffers physiological stress so that its reproductive capacity is impaired and smaller numbers are maintained. Organisms with a wide range of tolerance are **eurotopic,** while **stenotopic** refers to those tolerant of a narrow range of conditions.
3. **Biotic factors** result from interaction of plants and animals existing under similar conditions, they include competition and predation.
4. **Abiotic factors** relate to the physical environment and include; climate, relief and soi.
5. **Competition** is the struggle for limited resources by different species of plants and animals. Intracompetition occurs between populations of the same species and intercompetition occurs between populations of different species.

7.12. Revision Questions

1. Discuss the effects of climate on the distributions of living organisms in Kenya.
2. Explain how time influences ecosystems.
3. Discuss the species diversity and abundance as dictated by competition in drylands.
4. How have dispersal mechanisms resulted in the species distribution?
5. Explain how the following factors affect the pattern and distribution of living organisms in an ecosystem: Edaphic factors, Competition, Topography

7.13. Further Reading

1. Coe, M.J .*The Ecology of the Alpine Zone of Mt Kenya*
2. Cox C. and P. D. Moore 1986. *Biogeography, An Ecological and Evolutionary Study*, Longman
3. Harper J. L. and Townsend C. R.1986. *Individuals, Population and Communitie*s, Blackwell Scientific Publication.
4. Ojany F.F and Ogendo, R.B. 1973. *Kenya: A study in Physical and Human Geography* Longman, Nairobi