UNIT – I

Ecology: Scope and objectives. Individual, Triggering and Holistic impacts of climatic, edaphic and biotic factors on plant life. Community concepts, Succession. Methods of studying vegetation – Quadrats and transects. Population ecology, Ecophene, Ecotypes.

Ecology: Scope and Objectives

Ecology is a branch of science which deals with the study of inter•relationship between biotic and abiotic components of nature as well as relationship among the individuals of the biotic compo•nents. Ecology has been defined in a number of ways by different scientists and ecologists.

Ernest Haeckel (1866), a German biologist, for the first time defined ecology as "the body of knowledge is concerning the economy of the nature the investigation of the total relation of animal to its inorganic and organic environment including above all its friendly and animal relations with those animals and plants with which it comes directly or indirectly into contact." The term Ecology' was derived from two Greek words, OIKOS (means house) and LOGUS (means study of) to denote the relationship between the organisms and their environment.

According to Woodbury (1954), "Ecology is a science which investigates organisms in relation to their environment'. E.P. Odum (1969) defined ecology as "the study of structure and function of nature". R Margalef (1968) treated ecology as "study of ecosystems".

Thus, modern ecologists have broaden the definition of ecology considering all the fundamental aspects in the subject. Anyway, ecology is primarily a biological science in as much as it deals with the inter-relationships of organisms with their environ•ment.

Ecology plays a significant role in our day to day life. It is con•cerned with agriculture, horticulture, conservation of soil, wild•life, forest, water resources, etc. Its domain is so vast that it can•not be confined with limited discussion. However the study of ecological principles provides background knowledge for un•derstanding the problems of forests, soil, surface water etc.

Objectives of Ecology

The importance of ecology lies in the comprehensive under•standing of its objectives.

The important concepts discussed below throw light on various aspects of ecology

(i) The local and geographical distribution and abundance of organisms (habitat niche, community, bio-geography).

(ii) Temporal changes in the occurrence, abundance and ac•tivities of organisms (seasonal, annual, successional, geo•logical).

(iii) The inter-relationship between organism in population and communities (population ecology).

(iv) The structural adaptations and functional adjustment of organisms to their physical environment.

(v) The behaviour of organism under natural conditions (ethology).

(vi) The evolutionary development of all these inter-relations (evolutionary ecology).

(vii) The biological productivity of nature and its relations with mankind.

(viii) The development of mathematical models to relate in•teraction of parameters and predict effects (systems analysis).

(ix) The conservation and management of natural resources and pollution (applied ecology).

Classification of Ecology

Broadly speaking, the important sub-divisions of ecology are animal ecology and plant ecology. It is also classified as autecology and synecology. Autecology deals with the ecological study of one species of organism. Synecology deals with the ecological stud•ies of communities or entire eco-systems.

However, we can classify ecology into following branches:

(i) Habitat Ecology:

It deals with ecological study of differ•ent habitats on planet earth and their effects on the or•ganisms living there.

(ii) Community Ecology:

It deals with the study of the local distribution of animals in various habitats. Also, it is re•lated with the recognition and composition of commu•nity units, and succession.

(iii) Population Ecology:

This is also known as demonology. It deals with the study of the pattern of growth, structure and regulation of population organism. The population ecology also deals with interactions between populations of different species in a community.

(iv) Evolutionary Ecology:

It is concerned with the prob•lems of niche segregation, and speciation.

(v) Taxonomic Ecology:

It is related with the ecology of different taxonomic groups of living organisms.

(vi) Human Ecology:

It is mainly related to population ecol•ogy. It studies the inter-relationship between man and man along-with the environment. Effects of human be•ings on the biosphere and the implications of these ef•fects for mankind is the subject matter of human ecol•ogy.

(vii) Applied Ecology:

It is an important sub-division of ecol•ogy. It deals with the practical aspect of ecology. Mainly the application of ecological concept to human needs is the field of this study. We find wild-life management, forestry, conservation, insect control, animal husbandry, aqua-culture, agriculture, horticulture, land use, popula•tion ecology etc. as the application of ecology in practi•cal life.

(viii) Eco-system Dynamics:

It deals with the ecological study of the process of soil formation, energy flow, productiv•ity etc.

(ix) Production Ecology:

It examines the gross and net pro•duction of different eco-systems like fresh water, sea water, agriculture, horticulture etc. Production ecology attempts for the effective management of the eco-sys•tems so as to maximise the production.

(x) Ecological Energetics:

It deals with energy conserva•tion and its flow in the organisms within the eco-system.

(xi) Physiological Ecology (Eco-physiology):

The factors of environment have direct relation with the functional as•pects of the organism. The eco-physiology deals with the survival of the population as a result of functional ad•justment of organisms with different ecological condi•tions.

(xii) Chemical Ecology:

It is related with the adaptation of animals of preferences of particular organisms like in•sects to particular chemical substances.

(xiii) Ecological Genetics:

An ecologist recognised the kind of genetic plasticity in the case of every organism. In any environment only those organisms that are supported by the environment can survive. Thus, genecology deals with the study of variations of species based on their genetic potentialities.

(xiv) Palaeo Ecology:

It is the study of environmental condi•tions and life of the past ages.

(xv) Geographic Ecology (Eco-geography):

It focuses light on the study of geographical distribution of animals and plants.

(xvi) Space Ecology:

It is concerned with the development of partially or wholly regenerating eco-systems for sup•porting the life of man during long space flights.

(xvii) Pedology:

It deals with the study of soil, especially their acidity, human contents, mineral contents, soil types, etc. and their influence on their organism.

(xviii) Radiation Ecology:

It studies the gross effect of radia•tion and radio-active substances over the environment and living organisms.

(xix) Ethology:

It studies the animal behaviour under natu•ral conditions

(xx) Sociology:

It is the study of ecology and ethology of mankind.

(xxi) System Ecology:

It deals with the analysis and under•standing of the function and structure of eco-system through the use of applied mathematics, advanced sta•tistical techniques, mathematical models etc.

Biotic and Abiotic Factors

Many forces influence the communities of living organisms present in different parts of the biosphere (all of the parts of Earth inhabited by life). The biosphere extends into the atmosphere (several kilometers above Earth) and into the depths of the oceans. Despite its apparent vastness to an individual human, the biosphere occupies only a minute space when compared to the known universe. Many abiotic forces influence where life can exist and the types of organisms found in different parts of the biosphere. The abiotic factors influence the distribution of climates, flora, and fauna.

Biogeography

Biogeography is the study of the geographic distribution of living things and the abiotic factors that affect their distribution. Abiotic factors such as temperature and rainfall vary based mainly on latitude and elevation. As these abiotic factors change, the composition of plant and animal communities also changes. For example, if you were to begin a journey at the equator and walk north, you would notice gradual changes in plant communities. At the beginning of your journey, you would see tropical wet forests with broad-leaved evergreen trees, which are characteristic of plant communities found near the equator. As you continued to travel north, you would see these broad-leaved evergreen plants eventually give rise to seasonally dry forests with scattered trees. You would also begin to notice changes in temperature and moisture. At about 30 degrees north, these forests would give way to deserts, which are characterized by low precipitation.

Moving farther north, you would see that deserts are replaced by grasslands or prairies. Eventually, grasslands are replaced by deciduous temperate forests. These deciduous forests give way to the boreal forests found in the subarctic, the area south of the Arctic Circle. Finally, you would reach the Arctic tundra, which is found at the most northern latitudes. This trek north reveals gradual changes in both climate and the types of organisms that have adapted to environmental factors associated with ecosystems found at different latitudes. However, different ecosystems exist at the same latitude due in part to abiotic factors such as jet streams, the Gulf Stream, and ocean currents. If you were to hike up a mountain, the changes you would see in the vegetation would parallel those as you move to higher latitudes.

Species Distribution

Ecologists who study biogeography examine patterns of species distribution. No species exists everywhere; for example, the Venus flytrap is endemic to a small area in North and South Carolina. An endemic species is one which is naturally found only in a specific geographic area that is usually restricted in size. Other species are generalists: species which live in a wide variety of geographic areas; the raccoon, for example, is native to most of North and Central America.

Species distribution patterns are based on biotic and abiotic factors and their influences during the very long periods of time required for species evolution; therefore, early studies of biogeography were closely linked to the emergence of evolutionary thinking in the eighteenth century. Some of the most distinctive assemblages of plants and animals occur in regions that have been physically separated for millions of years by geographic barriers. Biologists estimate that Australia, for example, has between 600,000 and 700,000 species of plants and animals. Approximately 3/4 of living plant and mammal species are endemic species found solely in Australia (Figure 1).

Photo (a) depicts a wallaby, a member of the kangaroo family. The wallaby is brown with white flecks on its fur and a light brown underbelly. Its hands are clasped together. Photo (b) shows an echidna. Like a porcupine, the echidna has a compact body covered with brown and white quills. It has a long, slender snout.

Sometimes ecologists discover unique patterns of species distribution by determining where species are not found. Hawaii, for example, has no native land species of reptiles or amphibians, and has only one native terrestrial mammal, the hoary bat. Most of New Guinea, as another example, lacks placental mammals.

Plants can be endemic or generalists: endemic plants are found only on specific regions of the Earth, while generalists are found on many regions. Isolated land masses—such as Australia, Hawaii, and Madagascar—often have large numbers of endemic plant species. Some of these plants are endangered due to human activity. The forest gardenia (Gardenia brighamii), for instance, is endemic to Hawaii; only an estimated 15–20 trees are thought to exist.

Energy Sources

This photo shows a white flower with five diamond-shaped petals radiating out from a green center. Faint purple lines radiate out from the center of each petal toward the tip. Five stalk-like stamens with pink-tipped anthers extend from the flower's green center.

Figure 2. The spring beauty is an ephemeral spring plant that flowers early in the spring to avoid competing with larger forest trees for sunlight. (credit: John Beetham)

Energy from the sun is captured by green plants, algae, cyanobacteria, and photosynthetic protists. These organisms convert solar energy into the chemical energy needed by all living things. Light availability can be an important force directly affecting the evolution of adaptations in photosynthesizers. For instance, plants in the understory of a temperate forest are shaded when the trees above them in the canopy completely leaf out in the late spring. Not surprisingly, understory plants have adaptations to successfully capture available light. One such adaptation is the rapid growth of spring ephemeral plants such as the spring beauty (Figure 2). These spring flowers achieve much of their growth and finish their life cycle (reproduce) early in the season before the trees in the canopy develop leaves.

In aquatic ecosystems, the availability of light may be limited because sunlight is absorbed by water, plants, suspended particles, and resident microorganisms. Toward the bottom of a lake, pond, or ocean, there is a zone that light cannot reach. Photosynthesis cannot take place there and, as a result, a number of adaptations have evolved that enable living things to survive without light. For instance, aquatic plants have photosynthetic tissue near the surface of the water; for example, think of the broad, floating leaves of a water lily—water lilies cannot survive without light. In environments such as hydrothermal vents, some bacteria extract energy from inorganic chemicals because there is no light for photosynthesis.

Arrows in the illustration indicate that the prevailing wind direction is from the coastline toward the open ocean. The wind pushes the surface water away from shore, inducing a current in this direction. A counter-current flows from the depths toward shore, where it meets the surface current. The counter-current brings nutrients from the depths up toward the surface near the shoreline.

The availability of nutrients in aquatic systems is also an important aspect of energy or photosynthesis. Many organisms sink to the bottom of the ocean when they die in the open water; when this occurs, the energy found in that living organism is sequestered for some time unless ocean upwelling occurs. Ocean upwelling is the rising of deep ocean waters that occurs when prevailing winds blow along surface waters near a coastline (Figure 3). As the wind pushes ocean waters offshore, water from the bottom of the ocean moves up to replace this water. As a result, the nutrients once contained in dead organisms become available for reuse by other living organisms.

In freshwater systems, the recycling of nutrients occurs in response to air temperature changes. The nutrients at the bottom of lakes are recycled twice each year: in the spring and fall turnover. The spring and fall turnover is a seasonal process that recycles nutrients and oxygen from the bottom of a freshwater ecosystem to the top of a body of water. These turnovers are caused by the formation of a thermocline: a layer of water with a temperature that is significantly different from that of the surrounding layers. In wintertime, the surface of lakes found in many northern regions is frozen. However, the water under the ice is slightly warmer, and the water at the bottom of the lake is warmer yet at 4 °C to 5 °C (39.2 °F to 41 °F). Water is densest at 4 °C; therefore, the deepest water is also the densest. The deepest water is oxygen poor because the decomposition of organic material at the bottom of the lake uses up available oxygen that cannot be replaced by means of oxygen diffusion into the water due to the surface ice layer.

The illustration shows a cross-section of a lake in four different seasons. In winter, the surface of the lake is frozen with a temperature of 0°C. The temperature at the bottom of the lake is 4°C, and the temperature just beneath the surface is 2°C. During the spring turnover, the surface ice melts and warms to 4°C. At this temperature, the surface water is denser than the 2°C water beneath; therefore, it sinks. In summertime, the surface of the lake is 21°C, and the temperature decreases with depth, to 4°C at the bottom. During the fall turnover, the warm surface water cools to about 10°C; thus, it becomes denser and sinks.

In springtime, air temperatures increase and surface ice melts. When the temperature of the surface water begins to reach 4 °C, the water becomes heavier and sinks to the bottom. The water at the bottom of the lake is then displaced by the heavier surface water and, thus, rises to the top. As that water rises to the top, the sediments and nutrients from the lake bottom are brought along with it. During the summer months, the lake water stratifies, or forms layers of temperature, with the warmest water at the lake surface.

As air temperatures drop in the fall, the temperature of the lake water cools to 4 °C; therefore, this causes fall turnover as the heavy cold water sinks and displaces the water at the bottom. The oxygen-rich water at the surface of the lake then moves to the bottom of the lake, while the nutrients at the bottom of the lake rise to the surface. During the winter, the oxygen at the bottom of the lake is used by decomposers and other organisms requiring oxygen, such as fish.

Temperature

Temperature affects the physiology of living things as well as the density and state of water. Temperature exerts an important influence on living things because few living things can survive at temperatures below 0 °C (32 °F) due to metabolic constraints. It is also rare for living things to survive at temperatures exceeding 45 °C (113 °F); this is a reflection of evolutionary response to typical temperatures. Enzymes are most efficient within a narrow and specific range of temperatures; enzyme degradation can occur at higher temperatures. Therefore, organisms either must maintain an internal temperature or they must inhabit an environment that will keep the body within a temperature range that supports metabolism. Some animals have adapted to enable their bodies to survive significant temperature fluctuations, such as seen in hibernation or reptilian torpor. Similarly, some bacteria are adapted to surviving in extremely hot temperatures such as geysers. Such bacteria are examples of extremophiles: organisms that thrive in extreme environments.

Temperature can limit the distribution of living things. Animals faced with temperature fluctuations may respond with adaptations, such as migration, in order to survive. Migration, the movement from one place to another, is an adaptation found in many animals, including many that inhabit seasonally cold climates. Migration solves problems related to temperature, locating food, and finding a mate. In migration, for instance, the Arctic Tern (Sterna paradisaea) makes a 40,000 km (24,000 mi) round trip flight each year between its feeding grounds in the southern hemisphere and its breeding grounds in the Arctic Ocean. Monarch butterflies (Danaus plexippus) live in the eastern United States in the warmer months and migrate to Mexico and the southern United States in the wintertime. Some species of mammals also make migratory forays. Reindeer (Rangifer tarandus) travel about 5,000 km (3,100 mi) each year to find food. Amphibians and reptiles are more limited in their distribution because they lack migratory ability. Not all animals that can migrate do so: migration carries risk and comes at a high energy cost.

A chipmunk curled up tightly in its burrow

Some animals hibernate or estivate to survive hostile temperatures. Hibernation enables animals to survive cold conditions, and estivation allows animals to survive the hostile conditions of a hot, dry climate. Animals that hibernate or estivate enter a state known as torpor: a condition in which their metabolic rate is significantly lowered. This enables the animal to wait until its environment better supports its survival. Some amphibians, such as the wood frog (Rana sylvatica), have an antifreeze-like chemical in their cells, which retains the cells' integrity and prevents them from bursting.

Abiotic Factors Influencing Plant Growth

Temperature and moisture are important influences on plant production (primary productivity) and the amount of organic matter available as food (net primary productivity). Net primary productivity is an estimation of all of the organic matter available as food; it is calculated as the total amount of carbon fixed per year minus the amount that is oxidized during cellular respiration. In terrestrial environments, net primary productivity is estimated by measuring the aboveground biomass per unit area, which is the total mass of living plants, excluding roots. This means that a large percentage of plant biomass which exists underground is not included in this measurement. Net primary productivity is an important variable when considering differences in biomes. Very productive biomes have a high level of aboveground biomass.

Annual biomass production is directly related to the abiotic components of the environment. Environments with the greatest amount of biomass have conditions in which photosynthesis, plant growth, and the resulting net primary productivity are optimized. The climate of these areas is warm and wet. Photosynthesis can proceed at a high rate, enzymes can work most efficiently, and stomata can remain open without the risk of excessive transpiration; together, these factors lead to the maximal amount of carbon dioxide (CO_2) moving into the plant, resulting in high biomass production. The aboveground biomass produces several important resources for other living things, including habitat and food. Conversely, dry and cold environments have lower photosynthetic rates and therefore less biomass. The animal communities living there will also be affected by the decrease in available food.

Inorganic Nutrients and Soil

Inorganic nutrients, such as nitrogen and phosphorus, are important in the distribution and the abundance of living things. Plants obtain these inorganic nutrients from the soil when water moves into the plant through the roots. Therefore, soil structure (particle size of soil components), soil pH, and soil nutrient content play an important role in the distribution of plants. Animals obtain inorganic nutrients from the food they consume. Therefore, animal distributions are related to the distribution of what they eat. In some cases, animals will follow their food resource as it moves through the environment.

Water

Water is required by all living things because it is critical for cellular processes. Since terrestrial organisms lose water to the environment by simple diffusion, they have evolved many adaptations to retain water.

Animals will be covered in an oily or waxy skin or cuticle to retain moisture.

Plants have a number of interesting features on their leaves, such as leaf hairs and a waxy cuticle, that serve to decrease the rate of water loss via transpiration.

Organisms surrounded by water are not immune to water imbalance; they too have unique adaptations to manage water inside and out of cells.

Freshwater organisms are surrounded by water and are constantly in danger of having water rush into their cells because of osmosis. Many adaptations of organisms living in freshwater environments have evolved to ensure that solute concentrations in their bodies remain within appropriate levels. One such adaptation is the excretion of dilute urine; dilute urine has a low concentration of solutes and is mostly water, which allows them to expel excess water.

Marine organisms are surrounded by water with a higher solute concentration than the organism and, thus, are in danger of losing water to the environment because of osmosis. These organisms have morphological and physiological adaptations to retain water and release solutes into the environment. For example, Marine iguanas (Amblyrhynchus cristatus), sneeze out water vapor that is high in salt in order to maintain solute concentrations within an acceptable range while swimming in the ocean and eating marine plants.

Other Aquatic Factors

Some abiotic factors, such as oxygen, are important in aquatic ecosystems as well as terrestrial environments. Terrestrial animals obtain oxygen from the air they breathe. Oxygen availability can be an issue for organisms living at very high elevations, however, where there are fewer molecules of oxygen in the air. In aquatic systems, the concentration of dissolved oxygen is related to water temperature and the speed at which the water moves. Cold water has more dissolved oxygen than warmer water. In addition, salinity, current, and tide can be important abiotic factors in aquatic ecosystems.

Other Terrestrial Factors

Wind can be an important abiotic factor because it influences the rate of evaporation and transpiration. The physical force of wind is also important because it can move soil, water, or other abiotic factors, as well as an ecosystem's organisms.

Fire is another terrestrial factor that can be an important agent of disturbance in terrestrial ecosystems. Some organisms are adapted to fire and, thus, require the high heat associated with fire to complete a part of their life cycle. For example, the jack pine (Pinus banksiana)—a coniferous tree—requires heat from fire for its seed cones to open. A fire is likely to kill most vegetation, so a seedling that germinates after a fire is more likely to receive ample sunlight than one that germinates under normal conditions. Through the burning of pine needles, fire adds nitrogen to the soil and limits competition by destroying undergrowth.

Ecological succession

Succession is the order of colonization of species in an ecosystem from a barren or destroyed area of land. Mosses and lichens are the first species that inhabit an area. They make the area suitable for the growth of larger species such as grasses, shrubs and finally trees.

Ecological Succession

"Ecological succession is a series of changes that occur in an ecological community over time."

Ecological succession is the steady and gradual change in a species of a given area with respect to the changing environment. It is a predictable change and is an inevitable process of nature as all the biotic components have to keep up with the changes in our environment.

The ultimate aim of this process is to reach equilibrium in the ecosystem. The community that achieves this aim is called a climax community. In an attempt to reach this equilibrium, some species increase in number while some other decrease.

In an area, the sequence of communities that undergo changes is called sere. Thus, each community that changes is called a seral stage or seral community.

All the communities that we observe today around us have undergone succession over a period of time since their existence. Thus, we can say that evolution is a process that has taken place simultaneously along with that of ecological succession. Also, the initiation of life on earth can be considered to be a result of this succession process.

If we consider an area where life starts from scratch by the process of succession, it is known as primary succession. However, if life starts at a place after the area has lost all the life forms existing there, the process is called secondary succession.

It is obvious that primary succession is a rather slow process as life has to start from nothing whereas secondary succession is faster because it starts at a place which had already supported life before. Moreover, the first species that comes into existence during primary succession is known as pioneer species.

Types of Ecological Succession

These are the following types of ecological succession

Primary Succession

Primary succession is the succession that starts in lifeless areas such as the regions devoid of soil or the areas where the soil is unable to sustain life.

When the planet was first formed there was no soil on earth. The earth was only made up of rocks. These rocks were broken down by microorganisms and eroded to form soil. The soil then becomes the foundation of plant life. These plants help in the survival of different animals and progress from primary succession to the climax community.

If this primary ecosystem is destroyed, secondary succession takes place

Secondary Succession

Secondary succession occurs when the primary ecosystem gets destroyed. For eg., a climax community gets destroyed by fire. It gets recolonized after the destruction. This is known as secondary ecological succession. Small plants emerge first, followed by larger plants. The tall trees block the sunlight and change the structure of the organisms below the canopy. Finally, the climax community arrives.

Cyclic Succession

This is only the change in the structure of an ecosystem on a cyclic basis. Some plants remain dormant for the rest of the year and emerge all at once. This drastically changes the structure of an ecosystem.

Seral Community

"A seral community is an intermediate stage of ecological succession advancing towards the climax community."

A seral community is replaced by the subsequent community. It consists of simple food webs and food chains. It exhibits a very low degree of diversity. The individuals are less in number and the nutrients are also less.

There are seven different types of seres

Types of Seres	Explanation
Hydrosere	Succession in aquatic habitat.
Xerosere	Succession in dry habitat.
Lithosere	Succession on a bare rock surface.
Psammosere	Succession initiating on sandy areas.
Halosere	Succession starting in saline soil or water.
Senile	Succession of microorganism on dead matter.
Eosere	Development of vegetation in an era.

Examples of Ecological Succession

Following are the important examples of ecological succession

Acadia National Park

This national park suffered a huge wildfire. Restoration of the forest was left to nature. In the initial years, only small plants grew on the burnt soil. After several years, the forest showed diversity in tree species. However, the trees before the fire were mostly evergreen, while the trees that grew after the fire were deciduous in nature.

Ecological Succession of Coral Reefs

Small coral polyps colonize the rocks. These polyps grow and divide to form coral colonies. The shape of the coral reefs attracts small fish and crustaceans that are food for the larger fish. Thus, a fully functional coral reef exists.

The main causes of ecological succession include the biotic and climatic factors that can destroy the populations of an area. Wind, fire, soil erosion and natural disasters include the climatic factors.

Ecological succession is important for the growth and development of an ecosystem. It initiates colonization of new areas and recolonization of the areas that had been destroyed due to certain biotic and climatic factors. Thus, the organisms can adapt to the changes and learn to survive in a changing environment.

Community (ecology)

"Ecological community" redirects here. For human community organized around economic and ecological sustainability.

It has been suggested that Biocoenosis be merged into this article.

A bear with a salmon. Interspecific interactions such as predation are a key aspect of community ecology. In ecology, a community is a group or association of populations of two or more different species occupying the same geographical area at the same time, also known as a biocoenosis. The term community has a variety of uses. In its simplest form it refers to groups of organisms in a specific place or time, for example, "the fish community of Lake Ontario before industrialization".

Community ecology or synecology is the study of the interactions between species in communities on many spatial and temporal scales, including the distribution, structure, abundance, demography, and interactions between coexisting populations.[1] The primary focus of community ecology is on the interactions between populations as determined by specific genotypic and phenotypic characteristics.

Community ecology also takes into account abiotic factors e.g. annual temperature or soil pH. These non-living factors can influence the way species interact with each other. Abiotic factors filter the species that are present in the community, and therefore community structure. For example, the difference in plants present in the desert compared to the tropical rainforest is dictated by the annual precipitation. These non-living factors also influence the way species interact with each other. Humans can also have an effect on community structure through habitat disturbance, such as introduction of invasive species.

Community structure

On a deeper level the meaning and value of the community concept in ecology is up for debate. Communities have traditionally been understood on a fine scale in terms of local processes constructing (or destructing) an assemblage of species, such as the way climate change is likely to affect the make-up of grass communities. Recently this local community focus has been criticised. Robert Ricklefs has argued that it is more useful to think of communities on a regional scale, drawing on evolutionary taxonomy and biogeography, where some species or clades evolve and others go extinct.

Organisation

Niche

Within the community, each species occupies a niche. A species' niche determines how it interacts with the environment around it and its role within the community. By having different niches species are able to coexist. This is known as niche partitioning. For example, the time of day a species hunts or the prey it hunts.

Niche partitioning reduces competition between species.[6] Such that species are able to coexist as they suppress their own growth more than they limit the growth of other species. The competition within a species is greater than the competition between species. Intraspecific competition is greater than interspecific.

The number of niches present in a community determines the number of species present. If two species have the exact same niche (e.g. the same food demands) then one species will outcompete the other. The more niches filled, the higher the biodiversity of the community.

Trophic Level

a) A trophic pyramid showing the different trophic levels in a community. b) A food web of the same community

A species' trophic level is their position in the food chain or web. At the bottom of the food web are autotrophs, also known as primary producer. Producers provide their own energy through photosynthesis or chemosynthesis, plants are primary producers. The next level is herbivores (primary consumers), these species feed on vegetation for their energy source. Herbivores are consumed by omnivores or carnivores. These species are secondary and tertiary consumers. Additional levels to the trophic scale come when smaller omnivores or carnivores are eaten by larger ones. At the top of the food web is the apex predator, this animal species is not consumed by any other in the community. Herbivores, omnivores and carnivores are all heterotrophs.

A basic example of a food chain is; grass → rabbit → fox. Food chains become more complex when more species are present, often being food webs. Energy is passed up through trophic levels. Energy is lost at each level, due to ecological inefficiencies.

The trophic level of an organism can change based on the other species present. For example, tuna can be an apex predator eating the smaller fish, such as mackerel. However, in a community where a shark species is present the shark becomes the apex predator, feeding on the tuna.

Decomposers play a role in the trophic pyramid. They provide energy source and nutrients to the plant species in the community. Decomposers such as fungi and bacteria recycle energy back to the base of the food web by feeding on dead organisms from all trophic levels.

Guild

A guild is a group of species in the community that utilise the same resources in a similar way. Organisms in the same guild experience competition due to their shared resource. Closely related species tend to be in the same guild, due to traits inherited through common descent from their common ancestor. However, guilds are not exclusively closely related species.

Carnivores, Omnivores and herbivores are all basic examples of guilds. A more precise guild would be vertebrates that forage for ground dwelling arthropods, this would contain certain birds and mammals. Flowering plants that have the same pollinator also form a guild.

Influential species

Certain species have a greater influence on the community through their direct and indirect interactions with other species. The loss of these species results in large changes to the community, often reducing the stability of the community. Climate change and the introduction of invasive species can affect the functioning of key species and thus have knock on effects to the community processes.

Foundation species

Foundation species largely influence the population, dynamics and processes of a community. These species can occupy any trophic level but tend to be producers.[15] Red mangrove is a foundation species in marine communities. The mangrove's root provides nursery grounds for young fish, such as snappers.

Whitebark pine (Pinus albicaulis) is a foundation species. Post fire disturbance the tree provides shade (due to its dense growth) enabling the regrowth of other plant species in the community, This growth prompts the return of invertebrates and microbes which are needed for decomposition. Whitebark pine seeds provide food for grizzly bears.

A simple trophic cascade diagram. On the right shows when wolves are absent, showing an increase in elks and reduction in vegetation growth. The left one shows when wolves are present and controlling the elk population.

Keystone species

Keystone species have a disproportionate influence on the community than most species. Keystone species tend to be at the higher trophic levels, often being the apex predator. Removal of the keystone species causes top-down trophic cascades. Wolves are keystone species, being an apex predator.

In Yellowstone National Park the loss of the wolf population through overhunting resulted in loss of biodiversity in the community. The wolves had controlled the number of elks in the park, through predation. Without the wolves the elk population drastically increased, resulting in overgrazing. This negatively affected the other organisms in the park; the increased grazing from the elks removed food sources from other animals present. Wolves have since been reintroduced to return the park community to optimal functioning. See Wolf reintroduction and History of wolves in Yellowstone for more details on this case study.

A marine example of a keystone species is Pisaster ochraceus. This starfish controls the abundance of Mytilus californianus, allowing enough resources for the other species in the community.

Ecological engineers

An ecosystem engineer is a species that maintains, modifies and creates aspects of a community. They cause physical changes to the habitat and alter the resources available to the other organisms present.

Dam building beavers are ecological engineers. Through the cutting of trees to form dams they alter the flow of water in a community. These changes influence the vegetation on the riparian zone, studies show biodiversity is increased.[20] Burrowing by the beavers creates channels, increasing the connections between habitats. This aids the movement of other organisms in the community such as frogs.

Theories of community structure

Community structure is the composition of the community. It can be measured through species richness, species evenness. These measures help to understand the biodiversity of the community.

Holistic theory

Holistic theory refers to the idea that a community is defined by the interactions between the organisms in it. All species are interdependent, each playing a vital role in the working of the community. Due to this communities are repeatable and easy to identify, with similar abiotic factors controlling throughout.

Clements developed the holistic (or organismic) concept of community, as if it was a superorganism or discrete unit, with sharp boundaries. Clements proposed this theory after noticing that certain plant species were regularly found together in habitats, he concluded that the species were dependent on each other. Formation of communities is non-random and involves coevolution.

The Holistic theory stems from the greater thinking of Holism; which refers to a system's with many parts all of which are required for the functioning of the system.

Individualistic theory

Gleason developed the individualistic (also known as open or continuum) concept of community, with the abundance of a population of a species changing gradually along complex environmental gradients. Each species changes independently in relation to other species present along the gradient. Association of species is random and due to coincidence. Varying environmental conditions and each species' probability of arriving and becoming established along the gradient influence the community composition.

Individualistic theory proposes that communities can exist as continuous entities, in addition to the discrete groups referred to in the holistic theory.

Neutral theory

Hubbell introduced the neutral theory of ecology. Within the community (or metacommunity), species are functionally equivalent, and the abundance of a population of a species changes by stochastic demographic processes (i.e., random births and deaths).[28] Equivalence of the species in the community leads to ecological drift. Ecological drift leads to species' populations randomly fluctuating, whilst the overall number of individuals in the community remains constant. When an individual dies, there is an equal chance of each species colonising that plot. Stochastic changes can cause species within the community to go extinct, however this can take a long time if there are many individuals of that species.

Species can coexist because they are similar, resources and conditions apply a filter to the type of species that are present in the community. Each population has the same adaptive value (competitive and dispersal abilities) and resources demand. Local and regional composition represent a balance between speciation or dispersal (which increase diversity), and random extinctions (which decrease diversity).

Interspecific interactions

Species interact in various ways: competition, predation, parasitism, mutualism, commensalism, etc. The organization of a biological community with respect to ecological interactions is referred to as community structure.

Species can compete with each other for finite resources. It is considered to be an important limiting factor of population size, biomass and species richness. Many types of competition have been described, but proving the existence of these interactions is a matter of debate. Direct competition has been observed between individuals, populations and species, but there is little evidence that competition has been the driving force in the evolution of large groups.

Interference competition: occurs when an individual of one species directly interferes with an individual of another species. This can be for food or for territory. Examples include a lion chasing a hyena from a kill, or a plant releasing allelopathic chemicals to impede the growth of a competing species.

Apparent competition: occurs when two species share a predator. For example, a cougar preys on woodland caribou and deer. The populations of both species can be depressed by predation without direct exploitative competition.

Table visualising size-symmetric competition, using fish as consumers and crabs as resources.

Exploitative competition: This occurs via the consumption of resources. When an individual of one species consumes a resource (e.g., food, shelter, sunlight, etc.), that resource is no longer available to be consumed by a member of a second species. Exploitative competition is thought to be more common in nature, but care must be taken to distinguish it from apparent competition. An example of exploitative competition could be between herbivores consuming vegetation; rabbit and deer both eating meadow grass. Exploitative competition varies:

complete symmetric - all individuals receive the same amount of resources, irrespective of their size

perfect size symmetric - all individuals exploit the same amount of resource per unit biomass

absolute size-asymmetric - the largest individuals exploit all the available resource.[32]

The degree of size asymmetry has major effects on the structure and diversity of ecological communities

Predation

Predation is hunting another species for food. This is a positive–negative interaction, the predator species benefits while the prey species is harmed. Some predators kill their prey before eating them, also known as kill and consume. For example, a hawk catching and killing a mouse. Other predators are parasites that feed on prey while alive, for example a vampire bat feeding on a cow. Parasitism can however lead to death of the host organism over time. Another example is the feeding on plants of herbivores, for example a cow grazing. Predation may affect the population size of predators and prey and the number of species coexisting in a community.

Predation can be specialist, for example the least weasel predates solely on the field vole. Or generalist, e.g. polar bear primarily eats seals but can switch diet to birds when seal population is low.

Species can be solitary or group predators. Advantage of hunting in a group means bigger prey can be taken, however the food source has to be shared. Wolves are group predators, whilst tigers are solitary.

A generalised graph of a predator-prey population density cycle

Predation is density dependant, often leading to population cycles. When prey is abundant predator species increases, thus eating more prey species and causing the prey population to decline. Due to lack of food the predator population declines. Due to lack of predation the prey population increases. See Lotka–Volterra equations for more details on this. A well-known example of this is lynx-hare population cycles seen in the north.

Predation can result in coevolution – evolutionary arms race, prey adapts to avoid predator, predator evolves. For example, a prey species develops a toxin that will kill its predator, predator evolves resistance to the toxin making it no longer lethal.

Mutualism

Mutualism is an interaction between species in which both benefit.

An example is Rhizobium bacteria growing in nodules on the roots of legumes. This relationship between plant and bacteria is endosymbiotic, the bacteria living on the roots of the legume. The plant provides compounds made during photosynthesis to the bacteria, that can be used as an energy source. Whilst Rhizobium is a nitrogen fixing bacteria, providing amino acids or ammonium to the plant.

Insects pollinating the flowers of angiosperms, is another example. Many plants are dependent on pollination from a pollinator. A pollinator transfers pollen from the male flower to the female's stigma. This fertilises the flower and enables the plant to reproduce. Bees, such as honeybees, are the most commonly known pollinators. Bees get nectar from the plant that they use as an energy source. Un-transferred pollen provides protein for the bee. The plant benefits through fertilisation, whilst the bee is provided with food.

Commensalism

Commensalism is a type of relationship among organisms in which one organism benefits while the other organism is neither benefited nor harmed. The organism that benefited is called the commensal while the other organism that is neither benefited nor harmed is called the host.

For example, an epiphytic orchid attached to the tree for support benefits the orchid but neither harms nor benefits the tree. This type of commensalism is called inquilinism, the orchid permanently lives on the tree.

Phoresy is another type of commensalism, the commensal uses the host solely for transport. Many mite species rely on another organism, such as birds or mammals, for dispersal.

Metabiosis is the final form of commensalism. The commensal relies on the host to prepare an environment suitable for life. For example, Kelp has a root like system, called a holdfast, that attaches it to the seabed. Once rooted it provides molluscs, such as sea snails, with a home that protects them from predation.

Amensalism

The opposite of commensalism is amensalism, an interspecific relationship in which a product of one organism has a negative effect on another organism but the original organism is unaffected.

An example is the interaction been tadpoles of the common frog and a freshwater snail. The tadpoles consume large amounts of micro-algae. Making algae less abundant for the snail, the algae available for the snail is also of lower quality. The tadpole therefore has a negative effect on the snail without a gaining noticeable advantage from the snail. The tadpoles would obtain the same amount of food with or without the presence of the snail.

An older, taller tree can inhibit the growth of smaller trees. A new sapling growing in the shade of a mature tree will struggle to get light for photosynthesis. The mature tree will also have a well-developed root system, enabling it to outcompete the sapling for nutrients. Growth of the sapling is therefore impeded, often resulting in death. The relationship between the two trees is amensalism, the mature tree is unaffected by the presence of the smaller one.

Parasitism

Parasitism is an interaction in which one organism, the host, is harmed while the other, the parasite, benefits.

Parasitism is a symbiosis, a long-term bond in which the parasite feeds on the host or takes resources from the host. Parasites can live within the body such as a tapeworm. Or on the body's surface, for example head-lice

A red-chested cuckoo chick being feed by a significantly smaller Cape robin-chat adult

Malaria is a result of a parasitic relationship between a female Anopheles mosquito and ''Plasmodium''. Mosquitos get the parasite by feeding on an infected vertebrate. Inside the mosquito the plasmodium develops in the midgut's wall. Once developed to a zygote the parasite moves to the salivary glands where it can be passed on to a vertebrate species, for example humans. The mosquito acts as a vector for Malaria. The parasite tends to reduce the mosquito's lifespan and inhibits the production of offspring.

A second example of parasitism is brood parasitism. Cuckoos regularly do this type of parasitism. Cuckoos lay their eggs in nest of another species of birds. The host therefore provides for the cuckoo chick as if it was their own, unable to tell the difference.[45] The cuckoo chicks eject the host's young from the nest meaning they get a greater level of care and resources from the parents. Rearing for young is costly and can reduce the success of future offspring, thus the cuckoo attempts to avoid this cost through brood parasitism.

In a similar way to predation, parasitism can lead to an evolutionary arms race. The host evolves to protect themselves from the parasite and the parasite evolves to overcome this restriction.

Neutralism

Neutralism is where species interact, but the interaction has no noticeable effects on either species involved. Due to interconnectedness of communities, true neutralism is rare. Examples of neutralism in ecological systems are hard to prove, due to the indirect effects that species can have on each other.

ecology

AbundanceAllee effectDepensationEcological yieldEffective population sizeIntraspecific competitionLogistic functionMalthusian growth modelMaximum sustainable yieldOverpopulationOverexploitationPopulation cyclePopulation dynamicsPopulation modelingPopulation sizePredator–prey (Lotka–Volterra) equationsRecruitmentResilienceSmall population sizeStability

Species

BiodiversityDensity-dependent inhibitionEcological effects of biodiversityEcological extinctionEndemic speciesFlagship speciesGradient analysisIndicator speciesIntroduced speciesInvasive speciesLatitudinal gradients in species diversityMinimum viable populationNeutral theoryOccupancy–abundance relationshipPopulation viability analysisPriority effectRapoport's ruleRelative abundance distributionRelative species abundanceSpecies diversitySpecies homogeneitySpecies richnessSpecies distributionSpecies-area curveUmbrella species

Species

interaction

AntibiosisBiological interactionCommensalismCommunity ecologyEcological facilitationInterspecific competitionMutualismParasitismStorage effectSymbiosis

Spatial

ecology

BiogeographyCross-boundary subsidyEcoclineEcotoneEcotypeDisturbanceEdge effectsFoster's ruleHabitat fragmentationIdeal free distributionIntermediate disturbance hypothesisInsular biogeographyLand change modelingLandscape ecologyLandscape epidemiologyLandscape limnologyMetapopulationPatch dynamicsr/K selection theoryResource selection functionSource–sink dynamics

Niche

Ecological nicheEcological trapEcosystem engineerEnvironmental niche modellingGuildHabitatMarine habitatsLimiting similarityNiche apportionment modelsNiche constructionNiche differentiation

networks

Assembly rulesBateman's principleBioluminescenceEcological collapseEcological debtEcological deficitEcological energeticsEcological indicatorEcological thresholdEcosystem diversityEmergenceExtinction debtKleiber's lawLiebig's law of the minimumMarginal value theoremThorson's ruleXerosere

AllometryAlternative stable stateBalance of natureBiological data visualizationEcoclineEcological economicsEcological footprintEcological forecastingEcological humanitiesEcological stoichiometryEcopathEcosystem based fisheriesEndolithEvolutionary ecologyFunctional ecologyIndustrial ecologyMacroecologyMicroecosystemNatural environmentRegime shiftSystems ecologyUrban ecologyTheoretical ecology

Methods of Sampling Plant Communities

The following points highlight the five methods of sampling plant communities. The methods are: 1. Transect Method 2. Bisect 3. Trisect 4. Ring Counts 5. Quadrat Method.

1. Transect Method

When the vegetation is to be studied along an environmental gradient or eco-tone (e.g. tropical to temperate, high or low rainfall areas or precipitation gradient, adjacent areas with different types of soil, etc.) a line is laid down across a stand or several stands at right angles. This method of linear sampling of the vegetation is called transect.

Depending upon the object of study, two types of transect can be drawn

(1) Line Transect or Line Intercept; and

(2) Belt Transect.

The extent of area determines the number and size of transects. When transects are used to sample the vertical distribution of vegetation (i.e. stratification) they are called 'bisects'.

1. Line Transect

In this type of transect the vegetation is sampled only over a line (without any width). A line is laid over the vegetation with a metric steel tape or steel chain or long rope and kept fixed with the help of pegs or hooks. This line will touch some plants on its way from one point to the other. The observer will start recording these plants from one end and will gradually move towards the other end.

(a) The number of times each species appears along the line,

(b) The trend of increase or decrease of distance between the individuals of a species,

(c) The percentage of occurrence of different species in relation to the total species,

(d) The gradual disappearance or appearance of different species along the line, etc.

From the observations in a number of such parallel line transects, comments can be made on the habitat and other environmental conditions on different portions of the transect. Every species has its own ecological amplitude and tentatively expresses the status of available water and other edaphic condi•tions, atmospheric humidity, availability of light, grazing and other biological pressures, etc.

When two different types of vegetation develop side by side a gradual change of species content is generally seen in the intermediate region. For understanding the mode of such change the communities are generally studied by line transect method.

(i) A long thread or a rope,

(ii) A measuring tape,

(iii) Two surveyor's hooks or long nails.

A thread or a rope or a long measuring tape is laid across the stand or stands in the communities under study and fixed with two hooks at two ends. Record individual plants touching the thread and the distance from a particular end.

Inference

From the gradual change of the concentration of different species in different portions of the transect and the new arrival or disappearances of species, comments can be made on the habitat conditions of two communities and the transitional region.

2. Belt Transect

The belt is a long strip of vegetation of uniform width. The width of the belt is determined according to the type of vegetation or the stratum of vegetation under study. In close herba•ceous vegetation it is usually 10 cm, but it varies from 1 to 10 m in woodland.

The length of the vegetation is determined according to the purpose of the study. If a transect is essential then the lines should be marked using deep-seated wooden pegs at regular intervals. A belt could be kept isolated by installing tall wire-net fence on all its sides keeping safety-space from lines.

A belt is generally studied by dividing it into some equal sized segments. The length of each segment is generally equal to the width of the transect. These segments are sometimes called quadrats. Belt transects are used in determining and understanding the gradual change in abundance, domi•nance, frequency and distribution of different species in the transitional region between two different types of vegetation.

For understanding the gradual change in density and frequency of different species in the transitional region between two different types of vegetation the area is generally studied by Belt Transect method

(i) Long threads or ropes,

(ii) Measuring tape,

(iii) Surveyor's hooks or nails; and

(iv) Graph paper.

Place two hooks 50 cm apart at both ends of the transect (A & B and C & D). Connect these two sets of nails by long threads (A & C and B & D). Place more nails along these two lines at every 50 cm (F, G, J, etc. and E, H, I, etc.). Connect these nails crosswise with threads.

Now, a series of quad•rate (e.g. ABEF, EFGH, GHD, etc.) have been demarcated along the transect. Distribute the quadrats into three distinct zones: I: the first vegetation type; II: the transition region and III: the second vegetation type.

The Density (D) and Frequency (F) of different species in different zones can be calculated using following formulae:

D = No. of individuals of the species in all the sample plots/No. of sample plots studied

F = No. of points of occurrences of the species/No. of sample plots studied

Record all the species along with their numbers in all quadrats (if a sharp change is apprehended) or the alternate quadrats (if the change appears to be very slow) in the following Table 4 and calculate their Density and Frequency.

Inference

By transect method, one can estimate different qualitative and quantitative characters of the vegeta•tion and can correlate the findings with the different environmental conditions.

Further, in Belt-Transect, it is possible to determine the basal area or cover (by introducing another column in the Table) of all the recorded species from which Density, Frequency and Importance Value Index also can be calculated.

5. Quadrat Method

The quadrat is a square sample area of varying size marked-off in the plant community for the purpose of detailed study. Generally a number of quadrats are studied to acquire reasonably faithful data to realise different analytic and synthetic characters of the plant community.

It is also effectively used to determine the exact differences or similarities in the structure and composition between two or more plant communities of related or unrelated vegetation.

Quadrats can be of four types

1. List Quadrat

Enlisting the names of different species growing in the quadrat.

2. List-Court Quadrat:

Records the number of individuals of each species represented in each quadrat.

3. Chart Quadrat:

Records the position and areas covered by bunches, mats or tufts of grasses, mosses, etc. on the coordinated or graph paper. These graphs help to compare any change in structure of community in future.

4. Clip Quadrat:

For the study of biomass or weight of each species, all individuals are uprooted (but when the weight of a particular organ, e.g., branch, leaf, fruit, etc., is to be determined only the concerned organ is clipped or harvested) and its fresh or dry weight is recorded.

Demarcation or laying out of different types of quadrats are basically same. Generally, an adjustable wooden frame is prepared with perforations at regular intervals on each arm. Four arms are fixed in the field with the help of long nails or surveyor's hooks and it is ready to provide data necessary for list, list- count and clip quadrat.

But, in chart quadrat more nails or hooks are fixed to the perforations on quadrat arms at regular intervals. Nails of opposite arms are connected by threads to divide the plot into a number of smaller quadrats to facilitate the recording of the area covered by individual plants on a coordinate paper in scale. When such wooden frames are not easily available it can be replaced by long threads or ropes.

The best size of quadrat to use in a community should be determined with care. It should be large enough and enough quadrats should be studied to produce reliable results.

Size of Quadrats:

The size of quadrats to be used in a given community is determined by constructing a species area curve. This is done by sampling the vegetation with nested quadrat method.

Nested quadrats are a series of quadrats, laid one over the other with gradually increasing size and can be prac•ticed in the following way

(i) Long thread,

(ii) Surve-yor's hooks or long nails,

(iii) Measuring tape; and

(iv) Graph paper.

Put two nails 'O' and ' Y' 5 m apart. Place the nail 'X' 5 m away from 'O' nail at right angle with the OY arm. Connect YO and OX by a long thread. Place the nails A and B on OX and OY, respectively, 50 cm away from 'O'. Using another nail make a 50 cm x 50 cm square (Quadrat No. 1). Record all species growing in this quadrat.

Put another set of three nails increasing the length of arms 50 cm each (Quadrat No. 2). Record only newly found species in the list. Similarly, demarcate Quadrat Nos. 3, 4, 5 etc. increasing 50 cm arm length at every step. Continue the pro•cess so long as a recognisable number of new species is added each time

Nested Quadrat

If the total number of species in every Quadrat (e.g. 4, 7, 9 etc. as in the table) are plotted on a graph paper against the area and number, respec•tively, for OX and OY axes, it will yield a sigmoid curve which is known as 'Species area curve'

Species area curve

Inference:

The size of the Quadrat which recorded the highest number of species should be selected as the size of Quadrat for sampling the community under study.

[For general practice a 1 m × 1 m Quadrat sample is used for herbaceous vegetation, 5 m × 5 m for shrubby vegetation and 20 m × 20 m for trees.]

Selection of Quadrats:

For studying any plant community a number of quadrats should be studied. As the collected data will be processed statistically, the quadrats should be layed at random, with no bias for any particular region within the community. There are a number of methods for such random selection of quadrats.

Two such methods are:

I. Collect or prepare a map of the area under study. Draw a number of vertical or horizontal lines and number them separately. The numbers of vertical and horizontal lines are to be written separately on small pieces of paper and keep these two sets of paper squares in two separate beakers.

Mix these numbers in each beaker. Draw one number from each beaker and mark the place where lines representing these two numbers have crossed. Draw such number pairs repeatedly to find out the positions of a desired number of quadrats and mark the places properly.

II. Enter the area with blindfolded eyes and a stick in hand. Throw the stick over your shoulder at different parts of the vegetation. Each such point where the stick falls should be selected as a sample area.

For experimental purposes sometimes quadrats are marked permanently with the help of deep-seated wooden-pegs at four corners and studied at different times according to the need of the working programme. To understand the biotic pressure on the vegetation like grazing, etc. or to record its developmental history, some sample plots are needed to be kept isolated by fencing them properly with wire-nets.

Population ecology

Population ecology is a sub-field of ecology that deals with the dynamics of species populations and how these populations interact with the environment, such as birth and death rates, and by immigration and emigration).

The discipline is important in conservation biology, especially in the development of population viability analysis which makes it possible to predict the long-term probability of a species persisting in a given patch of habitat. Although population ecology is a subfield of biology, it provides interesting problems for mathematicians and statisticians who work in population dynamics.

History

In the 1940s ecology was divided into autecology—the study of individual species in relation to the environment—and synecology—the study of groups of species in relation to the environment. The term autecology (from Ancient Greek: αὐτο, aúto, "self"; οίκος, oíkos, "household"; and λόγος, lógos, "knowledge"), refers to roughly the same field of study as concepts such as life cycles and behaviour as adaptations to the environment by individual organisms. Eugene Odum, writing in 1953, considered that synecology should be divided into population ecology, community ecology and ecosystem ecology, renaming autecology as 'species ecology' (Odum regarded "autecology" as an archaic term), thus that there were four subdivisions of ecology.

Terms used to describe natural groups of individuals in ecological studies

Species population	All individuals of a species.
Metapopulation	A set of spatially disjunct populations, among which there is some migration.
Population	A group of conspecific individuals that is demographically, genetically, or spatially disjunct from other groups of individuals.
Aggregation	A spatially clustered group of individuals.
Deme	A group of individuals more genetically similar to each other than to other individuals, usually with some degree of spatial isolation as well.
Local population	A group of individuals within an investigator-delimited area smaller than the geographic range of the species and often within a population (as defined above). A local population could be a disjunct population as well.
Subpopulation	An arbitrary spatially delimited subset of individuals from within a population (as defined above).

Population dynamics

The development of population ecology owes much to the mathematical models known as population dynamics, which were originally formulae derived from demography at the end of the 18th and beginning of 19th century.

The beginning of population dynamics is widely regarded as the work of Malthus,formulated as the Malthusian growth model. According to Malthus, assuming that the conditions (the environment) remain constant (ceteris paribus), a population will grow (or decline) exponentially.:18 This principle provided the basis for the subsequent predictive theories, such as the demographic studies such as the work of Benjamin Gompertz and Pierre François Verhulst in the early 19th century, who refined and adjusted the Malthusian demographic model.

A more general model formulation was proposed by F. J. Richards in 1959, further expanded by Simon Hopkins, in which the models of Gompertz, Verhulst and also Ludwig von Bertalanffy are covered as special cases of the general formulation. The Lotka–Volterra predator-prey equations are another famous example, as well as the alternative Arditi–Ginzburg equations.

Fisheries and wildlife management In fisheries and wildlife management, population is affected by three dynamic rate functions.

Natality or birth rate, often recruitment, which means reaching a certain size or reproductive stage. Usually refers to the age a fish can be caught and counted in nets.

Population growth rate, which measures the growth of individuals in size and length. More important in fisheries, where population is often measured in biomass.

Mortality, which includes harvest mortality and natural mortality. Natural mortality includes non-human predation, disease and old age.

If N1 is the number of individuals at time 1 then

{\displaystyle N_{1}=N_{0}+B-D+I-E}N_{1}=N_{0}+B-D+I-E

where N0 is the number of individuals at time 0, B is the number of individuals born, D the number that died, I the number that immigrated, and E the number that emigrated between time 0 and time 1.

If we measure these rates over many time intervals, we can determine how a population's density changes over time. Immigration and emigration are present, but are usually not measured.

All of these are measured to determine the harvestable surplus, which is the number of individuals that can be harvested from a population without affecting long-term population stability or average population size. The harvest within the harvestable surplus is termed "compensatory" mortality, where the harvest deaths are substituted for the deaths that would have occurred naturally. Harvest above that level is termed "additive" mortality, because it adds to the number of deaths that would have occurred naturally. These terms are not necessarily judged as "good" and "bad," respectively, in population management. For example, a fish & game agency might aim to reduce the size of a deer population through additive mortality. Bucks might be targeted to increase buck competition, or does might be targeted to reduce reproduction and thus overall population size.

For the management of many fish and other wildlife populations, the goal is often to achieve the largest possible long-run sustainable harvest, also known as maximum sustainable yield (or MSY). Given a population dynamic model, such as any of the ones above, it is possible to calculate the population size that produces the largest harvestable surplus at equilibrium. While the use of population dynamic models along with statistics and optimization to set harvest limits for fish and game is controversial among some scientists, it has been shown to be more effective than the use of human judgment in computer experiments where both incorrect models and natural resource management students competed to maximize yield in two hypothetical fisheries. To give an example of a non-intuitive result, fisheries produce more fish when there is a nearby refuge from human predation in the form of a nature reserve, resulting in higher catches than if the whole area was open to fishing.

At its most elementary level, interspecific competition involves two species utilizing a similar resource. It rapidly gets more complicated, but stripping the phenomenon of all its complications, this is the basic principle: two consumers consuming the same resource. An important concept in population ecology is the r/K selection theory. The first variable is r (the intrinsic rate of natural increase in population size, density independent) and the second variable is K (the carrying capacity of a population, density dependent). An r-selected species (e.g., many kinds of insects, such as aphids is one that has high rates of fecundity, low levels of parental investment in the young, and high rates of mortality before individuals reach maturity. Evolution favors productivity in r-selected species. In contrast, a K-selected species (such as humans) has low rates of fecundity, high levels of parental investment in the young, and low rates of mortality as individuals mature. Evolution in K-selected species favors efficiency in the conversion of more resources into fewer offspring.

Metapopulation

Populations are also studied and conceptualized through the "metapopulation" concept. The metapopulation concept was introduced in 1969:

"as a population of populations which go extinct locally and recolonize.

Metapopulation ecology is a simplified model of the landscape into patches of varying levels of quality. Patches are either occupied or they are not. Migrants moving among the patches are structured into metapopulations either as sources or sinks. Source patches are productive sites that generate a seasonal supply of migrants to other patch locations. Sink patches are unproductive sites that only receive migrants. In metapopulation terminology there are emigrants (individuals that leave a patch) and immigrants (individuals that move into a patch). Metapopulation models examine patch dynamics over time to answer questions about spatial and demographic ecology. An important concept in metapopulation ecology is the rescue effect, where small patches of lower quality (i.e., sinks) are maintained by a seasonal influx of new immigrants. Metapopulation structure evolves from year to year, where some patches are sinks, such as dry years, and become sources when conditions are more favorable. Ecologists utilize a mixture of computer models and field studies to explain metapopulation structure.

The first journal publication of the Society of Population Ecology, titled Population Ecology (originally called Researches on Population Ecology) was released in 1952.

Scientific articles on population ecology can also be found in the Journal of Animal Ecology, Oikos and other journals.

Ecophene, Ecotype and Ecospecies

Life on Earth is a wondrous thing. It will do everything it possibly can, to make sure it survives. Every organism in this world has a wonderful ability to adapt to changes in it's surroundings. This adaptation is what allows it to tolerate small changes in it's environment; be in temperature, humidity or salinity changes. But what happens when an organism is taken and transported to a completely new environment? What if the conditions there are vastly different from it's native habitat?

Every species has a specific range within which it can tolerate ecological changes. This range is called ecological amplitude. Within this amplitude, an organism has three broad responses.

Ecophene

These are otherwise called ecads or morphologically-changed forms. When a species is transported to a new environment, it's first response will be to develop abilities to survive there. For example, when a European comes to the tropics, the immediate response is increased production of melanin-his skin becomes darker. Such changes are quite common in plants. For example, a species of grass called Euphorbia hirta has two different ecophenes; one that has adapted to grow in dry, hard soils and the other that grows in places that have been heavily trampled.

You can see examples of this in humans as well; an American living in Africa, and one living in northern Europe will have differences in the features.

These differences among ecophenes and not permanent. They are just temporary variations to survive the new conditions. The body of the organism assumes that it is going to be in these new conditions for a short while only. Therefore, ecophenes from different habitats, when brought together, become similar. If that American from Africa was to move to northern Europe, he would start to grow fairer.

This reversibility is because there has been no change in the genetics of the two separate ecophenes.

Ecotype

However, if two of these ecophenes were to remain in their new habitat for too long, these morphological (physical) changes will start becoming permanent. The body figures that if I'm going to be here permanently, might as well make these adaptations permanent!

That's why, if that American spends too long in Africa, he is going to develop a permanent tan. It will not go if he returns to America or goes to Northern Europe .

Likewise, the grass Euphorbia hirta has two ecotypes as well. One that has permanently adapted to surviving in moist conditions, and the other adapted to surviving in dry conditions (within this dry, you have the two ecophenes explained above).

euphorbia hirta that grows in dry conditions

Euphorbia hirta growing in dry conditions.

euphorbia hirta that grows in moist conditions

Euphorbia hirta growing in moist conditions.

This permanence in the adaptations arise due to changes in genes. Two ecotones of an organism will show minor variations in their genetic stock.

Ecospecies

Now, if two ecotones have been separated from each other for a very long time. The adaptations become a permanent part of the genes. They are still the same species, but their difference physically and genetically are very distinct. In fact, two ecospecies cannot produce viable off-springs (which the ecophenes and ecotones can).

These ecospecies, left alone for many, many generations, then develop sufficient changes in them to become a separate species.

That's the long version of how new species are born. What happens if the environmental conditions exceed the ecological amplitude? Extinction. The current extinction crisis is because of this very reason. The organisms are unable to adapt quickly because their amplitude is limited, with respect to the changing environment.