Community ecology

1. Introduction

Community is an organized ecological unit in which organism interact through various associations such a predation, competition, mutualism and parasitism, linked to each other via feeding relationships and are adapted to prevailing physical environmental surroundings. These interactions, associations and adaptations by the organisms provide community its distinct structure and influence other characteristics such as growth and developments of the community, dominance and species diversity.

2. Structure of the community

The basic structure of the community is divided into physical and biological structure. The physical structure of community is defined by the growth forms and life forms.

Physical Structure:

Growth forms and Life forms The structure and form of vegetation defines the differences between different terrestrial communities. On the basis of the growth forms the vegetation of the community can be classified. Plant community may exhibit different growth forms such as short or tall plants, woody or herbaceous plants or deciduous or evergreen plants. The herbs, shrubs and trees are further sub-divided these categories into evergreen sclerophylls, needle-leafed evergreens, thorn trees, broad-leafed evergreen or broad-leafed deciduous trees, dwarf shrubs, shrubs, grasses, ferns, mosses, lichens and forbs.

The plants are also classified on the basis of life forms by Christen Raunkiaer (1903). He is a Danish botanist, who defined life forms on the basis of perennating tissue above ground or simply height of the plant. He suggested that in a given area, all the species are grouped into six principal classes of life forms, namely epiphytes, phanerophytes, chamaephytes, hemicryptophytes, cryptophytes and therophytes. A community consisting mostly of phanerophytes are characterised by warm climate whereas when mostly comprised of hemicryptophytes and chamaephytes are characterised by cold climate.

3. Stratification

The ecological communities are arranged in different layer or strata forms, a phenomenon called stratification. For example in a natural forest community, as per the height of the plants the community is arranged into number of strata or layers such as herbaceous layer consisting of herbaceous plants followed by shrubs, smaller trees and tall trees. This fractionation in the community is caused by the gradations in the external environmental factors like water levels, temperature and light. Different strata or layer of forest community receives different degree of light intensity providing vertical stratification to the community structure. In a forest community generally three or more vertical layers or strata of plants are found including a herb layer, shrub, small tree layer followed by canopy tree layer. The canopy tree or other taller trees produces more foliage and interrupt the light to reach smaller

plants on the ground. The gradients in the physical environment of the community cause horizontal layering or patterns among species. Differences in the amount of factors such as nutrients and water can significantly alter the distribution of plant and animal species over a region.

A community consists of different growth form determining the community structure such as herbs, shrubs, trees. A growth form also has variations such as a tree can be long leaved or broad leaved etc. Various growth form have different mode of arrangement classifying community into (a) Horizontal Zonation and (b) Vertical stratification, i.e. Populations assembled to form communities and these populations are dispersed into definite vertical or horizontal strata.

a. Horizontal Zonation

The spatial arrangement of community species exhibit patterns and based on these patterns the community is divided into sub-communities which are ecologically related. If the distribution pattern is horizontal it's called zonation layering in community. For example in lakes or deep ponds majorly three zones are recognised i.e. littoral, limnetic (Photic or openwater) and profondal zone (Aphotic or Deep-water). The organism varies in each zone of zonation pattern. Another example include mountain associated vegetation, altitudinal and latitudinal variations of vegetation in relation to climate of the existing region.

b. Vertical Stratification

Vertical change in the pattern of community structure is called stratification. Vertical Stratification is as simple as the horizontal zonation community of pond, where each zone has different vertical storey, or complex stratification. For example in grassland communities distinct floor with different yet characteristics growth forms are exhibited. The lowest vertical sub-division is called **(1) Subterranean**-beneath the soil. Subterranean, which includes roots of plants, debris and living organisms like soil bacterium, protozoas or fungi etc. **(2) Herbaceous substratum**: Above the soil with roots of growth forms, the herbaceous substratum includes upper parts of growth forms. The forest community stratification is much more complex with five vertical layering including: The vertical stratification in the forest community mostly comprised of following strata's: Subterranean, Forest floor-with the upper parts of growth form along with the litters, fungi, bacteria etc., Herbaceous vegetation, Shrubs and Forest Strata (canopy). An additional stratum called emergent trees which are present in the tropical rain forest and these plants rises above the canopy of the forest.

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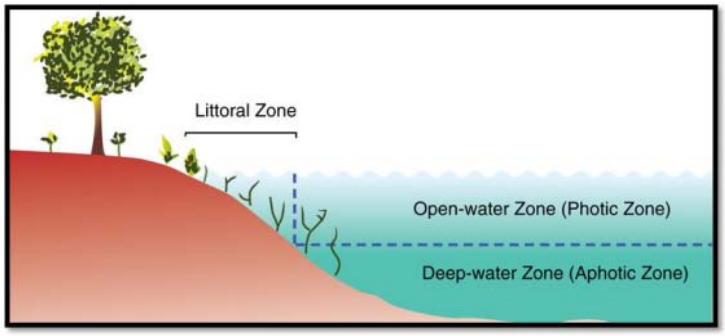
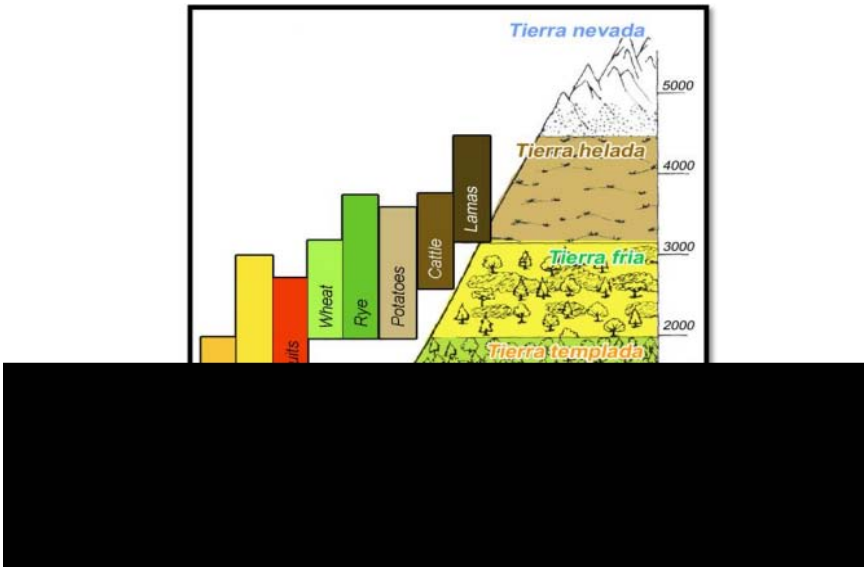


Figure 1: A deep lake depicting a Horizontal Zonation



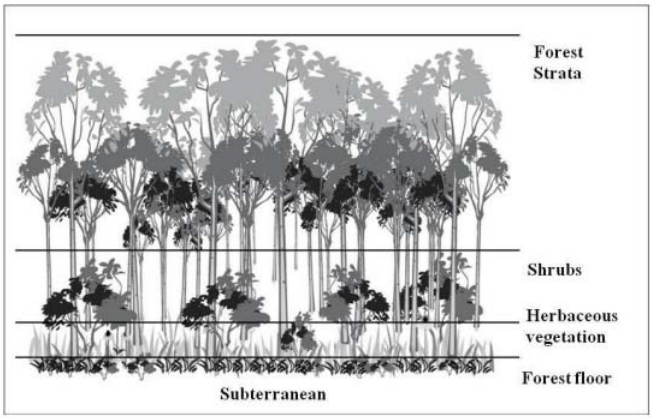


Figure 3: Vertical Stratification in a forest community

Forest animal's lives in different substrata and many of them may shift between substratums. The properties (requirement and adjustments) of one stratum can be similar to the same stratum of different community somewhere else in the world. For example forest floor of one community in country 1 share common requirements and adjustments to the community in country 2 although these countries are geographically separated. The animals living in such geographically separated but similar substratum are called **Ecological Equivalent**.

4. Biological Structure and Characteristics of a Community

A community has the following characteristics:

(a) Structure: By virtue of understanding the structure of the community, the frequency, density and abundance of different type of species are measured.

(b) Dominance: The community type is determined by the dominant species. These species of one or more type either occupy large space or occur in large number and called as dominant species.

(c) Diversity: The community show diversity which is composed of different species of plants and animals in different groups that may belong to different growth forms or life forms and are essentially prevailing in uniform environmental surroundings. Diverse communities are healthy and stable communities.

(d) Periodicity: The dominant species of the community are studied in various seasons of the year to determine various life processes such as reproduction, growth and respiration. Periodicity is defined as the expression and reoccurrence of various life processes annually at regular intervals in nature.

(e) Stratification: Within ecological communities, the habitat arrangement in form of layering (either vertical or horizontal) is called Stratification. The stratification of two different types of communities may differ such as the lake community represent horizontal stratification whereas mountain plant communities obey vertical stratification.

(f) Eco-tone and Edge-effect: Ecotones are easily recognisable marginal zones of vegetations separating two distinct types of communities. The species diversity is greater in the ecotone in comparison to the adjacent communities. This phenomenon of greater intensity and diversity at the common junction is defined as edge-effect.

(g) Ecological Niche: Ecological niche is defined as the role or function of species it plays in its ecosystem. In the ecological complex, different plants and animals of different species differ in their function and their combined interactions with other species in its environment are called its ecological niche. In other words, it can also be defined as the small habitat of single species within a large habitat in which it survives. E.P Odum defines and differentiate ecological niche and habitat by saying that ecological niche is the profession of the species within the ecosystem whereas the habitat is its address.

(h) Community Productivity: Community productivity is defined as the net storage of energy and production of biomass per unit time by the community. (i) Biotic Stability: Biotic stability is the ability of

a community to regain its equilibrium followed by disturbances causing population fluctuations. The stability of the community is directly dependent on the diversity of the community.

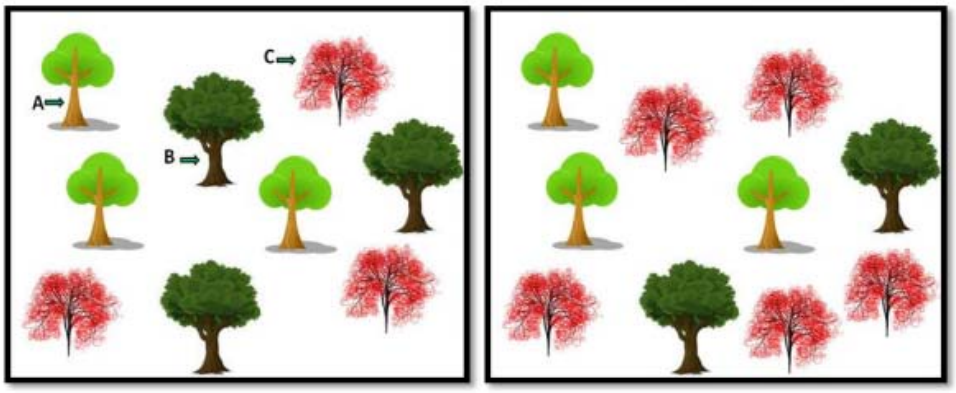
In 1994, Krebs characterized communities into five characteristics that can be studied, namely Growth forms and life forms (described earlier in section), species richness, dominance, relative abundance and trophic structure. Other major types of factors that constitute the structure of the community are as following:

a. Species Richness

Species Richness is given as number of species in a community. In an ecological habitat, landscape or community the count of different species represents the species richness. It does not indicate about the species abundance or relative abundance of species. For example beetles counted from a pitfall trap etc. Sample heterogeneity and the number of species influence the species richness. If the samples are collected from different environment and habitats then the collected data is higher for species richness. Thus sampling should be performed on large areas as the more heterogeneous environment prevails and large size of population. Species richness helps in assessing the conservation values of landscapes or habitat by relative comparisons. Although it does not consider the type of species but areas with rare species have higher conservation values than same number of species which are commonly found.

b. Species Diversity

The major biodiversity measurements are species richness, Shannon Weiner Index and Simpson's Index. Species diversity comprised of two factors species evenness and species richness (number of species). Species evenness indicates the relative abundance of each species.



Community "1" **Community "2"**

Both communities have three types of plant species depicting same species richness but relative abundance vary.

In community "1" species A, B and C are equal in proportion (three each) indicating higher species evenness thus revealed higher species diversity.

In community "2" species C is more in proportion indicating low species evenness and species diversity.

Diversity Indices:

In a given community, the species diversity can be measured mathematically by the Diversity Index. The measurement of diversity index is dependent on the species abundance and species richness. The species abundance is given as the number of organisms per species and the species richness is given as the number of species in the community. Information statistic indices and dominance indices are the two types of diversity indices given as Shannon Index and Simpson Index respectively.

The equations for the two indices are given as:

Shannon-Weiner Index

It's a common Index of species diversity represented as

$$H^{\circ} = -\sum_{i=1}^{s} p_i \log_e p_i$$

Where, N= total number of individuals found; n= individuals of one particular species found p= n/N; proportion; Σ= sum of the calculations; H° is the diversity index, the proportion of ith species is represented as pi while "s" is species richness i.e. number of species in community.

Simpson Index (Ds)

$$D_S = \sum_{i=1}^{s} (n_i (n_i-1))/ (N(N-1))$$

Where, N= total number of individuals in i th species

n= individuals of one particular i th species

p= n/N; proportion

Σ= sum of the calculations

The Shannon index is based on the assumptions that samples are randomly collected and all species are represented in that randomly collected sample. It's an information statistic index.

The Simpson index is majorly dependent on the dominant or common species and thus, it's a dominance index. In this type of index, rare species in less number with only few representatives do not produce any significant differences in the measurement of diversity. In 1949, Edward H. Simpson introduced Simpson index which measures the extent of concentration when organisms are classified. In 1950, Orris C. Herfindahl rediscovered the same index. In 1945, Albert O. Hirschman already introduced the square root of the index. Therefore, the Simpson index in ecology is also called as Herfindahl-Hirschman index (HHI) or Herfindahl index in economics.

c. Dominance

In a community different species interacts among themselves and in some communities the interaction results into dominance by one species or by a prominent species in group. The organisms dominating others are referred to as **dominants.**

In ecology the proportion of biomass or abundance of one species or taxon than other interacting species or taxon in a community. It's the dominant species that defines the ecological community. For example Alnus glutinosa (Alder) is the tree dominating in the Western Europe woodland areas. They are used to classify or identify the type of ecology.
In a community we can consider a community as dominant on the basis of following: Either they are occupying maximum space of community habitat or have highest biomass or play critical role in nutrient cycling, contribute maximum to energy flow or regulate other community organisms.

Sometimes numerically abundant (means more in number) makes organisms superior and dominant but not necessarily always. Microclimate within the community also effect and complicate this system by contributing more dominant species per microclimate. Microclimates have local environment differences like nutrients levels, moisture, topographic location etc.

Its only how impactful and important functions a species play in shaping the structure and function of community which decides its dominance. Sometimes even the low density group of species or a single species can be dominant.

Keystone species: Dominant species (plants/animals) playing crucial and unique role and highly effect community structure and function in relative to its abundance are called Keystone species. These keystone species have very intense inter species associations thus, controls the number and types of other species in community. Therefore, if we remove keystone species the community will shift to new form dramatically and vary from its original structure and function.

A classic example of keystone species is Pisaster ochraceus, a starfish. This starfish is a keystone predator and the only natural predator for mussels, sea urchins and many other shellfishes. So, if we remove starfish, the mussels or urchin population will proliferate in an uncontrolled manner shifting the community.

Another example includes a prey predator system where small predators like weevil E. lecontei which forage on herbaceous species called E. watermifoil. E. watermifoil can eliminate dominant plant species of the inhabited community but it's the predator E. lecontei which control E. watermifoil from doing so by feeding on it. E. watermifoil (prey) number is less and thus requires low density of predator (E. watermifoil). But if predator is eliminated out of the community, the prey will outgrow in number dramatically thereby, vanishing the dominant species of community and thus, by eliminating the small number predator, the community character will now be altered without its actual dominant species.

This example indicates that dominant species directly control the community character but keystone species indirectly alter the community character.

Several approaches are used to determine the ecological dominance. If a sample is collected from a large area than the individuals of a species found in large number represents the abundance of species and its distribution within ecosystem is called as relative species abundances.

a. **Relative abundance:** When the total abundance of all organisms is compared to numerically abundant one species it is called as species relative abundance. If a sample is collected from a large area than the individuals of a species found in large number represents the abundance of species and its distribution within ecosystem is called as relative species abundances.

b. Relative dominance: Dominance among same sized species can be measured by occupying by a species to the entire area of community.

c. Relative frequency: Among different sized species, the dominance is measured by the relative frequency. All these three measurements summed up to provide an important value to each species. These values of species ranked them in a list and index species are the species with high level of important value.

Sporadically/Locally abundant

The frequency of species occurrence in all samples is termed as incidence which relates to abundance. If the incidence or frequency is low but the abundance of species in sample is high it is called sporadically abundant. How to measure and calculate Relative species abundance? There are several kind of sampling methods such as Track count, Spotlight count, Monitoring point pressure, Roadkill counts and Plant cover for plant species etc. and the relative abundance of the community is calculated as:

Relative abundance of species = No. of species from one sampling/ Total no. of species of all sampling

d. Ecotone

The two integrating community meets at a transitional area called Ecotone. The transition area between ecosystems like grassland and forest forms regional ecotone and between forest and field forms a local ecotone which can be wide or narrow. This ecotone may appear as clear boundaries with homogenous surfaces or in gradual blending forms between two communities.

Formation of ecotone

When physical environment changes, example from forest to clean land, a clear and sharp interface is created between two communities. Moreover, gradual blended interface forms when unique local species and species common to both interacting community found together

for example in Mountain ranges. Most Wetlands are ecotones (eg. woodlands of Western Europe).

Type of ecotone

a. Halocline (gradient salinity)

b. Thermocline (gradient in temperature)

c. Pycnocline (water density gradient)

d. Chemocline (chemical gradient)

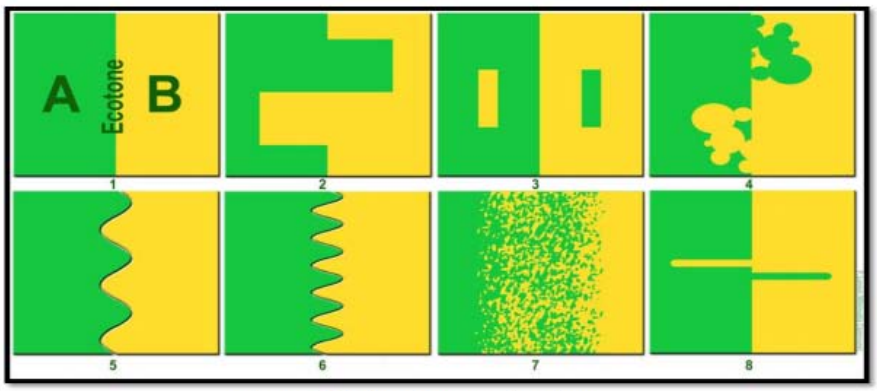


Figure 4: Different forms of ecotones

Features

1. A sharp vegetation transition for example change in grass colours indicates an ecotone.
2. Physiognomy: a key indicator of ecotone where the plant species differ in physical appearance.
3. Change in species is indicators of ecotone where we observe some specific organisms at one side of the ecotone boundary while some other specific organism on the other side.
4. Spatial mass effect: New plant establishment or migration obscures an ecotone as they cannot form self sustaining population in different ecotone. But if survives between two communities, then species richness is exhibited by the ecotone.
5. An ecotone can reveal the space sharing efficiency of two communities and the types of biomes by observing the exotic species abundance in ecotone.
6. Best model to study diverse ecosystem.
7. Shift in dominance represented by ecotone.
8. Ecotone act as an ecological niche for the species colonizing at the junction called **edge effect.**
9. **Ecoclines**: A physical transition zone between biological systems termed as ecoline relates to ecotone. It depicts the physiochemical environmental changes microclimatically or chemically signalling an ecotone via signals such as gradient of hydrothermal, salinity or pH respectively.

e. Edge Effects

In ecology, ecotone exhibit changes in population constituting community structure allowing for greater biodiversity at the boundaries of the merged habitats and this is called as **edge effects.** When two habitats are separated by wise edge effects called ecotone than they develop their own type of vegetation and environmental conditions.

Types of Edge effects

1. Narrow Edge effect: Abrupt ending of one habitat from where another habitat begins is a narrow edge effect.
2. Wide Edge effect: Significant distance between two habitats is exhibited as Wide edge effect or ecotone.
3. Induced Edge effect: The structural changes are induced over time either by the human interference or natural disturbances (eg. fire) and leads to induced edge effect.
4. Inherent Edge effect: The border between two habitats are separated and stabilized by natural features are called as Inherent edge effect.
5. Perforated Edge effect: The distance between two habitats has gaps in them which help in assisting other habitats.
6. Convoluted Edge effect: A nonlinear division of two habitats leads to convoluted edge effect.

Edge effects on Succession

When vegetation spreads the succession is affected by edge effects. Different species colonizes to central portions or to the edge leading to differential species distribution. With the change in orientation the edge also changes, thus, participating in different vegetation patterns.

Other structural factors may include **Seasonal and Diurnal Fluctuations:** With space and time the population fluctuates in the communities, **Pattern Diversity:** Community is organized on the basis of pattern diversity. The patterns can be horizontal segregation or vertical stratification etc.