Chapter 3: Ecology of Communities

Definition

What is a Community ecology?

- Community ecology is the study of the distribution, abundance, demography, and interactions between populations of coexisting species.
- It is part of the division of **synecology** that studies the organization of ecosystems at the level of the biotic community (or biocoenosis).
- Community ecology focuses on relationships between species, including the study of food webs, energy flow, and nutrient flow.

- **Communities** are collection of different kinds of species
- The concept of communities, in general, include the following parameters:
  - In a community organisms live together interacting as a society.
  - The interaction could be in terms of feeding or defense and offense, and others.
  - All the members living in a habitat face similar environment (place) and historic event (time).
    - For example they share factors such as temperature, moisture and light intensity, or events like flooding, earthquake and land slide

Why organisms live together?

- ***Environmental requirement:*** If different organisms have a similar requirement for an environmental factor, they tend to live together, exploiting the same class of environmental resources
- ***Modification of the environment****:* When an organism exploits a resource in a certain habitat, it modifies the nature of the environment. Modification of environment by one species allows the establishment of another species
- ***Associational defense:*** different species live together to protect a common enemy or predator, or to get shelter by the stronger species.

  Eg: d/nt plants and cactus with thorns; tropical acacia and ants
- ***Feeding relationship:*** Different species are interdependent to each other by feeding relationship. The presence of the prey attracts the presence of the predator.

  Eg: lion in savanna
- ***Other indirect effects***: Some organisms form association with others for the requirement of shade (e.g. mosses), support (epiphytes), of benefiting from the byproducts of different species.

Why we find different communities in different habitats?

- ***Minor difference in environment:*** *No two places in space have exactly the same* environment. Different organisms have also different limiting factors and environmental requirements
- ***The effect of chance:*** Organisms enter a certain habitat by migration (dispersal*). The* probability to land a certain habitat is governed by chance. As a result, areas of similar environmental condition may support different communities.
- ***History of the site:*** Communities have different preference of sites because they are evolved from long interaction and adaptation that lead them fit to the environment. New habitats usually support animals that are not adapted to the environment.

Naming of Communities

- We classify and name plant communities by looking into either the form of the **habitat** in which they live or the **dominant species** in the community.
- For example, plant communities growing on a sandbank or rocks are named “dunes” and rock pools, respectively.
- The same way we have savanna scrub (bushes), mountain forest, grassland communities, etc.
- Dominant species, a species that exerts control on the character of the community, which they are a part, are also used to name a community.
- For example, if *Acacia species are most abundant* or dominant species in a certain woodland vegetation, that community could be named as *Acacia wood lands*

Community Structuring

- Community can be structured based on
  1) Species composition
  2) Space
  3) Time
  4) Physiognomy and
  5) Feeding preference

1) Structuring in terms of Species composition

- Species composition is the best guide to describe communities.
- At any one time, a particular community has a pool of plant, animal, and microbe species.
- There is a certain interaction between different species in a community.
- The variation in species composition following the variations in complex ecological gradient is called **coenocline (community gradient)**

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Types of species in a community

- All species in a community are not alike. The ***role and relative importance*** of any specie in a particular community is different from the other.
- Based on their ***preference to associations species, a*** **community** can be classified into :

A. ***Character species*** are those species in a community that make a limited association only with members of the same community.

B. ***Differential species*** are those species that occur abundantly in one community, however, their association goes into another community.

C. **Constant species***: are those species that do not show any preference to association. They can* occur in any of the communities.

Based on distribution species in a community can be classified into

Fidel species*: species that tend to be restricted to a particular association or community.*

- These are confined to a certain habitat that has a specific gradient. For example, some grass species prefer acidic soil, and hence serve to ***indicate the nature of the habitat***.
- They are also called ***indicator species***. *There are a number of fidel species that serve as* **pollution indicator**.

Accidental species*: are guest species that are not member of that community. It includes* those species occurring outside their natural range.

- **Based** on **Relative importance and conservation** status in a community species could be classified in various ways:

Keystone species: *are species upon which other species of a community depend upon.*

- *They* are pillars of the community. If they are removed, a sever devastation is caused in the structure and function of the community.
- In some forests, for example, a tree species could serve as a food source for many animals, as well as, shelter and protection for other community members.
- Bats in a forest could be considered as keystones species because they perform an important function in **pollination.**
- If they are destroyed from the community, the balance of the ecosystem function would be disrupted.

Flag species: *are those species that serve as a center or focus for conservation of* community.

- For example, *Ethiopian wolf in Bale Mountains National Park could be considered* a flag species, because it is the focus of conservation for the whole ecosystem.

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***Dominant species**: are those species that exert control on the character of the community of* which they are a part.

- Trees in a forest ecosystem, for example, are dominant species creating a microclimate suitable for a certain group of organisms.

Common and rare species: Commonness and rareness is a measure of species composition in a community. They imply the relative abundance of species in a community.

- **A common species** is a species that is found abundantly in a community compared to others; while **a rare species** is the one that is not frequently observed in the community. A species that is rare in a community could be abundant in another community.

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2) Spatial structure (layering)

- Species in a community have their own preference to space.
- Not all species occupy exactly the same position in space either in terrestrial or aquatic ecosystems.
- In any community, there is a noticeable vertical structure or layering.
- For example: in forests we find two broad **trophic** strata or layers:
  - The **upper strata** where the machines for photosynthesis (that are leaves) are concentrated and the food making activities occur is called ***autotrophic layer.***
  - The **lower strata** where most of the **decomposers** are dwelling is called the ***heterotrophic layer***

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- In a more stratified forest, we can have the **upper canopy layer, the sub story layer, the under story layer, shrubby layer and the forest floor**

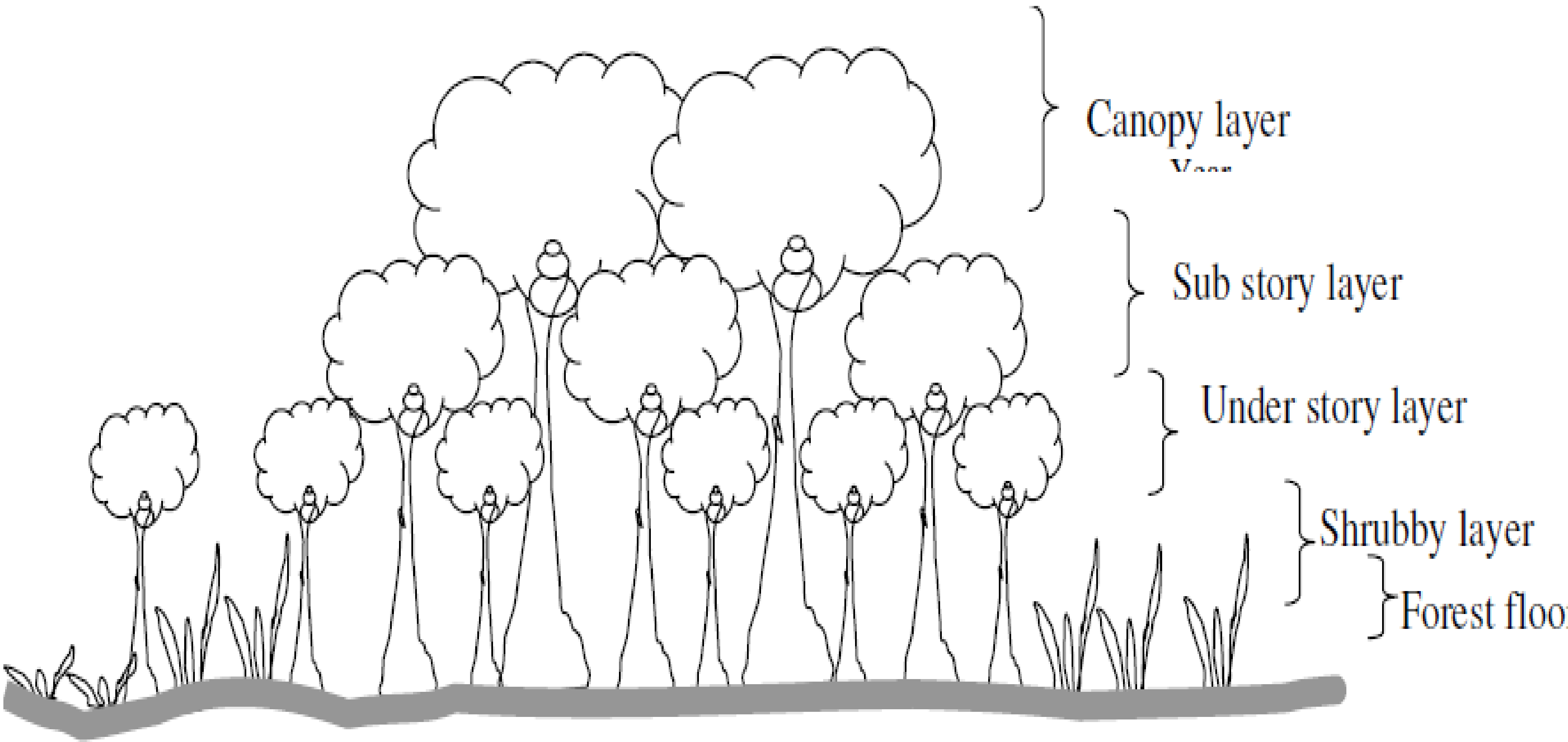

Figure 5.3 Spatial structuring /Vertical layering/ of tree species in a forest ecosystem

- The same way in aquatic systems, communities form vertical layering in which different species occupy different niches in the ecosystem

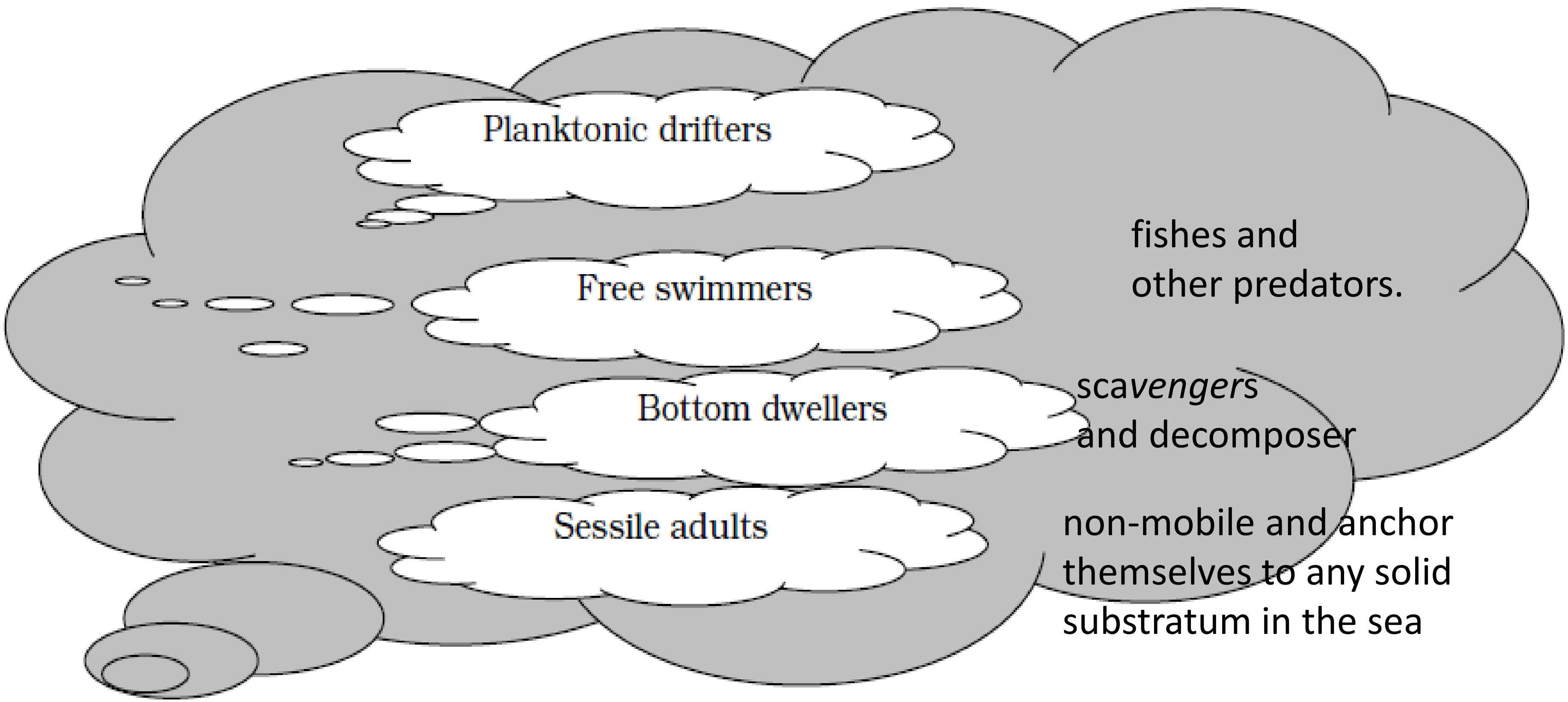

Figure 5.4 Vertical stratification in communities of aquatic ecosystems

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3) Physiognomic (Physical) structuring

- Briefly we can characterize a community’s structure, **particularly applied to plants**, based on their **appearance or growth forms** such as evergreens and deciduous trees, shrubs and herbaceous, succulents and climbers
- Dansereau (1951) proposed a system exemplary of the latter recognizing six growth forms (trees, shrubs, herbs, bryoids, epiphytes, and lianas

4) Temporal Structuring

- This is the structuring of community members in time.
- The activity of different species in a community varies with different hours of the day and different seasons of the year.
- The daily pattern affects the physiological activities such as the production of new cells and enzyme secretion.
- Some plants also show sleeping-movement at night by folding up their leaves and closing their flowers except few moth-pollinated species.
- Based on their activity in 24 hrs of the days species of a community, mostly applicable **for animals**, are structured in the following manner:
  - ***Diurnal***
  - ***Nocturnal***
  - ***Crepuscular***
  - ***Luna phobic***

- The abundance and dominance of different species with in a community also varies with respect to seasonal changes.
- One species dominates the ecosystem in one season than the other.
- *Phenology is the scientific study of seasonal change and its effect on organisms.*
- *Most ecosystems* show seasonal changes in structure, appearance, and function that are dependant on the physical environment especially, temperature, precipitation and light.
- Deciduous forests, for example, show marked change as any where on the earth.
- In each of the six recognized seasons (early spring, late spring, summer, late summer, fall and winter) the community members show different structure.
- Tropical forests, however, show little variation in different seasons of the year.

5) Trophic Structuring

- Members of a community are structured differently in terms of their feeding preference.
- Each species has a position in the food chain.
- Broadly, the community members are structured in to **producers, consumers and decomposers**
- All species, however, are equally important to the ecosystem, to function properly
- ***Guild*** *is a common name for a group or collection of various species in a community that exploit* or eat the same classes of environmental resource in a similar way.
- For example:
    - **Frugivores** are those species eating fruits;
    - **Leaf hoppers** feed on leaves; and
    - **Insectivores** feed on insects.
- The group, however, may include a variety of unrelated organisms

Community Dynamics (Change)

- Communities and ecosystems are dynamic i.e., they are in a state of continuous changes. A forest is a different places differ from night to day and from a season to another

1) Kinds of Community Changes

Two kinds of change: *directional and non-directional*

(a) Directional changes: - result in permanent alteration of the structure and function of the community.

- It results from permanent changes in environmental condition.
- It is irreversable

E.g., Long-term climatic change and **Succession**

***(b) Non-directional changes* -** do not alter or affect the community permanently.

- It is caused by temporary changes in the environment. Most obvious causes are the daily cycles of light and dark, and the seasonal changes in climate

  E.g. Fluctuation of species composition in grasslands associated with fluctuation of climate in different seasons (such as during drought years).

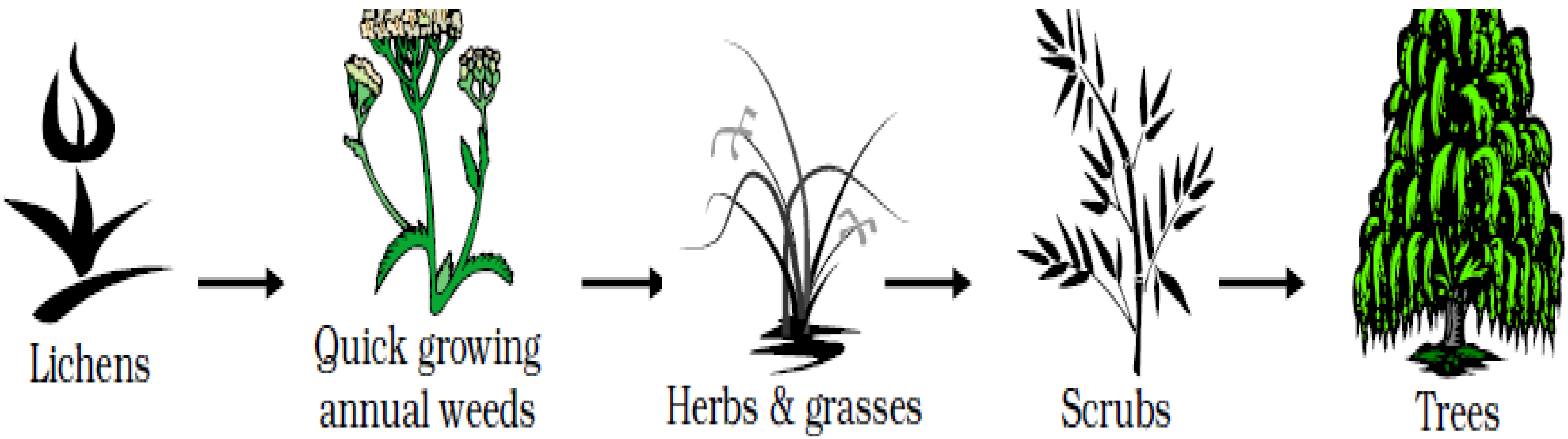
  - In this case some species may dominate the habitat temporarily, but when the condition is improved the previous species composition is replaced as it was before.

- All several kinds of **cyclic and periodic** changes in a community are non-directional changes.
- This kind of change is reversible, that does not cause permanent change in the structure of the community.

2 . Community Succession

- Community succession is a directional type of change, which is defined as *the process in which the same area is successively occupied by different communities*.
- *It is the pattern of community* replacement in an area.
- For example, if we have a new terrestrial area that has not been occupied by any community, such as volcanic sediment, the first communities that invade the area could **be simple non-vascular plants like lichens or mosses and liverworts.**

- As the depth and nutrient level of the soil increases, gradually the area will be replaced by another group of communities until it reaches the final stage of stability.
- This kind of successive replacement of one community by another taking place on the same place in different time is referred to **community succession**



Types of succession

- There are different types of community successions based on the following criteria:

a) Based on the water relations of the site where succession begins:

a) Hydrosere: is a successional sequence beginning in moist or aquatic environment.

b) Xerosere: is a successional sequence beginning from water deficient area such as bare rock (litho sere) or dry sands.

b) Based on their state of colonization

1. ***Primary succession (Prisere):*** *It is a succession taking place for the first time in the history* of the site.

2. ***Secondary succession (Subsere):*** *it is a succession taking place for the second or more* times in the history of the site, once the habitat is completely abandoned (destroyed) by some external factors

- Even though, there had been communities in the habitat before, the succession is starting from the scratch similar to the primary succession.
- For instance, on an abandoned cropland allowed to revegetate.

❖ ***Subsere succession*** *is usually relatively* faster than ***prisere,*** *because there is already well developed soil*, *from the previous* succession.

Causes of succession

- Community successions are initiated by a variety of causes which we can group in to four major categories

(a) Autogenic Causes:

- These are changes caused by the effects of the communities themselves. Auto means “self”.

Examples:

- ***Change in soil development****: As energy is fixed by photosynthetic process, more organic matter* is stored in the community. This accumulate humus from leaf litter fall and decay of dead organic matter that causes change in the pH and nutrient content of the soil. As the acidity increases, the soil becomes less favorable for their growth, then eventually are replaced by other group.
- ***Change in vegetation structure:*** *As the diversity of invaders increases, the degree of competition* for space and nutrients become more and more apparent. Highly competent plant species take the upper layer of the canopy to compete for light. This gradual change in the structure of the community eventually eliminates some of the **foundational species** due to the shading effect of the community itself.

(b) Allogenic Causes:

- These are changes caused by external environmental influences.
- These are predictable and manageable. The major causes are the following:

❖ ***Climatic changes:*** *change in rainfall pattern, drought, temperature*

❖ ***Soil development****: Include changes in soil texture and profile due to erosion*, *leaching*, drainage, and Lake Infill.

❖ **Animal influence:** Includes those changes caused by grazers (selective or over grazing), pollinators, and pathogens.

(c) Anthropogenic Causes:

- *These are those changes caused by human influence. They include the following:*

❖ ***Habitat change*****:** Change caused by vegetation clearing, drainage and irrigation.

❖ ***Agriculture***: introduction of exotic species, elimination of species by hunting or fire, selective grazing by livestock, misuse of agricultural inputs and etc.

❖ ***Pollution****:* addition of nutrient/fertilizers, use of pesticides, insecticide, herbicides and fertilizers, industrial and municipal wastes.

(d) Catastrophic Causes:

- It includes those factors that are unpredictable, in most cases, and uncontrollable natural hazards.

❖ ***Geological:*** those related to geological processes such as volcanic eruptions, earth quakes, landslips and sea level changes.

❖ ***Climatic:*** those related to climatic changes such as flood, wildfire and high winds (cyclone, El Nino).

3. Stages of Community Succession

- There are three major stages in community succession. These are: called
    - **a) The *Pioneer stage:*** Is the first stage in community succession
    - ***b) The seral stage:*** it is the intermediate stage
    - ***c) The climax stage:*** is the last stage

a) The Pioneer stage

- This is a stage by which an area is invaded by a new group of communities for the first time.
- Those species invading an area for the first time are called **pioneer species**.
- Pioneer communities are made up of relatively few kinds of species.
- These communities are usually made up of smaller plants that are able to immigrate quickly, example by wind, and they can disperse too long distance. They are also long-lived in the seed bank and able to live under extreme or harsh environmental conditions

b) The Seral stage

- Sere is a successional stages in the whole sequence from bare ground to climax community.
- Seral stages are the various communities existing at different points in time between the pioneer and climax stages.

C) The Climax stage

- It is the final or last stage in community succession it is mature and is in equilibrium with its environment. This is the stage where there is no more directional change in the community.
- A climax community has the following characteristics:

- It is able to tolerate its own reactions or autogenic causes
- It tends to be **mesic** (moderate) for the climate in which it occurs. Many pioneer communities, on the other hand, are relatively adapted to extreme environmental conditions
- Community members are highly organized with **complex stratification, complex food webs, and more mutualism.**
- It has **higher diversity as** compared to immature stages of succession. This is because of complex organization thus allowing **more niches**.
- The individual organisms tend to have **k-selected adaptation** that are long-lived, relatively large, and with a low biotic potential.

- **Energy is at steady state condition (**NPP is zero). This means the gross primary production is equivalent to community respiration, hence, no community growth/change. However, in immature ecosystems, energy is stored hence, the amount of plant or animal tissue or dead organic matter (litter or humus) is increasing that leads to autogenic succession.
- They are more stable and have more resilience such as more resistant to invasion by other species. **Resilience** is the tendency of ecosystems or communities to tolerate changes, and retaining the original balance after the disturbance is removed.

Types of Climax

- Based on the factors responsible in retaining the community at climax or stable state, we have three kinds of climax

1. ***Climatic climax****: stability of the community is retained by climatic factors such as rainfall or* temperature

- In most terrestrial ecosystems, the final stage of succession is forest, dominated by trees. The annual rainfall in such ecosystem is greater than 750mm. If the annual rainfall of an area is less than 750mm, the process of community succession might be stopped at a certain stage (e.g., grassland) before reaching its final stage. For example, in most of the tropical ecosystems the vegetation structure is retained as grassland or scrubland stage due to low rainfall.
- However, had the rainfall not been an issue, the community could have changed to forestland

2. **_Edaphic climax:_** *This kind of climax is maintained by soil factor.*

   - *For example, many types of* grassland are retained unchanged because of the nature of the soil that does not support trees. The soil is clay and shallow that is not favorable for trees to penetrate.

- Such soils are dominated by herbaceous plants that have shallow adventitious roots.

3. **_Biotic climax:_** *This climax stage is maintained by biotic factors (like human and herbivore* animals). Biotic climax are arrested sere. If the biotic factor is removed, succession could proceed to the next complex sere.

- For example, the climax of most of the tropical savanna is woodland or thorn scrub or closed forest. However, the grassland is retained stable by fire and game animals that eliminate and control the dominance of tree species.

Major Events Involved in the Process of Succession

- The main events involved in the process of ecological succession include the following structural and functional changes:

a. Change in Species structure

- Species composition changes at first rapidly and then more gradually.
- The number of species of autotrophs increases in primary and early in secondary successions but it may decrease in older ages.
- Numbers of heterotrophic species continue to increase until fairly the last seral stages.
- Species diversity increases initially, then becomes constant, finally may not decline in older stages.

b. Change in Organic structure

- Non living organic matter and total biomass increases with the progress of succession from early stages to climax
- Chlorophyll content of the community increases during early phase of primary succession but, no or little increase during secondary succession

c. Change in Community metabolism (energy flow)

- More GPP and NPP during early phases of primary succession
- The complexity of food-web increase during succession
- Community respiration increases and NPP declines through the process.
- The total information in the community (number of possible interaction between species, individuals, and materials) increase during succession

Community Diversity

Measures of Community Diversity

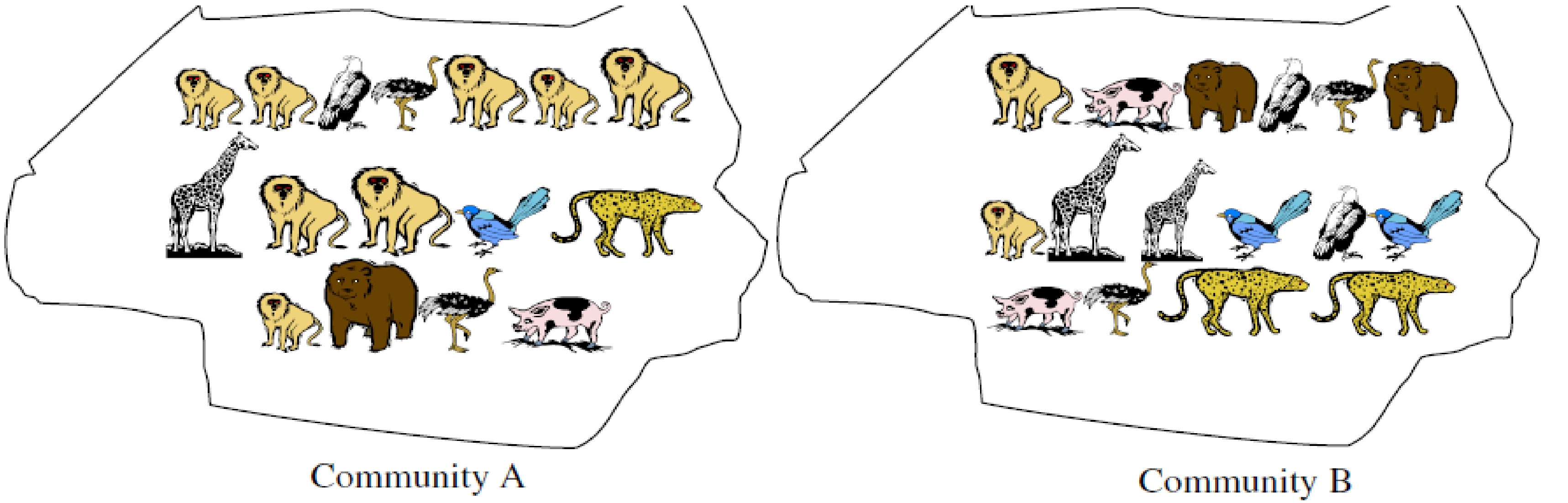
- Diversity is the measure of kinds and varieties between living organisms.
- A diverse community has a variety of species, although there are other measures of diversity at various levels.
- There are different levels of measuring biological diversity.
- The main levels **are *genetic diversity, species diversity, and ecosystem diversity***.
- *The variation between individuals of a species exhibited at* **genetic level** is called *genetic diversity. All individuals are different at genetic level; however, the* variation is very difficult to measure.
- The measure of variation between different species is called ***species diversity***.
- *The measure of variations between different ecosystem structures and functions* is called ***ecosystem diversity***
- A more convenient way of measuring the diversity of a community is made by considering species diversity.

Community Diversity

- Species diversity could be measured in various ways:

(a) Richness:

- It is the measure of the number of species in a community. For example in Figure below both community A and B have similar number of species. Their richness is there fore 8. It does not show the relative contribution of each species in the community



Community Diversity

(b) Evenness:

- It is the measure of **equitability or fairness** of representation of each individual in a community.
- It attempts to quantify the unequal representation of species in a community against a hypothetical community in which all species are equally common.
- From the same example in Figure above, eight of the species are evenly or equally represented in **community B.** hence, it is more diverse than **Community A.** In community A, 50% of the community is dominated by a single species.
- We can measure the evenness of a community using **Shannon-Wiener Index** of evenness that may enquire simple calculations.

Shannon-Wiener index of evenness (J) is given by:

$$J = \frac{H'}{H'_{\max}}$$

- Where:
  - **H'** is the heterogeneity of the community calculated using **Shannon wiener index,** and
  - **H'max** is equivalent to the natural logarithm of the absolute number of species in the community which is designated by ln(S).
- The total number of species in the community needs to be known beforehand

(c) Heterogeneity:

- It is the measure of the probability of which two individuals randomly picked from a community belong to different groups (species).
- It includes the concept of richness and evenness.
- There are different formulas used to calculate **heterogeneity of a community**. The famous indices are the ***Shannon-Wiener Index and Simpson Index***

- *Shannon-Wiener Index of Heterogeneity (H') is given by:*

$$H' = -\sum_{i=1}^{s} (P_i \times \ln(P_i))$$

- Where, **Pi** is the relative importance of the **i^th^** species. The value of **H'**, here, is mostly **between 0 and 5.**
- Relative importance is the measure of the dominance of each species as compared to other species present in the community.

- It could be computed by dividing the abundance/number or percentage cover of individuals of each species against the total number (or percentage cover) of individuals of all the species present in that community.
- Percentage cover is the percent of the total area of the ecosystem occupied by individuals of a species.
- It is an indirect way of estimating absolute density; usually employed for plants that are difficult for counting.
- For example, if we have 4 species in a community with 10, 20, 20 and 10 individuals each.
- The relative importance of each species would be 10/60, 20/60, 10/60 and 10/60, respectively.

- ***Simpson's index of Heterogeneity (H') =*** $1 - \Sigma(P_i^2)$

Where **Pi** is the relative importance of each species. The value of **H',** here is between 0 and 1. For the above group of animals, the heterogeneity of the communities is calculated as shown in the table below. Compute the diversity of community A and B using the **Shannon-Wiener and Simpson** Indices of Heterogeneity,

Community A					
Species	**density**	**Pi**	**Ln(Pi)**	**Pi * Ln(Pi)**	**(Pi)2**
Baboon	8	0.50	-0.69	-0.35	0.25
Bear	1	0.06	-2.77	-0.17	0.00
Eagle	1	0.06	-2.77	-0.17	0.00
Giraffe	1	0.06	-2.77	-0.17	0.00
Leopard	1	0.06	-2.77	-0.17	0.00
Ostrich	1	0.06	-2.77	-0.17	0.00
Warbler bird	2	0.13	-2.08	-0.26	0.02
Wild pig	1	0.063	-2.773	-0.173	0.004
Sum	**16**	**1**		**-1.6462**	**0.2891**
Shannon-Wiener Index (H') =				**1.6462**	
Simpson Index (H') =					**0.7109**

Community B					
Species	**density**	**Pi**	**Ln(Pi)**	**Pi * Ln(Pi)**	**(Pi)2**
Baboon	2	0.13	-2.08	-0.26	0.02
Bear	2	0.13	-2.08	-0.26	0.02
Eagle	2	0.13	-2.08	-0.26	0.02
Giraffe	2	0.13	-2.08	-0.26	0.02
Leopard	2	0.13	-2.08	-0.26	0.02
Ostrich	2	0.13	-2.08	-0.26	0.02
Warbler bird	2	0.13	-2.08	-0.26	0.02
Wild pig	2	0.13	-2.08	-0.26	0.02
Sum	**16**	**1**		**-2.0794**	**0.1250**
Shannon-Wiener Index (H') =				**2.0794**	
Simpson Index (H') =					**0.8750**

Exercise: A plant ecologist conducted a vegetation survey in two different habitats and found seven plant species. The percentage cover of each species is given in the table below. Compare the heterogeneity of the two communities using the two indices

Woodland Community					
No	Species list	% Cover	P_i	P_i x $\ln(P_i)$	P_i^2
1	*Acacia albida*	15			
2	*A. nilotica*	10			
3	*Sporobulus pyramidalis*	20			
4	*Cenchrus ciliaris*	25			
5	*Panicum maximum*	15			
6	*Cypress sp.*	12			
7	*Lucas martiliensis*	15			
	Sum	**112**			

Grassland Community					
No	Species list	% Cover	P_i	P_i x $\ln(P_i)$	P_i^2
1	*Acacia albida*	15			
2	*A. nilotica*	2			
3	*Sporobulus pyramidalis*	2			
4	*Cenchrus ciliaris*	45			
5	*Panicum maximum*	35			
6	*Cypress sp.*	0			
7	*Lucas martiliensis*	10			
	Sum				

- ***Solution:*** *The woodland community in the above table has more heterogeneity as compared to the* grassland community.
- Shannon-Wiener index value of heterogeneity (H') for woodland is 1.9 as compared to 0.698 for the grassland. The Simpson value of Heterogeneity for Com-1 is 0.59 as compared to 0.47 for Com-2.
- Generally, these measurements are usually used for comparison purpose between different communities. The **higher the heterogeneity value, the higher is the species diversity in that specific community.**
- Also, in certain circumstances, since diversity has direct relationship with stability, the heterogeneity may indicate about the degree of ecosystem stability or health.
- For example, disturbed and unstable ecosystems have lower heterogeneity. The Shannon-Wiener Index of heterogeneity is usually less than 3.0. More stable ecosystems have higher heterogeneity Value.

Factors Affecting Local Species Diversity

- The local species diversity of a community is affected by different **abiotic and biotic factors**

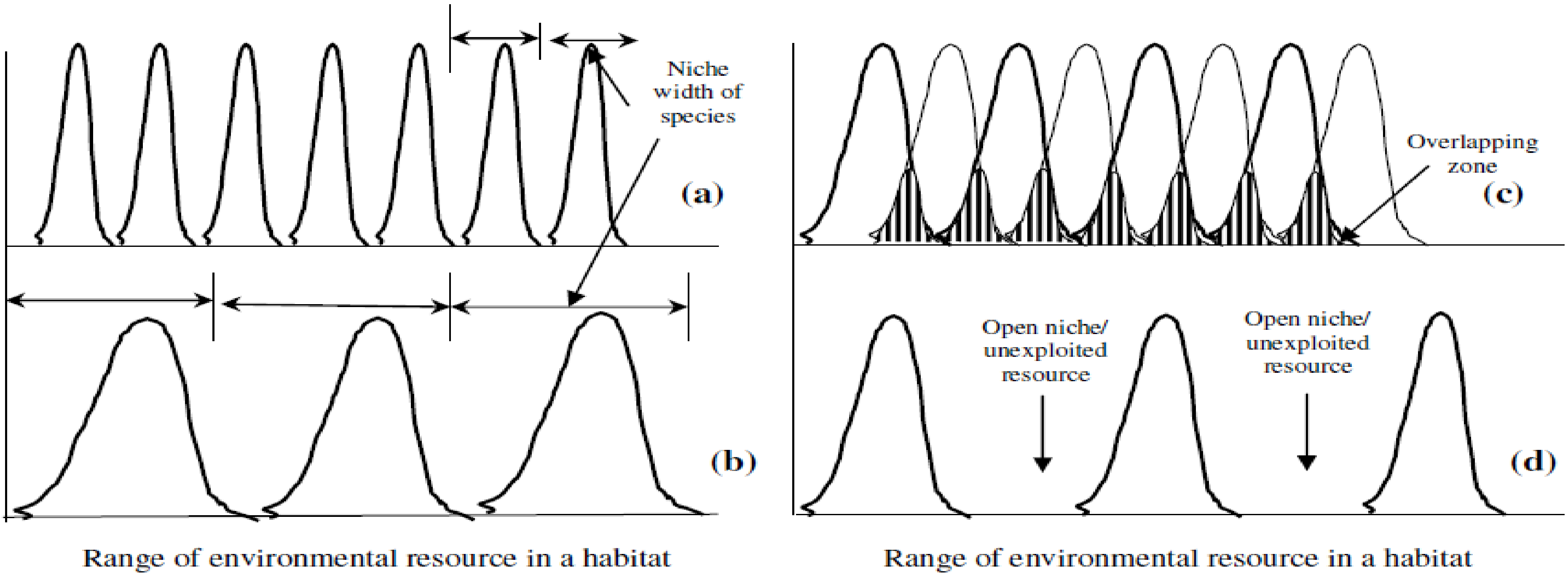
Abiotic factors

a. ***Resource diversity and niche:*** *If the resources for a particular trophic level or groups of* organism are diverse, that species level is likely to be diverse.

For example, there are more birds in forests than grasslands because of the presence of more **strata and resource diversity** in forests.

- **Ecotones,** transition zones between neighboring ecosystems, are also more diverse than uniform plains because of the effect of the adjacent habitats.
- I*t has the characteristic of both neighboring habitats*. This is called the *horse-shoe effect, in ecology.*
- *The species are* called *edge species.*

- Diversity is interrelated to the number **of niches, niche size, and niche width**
- **Niche** is the total account how an organism exploits a class of resources in a habitat. It is also considered as **specialization of resource utilization or feeding**. If the species in a community have a narrow niche width → they have highly specialized feeding (as in animals) or exploit very narrow range of **resources** (as in plants), the habitat can support more number of species (see the Figure below).



The impact of niche width (habitats (a) and (b)), and niche overlap (habitats (c) and (d)) on species diversity of the community

- As species restrict their niche, the species diversity has a tendency to increase, as in the case of most stable ecosystems.
- The same way, if there is availability of resources, the species overlap their niche (two or more species exploiting the same kind of resource); hence the habitat can support many different kinds of species as in the case of habitat (C) in the diagram.
- Availability of open niche, as in habitat (d), has also tendency of attracting more species, increasing the local species diversity.

b. *Climatic stability:*

- *areas of stable or predictable climate tend to have more number of species* with lower population density than unstable ones.
- Extreme habitats, (such as hot, cold, salty or acidic habitats), on the other hand, support only few species with high population densities.

c. *Disturbance:* *Little to medium disturbance may increase local species diversity. For example*, fire eliminates the dominant species, and minimizes the degree of competition. By doing so, it attracts less competent species, such as exotics, to establish in the habitat, hence increasing the local species diversity. However, if the disturbance is heavy, it can distract some species and cause the diversity to decline.

d. *Habitat size:* *As the habitat size increases, the diversity of resources, and number of* microhabitats or niches increase. This has a tendency of increasing the local species diversity, however, this may not be always true.

Biotic factors

a. Productivity:

- *More productive habitats have diverse kinds of species because; one class of* resource can be used by more than one species.
- Niche overlap is evident in highly productive and stable ecosystems.

b. *Complexity of community structure:*

- *As the community structure becomes more complex, more* niches are created that tend to increase species diversity. For example, as the number of vertical layering increases, different niches are formed to support more number of species in the community.

c. *Competition:*

- *Low to medium degree of competition between members of the community may* increase the efficiency of resource utilization in the ecosystem, which has a tendency of increasing the number of niches.
- However, if the competition is severe it is destructive, minimizing the local species diversity.

d. *Predation:*

- *In a similar way like that of disturbances, low to medium degree of predation has a* tendency of increasing local species diversity by eliminating the dominant species in the ecosystem and creating less competent environment.
- For example, predation of gazelles for 15 years in Serengeti declined grass diversity making the habitat mono-specific.
- This is because; the decline of gazelles (the herbivore) helped some competent grass species to dominate the area with out any stress, as their natural enemy, the gazelles that could control their density, were already eliminated from the habitat.

Diversity, Stability and Geographic Positions

- Diversity has a direct relationship with stability. Most stable ecosystems have higher species diversity.
- For example, in tropical rain forest, the most stable ecosystem in the globe, we find hundreds of tree species in a small plot of land. However, the reverse is not necessarily true.
- Increasing diversity might not bring ecosystem stability. For example, in an agricultural land we can increase the local diversity by planting different crop species but, it could be still one of the most unstable ecosystems.
- In the tropics there is high species diversity because of moderate and even distribution of rainfall and soil temperature.
- However, as we move to the north or south from the equator the diversity gradually decreases in increasing latitude.
- The same way, within the same geographic location or habitat, the species diversity tends to decline along increasing the altitude (Mac Arthur and Wilson, 1969).