ECOLOGICAL SUCCESSION

When stripped of its original vegetation by fire, flood, or glaciation, an area of bare ground does not remain devoid of plants and animals. Beginning with plants, area is rapidly colonized by a variety of both plant and animal species that subsequently modify one or more environmental factors. This modification of the environment may in turn allow additional species to become established. The transitional series of communities which develop in a given area are called **sere** or **seral stages**, while the final stable and mature community is called the **climax**. The development of the community by the action of vegetation on the environment leading to the establishment of new species is termed **succession**. Succession is the universal process of directional change in vegetation during ecological time. It can be recognized by the progressive change in the species composition of the community. Retrogression in community development does not occur unless succession is disturbed or halted by fire, grazing, scraping or erosion.

BASIC TYPES OF SUCCESSION

Based on different criteria, there are following kinds of succession:

1. **Primary succession.** If an area in any of the basic environments (such as terrestrial, fresh- water or marine) is colonized by organisms for the first time, the succession is called **primary succession**. Thus, primary succession begins on a sterile area (an area not occupied previously by a community), such as newly ex- posed rock or sand dune where the conditions of existence may not be favourable initially.

2. **Secondary succession.** If the area under colonization has been cleared by whatsoever agency (such as burning, grazing, clearing, felling of trees, sudden change in climatic factors, etc.) of the previous plants, it is called **secondary succession**. Usually the rate of secondary succession is faster than that of primary succession because of better nutrient and other conditions in area previously under plant cover.

3. **Autogenic succession.**
   After the succession has begun, in most of the cases, it is the community itself which, as a result of its reactions with the environment, modifies its own environment and, thus, causing its own replacement by new communities. This course of succession is known as **autogenic succession**.

4. **Allogenic succession.** In some cases replacement of one community by another is largely due to forces other than the effects of communities on the environment. This is called **allogenic succession** and it may occur in a highly disturbed or eroded area or in ponds where nutrients and pollutants enter from outside and modify the environment and in turn the communities.

5. **Autotrophic succession.** It is characterized by early and continued dominance of autotrophic organisms such as green plants. It begins in a predominantly inorganic environments and the energy flow is maintained indefinitely. There is gradual increase in the organic matter content supported by energy flow.

6. **Heterotrophic succession.** It is characterized by early dominance of heterotrophic organisms such as bacteria, actinomycetes, fungi and animals. It begins in a medium which is rich in organic matter such as small areas of rivers, streams; these are polluted heavily with sewage or in small pools receiving leaf litter in large quantities.

7. **Induced succession.** Activities such as overgrazing, frequent scraping, shifting cultivation or industrial pollution may cause deterioration of an ecosystem. Agricultural practices are retrogression of a stable state to a young state by man's deliberate action.

8. **Retrogressive succession.** It means a return to simpler and less dense or even impoverished form of community from an advanced or climax community. In most cases, the causes are allogenic, *i.e.,* forces from outside the ecosystem become severe and demanding. For example, most of our natural forest stands are degrading into shrubs, savanna or impoverished desert-like stands by the severity of grazing animals brought from surrounding villages. Excessive removal of wood, leaf and twig litter also leads to retrogressive succession.

9. **Cyclic succession.** It is of local occurrence within a large community. Here *cyclic* refers to repeated occurrence of certain stages of succession whenever there is an open condition created within a large community.

Further, in ecological literature, there are mentioned still so many other kinds of succession, depending mainly upon the nature of the environment where the process of succession has begun. Thus, it may be a **hydrosere** or **hydrarch** when succession occurs in regions where water is in plenty, as ponds, lakes, streams, swamps, bogs, etc., a **mesarch** when there are present adequate moisture conditions; and a **xerosere** or **xerarch** when there is present minimum amount of moisture, *e.g.,* deserts, rocks, etc. Sometimes, few more categories are recognized such as **lithosere** – succession initiating on rocks, **psammosere** –succession initiating on sand and **halosere** – succession occurring in saline water or saline soil.

GENERAL PROCESS OF SUCCESSION

The entire process of primary autotrophic succession is completed through the following sequential steps:

1. **Nudation**
   This is the development of a bare area without any form of life. Exposure of new surface may occur due to several causes such as landslide, erosion, deposition, or other catastrophic agency. These causes of nudation are of three main types :

i. **Topographic.** Due to soil erosion by gravity, water or wind, the existing community may disappear. Other topographic causes include deposition of sand, landslide, volcanic activity and other factors.
ii. **Climatic.** Glaciers, dry period, hails and storm, frost, fire, etc., may also destroy the community.
iii. **Biotic.** Man forms a most important biotic factor; he is responsible for destruction of forests, grasslands for industry, agriculture, housing, etc. Other factors are disease epidemics due to fungi, viruses, etc., which destroy the whole population.

2. Invasion

Invasion is the successful establishment of a species in a bare area. The species actually reaches this new site from any other area. Invasion includes the following three steps :

i. **Migration (dispersal).** The seeds, spores, or other propagules of the species reach the bare area. This process is called **migration** and is generally brought about by air, water, etc.,
ii. **Ecesis (establishment).** After reaching to new area, the process of successful establishment of the species, as a result of adjustment with the conditions prevailing there, is known as **ecesis**. Ecesis is followed by full-scale **colonization**. In plants, after migration, seeds or propagules germinate, seedlings grow, and adults start to reproduce.
iii. **Aggregation.** Colonization by successive offspring and new migrants help increase the population, a process called **aggregation**. Thus, after ecesis, as a result of reproduction, the individuals of the species increase in number and they come close to each other. Plants or autotrophic organisms which are the first to colonize and aggregate are called **pioneers**. The pioneer communities are likely to be more dynamic and have low-nutrient requirements and to take minerals in comparatively more complex forms. They are small-sized and make less demand from environment.

3. Competition and Coaction

Due to aggregation of a large number of individuals of the species at the limited place, there develops **competition** (*i.e.,* interspecific and intraspecific competition) for space and nutrition. Individuals of a species affect each other's life in various ways and this is called **coaction**. The species which fail to compete with other species are ultimately discarded. The reproductive capacity, wide ecological amplitude, etc., help the species to withstand the competition.

1. Reaction

Reaction includes mechanism of the modification of the environment through the influence of living organisms on it. Due to this very significant stage, changes take place in soil, water, light conditions, temperature, etc., of the environment. As a result of reaction, the environment is modified and become unsuitable for the existing community which sooner or later is replaced by an- other community (seral community). The whole sequence of communities that replaces one another in the given area is called a **sere**, and different communities constituting the sere are called **seral communi- ties**, **seral stages** or **developmental stages**.

2. Stabilization (Climax)

Finally, there occurs a stage in the process, when the final terminal community becomes more or less established for a longer period of time and it can maintain itself in equilibrium with the climate of the area. The final community is not replaced and is known as **climax community** and the stage as **climax stage**.

CONCEPT OF CLIMAX

The concept of climax has since long been a subject of much controversy and discussion. There are following three theoretical approaches to the climax :

1. **Monoclimax theory.** This theory is developed largely by **Frederick Clements**. This theory recognizes only one climax, determined solely by climate, no matter how great the variety of environmental conditions is at the start. All seral communities in a given region, if allowed sufficient time, would ultimately converge to a single climax. The whole landscape would be clothed with a uniform plant and animal community. All other communities than the climax are related to the climax by successional development and are recognized as subclimax, disclimax, preclimax, postclimax and so on. A **subclimax** is a stage in succession of forests just preceding the climate climax community. The **disclimax** is the particular type of vegetation maintained in an area as a result of recurrent disturbance, chiefly the biotic, thus preventing a successful establishment of climate climax community. The **preclimax** is a vegetation of lower-life forms than the one adjacent to it and results from different edaphic conditions. The **postclimax** is a strip of vegetation of higher life-forms occurring within a climate climax, for example, a forest along a stream in a grassland community constitutes postclimax community. Later on numerous other terms such as coclimax, superclimax, quasiclimax, anticlimax, pseudoclimax, etc., were coined by some post- Clements ecologists to describe specific situations. The monoclimax theory is supported by **Cowles**, **Ranganathan**, and **Puri**, but strongly objected by **Daubenmire** (1968).

2. **Polyclimax theory.** This theory was developed by **Tansley**. This theory considers that the climax vegetation of region consists of not just one type but a mosaic of vegetational climaxes controlled by soil moisture, soil nutrients, topography, slope exposure, fire and animal activity. The advocates of polyclimax theory preferred to call each stable community as a climax and described them with a prefix as edaphic climax, topographic climax, biotic (zootic, grazing or anthropogenic) climax and fire climax. For example, grassland communities of central India, Sri Lanka and parts of California have developed under the influence of fire, grazing and other biotic factors and so have been considered as biotic climaxes by **Misra**, **Pandeya** and **Holmes**.

3. **Climax pattern hypothesis.** This theory was developed by **Whittaker**, **Maclntosh** and **Sellack**. According to this theory, the composition, species structure and balance of a climax community are determined by the total environment of the ecosystem and not by one aspect, such as climate alone. Involved are the characteristics of each species population, their biotic interrelation- ships, availability of flora and fauna to colonize the area, the

chance dispersal of seeds and animals, and the soils and climate. The pattern of climax vegetation will change as the environment changes. Thus, the climax community presents a pattern of populations that corresponds with and changes with the pattern of environmental gradients, intergrading to form ecoclines. The central and most widespread community in the pattern is the prevailing or climatic climax. It is the community that most clearly expresses the climate of the area.

4. **Information theory.** This theory was proposed by **Leith**, **Odum** and **Golley**. It considered succession and climax in terms of ecosystem development. In autotrophic succession (ecosystem development), diversity of species tends to increase with an increase in organic matter content and biomass supported by the available energy. Thus, in a climax community, the available energy and biomass, which is called **information content**, increase. In contrast to it, in a heterotrophic succession occurs a gradual depletion of energy, because the rates of respiration always exceed production rates. However, in an ecosystem both the autotrophic and heterotrophic successions operates in a co-ordinate manner. The autotrophic individuals derive mineral elements from the soil and atmosphere, while the heterotrophic individuals carry on the return of the nutrients to soil and atmosphere, through decomposition of complex dead organic matter. Thus, succession reaches a stage, the climax stage, when the amount of energy and nutrients received from the environment by the plants is again returned in more or less similar amount to the environment by decomposition through heterotrophs.