Ecological Succession with Example

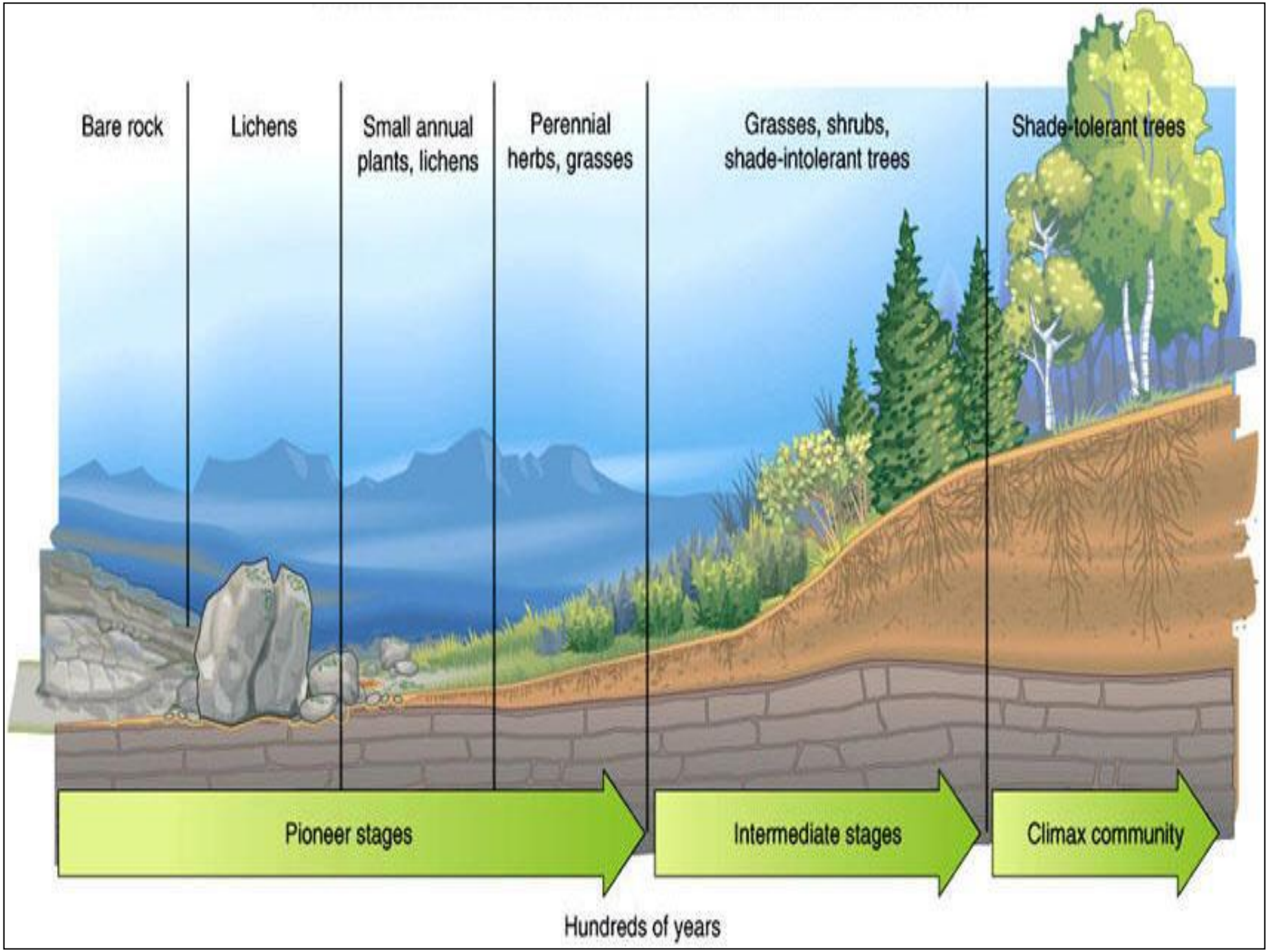
Dr. R. Prasad
Dept. of Zoology
Eastern Karbi Anglong College

The gradual change in species composition and processes of communities over time is known as ecological succession or community development. Understanding the process, rates and pattern of ecological succession is important for the management of ecosystems and for understanding vegetation potential and dynamic changes in the landscapes. From the stand point of time, ecosystem and community changes can be divided into two types:

i. Changes occurring over geological time scale (million years), and

ii. Those occurring over medium time scale, say in 1-1000 years.

Community changes occurring over geological time period are called Palaeo-ecological changes. These changes are synthesized on the basis of fossil records, e.g., leaves, twigs, cones, pollens and seeds. For example, fossil evidences indicate that in Rajasthan desert of India, the vegetation during the tertiary period consisted largely of trees species ascribed to humid environment. Later on, in response to drier climate the desert plants prevailed in this area. In this unit, we would be


Bare rock
Lichens
Small annual plants, lichens
Perennial herbs, grasses
Grasses, shrubs, shade-intolerant trees
Shade-tolerant trees
Pioneer stages
Intermediate stages
Climax community
Hundreds of years

CAUSES AND TRENDS OF SUCCESSION

The causes of succession are as follows:

i. Initial/Initiating causes: These are climatic as well as biotic. The factors include erosion and deposition, wind, fire, activities of organisms, etc. These causes produce the bare areas or destroy the existing population in the area.

ii. Ecesis/Continuing causes: These are the processes such as migration, ecesis, aggregation, competition, reaction, etc., which cause successive waves of populations as a result of changes, chiefly in the edaphic features of the area.

iii. Stabilizing causes: These cause the stabilization of the community. According to Clements, climate of the area is the chief cause of stabilization, other factors are of secondary value.

Trends in Succession

i. Change in species composition (i.e., kinds of plants change continuously with succession, the number of species often increase).

ii. Change in variety or diversity (the diversity of species tends to increase with succession).

iii. Progressive increase in biomass (the amount of both living and dead organic matter).

iv. Shift in community metabolism (a decrease in community production and corresponding increase in community respiration). In a young pond, P/R>1(P=production, R=respiration), whereas, in a stable pond (heterotrophic succession) P/R=1, P/R<1.

DIFFERENT KINDS OF SUCCESSIONS

1. **Primary succession**: If succession proceeds from a primary bare area or primitive substratum which has not been changed physically by organisms, it is called primary succession. The first group of plants establishing there are known as pioneers. The series of development stages are called prisere. For example, succession on a bare rock (lithosere).

2. **Secondary succession**: If succession starts in a secondary area previously colonized, but has been cleared off, it is called secondary succession. The series of developmental stages are called subseres. In subseres, the substratum contains already formed soil, humus and may contain seeds. The rate of change is more rapid and the time required for the completion of sere is much shorter than in primary succession. For example, succession in a forest area where vegetation has been devastated by natural catastrophes.

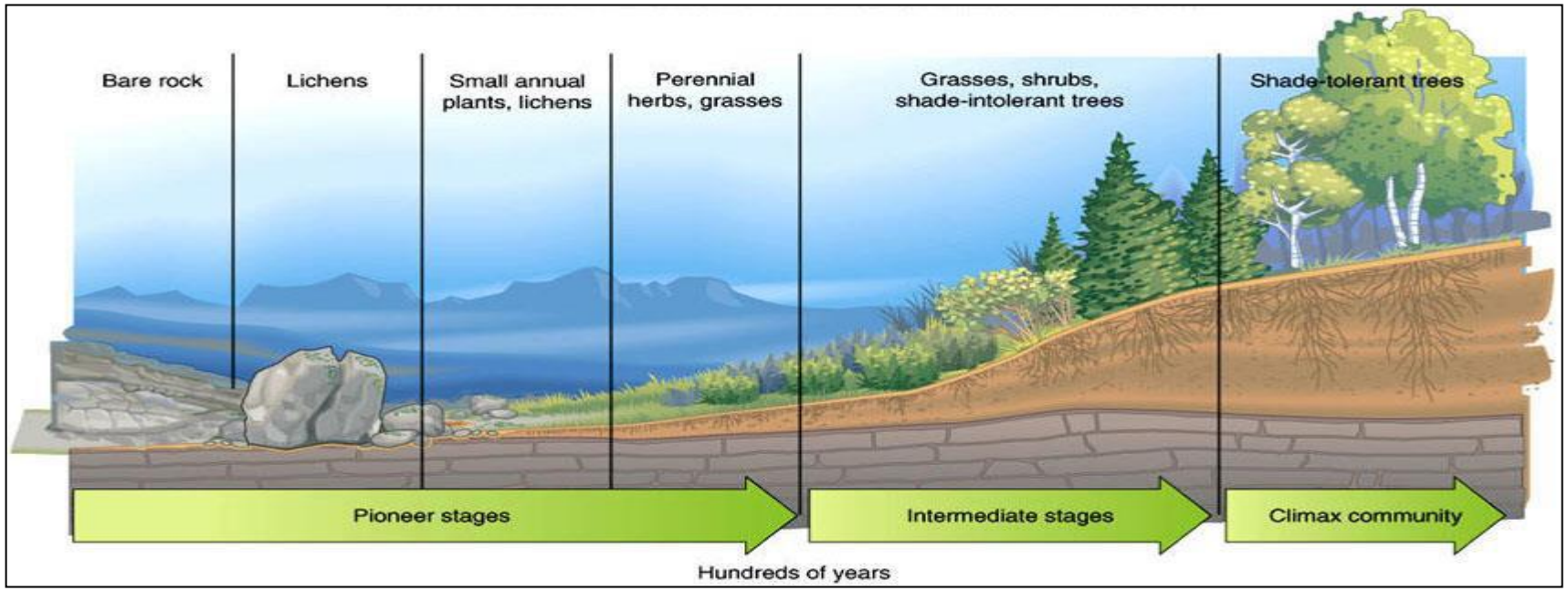


Fig.: Primary Succession

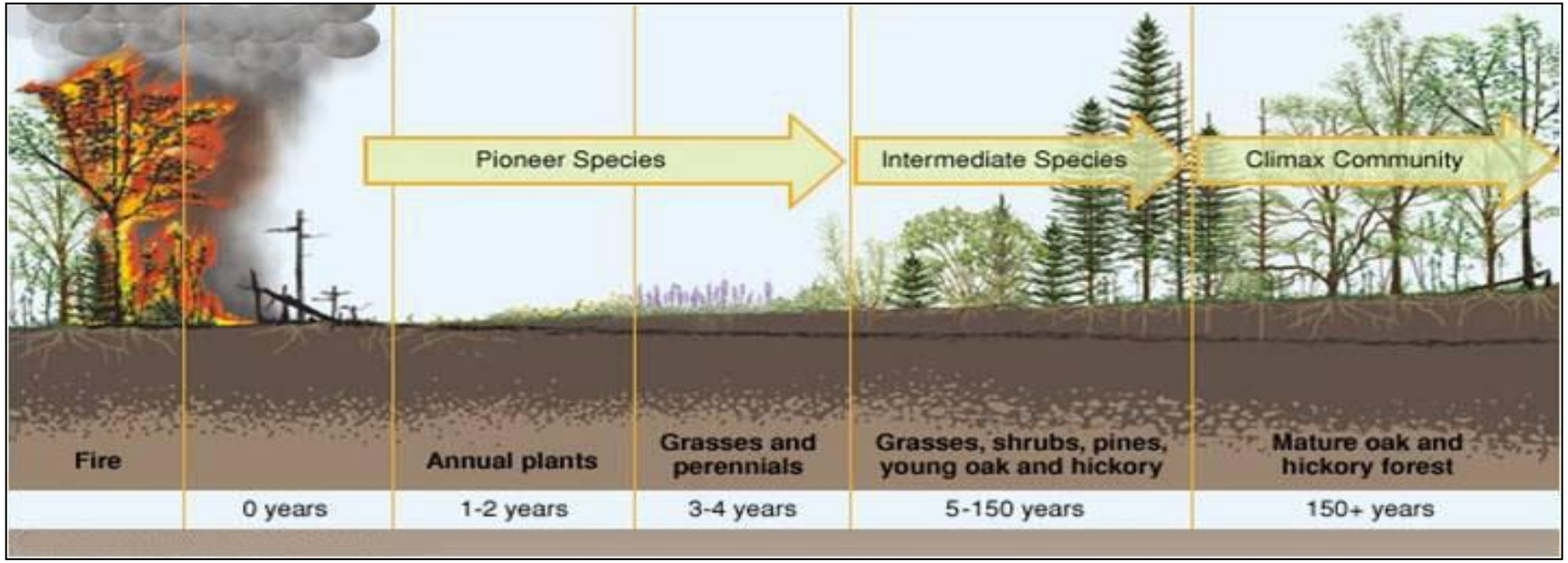


Fig.: Secondary Succession

3. **Autotrophic succession**: Succession characterized by early and continued dominance of autotrophic organisms like green plants. It begins in a predominantly inorganic environment and the energy flow is maintained indefinitely. There is gradual increase in the organic matter content supported by energy flow.

4. **Heterotrophic succession**: Succession characterized by an early dominance of heterotrophs, i.e., fungi, bacteria and animals. It begins in a predominantly organic environment, and there is a progressive decline in the energy content.

5. **Induced succession**: The climax community has low productivity as compared to initial communities. In a climax community respiration almost balances the production of organic matter. Therefore, very little is left for man to harvest.

6. **Allogenic succession**: Allogenic succession is due to major environmental changes beyond the control of the indigenous organisms. Dust bowls, winds, dry periods change the pattern of vegetation. The habitat is changed by the action of outside factors like change in climate, leaching of soil nutrients, increase in salt concentration of the soil and deposition of salt or sand.

7. **Autogenic succession**: Succession resulting from the resident population altering its own environment. For example, plants of a developmental state produce changes in the habitat initially to favor their growth but the changes go on beyond the optimum so that the habitat becomes unsuitable for them. It paves the way for the growth of another type of plant community.

8. **Retrogressive succession**: At times a climax vegetation may deteriorate and get replaced by a community of an earlier stage of succession due to destructive effects of organisms. Sometimes the development of the disturbed communities does not occur and the process of successive instead of progressive becomes retrogressive, e.g., forest may change to shrubby or grassland.

9. **Deflected succession**: A succession in which the vegetation does not pass through the normal stages of development but either adds or replaces a successional type.

10. **Serule (Microsere)**: It refers to the miniature succession of microorganisms like fungi, bacteria, actinomycetes, etc., that occurs within a microhabitat like fallen logs of decaying wood, tree, bark, etc. Serule is heterotrophic in nature and begins on substratum rich in organic matter.

Hydrarch and Xerarch Succession

Depending upon the nature of environment where the process begins, the succession is hydrarch or hydrosere if it starts in substratum where water is in plenty, e.g., in ponds, lakes, streams, swamps, etc. It is xerarch or xerosere, if it begins in dry areas such as deserts, rocks, etc. Xerarch is sometimes classified in further groups - **the lithosere:** initiating in rocks, **psammosere:** on sand, and **halosere**: in saline soil. The succession starting in an area with moderate moisture conditions is called as **mesarch.**

GENERAL PROCESS OF SUCCESSION

Clements, being the most influential ecologists to suggest the mechanism of succession, in *Plant Succession: An Analysis of the Development of Vegetation* (1916), stated the succession a universal process of community development. He believed firmly that climate was the main driving factor in determining the type of vegetation during succession. As per his philosophy, climates are like genomes, and vegetation is like an organism whose characteristics its genome determines. The final step in vegetation succession he referred to as a climax. He recognized the following basic processes in succession:

1. **Nudation:** Development of a bare area without any form of life. The area may develop due to several causes such as landslide, erosion, deposition or other catastrophic agency. The causes of nudation may be:

   Topographic: Soil erosion, landslide, volcanic activity, earthquake, etc.

   Climatic: Glaciers, dry period, hails and storm, frost, fire, etc.

   Biotic: Destruction of forest due to industrialization, agricultural expansion, urbanization, diseases due to fungi, bacteria, etc.

2. **Invasion:** Successful establishment of a species in a bare area. The species actually reaches this new site from any other area. It involves following successive stages

   i. **Migration (dispersal):** The seeds, spores, or other propagules of the species reach the bare area. The agencies which bring about dispersal are wind, water, animal including man.

   ii. **Ecesis (establishment):** After reaching the area, the process of successful establishment of the species, as a result of adjustment with the conditions prevailing there, is known as ecesis. This process is dependent upon the climatic, edaphic and biotic factors. The success of plant depends upon the climatic, edaphic and biotic factors. In plants, after migration, seeds or propagules germinate, seedlings grow, and adults start to reproduce. Only a few of them are capable of doing this under primitive harsh conditions and thus most of them disappear. As a result of ecesis, the individuals of species become established in the area.

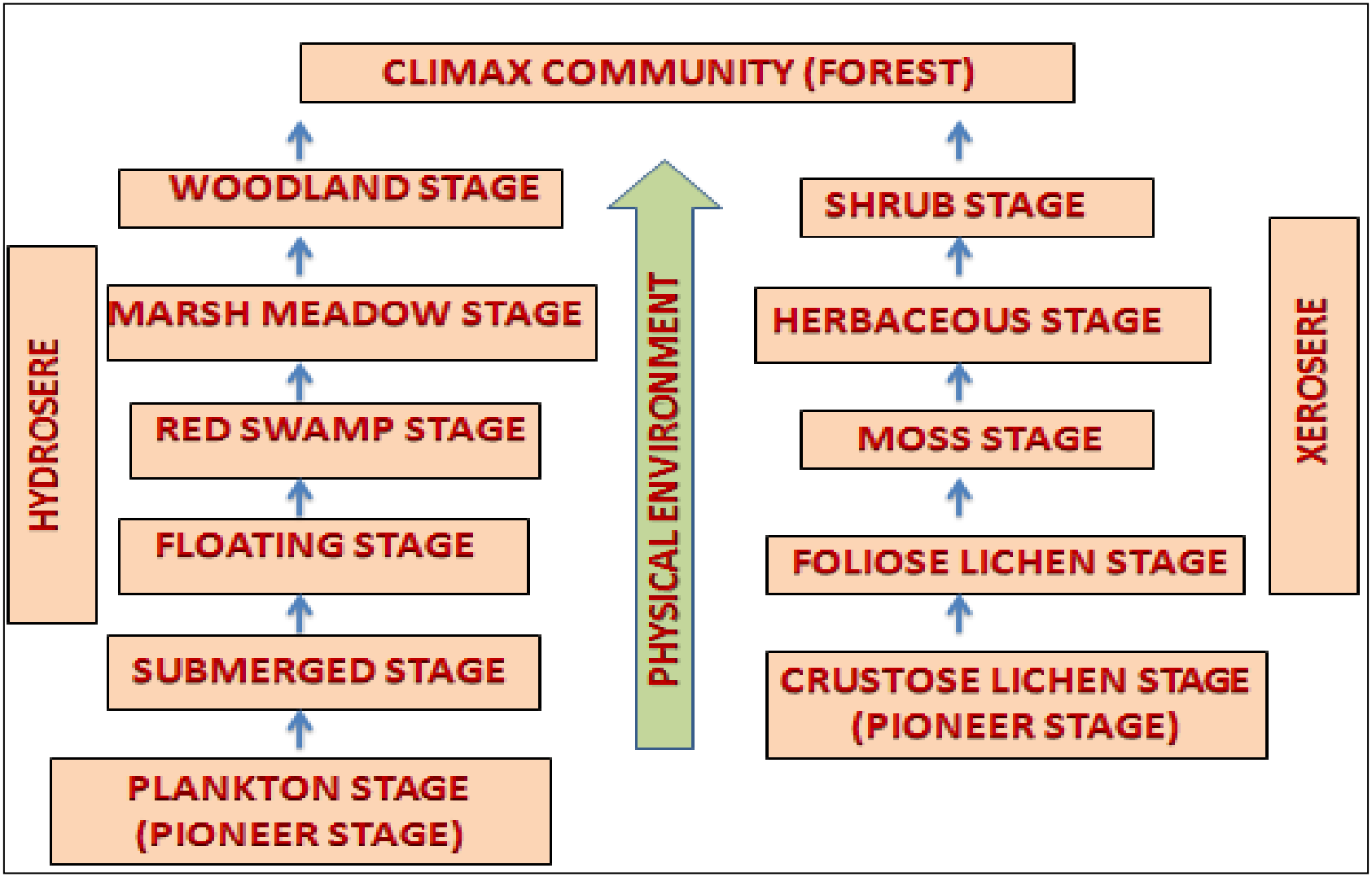
   iii. **Aggregation:** As a result of reproduction, the individuals of the species increase in number, and they come close to each other.

3. **Competition and coaction:** This phenomenon involve struggle for existence between two or more individuals growing in an area, that makes successive demands, that are similar in nature, on the soil. The struggle is usually between two individuals of same kind that have similar demands such as space, nutrients, water, light, etc. Competition can either be interspecific (between two different species) or intraspecific (within the individuals of same species). As a result of competition, the weak individuals are eliminated and the stronger ones are retained. The dead bodies of the eliminated plants and animals' decay and form humus enriching the soil.

4. **Reaction:** This is the most important stage in succession. The mechanism of the modification of the environment through the influence of living organisms on it, is known as reaction. As a result of reactions, changes take place in soil, water, light conditions, temperature, etc., of the environment. For example, plants change the structure and texture of soil in course of time by addition of humus into the soil. Due to all these, environment is modified, becoming unsuitable for the existing community which sooner or later is replaced by another community.

5. **Climax community:** The reactions of individuals collectively have a wider effect on the environment. The local climate is actually changed if the climax vegetation is forest. The reactions keep the vegetation in active state till the climax community is formed. Although strictly speaking vegetation can never be called as stable. Yet at maturity the community being mesic, further mesic changes being less possible the climax community can be called as relatively stable. Thus, we find the development of community living in harmony within the environment which has been the result of its reactions.

General process of succession with different developmental stages, viz., pioneer, seral and climax communities under the influence of physical environment, taking the examples of hydrosere and xerosere are shown in Fig.



Hydrosere

Plant successions which begin in ponds, lakes, marshes, or elsewhere in water, are termed hydrarch and different stages are called as hydrosere. The water is deep in the middle and becomes progressively shallow towards the bank.

1. **Pioneer stage:** This is characterized by a bottom barren of plant life. The pioneers include phytoplankton. This consists of microscopic algae, bacteria, diatoms and protozoa. This phytoplankton after death settles to the bottom. The soils are very much reduced with a pH value of not more than 5.

2. **Submerged stage:** This stage is found where the water is less than 20 feet deep. The plants are entirely submerged. Prominent submerged plants include pond weeds (Potamogeton), hornwort (*Ceratophyllum*), eelgrass (*Vallisneria*), water weed (*Elodea*), Hydrilla, bladderwort (*Utricularia*), Chara and *Ranunculus*. These are all rooted plants. When these plants die, their remains sink to the bottom where they become humus. The humus binds the soft muddy soil. These plants also help in depositing soil particles at the bottom. As a result of these reaction the water becomes shallow and the habitat becomes unsuitable for submerged plants, which in turn are replaced by floating plants.

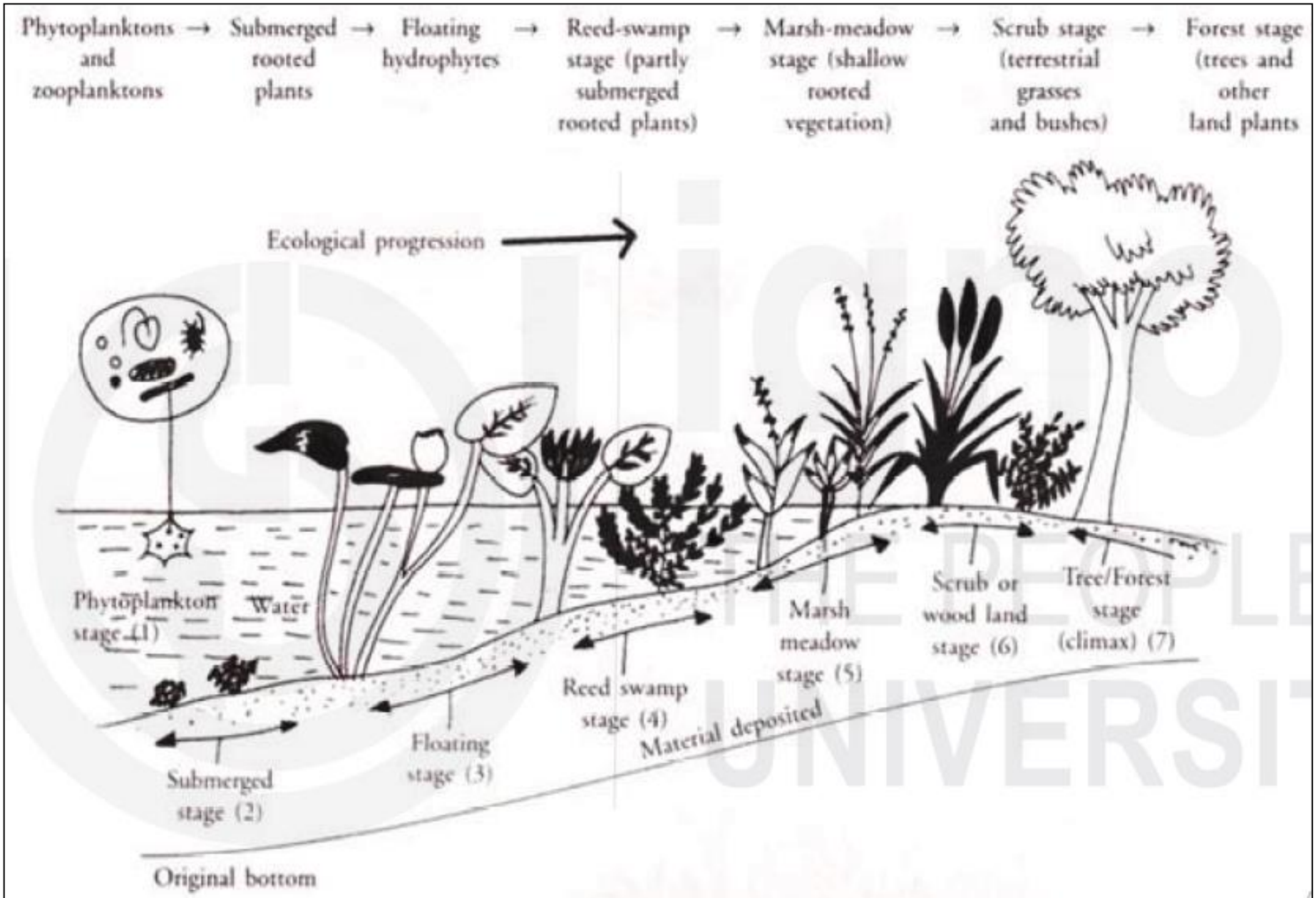
3. **Floating stage:** This stage is present where the water is only 6-8 feet, deep. This stage includes rooted plants with floating leaves like *Nyphaea* (water lily), *Nelumbium, Limnanthemum, Aponogeton, Monocharia, Trap* and free-floating plants like *Pistia, Azolla, Lemna, Spirodella, Wolffia, Eichhornia,* etc. The water level by now becomes very much decreased, making the pond shallower. By their death and decay humus is formed which results in the higher concentration of salts and organic matter and ultimately the water becomes unsuitable for these floating plants which are then replaced by reed swamp plants.

4. **Reed-swamp stage:** This stage also called as amphibious stage occurs where the water is 1-4 feet deep and includes the plants which are partly submerged, with their roots at the bottom and their foliage raised above the surface of water. The important plants consisting this stage include cattail (*Typha*), bulrush (*Scirpus*), reed grass (*Phragmites*), arrow head (*Sagittaria*), *Rumex* etc. These plants cut off the light from the floating plants and in this way make the water still shallower by settling down the sedimentary materials washed into the lake and by very rapid accumulations of humus. This changed habitat becomes highly suitable for the growth of plants of next seral stage i.e., marsh-meadow stage.

5. **Marsh-meadow stage:** This stage includes hydrophytes or water loving plants. The substratum at this stage is hardly covered by 1-2 inches of water, so to say the soil becomes marshy. This is now invaded by numerous species of sedge. *Juncus*, carice (*Carex*), spike rush (*Eleocharis*), *Polygonum,* etc. Many species of herbs like mint (*Mentha*), marsh marigold (*Caltha*), bell flower (Campanula), etc., also occur intermixed with sedges. All these hydrophytes react upon the habitat, raise the surface by binding water carried and wind-borne soil, accumulate plant debris, and transpire enormous quantities of water. This makes the soil more suitable for the mesophytes and terrestrial plants. Under these circumstances, hydrophytes cannot live long, they migrate inward giving room for grasses and woody plants.

6. **Woodland stage:** If the climate is dry then a grassland develops but under moist climate a woodland is formed containing certain shrubs and small tress. This stage is characterized by the plants that can tolerate water-logged soil around their roots. Shrubby willow (*Salix*), dog woods (*Cornus*), button bush (*Cephalanthus*), alder (*Alnus*), cotton wood (*Populus*), tree willows etc., are the plant species of the woodland stage. These plants by their reaction make the soil unsuitable for themselves and more suitable for shade enduring herbs which grow the trees and shrubs.

7. **Climax forest:** This represents the final stage of hydrarch. It includes mixed forest of alder (*Alnus*), willow (*Salix*), cottonwood (*Populus*), elm (*Ulmus*), ash tree (*Fraxinus*), oak (*Quercus*), etc. After a few generations a pure forest oaks or hickories may develop.



Various stages of Hydrosere

Lithosere (Xerarch)

Xerosere is the sequence of successional stage which occur on bare areas deficient in water. Succession on a bare rock is as follows:

1. **Pioneer stage (Crustose lichen stage):** The rocky habitat is extremely xeric and hostile. There is no water as the substratum does not absorb rain water. There is no nutrient holding mechanism. When exposed to sun, the surface temperature goes very high. In such a habitat, only the crustose lichens can become pioneer colonies that have ability to bear high degree of desiccation and temperature extremes. These lichens reach the bare rock through wind borne soredia, lichen fragments and spores. The lichens produce carbonic acid which has a corroding effect on rock matter:

$$Co_2 + H_2o \rightarrow H_2Co_3$$

Generally, species of *Rhizocarpon, Rinodena, Lecidea* and *Lecanora* establish themselves on the bare rocks.

2. **Foliose Lichen stage:** Foliose lichens i.e., those attached to the substratum at a single point or along a single margin appear as soon as a little soil has accumulated on the non-weathered portion of rock and in depressions or other slightly less exposed situations. They slowly replace the crustose form. These expanding leaf-like thalli may completely over shadow the crustose lichens causing the crustose species to die and decay. Above the foliaceous invaders water has better chance to collect and to be absorbed. Evaporation is greatly decreased. Wind and water borne lichen fragments and dust particle lodge and humus is more rapidly accumulated because of its less rapid oxidation. Acid produced by living and decaying plants are constantly eating further into the rocks. Indeed, it is possible that change from crustose to foliose lichen is a change of habitat.

   After the crustose give away to foliose species such as *Dermatocarpon, Parmelia, Umbilicaria,* a new type of invaders appears.

3. **Moss stage:** As soon as sufficient amount of soil has accumulated in the minute crevices and depression xerophytic mosses begin to appear. These are common species of *Gerimmia, Polytrichum* and *Tortula*. They may have migrated long distances by wind-blown spores that are caught in minute amount of soil and along foliose lichens and germinate there. Their rhizoids compete with those of foliose lichens for water and nutrients. The erect stems of mosses often exceeded the lichens in heights. The power of withstanding desiccation is almost as marked along these pioneers as among the lichens. These are the most exacting foliose species that may occur simultaneously or indexed. The mosses may sometimes precede foliose lichens.

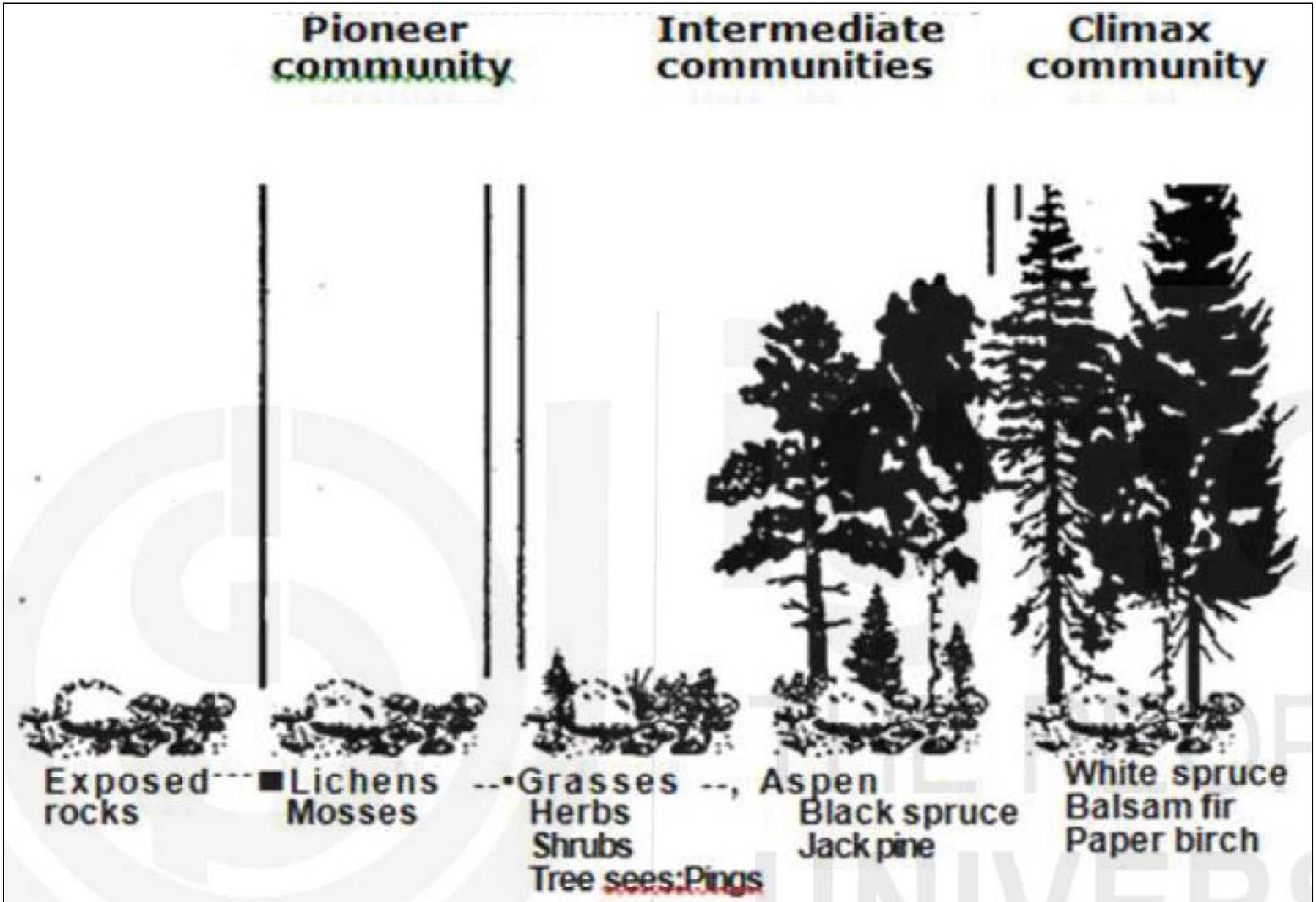
Soil rapidly accumulates among the erect stems as the plant die below and continue to grow above and build up the substratum and constantly increase their area. The depth of the soil under the cushion like mat is often one inch or even more. The crustose lichens like *Cladonia* grow along with mosses. The mosses form thick mats and play a significant role in building up thick substratum of soil. Their continuous growth, death and decay for several years builds up a good soil which is quite fit for the growth of herbaceous flora.

4. **Herbaceous Stage:** The soil forming and soil holding reaction of mosses are so pronounced that the seeds of some xerophytic herbs especially short-lived annuals are soon able to germinate and grow to maturity. They grow slowly and exhibit stunted growth because the soil is yet not very favourable and lacks nutrients. Drought conditions also prevail. The roots of these xeric herbs continue to grow and corrode the rocks. Their dead remains enrich the soil further and more humus collects.

   Depending upon the plants growing in surrounding communities the invading herbs are *Potentilla, Solidago* and *Saxifraga.* Their growth makes the conditions less dry. Bacteria, fungi and microfauna appear along with grasses. Their death and decay further add to the soil layers.

5. **Shrub stage:** Woody shrubs like *Rhus glabra,* or *Rubus* and *Sassafras* invade these areas. Their shade makes the growth of herbs impossible and thus they disappear. The humidity increases and wind velocity is decreased. The addition of organic matter to the soil increases water holding capacity of soil, its texture and structure is changed so that the seeds of trees find suitable place for growth.

6. **Climax forest:** The tress which make their appearance are dwarf sized, xeric and grow separated apart. They are however followed by mesophytes as the climate becomes more mesic. *Quercus*, *Tilia* are the trees which find place in climax communities.



Various stages of Lithosere