উদ্ভিদ পর্যায়ের প্রকারভেদ (Types of Plant Succession)

উদ্ভিদ পর্যায়ের মৌলিক ধরনগুলি হল –

1) প্রাথমিক বা মুখ্য পর্যায় :

এটি হল বাস্তুবিদ্যা সংক্রান্ত উদ্ভিদ পর্যায়, যেটি লাভা প্রবাহ বা তীব্র বন্যা প্রভৃতির ফলে নতুনভাবে জন্ম উদ্ভিদবিহীন মাটিতে প্রথম শুরু হয়।

এক্ষেত্রে প্রবর্তক প্রজাতিগুলি যথা লাইকেন, শৈবাল এবং ছত্রাক ও কিছু জলবায়ু সংক্রান্ত প্রভাবক (বাতাস, জল প্রভৃতি) বাসস্থানকে আদিরূপ অবস্থায় ফিরিয়ে আনতে শুরু করে, ধীরে ধীরে মৃত্তিকা গঠিত হয় এবং উন্নতশ্রেণির নালিকা বান্ডিল অন্বিত উদ্ভিদগুলির বাসস্থানের উপযুক্ত হয়।

2) গৌণ পর্যায় (Secondary Succession) :

এটি হল বাস্তুবিদ্যা সংক্রান্ত একটি উদ্ভিদ পর্যায়, যেটি জীব অঞ্চলে জন্মায়। এই অঞ্চলগুলিতে প্রথমে উদ্ভিদ পর্যায় বর্তমান ছিল, কিন্তু এগুলি কিছু বিশৃঙ্খলার কারণ, যথা – আগুন, প্রবল আধুনিক ঝড়, প্রবল বায়ুপ্রবাহ ও বন্যার ফলে নষ্ট হয়েছিল।

3) অটোজেনিক পর্যায় (Autogenic Succession)

একটি উদ্ভিদ পর্যায় শুরু হওয়ার পর, উদ্ভিদগুলির অজীব পরিবেশের আন্তঃক্রিয়ার ফলে নিজেদের পরিবেশই বদলে যায়, ফলে ওই অঞ্চলটি নতুন ধরনের উদ্ভিদ সম্প্রদায় দ্বারা প্রতিস্থাপিত হয়। এই ধরনের উদ্ভিদ পর্যায়কে অটোজেনিক পর্যায় বলে।

মৃত্তিকাস্থিত জীবের দ্বারা লিটার বা হিউমাস-স্তরে জৈব বস্তু জমা হওয়া, মৃত্তিকার সুষি ও pH পরিবর্তনের ফলে, মৃত্তিকার অবস্থার পরিবর্তন হয়, ফলে উদ্ভিদ পর্যায়ের ও পরিবর্তন হয়, এই পরিবর্তনের জন্য উদ্ভিদগুলি নিজেরাই দায়ী।

4) অ্যালোজেনিক পর্যায় (Allogenic Succession)

অ্যালোজেনিক পর্যায় হল উদ্ভিদ পর্যায়ে গুরুত্বপূর্ণ পরিবর্তন, যেটি বাহ্যিক প্রাকৃতিক প্রভাব দ্বারা হয়ে থাকে, কিন্তু গাছপালা গুলি দ্বারা হয় না।

এই ধরনের উদ্ভিদ পর্যায় বিভিন্ন কারনে হয়ে থাকে, যেগুলি হল - আগ্নেয়গিরির অগ্ন্যুৎপাত, বন্যা, হিমবাহ আর বা পুর্ণির নিষ্কাশন, হিমবাহ ঘনত্ব বৃদ্ধি ইত্যাদি।

5) স্বভোজী পর্যায়ঃ (Autotrophic Succession)

স্বভোজী পর্যায়ে স্বভোজী উদ্ভিদ, যথা অনুজ উদ্ভিদ গুলির প্রথম পর্যায় থেকেই কর্তৃত্ব দেখা যায়। এই ধরনের পর্যায় আরম্ভ হয়, যখন অজৈব পরিবেশ সৃষ্টি হয়, যেখানে প্রচুর পরিমানে শক্তির প্রবাহ থাকে।

6) পরভোজী পর্যায় (Heterotrophic Succession) ঃ

এই পর্যায়ের প্রথম দিকে পরভোজী, যথা ব্যাকটেরিয়া, ছত্রাক প্রকৃতির কর্তৃত্ব দেখা যায়। এগুলি জৈব পরিবেশে কর্তৃত্বপূর্ণভাবে আরম্ভ করে কিন্তু পরবর্তীতে ধীরে ধীরে শক্তির পরিমান কমে যায়।

7) চক্রাকার পর্যায় (Cyclic Succession) ঃ

এই ধরনের চক্রাকার পর্যায়ের নকশা আলবার্টার ওয়ালী প্রথম উপস্থাপন করেন।

এটি এক ধরনের গাছপালার পরিবর্তন, যেখানে অনেকের পরিপেক্ষিতে বিজ্ঞান বিশৃঙ্খলার অনুপস্থিতিতেও কিছু সংখ্যক প্রজাতি অন্যদের স্থানান্তরিত করে। আবহাওয়া চক্রের পরিবর্তনের সাথে সাথে মাটি পরিবেশের পরিবর্তনের মাধ্যমে চক্রাকার গাছপালার ও পরিবর্তন হয়।

৫) চরম অঞ্চলের কয়েকটি বৈশিষ্ট্য লেখো

i) গাছপালা গুলি পরিবেশের অবস্থায় সহনশীল

ii) এখানে উদ্ভিদ বৈচিত্র্য বিস্তৃত

iii) অপেক্ষে খাদ্যশৃঙ্খল জটিল প্রকৃতির

iv) এটি একটি সুসমন্বিত্য চরম বাস্তুতন্ত্র

v) এখানে গৃহীত সৌরশক্তি এবং পচনকারী জীবদের আহার্য শক্তির মুক্তি সমতাপূর্ণ।

vi) এখানে পুর্ণির উত্তম এবং খরচ হওয়ার মধ্যে - ভারসাম্য বর্তমান।

vii) এখানে জীবনের গঠন ভিন্ন ধরনের।

৫) উদ্ভিদ পর্যায় পদ্ধতি সম্বন্ধে লেখো। (process of Plant succession)

উদ্ভিদ পর্যায় পদ্ধতি (Process of Plant Succession)

1916 খ্রিস্টাব্দে ফ্রেডেরিক ক্রিমেন্টস্ (Frederic Clements) সর্বপ্রথম উদ্ভিদ পর্যায় পদ্ধতির তত্ত্বটি উপস্থাপন করেন, যাহা **"অত্যুত্তম বাস্তুবাবিদ্যার তত্ত্ব"** বা **"ক্ল্যাসিক্যাল ইকোলজিক্যাল থিওরি"** (Classical ecological theory) নামে পরিচিত। এটিকে **"ক্লিমেন্টস্-র উদ্ভিদ পর্যায় তত্ত্ব"** (Clement's theory of succession)-ও বলা হয়। তাঁর মতে উদ্ভিদ পর্যায় হল একটি পদ্ধতি যেখানে পদ্ধতির বিভিন্ন পর্যায়গুলি একে অপরকে অনুসরণ করে। এই পর্যায়গুলি হল—

1. **নুডেশন (Nudation)** : জীবনের কোনো অস্তিত্ববিহীন একটি অনাবৃত অঞ্চল (bare site) সৃষ্টিকে নুডেশন বলে।

   এই ধরনের অঞ্চলটি বিভিন্ন কারণে সৃষ্টি হয়, যথা—মৃত্তিকার ধস্ (land slide), মৃত্তিকার ক্ষয় (soil erosion), বিভিন্ন পদার্থ জমা হওয়া (deposition) এবং অন্যান্য আকস্মিক বিপত্তি। এটি প্রধানত 3টি কারণে ঘটে থাকে। যেগুলি হল—টোপোগ্রাফিক (topographic), ক্লাইমেটিক (climatic) এবং বায়োটিক (biotic)।

2. **অনুপ্রবেশ (Migration)** : এক্ষেত্রে উদ্ভিদের বীজ, রেণু বা অন্যান্য বংশবিস্তারকারী গঠন (propagule) ওই অনাবৃত অঞ্চলে পৌঁছায়, যাকে **অনুপ্রবেশ** বলে। এটি সাধারণভাবে জল, বাতাস বা অন্য বাহকের (agent) মাধ্যমে সংগঠিত হয়।

3. **ইশেসিস (Ecesis)** : নতুন অঞ্চলে পৌঁছানের পর বীজ ও রেণু অঙ্কুরিত হয়ে শিশু উদ্ভিদ সৃষ্টি করে অথবা অঙ্কুরিত না হতে পারলে, বিলুপ্ত হয়। একইভাবে অন্যান্য বংশবিস্তারকারী গঠন থেকেও নতুন উদ্ভিদের সৃষ্টি হয়। নতুন উদ্ভিদগুলি ওই স্থানের পরিবেশের সঙ্গে মানিয়ে নিয়ে সফলভাবে নিজেদের প্রতিষ্ঠিত করে। ইশেসিস পদ্ধতির মাধ্যমে ওই অঞ্চলে বিভিন্ন উদ্ভিদ প্রজাতিদের উপনিবেশ গঠিত হয়।

4. **প্রতিযোগিতা (Competition)** : এরপর নির্দিষ্ট স্থানে একটি প্রজাতির উদ্ভিদগুলির মধ্যে বাসস্থান ও পুষ্টির জন্য প্রতিযোগিতার সম্মুখীন হয়। আবার এক্ষেত্রে প্রজাতির প্রত্যেক উদ্ভিদ প্রত্যেকের জীবনকে বিভিন্নভাবে প্রভাবিত করে, যাকে **সহযোগিতা** বলে। অন্যদিকে, একটি প্রজাতির উদ্ভিদ, উপস্থিত অন্য প্রজাতির সঙ্গে প্রতিযোগিতায় সফল না হলে, সেগুলি অবলুপ্ত হয়। নতুন এই অঞ্চলে বেঁচে থাকার জন্য অন্তঃ ও আন্তঃ প্রজাতির উদ্ভিদদের মধ্যে প্রতিযোগিতা হয়, সফলগুলিই বেঁচে থাকে এবং বিফলগুলি অবলুপ্ত হয়।

5. **প্রতিক্রিয়া (Reaction)** : উদ্ভিদ পর্যায়ের জন্য এটি একটি প্রয়োজনীয় ও গুরুত্বপূর্ণ দশা। জীবের উপস্থিতির মাধ্যমে পরিবেশের বিভিন্ন ধরনের পরিবর্তন হয়, যাকে **প্রতিক্রিয়া** বলে। এইরূপ প্রতিক্রিয়ার ফলে পরিবেশের বিভিন্ন উপাদান, যথা—জল, মৃত্তিকা, আলো, তাপমাত্রা প্রভৃতির পরিবর্তন হয়। পরিবেশ পরিবর্তনের ফলে ওই অঞ্চলে পূর্বেকার সম্প্রদায়ের উদ্ভিদগুলি এখানে থাকতে অক্ষম হয় ও পার্শ্ববর্তী স্থানে সরে যায় এবং নতুন প্রজাতিগুলি এখানে এসে ওই স্থান দখল করে। ফলে ওই স্থানে নতুন উদ্ভিদের পর্যায়ক্রম তৈরি হয়।

একটি নির্দিষ্ট স্থানে একটি সম্প্রদায়ের সমস্ত উদ্ভিদগুলি যখন অন্য সম্প্রদায়ের উদ্ভিদ দ্বারা প্রতিস্থাপিত হয় তাকে **সেরি** (cere) বলে। এবং বিভিন্ন সম্প্রদায়ের উদ্ভিদ দ্বারা গঠিত সেরিকে **সেরাল কমিউনিটিস** (seral communities) বা **সেরাল স্টেজেস** (seral stages) বলে। এইভাবে ওইস্থানে বিভিন্ন স্তরে বিভিন্ন ধরনের গাছপালার স্বাভাবিক আবাস গঠিত হয়।

6. **সুপ্রতিষ্ঠিত হওয়া (Stablisation)** : এই পর্যায়ে সকল প্রজাতিদের মধ্যে সুপ্রতিষ্ঠিত হওয়ার সাফল্যের জন্য প্রতিযোগিতা হতে থাকে এবং সর্বশেষ পর্যায়ে একটি **চরম সম্প্রদায়** (climax community) গঠন করে।

সুতরাং **চরম সম্প্রদায়** (climax community) বা **চরম গাছপালা** (climax vegetation) হল সেরির মধ্যে একটি চূড়ান্ত বা সুপ্রতিষ্ঠিত সম্প্রদায় যারা ভৌত আবাসের সঙ্গে ভারসাম্য বজায় রেখে দৃঢ়ভাবে অবস্থান করে। চরম সম্প্রদায় সমন্বিত স্থানে সাধারণভাবে কোনো জৈব পদার্থ সঞ্চিত হয় না, কারণ এখানে শক্তির ব্যবহার ও উৎপাদনের মধ্যে ভারসাম্য বজায় থাকে।

1.5 PLANT SUCCESSION

Plant succession is the observed process of change in the plant species structure of an ecological community over time. Clements (1916) defined succession as "the natural process by which the same locality becomes successively colonised by different groups or communities of plants".

Knight (1965) defined it as "succession from ecological point of view refers to an orderly sequence of different communities over a period of time in a particular area".

According to Eugene Odum (1983) "plant succession is an orderly process of community change in an unit area".

The community begins with relatively few pioneering plants and develops through increasing complexity until it becomes stable as a climax community. In this process, an ecological community undergoes more or less orderly and predictable changes following disturbance or initial colonization of new habitat. Succession may be initiated either by formation of new, unoccupied habitat (e.g. a lava flow or a severe landslide newly exposed rock or sand surfaces) or by some form of disturbance (e.g., fire, severe windthrow, flood, human-caused disturbance such as logging and agriculture). Succession was among the first theories advanced in ecology and was first documented in the Indiana Dunes of North-West Indiana, USA.

TYPES OF SUCCESSION

The basic types of successions are:

1. **Primary succession**: It is an ecological succesion of plant life, occurring in an environment in which the new substrate lacking vegetation as a result of lava flow or a severe landslide or area left from retreated glacier, is formed.

   In primary succession, pioneer species such as lichen, algae and fungi alone with some climatic factors (wind, water, etc.) start to normalize the habitat. This creates conditions conducive for vascular plant growth or for the formation of soil. The pioneer species are then dominated and subsequently replaced by plants that are better adapted. These include vascular plants like grasses, shrubs that are able to live in mineral based thin soil.

   Example: Spores of lichen or fungi (pioneer species) are spread onto a barren land of rocks. The rocks are further broken down into smaller pieces, then organic matters are accumulated gradually, favouring the growth of larger plants like grasses, herbs, ferns. These plants further improve the habitat so that larger vascular plants like shrubs, or even trees get settled over there. More animals are attracted, to the place and finally a **climax community** is reached.

2. **Secondary succession**: It is the succession that occurs in a secondary area previously colonised, but has been removed following severe disturbances such as forest fire, hurricane, harvesting, severe windthrow, flood.

Example:

A stable forest community
↓
A disturbance that destroys the forest
↓
The Fire burns the forest and destroys it, the ground remains empty within destroying soil
↓
Grasses and herbs start to grow on barren soil
↓
Small bushes and trees start to colonize on the land
↓
Fast growing trees develop and shade-tolerant trees grow in the understory
↓
The short-lived and shade-intolerant trees die. Tall trees overtop the shade-tolerant trees
↓
The ecosystem is now back to a similar state to where it began

3. **Autogenic succession**: After the succession has began 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 called **autogenic succession**, coined by Tansley (1955). This succession can be brought by changes in the soil caused by the organisms through accumulation of organic matter in litter or humic layer, alteration of soil nutrients, change in pH of soil. Hence plants themselves are responsible to change the structure of their own vegetation by the series of their developmental changes.
4. **Allogenic succession**: Allogenic succession is a major change in succession caused by external environmental influences (abiotic components) and not by the vegetation. An allogenic succession can be brought about in a number of ways such as volcanic eruptions, floods, non-anthropogenic climate change, leaching of soil nutrients, increase in salt concentration, dust bowls, winds, etc.
5. **Autotrophic succession**: It is characterized by early and continued dominance of autotrophic organisms like green plants. It starts in a predominantly inorganic environment where energy flow is maintained indefinitely. The organic matter content is gradually increased, supplemented by continuous flow of energy.
6. **Heterotrophic succession**: In this succession there is an early dominance of heterotrophs like bacteria, actinomycetes, fungi and animals. It starts in a predominantly organic environment with a progressive decline in the energy content.
7. **Cyclic succession**: The cyclic succession model was proposed by Alexander Watt in 1947. It is a pattern of vegetation change in which a small number of species tend to replace each other over time in the absence of large-scale disturbance. On geologic time scales, climate cycles results in cyclic vegetation changes by directly altering the physical environment.

PROCESS OF SUCCESSION/ CLEMENT'S THEORY OF SUCCESION

In 1916, Frederic Clements proposed the theory of succession which is usually termed as '**Classical ecological theory**'. According to him, succession is a process involving several sequential phases that follow one another. These phases are:

1. **Nudation**: Succession begins with the development of a bare site without any form of life, called nudation (disturbance).

This bare area may develop due to several reasons such as landslide, erosion, deposition or other catastrophic agency. The causes of nudation are:

(a) *Topographic:* The existing community may disappear due to soil erosion caused by wind, water or gravity or deposition of sand. Several natural calamities like volcanic eruption, landslide, etc., are responsible to destroy existing community.

(b) *Climatic*: Fire, frost, glaciers, dry period, hails, and storm may destroy the existing community.

(c) *Biotic*: It includes clearance or destruction of forests for agriculture, housing, industry, etc. by man. In some instances, fungal or viral disease epidemics may destroy the whole population.

2. **Migration**: It refers to arrival of propagules.

All plants possess their effective organ of reproduction. Spores are the effective propagules for both lower groups (algae, fungi, bryophytes) and higher groups (pteridophytes) of plants. Seeds are the important propagules for flowering plants (gymnosperms and angiosperms). These propagules are transmitted to the bare land, aided by air, water and even by animals including man.

3. **Ecesis**: It involves establishment and initial growth of plants on a bare area following adjustment with the prevailing conditions.

The propagules or seeds germinate and subsequently, the seedlings grow and the adult plants

start to reproduce. A few propagules or seeds are capable of doing this under the extreme harsh environment, but most of them can not complete the ecesis and ultimately disappear. Thus as a result of ecesis, the individuals of a species become established on the bare land.

4. **Competition**: As vegetation became well established, grew, and spread, various species began to compete for space, light and nutrients. This phase is called competition.

This phenomenon involves struggle for existence between individuals of different species (interspecific) or between individuals of the same species (intraspecific), mainly for space and nutrition.

5. **Reaction**: The process of modification of the environment due to the influence of living organisms is called **reaction**. During this phase autogenic changes affect the habitat resulting in replacement of one plant community by another.

The whole sequence of communities that replaces one another in a given area is called **sere**, and the various communities constituting the sere is called **seral communities** or **seral stages**.

6. **Stabilization**: Reaction phase leads to development of a climax community.

The **climax community** or **climax vegetation** is the final or stable community in a sere which is self perpetuating and in equilibrium with the physical habitat. There is generally no net annual accumulation of organic matter in a climax community because, a balance between annual production and use of energy is maintained here.

Characteristics of Climax community

- The vegetation is tolerant of environmental conditions
- It has a wide diversity of species
- It has a well-drained spatial structure
- It has a complex food chains
- It has a balanced climax ecosystem
- There is equilibrium between gross primary production and total respiration
- The energy used from sunlight is balanced with the energy released by decomposers
- There is an equilibrium between source and sink of nutrients
- The species composition maintains equilibrium as individuals in the climax stage are replaced by others of the same kind
- The life forms indicate the climatic type. Hence it is an index of the climate of the area.

Types of Climax

1. **Climatic climax**: If there is only a single climax and the development of climax community is under the control of the climate of that region, it is called climatic climax.
2. **Edaphic climax**: When there are more than one climax communities in the region, modified by the local conditions of the soil such as soil nutrients, soil moisture, topography, slope exposure, etc., it is known as edaphic climax.
3. **Catastrophic climax**: The climax vegetation which is vulnerable to a catastrophic event such as a wild fire, is termed as catastrophic climax.
4. **Disclimax**: When a stable community, that is not the climatic or edaphic climax for a given site, is maintained by man or his domestic animals, it is termed as disclimax (disturbance climax) or **anthropogenic subclimax** (man-generated).
5. **Preclimax and Postclimax**: In some areas various climax communities develop under similar climatic conditions. If the community developed in moist and hotter areas has life forms lower than those in the expected climatic climax, it is designated as preclimax. In contrast, if a community developed in more moist and cooler areas has life forms higher than those in the expected climatic climax, it is called postclimax.
6. **Subclimax**: The prolonged stage in succession just preceding the climatic climax is called subclimax.

Theories regarding nature of climax

There are three schools of thoughts for interpretation of climax concept:

- **Monoclimax or Climatic climax theory**: This theory was advocated by Clements in 1916 which recognises only one climax. The characteristics of the climax are determined solely by climatic climax. The whole area is covered with uniform plant community. Communities other than the climax are recognised as subclimax, postclimax and disclimax.
- **Polyclimax theory**: This theory was advanced by Tansley in 1935. In this proposition the climax vegetation of a region consists of more than one vegetation climaxes and are controlled by edaphic climax.
- **Climax pattern theory**: This theory was proposed by Whittaker in 1953 which recognizes a variety of climaxes governed by responses of species population to biotic and abiotic conditions. This theory proposes that the composition, species structure and balance of a climax community are controlled by the total environment of the ecosystem where the central and most widespread community is the climatic climax.

SERAL COMMUNITIES

The entire sequence of communities that replaces one another in a given area is a **sere** and the various communities constituting the sere is called **seral communities**. Thus a seral community is an intermediate stage found in an ecosystem advancing towards its climax community. A **presere** is a collection of seres making up the development of an area from vegetation-less surfaces to a climax community. Depending on the substratum and climate, seral community can be classified into several groups:

- Hydrosere—community in fresh water
- Lithosere—community on rock
- Psammosere—community on sand
- Xerosere—community in dry area
- Halosere—community in saline body

HYDROSERE

A hydrosere is a succession in an area of freshwater which starts with the colonisation of phytoplankton (the pioneer community) that will naturally dry out and finally terminates into a forest (the climax community). However, if the body of water is large and very deep with a strong wave action, the succession results in a stable aquatic community, in which any considerable

Table 1.5.1: The trends of succession in a hydrosere

Pioneer community	Seral communities					Climax community
1 Phytoplankton stage	2 Rooted submerged stage	3 Floating stage	4 Reed-swamp stage	5 Sedge-meadow stage	6 Woodland stage	7 Forest stage
Diatoms	*Myriophyllum*	*Nelumbium*	*Scripus*	*Carex*	*Salix*	*Ulmus*
Cyanobacteria	*Hydrilla*	*Nymphaea*	*Typha*	*Juncus*	*Populus*	*Acer*
Green algae	*Potamogeton*	*Limnanthemum*	*Sagittaria*	*Cyperus*	*Alnus*	*Quercus*
Bacteria	*Utricularia*	*Monochoria*	*Phragmites*	*Eleocharis*	*Cornus*	
	Elodea	*Lemna*	*Zizania*	*Caltha*		
	Vallisnaria	*Wolffia*		*Iris*		
	Ceratophyllum	*Pistia*		*Gallium*		
		Eichhornia		*Polygonum*		

further change cannot easily be detected. The succession from pioneer community to climax community takes centuries or millennia which largely depends on the amount of siltation occurring in the area of open water.

The trends of succession in a hydrosere are (Table 1.5.1 and Fig. 1.5.1):

Pioneer community

1. **Phytoplankton stage**: Some diatoms, cyanobacteria, green algae, bacteria, etc., are the first organisms to colonize the bare water body of the pond. The phytoplanktons are followed by zooplanktons which settle down to the bottom of the pond after death and decay as humus. This humus mixes with silt and clay particles brought by run off water and form soil. Now the pond becomes shallower and further environmental changes follow.

Seral communities

It is represented by five seral communities that follow one another in a sequential manner.

2. **Rooted submerged stage**: As a result of death and decomposition of phytoplanktons and their mixing with the soil, there develops a soft mud at the bottom of the pond rich in organic matter. This new habitat which tends to be a bit shallow with increasing light penetration, becomes suitable for the growth of rooted submerged plants such as *Myriophyllum, Elodea, Hydrilla, Vallisnaria, Ceratophyllum, Utricularia*, etc. Once submerged species colonize the successional changes are more rapid, thus organic matter accumulates. Inorganic sediments still enter the lake. The pond becomes sufficiently shallow for floating species and less suitable for rooted submerged plants.

3. **Floating stage**: The new plants colonize the habitat with their roots anchored to the mud and some or all their leaves float on the water surface. These include *Nelumbium, Nymphaea, Trapa, Monochoria*, etc. Some free floating plants like *Azolla, Lemna, Wolffia, Eichhornia, Pistia, Salvinia*, etc., also become associated with floating plants, due to the availability of salts and other mineral in the water.

The leaves of floating plants shade the water surface which create a condition unsuitable for growth of submerged species which start disappearing. The decomposing organic matter formed due to death of these plants makes the pond more shallow (1–3 ft).

4. **Reed swamp stage**: The plant communities of this stage are rooted but their aerial parts remain well above the water level. The important plants include *Scripus, Typha, Phragmites, Sagittaria*, etc. These plants form dense vegetation by virtue of their well developed rhizome. They cut off the light from floating plants and make the habitat more unsuitable for their growth and multiplication. These plants produce large quantities of leaf litter which are resistant to decay. As a result, reed peat builds up, thus the surface of the pond is converted into water-saturated marshy land.

5. **Sedge-meadow stage**: Successive decrease in water level and changing in substratum help several hydrophytes like *Carex, Juncus, Cyperus, Eleocharis, Polygonum*, etc. to establish and colonize themselves. They form a mat of vegetation extending towards the centre of the pond with the help of their branched rhizomatous systems. As a result of high rate of transpiration there is rapid loss of water and sooner or later the mud gets exposed to the air. In this process the nutrients like ammonia, sulphides, etc., become oxidized to nitrates and sulphates. Thus mesic conditions start approaching and the marshy vegetation begins to disappear.

6. **Woodland stage**: On account of disappearing marshy vegetation the soil remains drier for most of the year and becomes suitable for development of wet woodland. The area is now invaded by terrestrial plants, which include shrubs like *Salix, Cornus*, etc. and trees like *Populus, Alnus*, etc. These plants

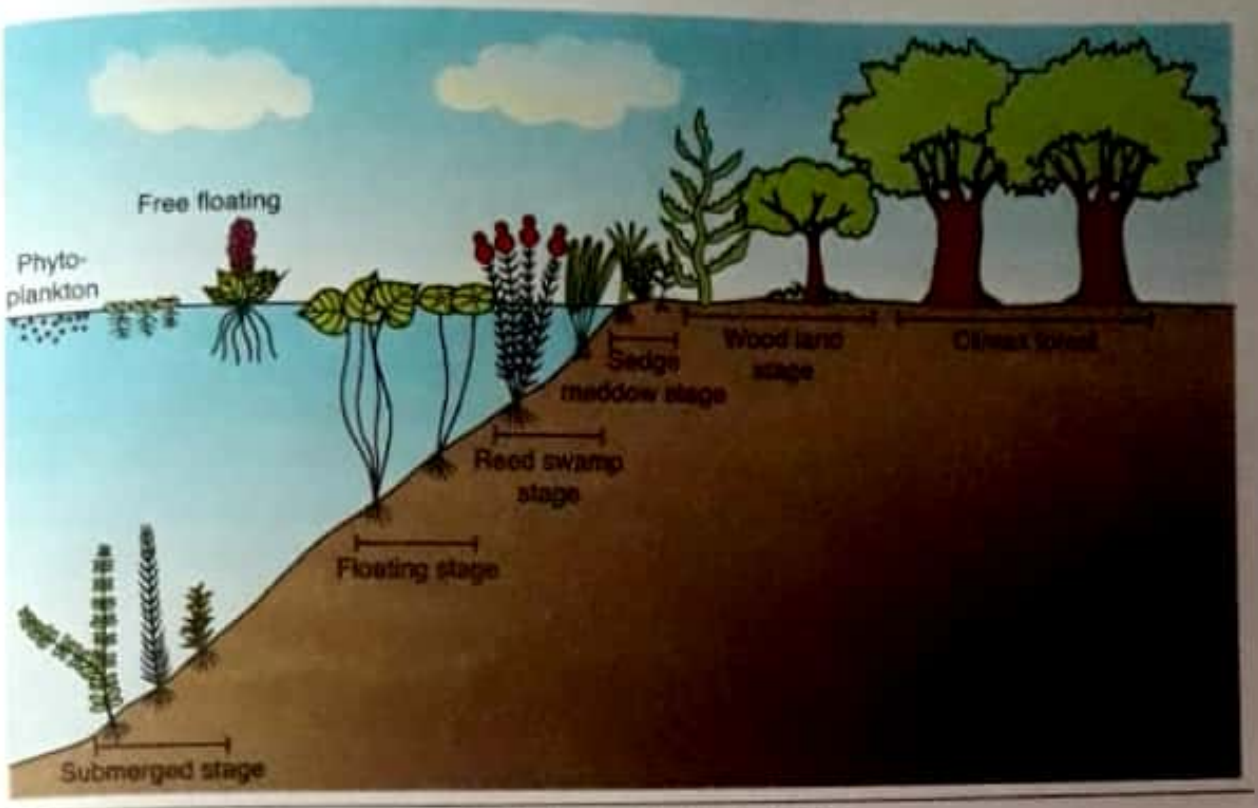

Fig. 1.5.1: Succession in a hydrosere

react upon the habitat by producing shade, lower the water table, lead to accumulation of humus with rich flora of microorganisms. Thus rapid mineralization of the soil favours the arrival of shade enduring herbs and make the soil unsuitable for themselves.

7. **Climax stage**: This is the final stage of hydrosere where a self-perpetuating climax community is developed. It may be a forest if climate is humid, a grassland in semi-humid environment, a desert in arid or semi-arid environment. In a tropical climate with heavy rainfall, there develops a tropical rain forest, whereas in temperate regions there develops mixed forests of *Ulmus*, *Acer* and *Quercus*.

XEROSERE

Xerosere is a plant succession which occurs on bare rocks limited by water availability. Xerosere includes the different stages in a **xerarch succes-**

Table 1.5.2: Trends of succession in a Xerosere

Pioneer community	Seral communities					Climax community
1 Crustose lichen stage	2 Foliose & Fruticose lichen stage	3 Moss stage	4 Herb stage	5 Shrub stage	6 Tree stage	7 Climax stage
Rhizocarpon *Rinodena* *Lecanora* *Lecidea*	*Darmatocarpon* *Umbilicaria* *Parmelia*	*Polytrichum* *Tortula* *Grimmia* *Barbula* *Fissidens*	*Aster* *Potintilla* *Solidago* *Saxifraga* *Aristida* *Festuca* *Poa*	*Rhus* *Rubus* *Phytocarpus* *Zizyphus* *Capparis* *Zygophyllum*	Oak Hickory Beech Hemlock Maple Spruce Fir	Oak–Hickory Beech–Hemlock American Beech– Sugar Maple Spruce–Alpine Fir

sion originated in extremely dry situation such as rock deserts, sand deserts, sand dunes, salt deserts (Table 1.5.2 and Fig. 1.5.2).

1. **Pioneer stage (Crustose lichen stage)**: A bare rock in extreme dry condition is devoid of water as it does not absorb rain water. The surface temperature of rock goes very high in day time. The crustose lichens have the ability to withstand high degree of desiccation and temperature extreme and they can adhere to the rock surface and absorb moisture from atmosphere. Hence, the crustose lichens are the only organisms to become to pioneer colonisers on this extreme habitat. The propagules (soredia or spores) of crustose lichens are brought to the bare rocks by air current from the surrounding areas. These lichens produce acid (carbonic acid) which corrode the rocks and lichen's thalli collect wind blown soil particles on their body surface. These two mechanisms help them to form a thin film of soil.

   The crustose lichens such as *Rhizocarpon, Rinodena, Lecanora, Lecidea*, etc., eventually die and their thalli decompose to add humus, thus making a suitable environment for growth of foliose and fruticose type of lichens.

Seral communities

2. **Foliose and fructicose lichen stage**: Thalli of foliose lichens are leaf-like, while the fructicose lichens look small bushes. They are attached to the substratum at a single point only and thus do not cover the soil completely. They absorb more water and accumulate more dust particles and slowly replace the crustose lichens. The most common foliose lichens are *Dermatocarpon, Umbilicaria, Parmelia*, etc. When these lichens die, their thalli are decomposed to add humus that mixes with soil. This helps to build substratum and improve soil moisture content. The crevices of rocks become filled with soil particles which favour growth and establishment of mosses.

3. **Moss stage**: The spores of xeric mosses like *Polytrichum, Tortula, Barbula, Fissidens*, and *Grimmia* are brought by air to the rock where they succeed lichens. The moss rhizoids penetrate soil of the crevices and corrode the rocks by secreting acids. Mosses are rich in organic and inorganic compounds. After their death and decay they add these compounds to the soil and increase soil fertility. This changing environment leads to extermination of lichens and helps invasion of herbaceous flora.

4. **Herb stage**: Annual herbaceous plants like *Aster, Potintilla, Solidago, Saxifraga* invade the rock. Their roots deeply penetrate and secrete acids, thus promote weathering of rocks. The death and decay of herbs and their subsequent deposition forming humus to the soil. Their growth makes the condition less drier. The biennial and perennial herbs and xeric grasses like *Aristida, Festuca* and *Poa*, begin to inhabit. Change in environment favours growth of bacteria and fungi and enhance decomposition activity.

5. **Shrub stage**: The mixed vegetation of herb and grass is invaded by shrub species like *Rhus, Rubus, Zizyphus, Capparis, Zygophyllum* and *Phytocarpus*. Initially, the invasion of shrub is slow, but once a few bushes are settled down, birds invade the area and help to disseminate scrub seeds. The dense shaded scrub make conditions unfavourable for the growth of herbs. The soil formation proceeds and its moisture content increases. This situation is quite favourable for the growth of tree species.

6. **Tree stage**: Seeds of tree species invade to the soil of dense scrub. Subsequently, the tree saplings begin to grow and colonize themselves among the scrubs. The nature of tree species grown in the scrub depends upon the nature of the soil, e.g. in poorly drained soils *Quercus* grows. The tree form canopy where shade-loving scrubs grow as secondary vegetation. Leaf litter and decaying roots add more humus to it, thus making the habitat more favourable for trees.

7. **Climax stage**: The succession culminates in a forest (**climax community**). Several intermediate tree stages may develop prior to forming a climax community. The various climax forests with reference to their climatic condition are mentioned in right side.

- Oak-Hickory climax forest (Dry habitat)
- Beech-Hemlock climax forest (Mesic)
- American Beech-Sugar Maple Climax forest (Mesic)
- Spruce-Alpine Fir climax forest (High altitude Rocky Mountains).

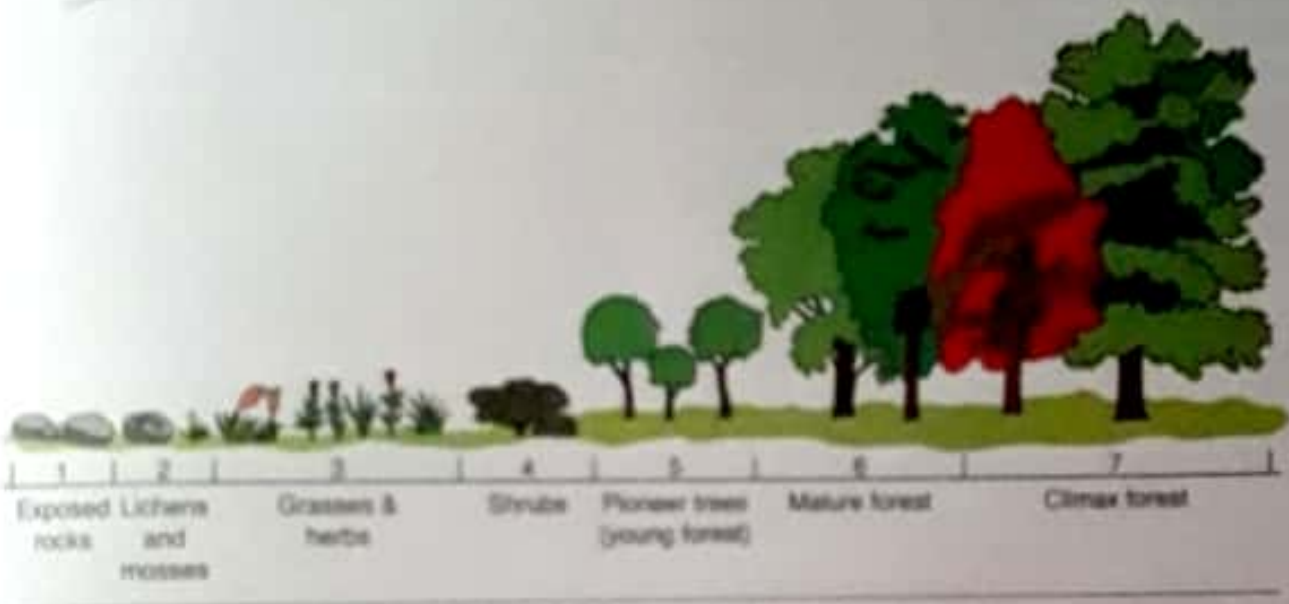

Fig. 1.5.2: Succession in Xeroseres