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Plant Ecology, Conservation and Phytogeography

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UNIT –II

Methods of studying vegetation

Floristic methods

Detailed surveys of vegetation involve the identification of individual species and also the assessment of abundance of species. The techniques applied are known as floristic methods of vegetation description.

Physiognomic method

Physiognomic superficial analysis or structure is a visibly outstanding feature of vegetation eg In typical forest ecosystem one can use the component strata as a general structural definition. These strata consist of tree layer, shrub layer , herb layer and often mosses and lichens.

Phytosociological method

The special field of synecology which is concerned with the structure and classification of plant community is known as phytosociology. Two sets of characters, viz., analytical and synthetic are studied in a community at the same time.

Analytical Characters:

Analytical characteristics are include kinds and number of species, distribution of individuals, species vigour, form, number of individuals height of plants, area volume, growth rate and periodicity, etc. There are two different aspects of vegetational analysis-namely quantitative characters and qualitative characters.

Synthetic Characters:

Those aspects of community which are based on analytical characteristics and utilize data obtained in the analysis of a number of stands.

A. Qualitative Structures of Plant Community:

The qualitative structure and composition of plant community can be described on the basis of visual observations without any special sampling and measurement. In the qualitative Characteristics floristic enumeration (species content), stratification, aspection, sociability, interspecific associations, life-forms and biological spectrum, etc. are studied in the field.

1. Floristic composition or species content of community:

The species content of a community can be studied by periodic collection and identification of plant species for the whole year.

2. Stratification and aspection:

The number of strata or layers in a community can be determined by general observation of the vegetation periodically for the whole year, changes in the appearance of vegetation may be apparent with the change in the season. On the basis of general observations of the vegetation a number of layers have been distinguished:

L1—ground stratum like mosses, thallophytes, lichens, etc.,
L2—herbaceous or ground flora,
L3—middle layer or shrubby layer, and
L4—top layer or canopy layer of trees.
In grasslands even two to three strata may be distinguished:

3. Life-forms:

On the basis of general appearance and growth, the species of community are grouped into different life-form classes.

4. Sociability:

In a plant community, the individuals of species are not evenly distributed. Individuals of some species grow widely spaced while those of some other species are found in clumps or mats. There are five sociability classes which accommodate different types of species:

Class 1. Shoots grow singly,
Class 2. Scattered groups or tufts of plants.
Class 3. Small scattered patches or cushions,
Class 4. Large patches or broken mats, and
Class 5. Very large mats of nearly pure population covering the entire area.

5. Interspecific associations:

When the plants belonging to two or more different species grow near one another they form a community. This type of association is known as interspecific association.

Interspecific association is possible if:

(i) The species can live in similar environment,
(ii) The species in question have similar geographical distribution,
(iii) The species belong to different life-forms (this reduces the competition), and
(iv) The plants of one species are related to the plants of other species. The relationship may be obligatory in one or both the directions.

B. Quantitative analysis of Plant Community:

The structure of sociological order in any plant community cannot be studied by observing each and every individual of plant species growing in a habitat.
The methods are: 1. Transect Method 2. Bisect 3. Trisect 4. Ring Counts 5. Quadrat Method.

1. Transect Method:

The method of linear sampling of the vegetation is called transect. Two types of transect are
(I) Line Transect or Line Intercept; and
(II) Belt Transect.

1. Line Transect:

A line is laid over the vegetation with a metric steel tape or steel chain or long rope and kept fixed with the help of pegs or hooks. This line will touch some plants on its way from one point to the other. The observer will start recording these plants from one end and will gradually move towards the other end.

From this type of transect following information could be collected:

(a) The number of times each species appears along the line,
(b) The trend of increase or decrease of distance between the individuals of a species,
(c) The percentage of occurrence of different species in relation to the total species,
(d) The gradual disappearance or appearance of different species along the line, etc.

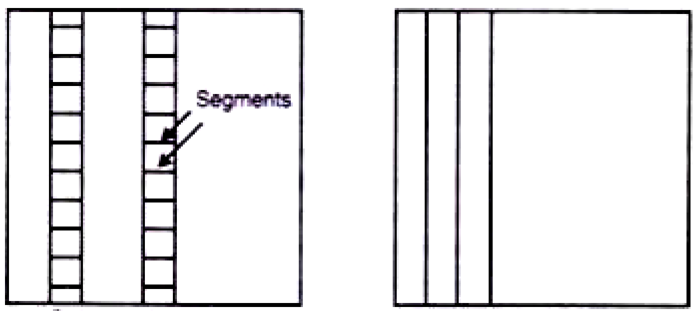


Fig. 6.8. Transects

II. Belt Transect:

A belt is generally studied by dividing it into some equal sized segments. The length of each segment is generally equal to the width of the transect. Belt transects are used in determining and understanding the gradual change in abundance, dominance, frequency and distribution of different species in the transitional region between two different types of vegetation.

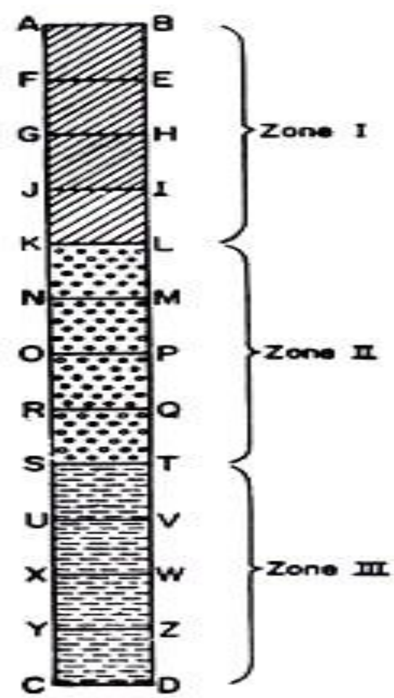


Fig. 1.10 : Layout of a belt-transect

2. Bisect:

The structure of vegetation with regard to the relative height, depth and lateral spread of plants in both aerial and underground parts could be determined by the use of bisects. This method reveals the form and interrelationship of underground systems of different species growing in the community and also their relationship to different types and/or layers of soil.

So, the bisect studies provide the following information:

(a) A rough floristic picture of the community,
(b) Stratigraphic distribution of different species,
(c) Utilization of space by different species,
(d) Underground structures of plants,
(e) Arrangement and extent of root-system, etc.

3. Trisect:

It is the photographic method of recording the dynamic characters of plant community. In this technique a particular plot of the vegetation is photographed periodically by keeping the camera in the same direction and at the same height. This is done by permanently fixing three wooden pegs at a place in the vegetation so that the bases of a tripod camera-stand can be set on these pegs. The technique is effectively used in monitoring the degradation or the recovery of rangeland, secondary succession of a denuded place, spread of a disease or some newly introduced weed into the area, etc.

4. Quadrat Method:

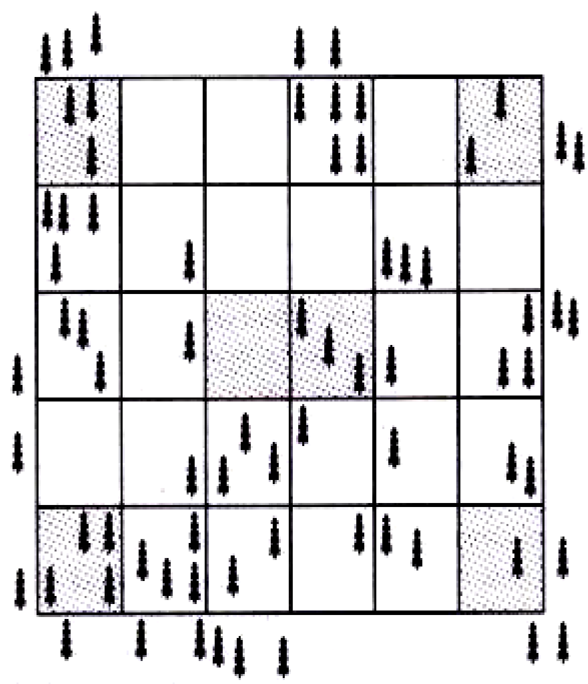


Fig. 6.4. Quadrat sampling method for population estimation.

5. Ring Counts:

The age of different types of woody plants may be determined by counting the annual growth rings of the aerial or subterranean stems. Growth rings can also reveal the climatic history of a place chronologically like the years of high rainfall or drought, presence of some chemical in the soil or atmosphere, forest fire, heavy snowfall etc.

The quadrat is a square sample area of varying size marked-off in the plant community for the purpose of detailed study. It is also effectively used to determine the exact differences or similarities in the structure and composition between two or more plant communities of related or unrelated vegetation.

Quadrats can be of four types:

1. List Quadrat: Enlisting the names of different species growing in the quadrat.
II. List-Court Quadrat: Records the number of individuals of each species represented in each quadrat.
III. Chart Quadrat: Records the position and areas covered by bunches, mats or tufts of grasses, mosses, etc. on the coordinated or graph paper. These graphs help to compare any change in structure of community in future.
IV. Clip Quadrat: For the study of biomass or weight of each species, all individuals are uprooted (but when the weight of a particular organ, e.g., branch, leaf, fruit, etc., is to be determined only the concerned organ is clipped or harvested) and its fresh or dry weight is recorded.

Loop Method:

This is a simple, accurate and quick method for sampling of only grassland and low herbaceous communities. It is used for determining community composition, species frequency and range condition.

Pointless or Point Method:

In this method of sampling observations are taken on the point in the study area where a nail or set of nails touch the ground on grid lines or at random places.
There are several point methods of sampling but here only the following two methods will be discussed:

(i) Point frame method.
(ii) Point centre method.

(i) Point frame method:

This consists of a scale like frame, supported by a pair of legs. The frame bears 10 equidistant holes having 60 cm long pointers or pins It is placed one after another at several observation points in the study area and the plant species that are hit by the pointed end of the Pointers or nails are recorded.

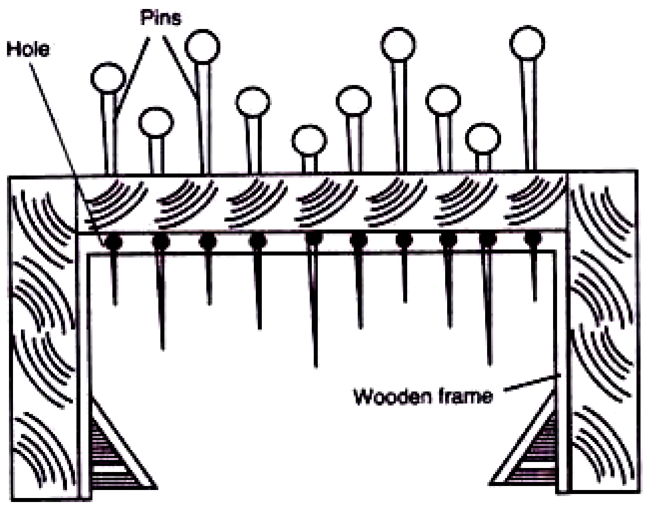


Fig. 6.9. Point frame apparatus.

(ii) Point Centre or Quarter method:

In this method of sampling four measurements are taken at each observation point. The observation points can be mechanically placed along a straight line or they can be located at randomIn this method an easy instrument is used which consists of a brass needle or a nail fitted with rubber cork and compass on the top.

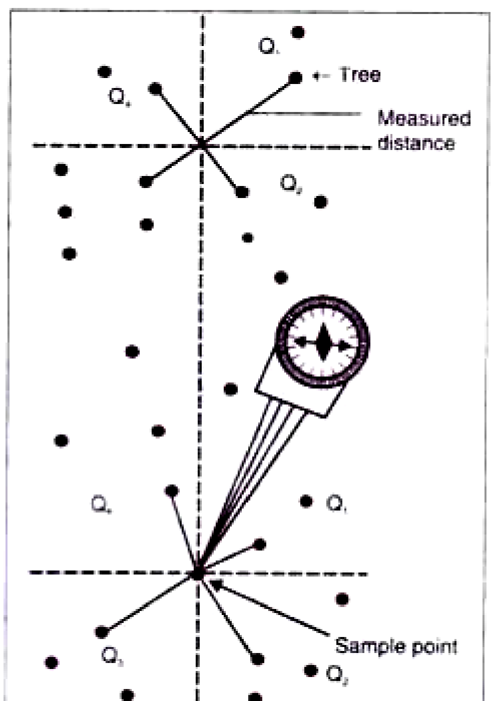


Fig. 6.10. Quarter or Point centre method of sampling.

Quantitative Structure of Plant Community:

Frequency, density, abundance, shadow and area coverage of species in the community, importance value index, total estimates, index of association, index of similarity, and fidelity of species give a clear picture of community structure in quantitative terms.

1. Density:

The numerical strength of a species in relation to a definite unit space is called its density. Density of a species per unit area = Total number of individuals of a species in all the sample plots/Total No. of sample plots studied

Density of species in a field is determined by the method given in the following table:

Names of species	Number of individuals in different quadrats each of 1 square metre size										Total No. of Individuals	Density
	1	2	3	4	5	6	7	8	9	10		
1. *Evolvulus alsinoides*	5	4	7	×	1	3	9	2	8	5	44	$\frac{44}{10}$ = 4.4 plants/m^2
2. *Indigofera sp.*	×	7	6	9	2	4	×	1	5	×	34	$\frac{34}{10}$ = 3.4 plants/m^2
3. *Peristrophe sp.*	3	1	4	×	×	×	1	2	×	7	18	$\frac{18}{10}$ = 1.8 plants/m^2
4.												
5.												
6.												

The proportion of density of a species to that of stand as a whole is referred to as relative density. Relative density of a species = Total no. of individuals of a species /Total no. of individuals of all species x 100

2. Frequency:

Frequency refers to the degree of dispersion in terms of percentage occurrence. Frequency = Total no. of quadrats in which the species occur/ Total no. of quadrats studied x 100
Raunkiaer recognized five frequency classes of plant species in the community on the basis of their frequency percentages.

These are as follows:

Class A—1 to 20% frequency
Class B—21 to 40% frequency
Class C—41 to 60 % frequency
Class D—61 to 80% frequency
Class E—81 to 100% frequency

species	Number of sample plots										Frequency Percentage
	1	2	3	4	5	6	7	8	9	10	
1. *Evolvulus alsinoides*	×	×	–	–	×	×	–	–	×	×	$\frac{6}{10} \times 100 = 60\%$
2. *Peristsophe bicalyculata*	–	–	×	×	×	×	–	×	–	–	$\frac{5}{10} \times 100 = 50\%$
3. *Cynodon sp.*	×	×	×	×	×	×	×	×	×	–	$\frac{9}{10} \times 100 = 90\%$
4. *Euphorbia sp.*	×	–	–	–	–	×	×	×	–	×	$\frac{5}{10} \times 100 = 50\%$
5. *Boerhaavia sp.*	–	–	–	–	–	–	–	×	–	×	$\frac{2}{10} \times 100 = 20\%$
6.											

Raunkiaer (1934) suggested that the number of species in frequency class A is greater than that of class B; B is greater than in class C, class C is greater, or equal or lesser than class D; and D is lesser than class E. A > B > C = D < E. This is also read as Raunkiaer's 'frequency law'. From the above frequency law it is apparent that the species with low frequency value are higher in number than the species with higher frequency value in most natural communities. Relative frequency is determined by the following formula:

Relative frequency of a species = Frequency of the species in stand x / Sum of the frequencies for all species in stand x 100

3. Abundance:

The estimated number of individuals of a species per unit area is referred to as abundance.

Abundance of a species = Total number of individuals of the species in all quadrats /Total number of quadrats in which the species occurred

Abundance Classes:

Classes	Stalks per square metre quadrat
Rare	1 to 4
Occasional	5 to 14
Frequent	15 to 29
Abundant	30 to 90
Very abundant	100 +

4. Cover:

The cover implies the area covered or occupied by the leaves, stems and flowers, as viewed from the top. The coverage is studied at the canopy level and the basal region.

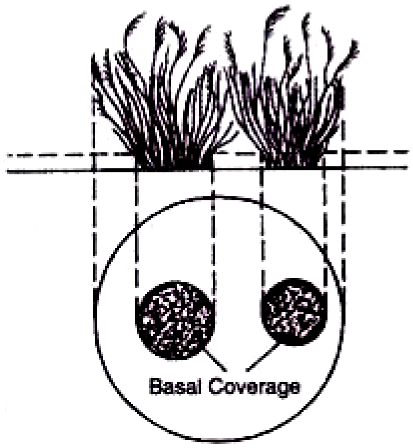


Fig. 6.11. Herbage cover of two clumps of grasses. Basal coverage of each clump one inch above the ground level is shown by shaded smaller circles and total coverage by large circle.

Basal area of tree is calculated by the following formula:
Basal area per tree = Total basal area = dumber of trees.

Area of coverage

The area of coverage is used to express the dominance. The higher the coverage area the greater is the dominance. The coverage area of one stem multiplied by the density gives the basal cover per unit area.

Relative dominance (R.D.) is the proportion of the basal area of a species to the sum of the basal coverage of all the species in the area.

Relative dominance of the species = Total basal area of the species in all the quadrats/Total basal area of all the species in all the quadrats x 100

5. Total estimate:

It is probably the best method for obtaining a complete general picture of a plant community.
Total estimate (abundance plus coverage) scale as suggested by Braun-Blanquet is as follows:
+ Individuals of a species very few; coverage very poor.
1. Individuals of a species in plenty; but coverage small.
2. Individuals numerous if small and a few if large; coverage 5% of the total area.
3. Individuals few or many; coverage 25 to 50% of the total area.
4. Individuals few or many; coverage 50 to 75% of the total area.
5. Plant species over 75-100% of the total area.

6. Association Index and Index of similarity:

The inter-specific association can be evaluated by association index and also by calculating the index of similarity. Suppose that in one group of coexisting species the number of plant species is 30 and in the other group the number of plant species is 20 and in first and second groups 15 species are common:

Index of similarity = 2 x no. of common species /Total number of species in both associations x 100= 2 x 15 / 20 + 30 x 100 = 30 x 100 / 50 = 60

7. Importance value:

This total value out of 300 is called Importance Value Index (IVI) of the species.
In one type of phytograph a circle is made and then the circle is divided into four equal quarters by two diagonal lines lying at right angles to each other. Three radii from centre to circumference are divided into 100 segments and the fourth radius is divided into 300 parts. On radius A is marked the value of relative frequency, on radius B is marked the value of relative density, on radius C is marked the value of relative dominance, and on D IVI on 0—300 scale. All these points on different radii are joined by lines. Thus, a phytograph illustrating the sociological characters and IVI of individual species is obtained.

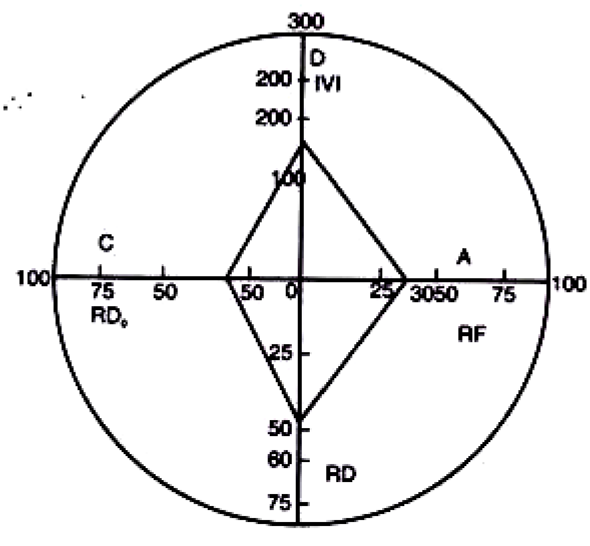


Fig. 6.12. Phytograph of species with Relative frequency (RF) 30%, Relative density (RD) value 60%, Relative dominance (RD) value 40% and Importance value index 130.

Synthetic characters:
Synthetic characters such as presence, Constance and fidelity describe the make-up of a community.

Fidelity:

The term fidelity refers to the faithfulness of a species to its community. In the community, there are different types of species. Some plant species are confined to one particular community and they are called indicator species.

Fidelity Classes	Characters
Class—1	**Strange species** or **accidentals** which are either intruders from other community or relics from other successional stages.
Class—2	**Indifferent species** or companions which have no preference or affinities for any community.
Class—3	**Preferential species** which may be found in several communities but have affinity for only one community.
Class—4	**Selective species** which may occur rarely in other communities but have strong affinity to one particular community.
Class—5	**Exclusive species** which occur exclusively or almost exclusively in one community.

Presence:

It indicates the presence of a species in a stand. It is generally expressed in a scale of 1 to 5.

(i) Rare, which occur in 1% to 20% of stands examined
(ii) Seldom present, which occur in 21-40% of stands examined
(iii) Often present, which occur in 41-60% of the stands examined
(iv) Mostly present, which occur in 60 to 80% of stands examined
(v) Constantly present, which are present in 81 to 100% stands

Constance:

It is the degree of "presence" in a unit area (sample area) instead of the whole stand. It is generally determined from frequency and the following 5 Constance classes have been recognized.

Con. 1—1 to 20% frequency
Con. 2—21 to 40% frequency
Con. 3—41 to 60% frequency
Con. 4—61 to 80% frequency
Con. 5—81 to 100% frequency

Concepts of vegetation structure

Units of vegetation

i. Plant communities

Plant communities because they possess a certain degree of individuality can be compared as a whole with a living organism in that they also have developmental history and only finally attaining a stable maturity, which is called a climax.

Pro-climaxes include:

(1) Sub-climaxes where the development of typical vegetation for a particular climate type has been arrested before attainment of the final stage due to an influence other than climate,

(2) Pre-climaxes and post-climaxes where the climax formation deviates from the normal type on account of some local physiographic factor and

(3) Dis-climaxes which may result from some disturbance due to biotic modifications or change of typical climax.

ii.Plant Formations

The largest and the most comprehensive kind of plant community, equivalent to climax and biome, is the plant formation. Plant formations may be determined primarily either by the climatic factors of the habitat climatic plant formations or by factors of the soil edaphic plant formation.

The Plant Association and Consociation:

The actual units of natural vegetation belonging to one of the plant formations are of various nature and status. The largest of these vegetation classes, apart from the climatic types dominated by, one or more species, are called the plant associations. Thus the term association refers to the major subdivisions of a formation.

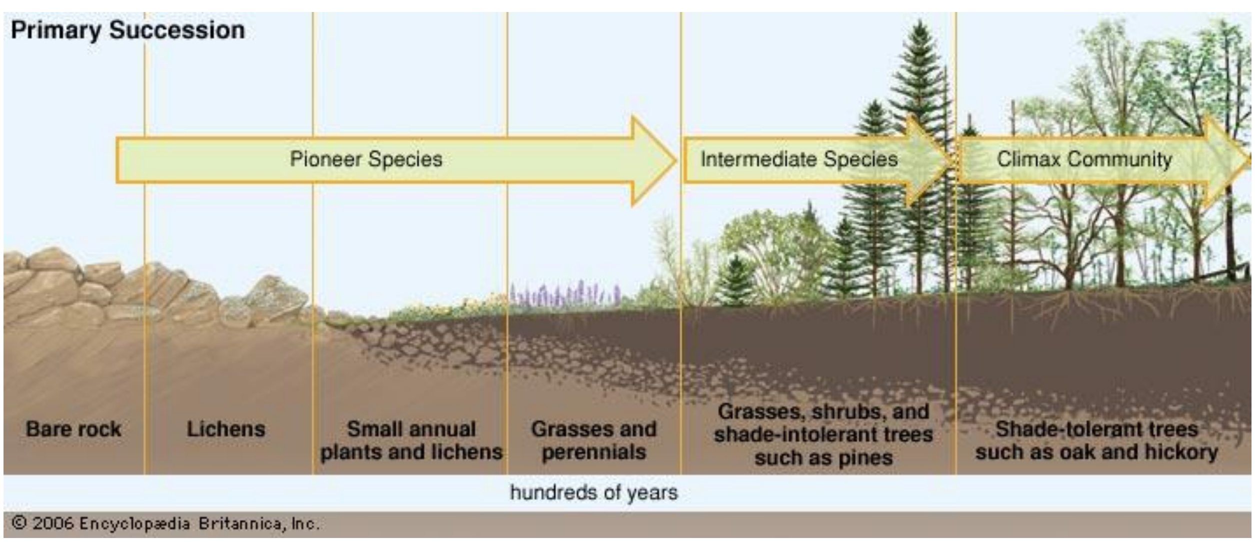
Succession

Ecological succession is the steady and gradual change in a species of a given area with respect to the changing environment. Succession is the order of colonization of species in an ecosystem from a barren or destroyed area of land. Mosses and lichens are the first species that inhabit an area. They make the area suitable for the growth of larger species such as grasses, shrubs and finally trees.

In an area, the sequence of communities that undergo changes is called sere.

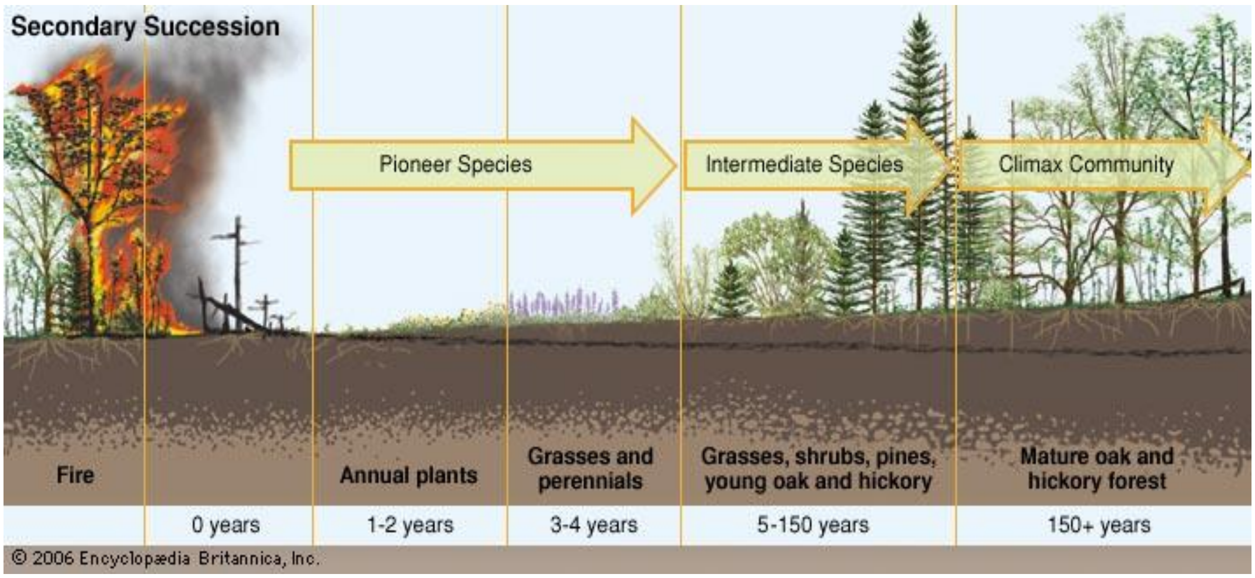
Types of Ecological Succession

These are the following types of ecological succession:



Primary succession

Successional dynamics beginning with colonization of an area that has not been previously occupied by an ecological community, such as newly exposed rock or sand surfaces, lava flows, newly exposed glacial tills, etc., are referred to as primary succession.



Secondary succession

However, if life starts at a place after the area has lost all the life forms existing there, the process is called secondary succession. Dynamics in secondary succession are strongly influenced by pre-disturbance conditions, including soil development, remaining organic matter, and residual living organisms.

Types of Secondary Succession:

(i) **Micro-succession**

Succession of micro-organisms including fungi and bacteria occurring within a microhabitat is known as micro-succession or serule.

(ii) Allogenic Succession:

Allogenic succession is caused by a change in environmental conditions which in turn influences the composition of the plant community. The deposition of silt into river, lake or any water body may be causing an allogenic succession and leads to from salt marsh to woodland.

(iii) Autogenic Succession:

Autogenic succession is a succession where both the plant community and environment change, and this change are caused by the activities of the plants over time.

(iv) Progressive Succession:

Progressive succession is a succession where the community becomes complex and contains more species and biomass over time.

(v) Retrogressive Succession:

Retrogressive succession is a succession where the community becomes simplest and contains minimum or fewer species and less biomass over time.. For example, the introductions of grazing animals result in degenerated rangeland.

Cyclic Succession

This is only the change in the structure of an ecosystem on a cyclic basis. Some plants remain dormant for the rest of the year and emerge all at once. This drastically changes the structure of an ecosystem.

Causes of plant succession

Autogenic

It can be brought by changes in the soil caused by the organisms there. These changes include accumulation of organic matter in litter or humic layer, alteration of soil nutrients, or change in the pH of soil due to the plants growing there.

Allogenic

It is caused by external environmental influences and not by the vegetation. For example, soil changes due to erosion, leaching or the deposition of silt and clays can alter the nutrient content and water relationships in the ecosystems. Animals also play an important role in allogenic changes as they are pollinators, seed dispersers and herbivores. They can also increase nutrient content of the soil in certain areas, or shift soil about (as termites, ants, and moles do) creating patches in the habitat.

Mechanisms

Succession is a process involving several phases:

1. Nudation: Succession begins with the development of a bare site, called Nudation (disturbance).
2. Migration: refers to arrival of propagules.
3. Ecesis: involves establishment and initial growth of vegetation.
4. Competition: as vegetation becomes well established, grows, and spreads, various species begin to compete for space, light and nutrients.
5. Reaction: during this phase autogenic changes such as the buildup of humus affect the habitat, and one plant community replaces another.
6. Stabilization: a supposedly stable climax community forms.

Sere

The entire sequence of development stages of biotic **succession** from pioneer to a climax community is known as **sere**. (Fig. 4.8).

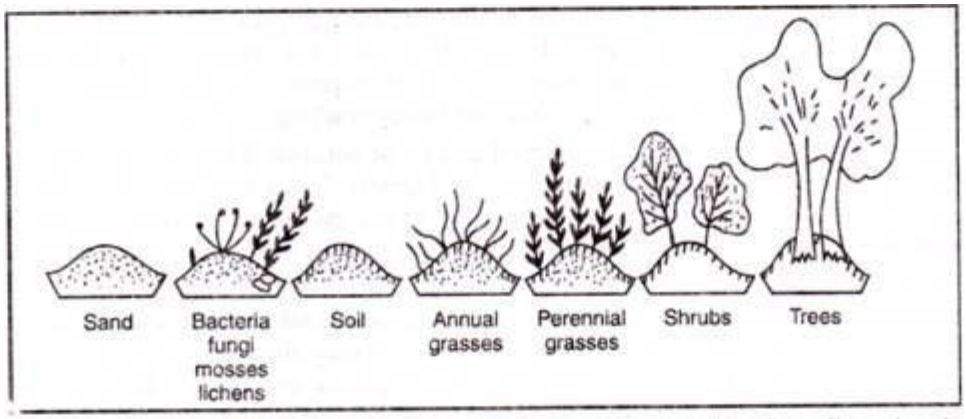


Fig. 4.8. Ecological succession. A sequence of seres from virgin land (sand) to climax (trees).

There are seven different types of seres: Hydrosere, Xerosere, Lithosere, Psammosere, Halosere, Serule, Eosere.

Hydrosere

Succession is recognizable only if the colonization of plant communities takes place in artificial small and shallow ponds, lakes, etc. Fig. 7.1 illustrates the different types of vegetation at different depths in a pond; floating plants in the central region; rooted hydrophytes in shallow region, amphibious plants in the marginal mud and trees developing in dry habitat.

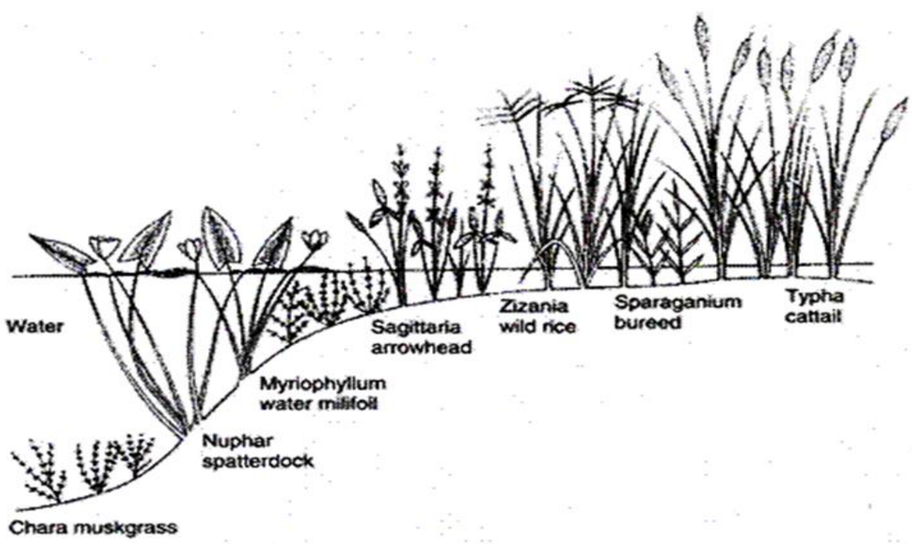


Fig. 7.1. Zonation of aquatic vegetation (hydrophytes) along a pond and along river banks. Note the changes in vegetation with water depth.

The process of aquatic succession completes in the following stages (Fig. 7.2):

1. Phytoplankton stage:

The simple forms of life like bacteria, algae and many other aquatic plants (phytoplankton) and animals (zooplankton) floating in water are the pioneer colonizers. All these organisms add large amount of organic matter and nutrients due to their various life activities and after their death, they settle at the bottom of pond to form a layer of mud.

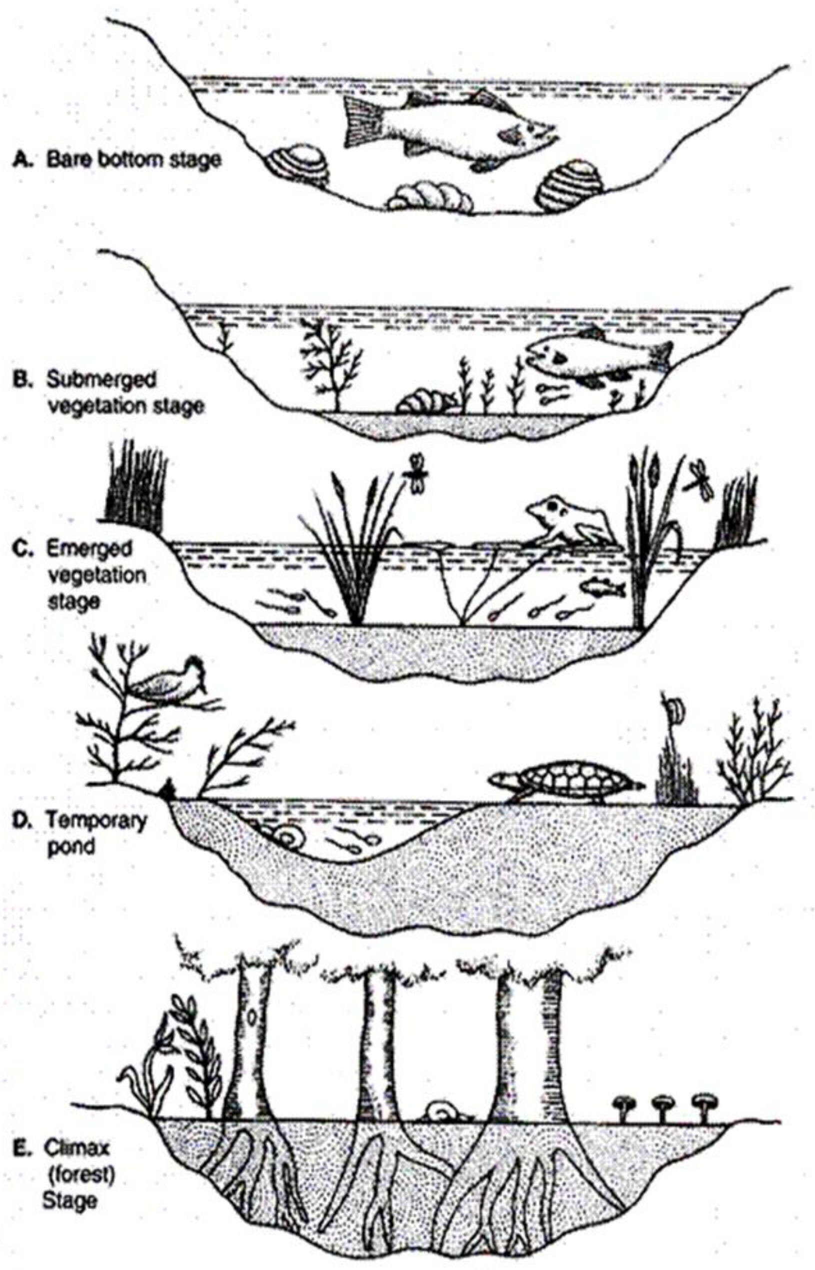


Fig. 7.2. Community succession in an open pond.

2. Submerged stage:

The phytoplankton stage is followed by submerged plant stage. When a loose layer of mud is formed on the bottom of the pond, some rooted submerged hydrophytes begin to appear on the new substratum. The pioneers are *Elodia, Potamogeton, Myriophyllum, Ranunculus, Utricularia, Ceratophyllum, Vallisnena, Chara*, etc.

3. Floating stage:

When the depth of water reaches about 4 to 8 feet, the submerged vegetation starts disappearing from its original place and then the floating plants make their appearance gradually in that area. Important floating plants that replace the submerged vegetation are *Nelumbmm, Trapa, Pistia, Nymphaea, and Limnanthemum* etc.

4. Reed-swamp stages:

The floating plants start disappearing gradually and their places are occupied by amphibious plants which can live successfully in aquatic as well as aerial environment Important examples are *Bothrioclova, Typha, Phragmites* (Reed), etc.The foliage leaves of such plants are exposed much above the surface of water and roots are generally found either in mud or submerged in water. The foliage leaves form a cover over submerged and floating plants and thus they cut off light from the plants underneath them. When the bottom reaches very close to the water surface many secondary species, such as those of *Polygonum, Sagittaria*, etc. make their appearance.

5. Sedge Marsh or Meadow stage:

The filling process finally results in a marshy soil which may be too dry for the plants of pre-existing community. Now the plants well adapted to new habitat begin to appear in the pre-existing community in mixed state. Important plants that are well suited to marshy habitat are the members of cyperaceae and grammeae. The species of sedge (*Carex*) and rushes (*Juncus*), species of *Themeda, Iris, Dichanthium, Eriophorum, Cymbopogon, Campanula, Mentha, Caltha, Gallium, Teucrium, Cicuta,* etc. are the first invaders of marshy area.

6. Woodland stage:

In the beginning some shrubs and later medium sized trees form open vegetation or woodland. These plants produce more shade and absorb and transpire large quantity of water. Thus, they render the habitat more dry. Shade loving herbs may also grow under trees and shrubs. The prominent plants of woodland community are species of *Buteazon, Acacia, Cassia, Terminalia, Salix, Cephalanthus,* etc.

7. Climax forest:

In the climax forest, all types of plants are met with. Herbs, shrubs, mosses and shade loving plants represent their own communities. Trees are dominant and they have control over the entire vegetation. Bacteria, fungi, and other micro-organisms are more frequently found in the climax vegetation.

Xerosere

This is a type of xerosere originating on bare rock surfaces. The original substratum is deficient in water and lacks any organic matter, having only minerals in disintegrated unweathered state.

The various stages of succession are described below:

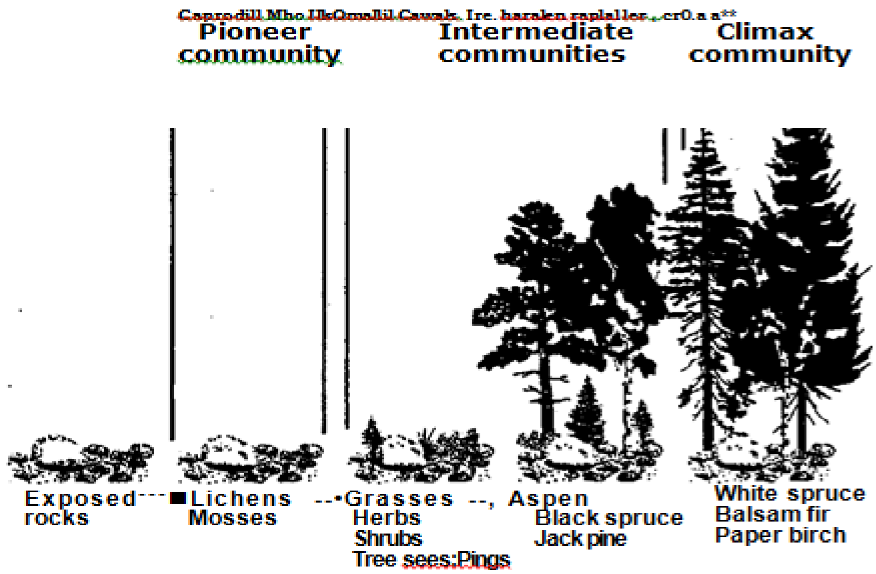


Fig: Different stage of Xerosere

1. Crustose Lichen Stage:

The pioneer colonisers on the bare area are crustose lichens which occur on the rock surface in the form of membranous crusts. Important crustose lichens are *Rhizocarpus*, *Lacidea* etc. These plants grow only when water becomes available in the habitat. The lichens secrete carbonic acid in excess. The carbonic acid reacts with the rocky materials and loosens the rock particles. The corroded rock particles together with decaying lichens make the first thin layer of soil on the rock surface

2. Foliose Lichens Stage:

After accumulation of little soil and humus, the rock surface, previously occupied by crustose lichens, now becomes covered with xeric foliose and fructicose lichens, e.g., *Dermatocarpon Parmelia*, *Umbilicaria*, etc.

3. Moss Stage:

When the habitat is changed, the existing foliose lichens start disappearing and in that area xerophytic mosses grow and become dominant.

4. Herbs Stage:

When the soil increases in thickness, the herbaceous vegetation, which consists mainly of annual and perennial herbs, develops very quickly. Increased moisture content of the soil favours the growth of herbs.

5. Shrub Stage:

With the change of habitat, herbaceous vegetation also shows the sign of degeneration and xerophytic shrubs gradually occupy the area. Decaying leaves, twigs and roots of these shrubs also enrich the soil with humus.

6. Xerophytic Trees Stage:

Now the xerophytic trees invade the area which has been occupied previously by shrubs.

7. Forest Stage:

The mesophytic trees are deeply rooted and their roots are profusely branched hence they can absorb sufficient quantity of water and nutrients.

Lithosere

A **lithosere** is a plant succession that begins life on a newly exposed rock surface, such as one left bare as a result of glacial retreat, tectonic uplift as in the formation of a raised beach, or volcanic eruptions.

1. Crustose Lichen Stage:

Lichen species like *Graphis Rhizocarpon, Rinodina and Lacanora* forms are the pioneer community in a lithosere, as they can tolerate desert or extreme hot condition. Organic acids produced by lichens leach the rock surface and release minerals for proper growth of lichens.

2. Foliose and Fruticose Lichen Stage:

Foliose lichen retain more water and accumulate more soil particles, helping in the development of a fine layer of soil on the rock surface. As the soil formation proceeds it leads to the growth of foliose lichens like *Parmelia, Physcia* etc. Foliose lichens have leaf-like thalli, while the fruticose lichens are like small bushes.

3. Moss Stage:

Accumulation of soil and humus leads to the growth of mosses such as *Polytrichum* and *Grimmia.* After some times as a lot of soil and organic matter accumulate, that favour the growth of moisture loving mosses like *Hypnum, Bryum* etc. The spores of xerophytes mosses, such as *Polytrichum, Tortula and Grimmia,* are brought to the rock where they succeed lichens.

4. Herb Stage:

Death and decay of mosses produce a mat of organic moss rich in organic soil, that help the germination to seeds of hardy grasses like *Eleusin, Aristicla, Poa,* etc. Further decomposition of these annual grasses promotes the growth of perennial grasses like *Cymbopogon, Heteropogon* etc.

5. Shrub Stage:

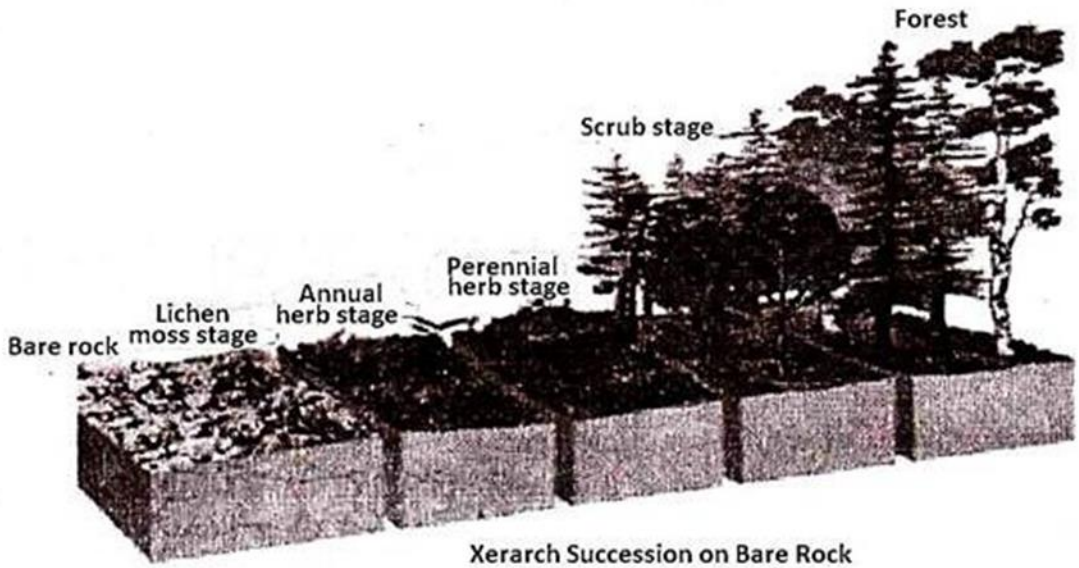
The herb and grass vegetation is replaced by shrub species, such as *Rhus* and *Phytocarpus*. This results in dense organic soil and making conditions unfavorable for the growth of herbs, which then begin to migrate.

6. Trees Stage:

Change in environment favors colonization of tree species. Leaf litter and decaying roots weather the soil further and add humus to it making the habitat more favorable for growth to trees.

7. Climax Stage:

Many intermediate tree stages develop prior to establishment of a climax community. The forest type depends upon climatic conditions. Vegetation finally becomes mesophytic. A steady state is reached between the environment and the biotic community.



Xerarch Succession on Bare Rock

Psammosere

Succession in sand dunes is sometimes called a psammosere.In a psammosere, the organisms closest to the sea will be pioneer species: salt-tolerant species such as littoral algae and glasswort

Stage 1: Migration

Sand grains moved by onshore winds can accumulate downwind of the strand line. Over time, a small embryo dune is formed. The embryo dune will grow if the rate at which soil is trapped is higher than the rate at which soil is blown away by the wind.

Stage 2: Colonisation

Plant seeds and spores are carried by the wind. Some of these land on the embryo dune, where they can germinate and develop. Colonisation means the growth of plants in a new place.Physical conditions in embryo dunes are harsh. Embryo dune pioneer plant species include: Sand Couch (*Elytrigia juncea*), Sea Sandwort (*Honckenya peploides*), Sea Rocket (*Cakile maritima*), Prickly Saltwort (*Salsola kali*), Sea Mayweed (*Tripleurospermum maritimum*) and Orache (*Atriplex* spp.).

Stage 3: Establishment

Over time, the mobile dunes become less stressful for plants, as death and decay of vegetation continues to add organic matter to the soil. Vegetation cover becomes more continuous, with only a few small patches of bare sand, and this stage is called semi-fixed dunes.

Stage 4: Competition

The number of new species will be slowing down now. In fact the amount of free space is very limited and the chances are there will be few signs of bare sand. These are called fixed dunes.
The fixed dunes will be dominated by a continuous cover of grasses, sedges and low-growing flowering plants.

If the dune slack is old enough then the community may develop to scrub, with willow (*Salix* spp.), and moisture loving associates such as Marsh Pennywort (*Hydrocotyle vulgaris*), Marsh Orchid (*Dactylorhiza praetermissa*), and various rushes and sedges.

Stage 5: Stabilisation

The next seral stage is characterised by the colonisation of woody plants such as brambles, sea buckthorn and small trees. Over time, a thick, sometimes acidic layer of humus develops.

Stage 6: Climax

Shading by taller vegetation means that woody species out-compete species from earlier seral stages, and so the resulting species diversity is lower. The climax vegetation of sand dune succession is deciduous woodland. No new species are added and the community remains the same over long periods of time (theoretically forever).

Halosere

Primary succession can happen when bare mud at the seashore is colonised by plants. Over time the mud builds up into a saltmarsh, raising the ground level above the height of the land above sea level. Succession in a saltmarsh is sometimes called a halosere.

Stage 1: Migration

Migration must have occurred for anything at all to be present on the site. Plant seeds and spores are carried by the wind. Some of these land on the bare mud, where they can germinate and develop.

Stage 2: Colonisation

Microscopic, filamentous cyanobacteria (blue–green algae) colonise the surface of the mud. They held to bind the mud surface together, trapping particles against their fronds. In summer fast growing ephemeral green algae like *Enteromorpha* spp. (gut weed) or *Ulva* spp. (sea lettuce) grow attached to small stones (or anything they can stick to) in the mud.

Stage 3: Establishment

More seeds and spores germinate and develop. Small halophytic (salt tolerant) pioneer plants such as glasswort (*Salicornia* spp.) and cord grass (*Spartina* spp.) can then colonise the surface of the mud.

Stage 4: Competition

With the physical environment improving over time, conditions become suitable for additional species to be present and plants such as sea purslane (*Atriplex portulacoides*), sea lavender (*Limonium* spp.), sea aster (*Aster tripolium*), plantain (*Plantago* spp.), scurvy grass (*Cochlearia officinalis)* and thrift (*Armeria maritima*) will take over from the pioneer species.

The number of species continues to increase as abiotic factors become more favourable. As there are not enough resources to go round, it produces competition.

Stage 5: Stabilisation

Each species occupies its own niche, and therefore avoids having to compete strongly with other species. Vegetation is dominated by low-growing flowering plants such as scurvy grass (*Cochlearia officinalis)* and sea lavender (*Limonium humile*). Few new species appear at this stage.

Stage 6: Climax

The climax vegetation of saltmarsh succession is deceiduous woodland. No new species are added and the community remains the same over long periods of time.

Serule:

This type of succession occurs within communities it includes dead trees, animal droppings, etc. Succession of micro-organisms like fungi, bacteria, etc. occurring within a micro-habitat is known as micro-succession or Serule. Microbial communities may also change due to products secreted by the plants, animals and also bacteria. Changes of pH in a habitat could provide ideal conditions for a new species to inhabit the area. In some cases the new species may compete with the present ones for nutrients leading to the primary species.

Seral community or Ecosere

Ecosere or Seral community refers to the several individual communities formed in between the pioneer community and the climax community in a succession

Impact of human interference on succession

Plant succession undergoing large, rapid changes because of human actions. Recent human activities have more than doubled the preindustrial rate of supply of N to terrestrial ecosystems.. In addition, land clearing, biomass burning, and other human activities mobilize and release about an additional 70 Tg of N/yr.

Nitrate is readily leached from soil, carrying with it positively charged ions such as Ca. This depletion of base cations could cause elements that had not been limiting in a region to become limiting. Plant species often have distributions constrained by soil pH and Ca.

Phosphorus is a commonly applied agricultural fertilizer, and current P application is a doubling of the natural global rate for terrestrial ecosystems

The accumulation of such greenhouse gases as CO_2 and methane may lead to global climate change, with the greatest changes, especially warmer winter temperatures, forecast for temperate and polar ecosystems

Community composition changes over time can result from a variety of factors, including disturbances. The effects of disturbances can be contingent on their characteristics, including frequency, extent, and severity. In the context of succession, a disturbance can shift the community to the beginning or to an earlier sere. For example, fire can remove aboveground biomass of plants, as well as alter the nutrient availability and use in a community. Fire-adapted species may have seeds that germinate in response to fire, or re-sprout from underground parts. In contrast, fire-intolerant species may need to re-colonize from outside the burned area. Another factor that can affect succession involve the rate at which the habitat is modified. For example, the rate of soil formation can limit the presence of some species in the habitat. The rates at which species disperse into a site can also dictate the rate of succession. This rate can also interact with the timing, and order of arrival, to produce patterns of composition change in a .Modern transportation and commerce have immensely increased both accidental and deliberate introductions of species to novel biogeographic realms.

Human actions have also fragmented habitats via conversion of native ecosystems to agricultural lands, urban or suburban lands, roads, power line rights-of-way, etc. Fragmentation is likely to escalate as population and per capita incomes increase globally. Habitat destruction can cause immediate extinction of those species that lived only in areas destroyed, and delayed extinction of poorly dispersing, perhaps competitively superior, species of extant ecosystems.

Finally, humans have decreased the geographic ranges and abundance of top predators, especially large carnivores. Decreased abundance of predators have had impacts in both aquatic and terrestrial habitats that have cascaded down the food chain increasing abundance of some herbivores, decreasing abundance of their preferred plant species, and freeing herbivore-resistant species from competitive pressure.

In total, human actions are modifying many environmental constraints that, in combination with intraspecific and interspecific trade-off, led to the evolution of extant plant species and thus influenced the composition, diversity, and functioning of terrestrial and aquatic plant communities.

Conservations of Biodiversity

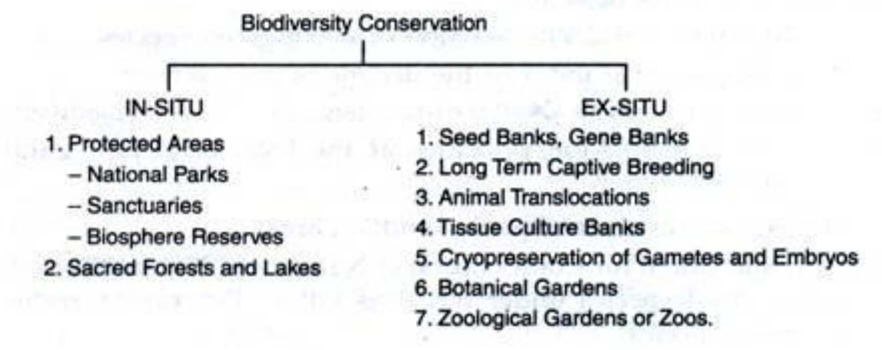
In-Situ Conservation and Ex-Situ Conservation

Humans have been directly or indirectly dependent on biodiversity for sustenance to a considerable extent. However, increasing population pressure and developmental activities have led to large scale depletion of the natural resources.

Conservation is the protection, preservation, management, or restoration of wildlife and natural resources such as forests and water. Through the conservation of biodiversity and the survival of many species and habitats which are threatened due to human activities can be ensured.

Types of Conservation:

Conservation can broadly be divided into two types:
1. In-situ conservation
2. Ex-situ conservation



In-situ Conservation

In-situ conservation is on site conservation or the conservation of genetic resources in natural populations of plant or animal species, such as forest genetic resources in natural populations of tree species. It is the process of protecting an endangered plant or animal species in its natural habitat, either by protecting or cleaning up the habitat itself, or by defending the species from predators.

In India following types of natural habitats are being maintained:

1. National parks
2. Wildlife sanctuaries
3. Biosphere reserves

INDIA has over 600 protected areas, which includes over 90 national parks, over 500 animal sanctuaries and 15 biosphere reserves.

Although there are more than 100 National Parks and Sanctuaries in India

1.N**ational park**

A **national park** is a park in use for conservation purposes, created and protected by national governments. Often it is a reserve of natural, semi-natural, or developed land that a sovereign state declares or owns. Although individual nations designate their own national parks differently, there is a common idea: the conservation of 'wild nature' for posterity and as a symbol of national pride.

Popular National Parks

- Corbett National Park
- Dachigam National Park
- Dudhwa National Park
- Panna National Park
- Madhav National Park
- Indravati National Park
- Hazaribagh National Park
- Sunderban National Park
- Kaziranga National Park
- Bandipur National Park
- Nagarhole National Park
- Periyar National Park
- Silent Valley National Park
- Bannerghatta National Park
- Mahatma Gandhi Marine National Park
- Guindy National Park
- Eravikulam National Park
- Kudremukh National Park

2. Wildlife sanctuaries

Any area other than area comprised with any reserve forest or the territorial waters can be notified by the State Government to constitute as a sanctuary if such area is of adequate ecological, faunal, floral, geomorphological, natural. or zoological significance, for the purpose of protecting, propagating or developing wildlife or its environment. Some restricted human activities are allowed inside the Sanctuary . There are 553 existing wildlife sanctuaries in India covering an area of 119776.00 km^2, which is 3.64 % of the geographical area of the country

- Gobind Sagar Wildlife Sanctuary
- Chilika Wildlife Sanctuary

- Manas Tiger Reserve
- Chinnar Wildlife Sanctuary
- Dandeli Wildlife Sanctuary

3. Biosphere Reserves

It is a special category of protected areas where human population also forms a part of the system. They are large protected area of usually more than 5000 sq.km. A biosphere reserves has 3 parts- core, buffer and transition zone.

1. Core zone is the inner zone; this is undisturbed and legally protected area.
2. Buffer zone lies between the core and transition zone. Some research and educational activities are permitted here.
3. Transition zone is the outermost part of biosphere reserves. Here cropping, forestry, recreation, fishery and other activities are allowed.

The main functions of biodiversity reserves are:
1. Conservation: To ensure the conservation of ecosystem, species and genetic resources.
2. Development: To promote economic development, while maintaining cultural, social and ecological identity.
3. Scientific Research: To provide support for research related to monitoring and education, local, national and global issues. Biosphere reserves serve in some ways as 'living laboratories' for testing out and demonstrating integrated management of land, water and biodiversity.

List of some major Biosphere Reserves of India:

	Name	**States/ UT**	**Year**
1	Nilgiri Biosphere Reserve	Tamil Nadu, Kerala and Karnataka	2000
2	Gulf of Mannar Biosphere Reserve	Tamil Nadu	2001
3	Sundarbans Biosphere Reserve	West Bengal	2001
4	Nanda Devi Biosphere Reserve	Uttarakhand	2004
5	Nokrek Biosphere Reserve	Meghalaya	2009
6	Pachmarhi Biosphere Reserve	Madhya Pradesh	2009
7	Simlipal Biosphere Reserve	Odisha	2009
8	Great Nicobar Biosphere Reserve	Andaman & Nicobar Islands	2013
9	Achanakmar-Amarkantak Biosphere Reserve	Chhattisgarh, Madhya Pradesh	2012
10	Agasthyamalai Biosphere Reserve	Kerala and Tamil Nadu	2016
11	Khangchendzonga National Park	Sikkim	2018
12	Panna	Madhya Pradesh	2020

Advantages of in-situ conservation:

1. The flora and fauna live in natural habitats without human interference.
2. The life cycles of the organisms and their evolution progresses in a natural way.
3. In-situ conservation provides the required green cover and its associated benefits to our environment.
4. It is less expensive and easy to manage.
5. The interests of the indigenous people are also protected.

Ex-Situ Conservation:

Ex-situ conservation is the preservation of components of biological diversity outside their natural habitats. This involves conservation of genetic resources, as well as wild and cultivated or species, and draws on a diverse body of techniques and facilities. Such strategies include establishment of botanical gardens, zoos, conservation strands and gene, pollen seed, seedling, tissue culture and DNA banks.

Advantages of ex-situ preservation:

1. It is useful for declining population of species.
2. Endangered animals on the verge of extinction are successfully breeded.
3. Threatened species are breeded in captivity and then released in the natural habitats.
4. Ex-situ centres offer the possibilities of observing wild animals, which is otherwise not possible.
5. It is extremely useful for conducting research and scientific work on different species.

Gene banks

Gene banks are a type of biorepository that preserves genetic material. For plants, this is done by in vitro storage, freezing cuttings from the plant, or stocking the seeds (e.g. in a seedbank). For animals, this is done by the freezing of sperm and eggs in zoological freezers until further need. With corals, fragments are taken and stored in water tanks under controlled conditions. Genetic material in a 'gene bank' is preserved in a variety of ways, such as freezing at -196° Celsius in liquid nitrogen, being placed in artificial ecosystems, and put in controlled nutrient mediums. Accession is the common term given to an individual sample in a gene bank, such as a distinct species or variety.

Types of gene banks

Seed bank

A seed bank preserves dried seeds by storing them at a very low temperature. Spores and pteridophytes are conserved in seed banks, but other seedless plants, such as tuber crops, cannot be preserved this way.

Tissue bank

In this technique, buds, protocorm and meristematic cells are preserved through particular light and temperature arrangements in a nutrient medium. This technique is used to preserve seedless plants and plants that reproduce sexually.

Cryobank

In this technique, a seed or embryo is preserved at very low temperatures. It is usually preserved in liquid nitrogen at -196 °C. This is helpful for the conservation of species facing extinction.

Storage of pollen

This is a method in which pollen grains are stored. Using this technique, plants with one set of chromosomes can be made. The pollen is stored in liquid nitrogen. This method is useful for crossbreeding.

Field gene bank

This is a method of planting plants for the conservation of genes. For this purpose, an ecosystem is created artificially. Through this method, one can compare the differences among plants of different species and can study them in detail. It needs more land, adequate soil, weather, etc. Germ plasma of important crops are conserved through this method. 42,000 varieties of rice are conserved in the Central Rice Research Institute in Orissa.

Arboretum

An **arboretum** in a general sense is a botanical collection composed exclusively of trees. More commonly a modern arboretum is a botanical garden containing living collections of woody plants and is intended at least in part for scientific study. In an arboretum a wide variety of trees and shrubs are cultivated. Typically the individual trees are labelled for identification. The trees may also be organised in a way to aid their study or growth.

Asia – India

Udhagamandalam (Ooty) Arboretum, The Nilgiris, India

Both indigenous and exotic tree species are included; about 80 trees were previously present, including the following tree species were also planted: *Celtis tetrandra*, *Dillenia pentagyna*, *Elaeocarpus ferrugineus*, *Elaeocarpus oblongus*, *Evodia lunuankenda*, *Glochidion neilgherrense*, *Ligustrum perrotetti*, *Litsaea ligustrina*, *Litsaea wightiana*, *Meliosma arnotiana*, *Meliosma wightii*, *Michelia champaca*, *Michelia nilagirica*, *Pygeum gardneri*, *Syzygium amothanum*, *Syzygium montanum*, *Alnus nepalensis*, *Viburnum erubescens*, *Podocarpus wallichianus*, *Rhodomyrtus tomentosa*, *Rapanea wightiana*, *Ternstroemia japonica*, *Microtropis microcarpa*, *Psychotria conjesta*, *Photinea notoniana*, *Cedrela toona*, *Symplocos cochinchinensis*, *Elaeocarpus ganitrus*, *Platanus orientalis*, *Jacaranda mimosaefolia*, *Magnolia grandiflora* etc.

Bambusetum

Bambusetum aims to have an exhaustive collection of Sympodial bamboos that can be grown in a typical agro-climatic zone and to gather invaluable scientific information on bamboo growth in state. The Bamboosetum also serves as genetic resource for future crop improvement programmes and for forest managers and farmers.

List of Bamboo species are *Arundinaria griffithiana, Bambusa affinis, Bambusa albociliata, Bambusa albostriata, Bambusa balcooa, Bambusa bambos, Bambusa bambos var. gigantean, Bambusa blumeanas, Bambusa dissimilator, Bambusa glaucesence, Bambusa longispiculata, Bambusa membranacus, Bambusa multiplex, Bambusa multiplex (yellow), Bambusa nana, Bambusa nutans, Bambusa oldhami, Bambusa pellida, Bambusa polymorpha, Bambusa textiles, Bambusa tulda, Bambusa vulgaris, Bambusa vulgaris var. striata, Bambusa vulgaris var. wamin, Cephalostachyum fussianum, Cephalostachyum pergracile, Dendrocalamus asper, Dendrocalamus brandisii, Dendrocalamus giganteus, Dendrocalamus hamiltonii.*

vi. Botanical gardens:

A **botanical garden** or **botanic garden** is a garden dedicated to the collection, cultivation, preservation and display of a wide range of plants labelled with their botanical names. It may contain specialist plant collections such as cacti and other succulent plants, herb gardens, plants from particular parts of the world, and so on; there may be greenhouses, shadehouses, again with special collections such as tropical plants, alpine plants, or other exotic plants. Visitor services at a botanical garden might include tours, educational displays, art exhibitions, book rooms, open-air theatrical and musical performances, and other entertainment.

Botanical gardens are often run by universities or other scientific research organizations, and often have associated herbaria and research programmes in plant taxonomy or some other aspect of botanical science. In principle, their role is to maintain documented collections of living plants for the purposes of scientific research, conservation, display, and education, although this will depend on the resources available and the special interests pursued at each particular garden.

Role and functions

Many of the functions of botanical gardens, which emphasise the scientific underpinning of botanical gardens with their focus on research, education and conservation. However, as multifaceted organisations, all sites have their own special interests.

- availability of plants for scientific research
- display of plant diversity in form and use
- display of plants of particular regions (including local)
- research facilities utilising the living collections
- studies in plant taxonomy
- examples of different vegetation types
- student education

- plants sometimes grown within their particular families
- plants grown for their seed or rarity
- major timber (American English: *lumber*) trees
- plants of economic significance
- glasshouse plants of different climates
- all plants accurately labelled
- records kept of plants and their performance
- catalogues of holdings published periodically
- a herbarium
- selection and introduction of ornamental and other plants to commerce
- studies of plant chemistry (phytochemistry)
- report on the effects of plants on livestock
- at least one collector maintained doing field work

Sacred gardens

Sacred gardens are an ancient tradition in many major cultures, including our own. They are the cultivated counterparts of the sacred groves and are a place for meditation, spiritual awakening and celebration.Although, there is less archaeological evidence of early gardens in India, the Hindu scriptures and books (Ramayana, Abijnana Shakuntalam, Mrichchakatika etc.) give remarkably detailed description of elaborate gardens with flowerbeds, lotus ponds, fruiting trees, creepers and shady spaces. In fact, gardens are a symbol of paradise in Hindu philosophy and art.

TYPES OF SACRED GARDENS:

Nandavanam – Divine plays (leelas) of Hindu Gods are often depicted in gardens. Most Hindu temples are therefore associated with gardens, also known as Nandavanam. These gardens are usually managed and maintained to serve the temple. Example: the Thirunandavanam or Madurakavi nandavanam attached to the Ranganathar temple at Srirangam.

Buddhists gardens – In Buddhism, gardens are described as a place for meditation and healing. There were beautiful gardens in Nalanda and Taxila. It is even believed that Lord Buddha was born under a tree at the Lumbini garden (now in Nepal), which is now listed as a World Heritage Site. The monasteries played a central part of the life in the monasteries during early periods. Even today, monasteries in India have attractive gardens attached to them.

Bagh (Bagicha) – They are ethno-silvi-horticultural gardens, traditionally planted near tanks, settlements or amidst forests, especially in the northern parts of our country. The biodiversity mainly consists of utility trees such as Mangifera indica, Madhuca latifolia, Syzygium cuminii etc. Green felling is totally banned in these gardens. Also, there is temple or separate space dedicated to the Gods (or village deity). For example, an excellent Bagh exists near a village inside the Darrah Wildlife Sanctuary in Kota.

Gardens of Paradise - Mughal Gardens are square or rectangular in shape, along the lines of Persian gardens. They are generally enclosed by a high wall with imposing gates on four sides.

The garden is an orderly view of paradise. They are generally associated with tombs, since the soul of the dead person is believed to have reached paradise, which is replicated on earth in the garden. The tomb garden is called Char Bagh and is based on *hasht-vihisht* or eight paradises plan making a cross-axial garden. The well-known tomb gardens of India are Humayun's Tomb (1571), Delhi; Akbar's Tomb (1613), Sikandra, Agra; Taj Mahal (1630), Agra; and Bibi Ka Maqbara (1661) Aurangabad.

Sacred Gardens of Tamil Nadu:

Garden
Koodal Azhagar Koil
Madanagopalaswamy Temple Garden
Madurai Meenakshi Amman temple
Mannargudi Rajagopalswamy Temple Garden
Sri Oppiliappan Temple Garden
Sri Varadaraja Perumal Temple Garden
Srirangam Madurakavi Nandavanam
Srivilliputhur Andal Nandavanam
Thiruvanaikkaval Vaaleeswarar Temple Garden

Sacred groves of India

Sacred groves of India are forest fragments of varying sizes, which are communally protected, and which usually have a significant religious connotation for the protecting community. Indian sacred groves are often associated with temples, monasteries, shrines or with burial grounds. Historically, sacred groves find their mentions in Hindu, Jain and Buddhist texts, from sacred tree groves in Hinduism to sacred deer parks in Buddhism for example. Sacred groves may be loosely used to refer to natural habitat protected on religious grounds.

The Hindu tradition considers forests to be of three types - *Tapovan*, *Mahavan* and *Sreevan*. *Tapovan* are forests associated with penance (and are inhabited by saints and *rishis*. *Mahavan* refers to the grand natural forests. *Tapovan* and *Mahavan* are considered to be a *Raksha* for flora and fauna as ordinary human beings are not allowed to enter these forests. *Sreevan*, which means, "forests of prosperity", consists of dense forests and groves.

Uses

Traditional uses: One of the most important traditional uses of sacred groves was that it acted as a repository for various Ayurvedic medicines. Other uses involved a source of replenishable resources like fruits and honey. However, in most sacred groves it was taboo to hunt or chop wood. The vegetation cover helps reduce soil erosion and prevents desertification, as in Rajasthan. The groves are often associated with ponds and streams, and meet water requirements of local communities. They sometimes help in recharging aquifers as well.

Modern uses: In modern times, sacred groves have become biodiversity hotspots, as various species seek refuge in the areas due to progressive habitat destruction, and hunting. Sacred groves often contain plant and animal species that have become extinct in neighboring areas. Sacred groves are scattered all over the country, and are referred to by different names in different parts of India. Sacred groves occur in a variety of places – from scrub forests in the Thar Desert of Rajasthan maintained by the Bishnois, to rain forests in the Western Ghats of Kerala. Himachal Pradesh in the north and Kerala in the south are specifically known for their large numbers of sacred groves. The Gurjar people of Rajasthan have a unique practice of neem (Azadirachta indica) planting and worshipping as abode of God Devnarayan.Thus, a Gurjjar settlement appears like a human-inhabited sacred grove. Similarly Mangar Bani, last surviving natural forest of Delhi is protected by Gurjars of nearby area. 14,000 sacred groves have been reported from all over India, which act as reservoirs of rare fauna, and more often rare flora, amid rural and even urban settings. Experts believe that the total number of sacred groves could be as high as 100,000.

It is estimated that around 1000 km^2 of unexploited land is inside sacred groves. Some of the more famous groves are the *kavu*s of Kerala, which are located in the Western Ghats and have enormous biodiversity; and the *law kyntang*s of Meghalaya – sacred groves associated with every village () to appease the forest spirit. Among the largest sacred groves of India are the ones in Hariyali, near Gauchar in Chamoli District of Uttarakhand, and the Deodar grove in Shipin near Simla in Himachal Pradesh.

A large number of distinct local art forms and folk traditions are associated with the deities of sacred groves, and are an important cultural aspect closely associated with sacred traditions. Ritualistic dances and dramatizations based on the local deities that protect the groves are called *Theyyam* in Kerala and *Nagmandalam*, among other names, in Karnataka. Often, elaborate rituals and traditions are associated with sacred groves,as are associated folk tales and folk mythology.