Practical manual

Forest Ecology & Biodiversity

FNR 219 3(2+1)
For B. Sc. (Hons.) Forestry III Semester students

Dr. PANKAJ LAVANIA
Dr. RAKESH NEGI

2019

College of Horticulture & Forestry
Rani Lakshmi Bai Central Agricultural University, Jhansi 284003

Syllabus FNR 219 Credit Hrs. 3(2+1)

Study of ecological modifications in plants; Effects of fire on forest ecosystem; Study of population dynamics using model systems; Preparation of life tables; Study of spatial dispersion among plants; Study of Forest composition; Niche analysis; Computation of diversity indices; Measurement of diversity of plants and insects in a nearby forest; Study of succession in field and water bodies; Visit to different ecosystems.

Name of Student .....

Roll No. .....

Batch .....

Session .....

Semester .....

Course Name : .....

Course No. : .....

Credit .....

Published: 2019

No. of copies: ……..

Price: Rs.

CERTIFICATE

This is to certify that Shri./Km. .....ID No..... has completed the practical of course.....course No. ..... as per the syllabus of B.Sc. (Hons.) Agriculture/ Horticulture/ Forestry ..... semester in the year.....in the respective lab/field of College.

Date: Course Teacher

INDEX

Practical No. 1

Objective: To study ecological modifications /adaptation in xerophyte plants in Bundelkhand region.

Required material: ……..……

……..……

Observation:

Xerophytes: ……

……

……

……..

Morphological characteristics

Roots: ……

……

……

……...

.....

.....

……..……

Stems: ……

……

……...…

……..……

……..……

……..……

……..

Draw the line diagram	

Leaves: ……

……

……

……

……

……

……

……

……

……

Draw the line diagram		

Anatomical Modifications

Roots: ……

……

……

……

……

……

……

Stems: ……

……

……

……

……

……

……

Leaves: .....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Draw the line diagram	

Conclusion: .....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Practical No. 2

Objective: To study ecological modifications /adaptation in hydrophyte plants in Bundelkhand region.

Required material: ……..……

……..……

Observation:

Hydrophytes: ……..……

……..……

……..……

……..

Morphological characteristics

Roots: ……..……

……..……

……..……

……..…..

……..…

……..……

……..……

Stems: ……..……

……..……

……..…..…

……..……

……..……..……

……..……

……..

Draw the line diagram	

Leaves: ……

……

……

……

……

……

……

……

……

……

Draw the line diagram		

Anatomical Modifications

Roots: ……

……

……

……

……

……

……

Stems: ……

……

……

……

……

……

……

Leaves: .....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Diagram of free-floating hydrophyte	

Conclusion: ……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

Practical No. 3

Objective: To study the effect of fire on forest in Bundelkhand region.

Required material: ……

……

……..…..

……..……

Observation:

Forest fire: ……..……

……..……

……..……

……..……

……..……

Segments	Observation way of fire effected sites
Forest tree/ crop	**A. Species:** The tree/ crop species with thick corky bark are comparatively less damaged than those with thin bark. The broad leave tree is less effected than confer tree. **Highly sensitive to Fire** …… …… …… …… …… …… …… …… …… …… **Low sensitive to fire** …… …… …… …… …… …… …… …… …… …… **(B) Age of tree/crop:**
	(C) Condition of trees/ Crops:
	•
	•
	•
	•
	•
	•
Productivity of forest	•
	•

	•
	•
	•
	•
Regeneration Problem	•
	•
	•
	•
	•
Reduce the protective function of forest	•
	•
	•
Soil and Microorganism	•
	•
	•
	•
	•
	•
	•
	•
Air quality	•
	•
Wildlife	•
	•
	•
	•
	•
Effect of Forest fire	•
	•
	•

Bundelkhand region where they found? As title says: ……

……

Conclusion: ……

……

……

……

Practical No. 4

Objective: To identify and enlist the vegetation found at RLBCAU campus.

Required material: ……

……

……

……

……

Observation:

Vegetation: ……

……

……

……

Species diversity: ……

……

……

……

TREE SPECIES:

Sl. No.	Common Name	Botanical Name
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		

SHRUB/HERB/CLIMBER & CREEPER SPECIES

Sl. No.	Common Name	Botanical Name
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

17		
18		
19		
20		

Grass species

Sl. No.	Common Name	Botanical Name
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Practical No. 5

Objective: To study forest ecosystem of forest division, Jhansi

Required material: ……

……

Observation

Forest ecosystem: ……

……

……

Different component of forest ecosystem

Abiotic component: ……

……

Climate condition:……

Light: ……

Temperature ……

Rainfall -……

Humidity-……

Atmospheric pressure:……

Winds: ……

Edaphic condition -……

……

……

Physical properties of soil ……

……

……

……

Chemical properties of soil :-……

……

……

……

Major elements: ……

……

Minor elements ……

……

……

Biotic component: ……

……

……

……

……

Producers: ……

……

……

Sl. No.	Common Name	Botanical Name
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Consumers: ……

……

……

……

Primary consumers:

S.No	Size	Nature of feeds	Primary consumers.
1.	Micro organism		
2.	Macro-organism (large animals grazing)		

Secondary consumers

S.No	**Primary consumer as feeds materials**	**Secondary consumers as**
1		
2		
3		

Decomposers: Rate of decomposition in tropical and subtropical forest more rapid than in Temperate one.

S. No	**micro-organisms**	**Example**
1	fungi species	…….. …… …… …… ……...
2	Bacteria species	……

Conclusion: ……..……

……

……..……

……

……

……..……

……

……..……

……

……

……

……

……..……

……

……

……

……

……

……

Practical No. 6

Objective: To study cropland ecosystem in RLBCAU Campus Jhansi

Required materials: ……

……

……

Observation:

Cropland ecosystem: ……

……

……

Components-

Abiotic component: ……

……

……

Climate condition: ……

……

……

Light: ……

Temperature ……

Rainfall ……

Humidity ……

Atmospheric pressure: ……

Winds: ……

Edaphic Condition: ……

……

……

Physical properties of soil: ……

……

……

……

Chemical properties of soil: ……

……

……

……

Major elements: ……..

……

Minor elements: ……

……

……

Biotic component ……..

……

……

Producers: ……

……

……

……

Consumer: ……

……

……

……

Primary consumers: ……

……

……

S.N.	Name of primary consumer	Nature of foods
1		
2		

Secondary consumers: ……

……

Tertiary consumers: ……

……

Decomposers: ……

……

……

……

Conclusion: ……..

……

……

……

Practical No. 7

Objective: To study various stage of hydrosere/ hydrarch in pond

Required materials: ……

……

Observation: ……

Hydrosere: ……

……

……

……

……

……

……

……

Phytoplankton stage: ……

……

……

……

……

Rooted submerged stage: ……

……

……

……

……

Rooted floating stage: ……

……

……

……

……

Reed- swamp stage: ……

……

……

……

……

Sedge-meadow stage: ……

……

……

……

……

……

Woodland stage: ……

……

……

……

……

……

Forest stage: ……

……

……

……

……

……

Diagram showing different plant communities appearing at different stage of hydrosere in a pond (the gradual decrease in water level and successive development of the soil in area to give finally a terrestrial habitat for forest community)

Conclusion: .....

.....

.....

.....

.....

.....

.....

Practical No. 8

Objective: To study various stage of a lithosere appearing on rocks.

Required Material: ……

……..

……..…

Observation: ……

……..

……..…

……..

……..…

……..

……..…

Xerosere:

Crustose Lichens stage: ……

……..

……..…

……..

……..…

……..

Foliose lichen stage: ……

……..

……..…

……..

……..…

……..

Moss stage: ……

……..

……..…

……..

……..…

Herb stage: ……

……..

……..…

……..

……..…

Shrub stage: ……

……..

……..…

……..

……..…

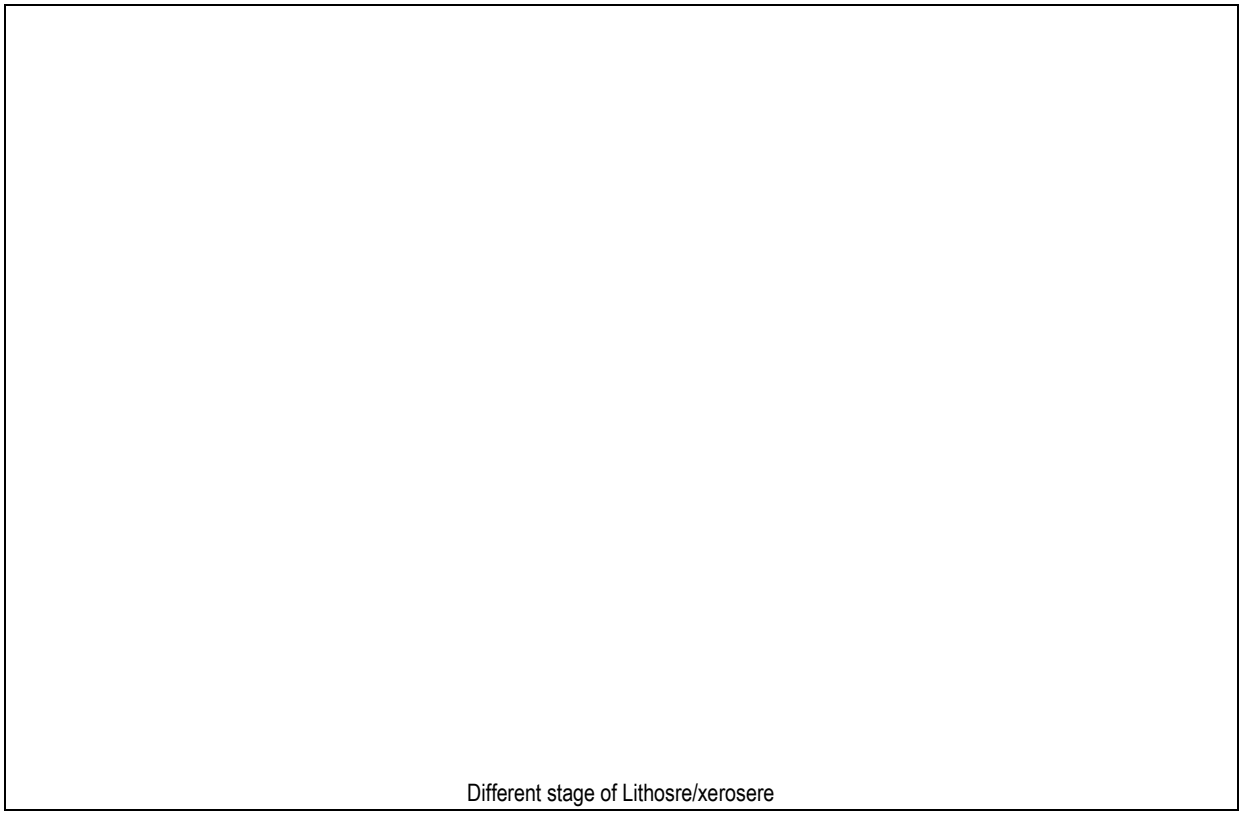
Forest stage: ……

……..

……..…

……..

……..…



Different stage of Lithosre/xerosere

Conclusion: .....

.....

.....

.....

.....

.....

.....

.....

Practical No. 9

Objective: To observe different forest types composition of Jhansi Forest Division

Required Material ……

……..…

Observation

Forest Division: ……..……

Range: ……..……..

Composition of forest (Pure/Mixed): ……..……

Area (ha): ……...

Forest composition brief

Location	Forest type	Over story			Under story			
		Principal species	Accessory species	Auxiliary species	Shrubs	Herbs	Grass	climber

Management strategies used by the Forest Department.

Conclusion: .....

.....

.....

.....

Practical No. 10

Objective: To determine minimum size of quadrat (sampling Unit) by species - area-curve method.

Required Material ……

……

Procedure ……

……

……

……

……

……

……

……

……

……

……

……

……

Observation Table:

Area (cm^2)	Total Number of Species present
10 X 10 cm = 100 cm^2	10
20 X 20 cm = 400 cm^2	12
30 X 30 cm = 900 cm^2	15
40 X 40 cm = 1600 cm^2	22
100 X 100 cm = 10,000 cm^2	22
200 X 200 cm = 40,000 cm^2	22

Diagram showing the Species: Curve and ”M requisite size of quadrat (cm)

List of different species and other data as recorded by quadrat method.

(Area of quadrat taken in the study 40 cm x 40 cm = 1600 cm^2)

S. No	Name of the species	Quadrats laid down										Total No of Individual spp.	Total No of Quadrat	Total No of quadrat studies	Frequency (%)	Density	Abundance
		1	2	3	4	5	6	7	8	9	10						

Conclusion: ……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

Practical No. 11

Objective: To determine minimum number of quadrats for ecological studies

Required Material ……

……

Procedure ……

……

……

……

……

……

……

……

……

……

……

Observation Table

Name of Species	Number of quadrats									
	1	2	3	4	5	5	7	8	9	10
Accumulation total species										

Conclusion: ……

……

……

……

……

Practical No. 12

Objective: To study life table of ecological population

Required Material ……

……

Observation

Ecological populations: ……

……

……

……

……

……

Key traits of population structure: ……

……

……

……

Life history tables, or life tables: ……

……

……

……

Horizontal (dynamic or cohort): ……

……

……

……

Anatomy of life tables: ……

……

……

……

……

……

……

……

……

……..……...

……..……

Life table:

Age in Month X	Number/Age class N (x)	Survival rate l(X)	Fecundity b(X)	Offspring/indiv. l(X) * b(X)	Age-weighted fecundity l(X) * b(X)*X
0	134				
1	117				
2	82				
3	64				
4	52				
5	43				
6	23				
7	13				
8	3				
9	2				
10	1				
11	0				
SUM					
		R_0 **G** **Optimal age for sexual maturity**			

Calculation: ……..……

……..……...

……..……

……..……...

……..……

……..……...

……..……

……..……...

……..……

……..……...

……..……

Conclusion: ……..……

……..……

……..……

……..……

……..……

……..……...

Practical No. 13

Objective: To elaborate methods used in measurement of diversity of plants and insects in a nearby forest

Required material: ……

……

……

Observation: ……

Biodiversity: ……

……

……

……

……

……

……

……

……

……

Various methods	Picture
Canopy fogging …… …… …… …… …… ……	
Quadrat sampling …… …… …… …… …… …… ……	

Transect sampling …… …… …… …… …… ……	
Netting …… …… …… …… …… ……	

Conclusion: ……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

Practical No. 14

Objective: To study floristic composition and plant diversity of RLBCAU, Campus.

Required material: ……..……..…….

……..……

……..……

Procedure: ……..

……..……

……..……

……..……

……..……

……..……

……..……

……..……

……..……

……..……

……..……

……..……

……..……

Observation

Plant data recorded from the Field observation.

	S. No	Name of plant species	Diameter (cm)	Girth (cm)	Basal Area
Quadrate-1					
Quadrate-2					

Quadrate-6				Quadrate-5								Quadrate-4								Quadrate-3											

Quadrate-10				Quadrate-9								Quadrate-8								Quadrate-7											

Floristic composition of different plant species in RLBCAU, Jhansi campus

S. No	Name of species	Total no. of plants	Total Quadrants of occurrence	Basal Area	Relative Density	Relative frequency	Relative Dominance	IVI
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

Relevant of studies the floristic composition of species in area.

.....

.....

.....

.....

Conclusion: .....

.....

.....

.....

.....

Practical No. 15

Objective: To study population structure using diversity indices.

Required material: ……

……..……

Observation: Plant species found in different direction at RLBCAU, campus.

S.No	Species name	Family	North	South	East	West
1.						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						

28						
29						
30						
31						
32						
33						
34						
35						

+ Present **- absent**

Similarity and Dissimilarity index.

S / D	Aspects	North	South	East	West
	North				
	South				
	East				
	West				

Vegetation indices of trees, shrubs and herbs in different aspect of RLBCAU campus (refer to previous practical table data).

Aspects	Plant categories	Vegetation indices		
		Shannon –Weiner diversity	Simpson 's dominance	Species richness
North	*Herbs*			
	Shrubs			
	Trees			
South	*Herbs*			
	Shrubs			
	Trees			
East	*Herbs*			
	Shrubs			
	Trees			
West	*Herbs*			
	Shrubs			
	Trees			

Conclusion: .....

.....

.....

.....

.....

.....

Practical No. 16

Objective: To study population ecology in given forest area in Jhansi forest division.

Required material: ……

……

Observation: Attributes of population: ……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

Draw and comments on the population Growth / population density curve.

Exponential Population Growth Curve	……
Logistic Population Growth Curve	……

Population interaction: ……

……

……

Positive interaction: - ……

……

……

a) Commensalism: ……

……

……

……

……

……

……

……

b**) Photo cooperation:** ……

……

……

……

……

……

……

c) **Mutualism:** ……

……

……

……

……

……

……

……

……

……

……

Negative interaction: - ……

……

……

……

a) Competition:……

……

……

……

……

……

……

……

Predation: -……

……

……

……

……

……

……

Parasitism: ……

……

……

……

……

……

……

……

……

Conclusion: ……

……

……

……

……

……

Practical No. 17

Objective: To study spatial dispersion among plants in given forest area in Jhansi forest division.

Required material: ……

……

Observation: Population dispersion: .....

.....

.....

.....

.....

.....

.....

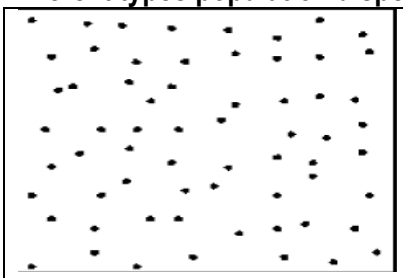
.....

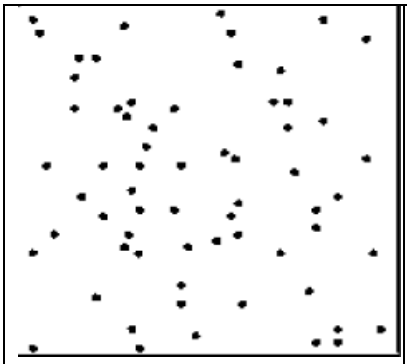
.....

.....

.....

Different types population dispersion.

	.....
Regular or uniform distribution	.....
	.....
	.....
	.....
	.....
	.....
	.....
	.....
	.....

 **Random Distribution**	.....
 **Clumped distribution**	.....

Question No.3. Calculate the types of population dispersion of a given table (using equation $S^2 = \frac{\text{Variance}}{\text{mean}}$ where s = dispersion)

Case

S=1 ; Random distribution
S <1 ; uniform distribution
S >1 ; Clumped distribution

Statistics	Species -A	Species- B	Species -C
Mean $\bar{X}$	5.30	7.05	5.30
Variance S^2	5.05	0.35	50.5

Calculation .....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Different factor which affect the population structure: .....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Conclusion: .....

.....

.....

.....

.....

.....

Practical No. 18

Objective: To write comments on various biodiversity conservation organizations and agencies of India and abroad.

Biodiversity: ……..…

……

……

……

……

……

Conservation : ……

……

……

……

……

……

Organizations and agencies: ……

……

……

……

……

Some of the important bodies of them are given below:

1. **Earth scan:** ……..

.……

……

……

……

……

Convention on International trade in Endangered Species (CITES): ……

……

……

……

……

Environmental Protection Agency (EPA): ……

……

……

……

……

European Economic Community (EEC): ……

……

……

……

……

……

……

……

……

Human Exposure Assessment Location (HEAL): ……

……

……

……

……

International Council of Scientific Union (ICSU): …….

……

……

……

……

International Union for the Conservation of Nature and Natural Resources (IUCN): ……

……

……

……

……

International Marine Consultative Organization (IMCO): ……..

……

……

……

South Asia Co-operative Environment Programme (SACEP): …….

……

……

……

United Nations Educational, Scientific and Cultural Organization (UNESCO): ……

……

……

……

……

……

……

United Nations Environmental programme (UNEP): ……

……

……

……

World Commission on Environment & Development (WCED): ……..……

……

……

……

Earth Watch Programme: ……..……

……

……

……

Men and the Biosphere Programme (MAB): ……

……..……

……

.

Xerophytes: Plants which grow in dry habitats or xeric conditions are called xerophytes. Places where available water is not present adequate quantity are termed xeric habitats.

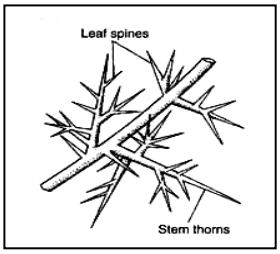
Morphological characteristics

Roots:

a. Xerophytes have well developed root systems which may be profusely branched.
b. It is extensive and more elaborate than shoot system.
c. Many desert plants develop superficial root system where the supply of water is restricted to surface layer of the earth.
d. The roots of perennial xerophytes grow very deep in the earth and reach the layers where water is available in plenty.
e. Root hairs are densely developed near the growing tips of the rootlets. These enable the roots to absorb sufficient quantity of water.

Stem:

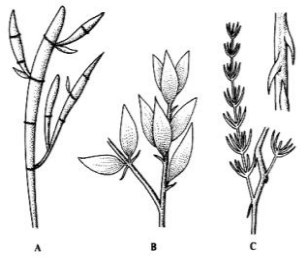
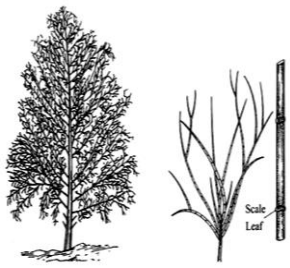
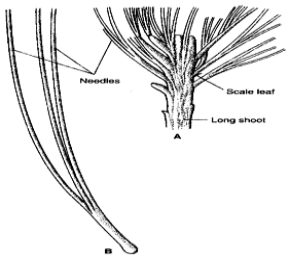
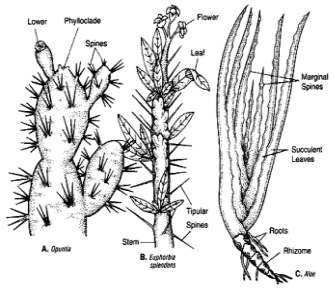
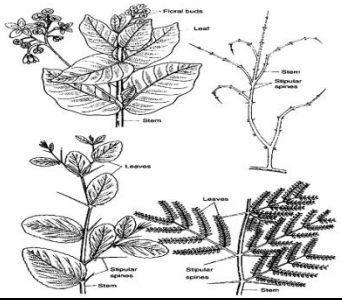
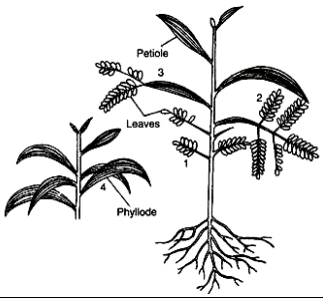
a. Stems of some xerophytes become very hard and woody. It may be either aerial or subterranean.
b. They are covered with thick coating of wax and silica found in *Equisetum strobilus*. *Calotropis procera* may be covered with dense hairs.
c. In some xerophytes, stems may be modified into thorns, e.g., *Duranta, erecta, Ulex europaeus*
d. Stems in some extreme xerophytes are modified into leaf-like flattened, green and fleshy structures which are termed as phylloclades. In **Asparagus plant** also a number of axillary branches become modified into small needle-like green structures which look exactly like leaves.



Ulex stem

Leaves:

a. In some xerophytes the leaves, if present, are greatly caducous, i.e., they fall early in the season, but in the majority of the plant's leaves are generally reduced to scales, as in Casuarina, Ruscus and Asparagus.
b. Some evergreen xerophytes have needle-shaped leaves, e.g., Pinus.
c. In leaf succulents, the leaves swell remarkably and become very fleshy owing to storage of excess amount of water and latex in them. Plants with succulent leaves generally develop very reduced stems. Examples, *Aloe spinossissima (Gheekwar), Mesembryanthemum, Kleinia ficoides and several members of family Chaenopodiaceae*.
d. In majority of xerophytes, leaves are generally much reduced and are provided with thick cuticle and dense coating of wax or silica. Sometimes they may be reduced to spines, as for example, in Ulex, Opuntia, Euphorbia splendens.
e. Generally, the leaves of xerophytic species possess reduced leaf blades or pinnae and have very dense network of veins e.g., *Acacia auriculiformis*
f. Trichophylly: In some xerophytes especially those growing well exposed to strong wind, the under surfaces of the leaves are covered with thick hairs which protect the stomatal guard cells and also check the transpiration. Those xerophytes which have hairy covering on the leaves and stems are known as trichophyllous plants. *Zizyphus, Nerium, Calotropis procera*
g. Rolling of leaves. Leaves in some extreme xerophytic grasses have capacity for rolling or folding. This is effective modification in these plants for reducing the water loss.

<table>
<tr>
<td>  </td>
<td>  </td>
<td>  </td>
</tr>
<tr>
<td>A-Phylloclade of Cocoloba; B-Cladodes of Ruscus; C-Cladodes of Asparagus</td>
<td>Casuarina</td>
<td>Long & dwarf shoots of Pinus roxburghii showing needle like leaves and scales</td>
</tr>
<tr>
<td>  </td>
<td>  </td>
<td>  </td>
</tr>
<tr>
<td>Some succulent xerophytes</td>
<td>Some common true xerophytes</td>
<td>Acacia phyllode. 1,2,3&4 showing gradual loss of pinnae and development of phyllodes</td>
</tr>
</table>

Anatomical Modifications

Roots

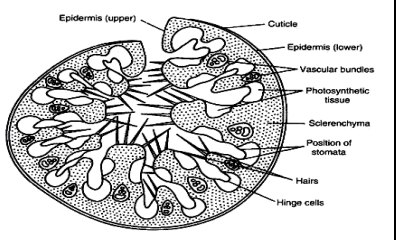
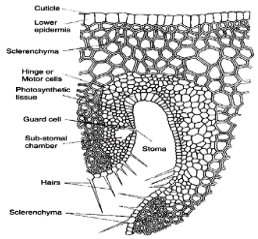
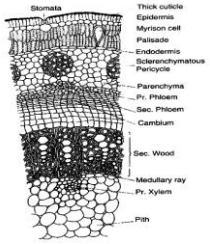
a) Roots hairs and roots caps are well developed e.g., *Opuntia*
b) Roots may become fleshly to store water e.g., *Asperagus*
c) Roots possess rigid and thickened walls.

Stems

a) In succulent, xerophytes, Stem possess a water storage region.
b) In non-succulent xerophyte, most of the stem having the characteristics
   - Cuticle is very thick.
   - Epidermis is well developed, with heavily thickened cell walls.
   - Hypodermis is several layered and slerenchymatous.
   - Stomata are of sunken type.
   - Vascular tissues are very well developed, differentiate heavily lignified.
   - Vascular bundles are well developed several layered bundle sheaths.
   - Mechanical tissues are very well developed
c) Bark is very well developed.
d) Oil and resins are well developed.

Leave modification in Xerophytes

A. In succulent leaves of malacophyllous like as *Peperomia* spp. Epidermal cells of leave serve as water storage organs.
B. Leave of non –succulent xerophytes such as Nerium and Pinus possess.
   (1) Well develop heavy cuticle.
   (2) Several layered epidermises in Nerium and several layered sclerenchymatous hypodermis in Pinus species.
   (3) Mesophyll very well differentiate into palisade and spongy parenchyma.
   (4) Stomata of sunken type confined only to lower epidermis. In some xerophyte as Nerium, Stomata are situated in pits lined with hairs.
   (5) Vascular tissues very well developed and differentiate into xylem with lignified elements and phloem.
   (6) Mechanical tissues are very well developed.

		
T.S. of *Ammophila arenaria* leaf showing protected stomata	T.S. of *Ammophila arenaria* leaf between two ridges	T.S. of *Capparis* stem

MORPHOLOGICAL AND ANATOMICAL FEATURE OF HYDROPHYTE

Hydrophyte: they grow on extremely wet soil where water is available to plants in abundance. According to the way in which they develop in water.

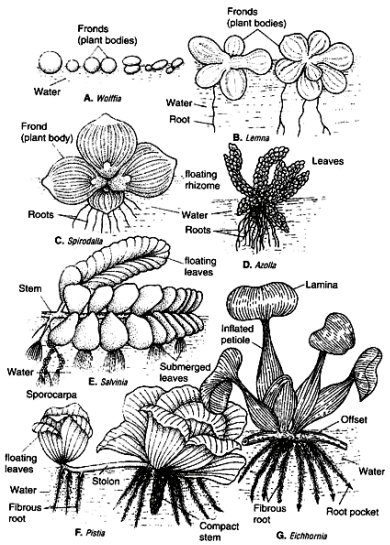
Morphological features:

Roots:

- Roots may be entirely absent as in wolfia, Salvinia and ceratophylum, Ceratophyllum, Salvinia, Azolla, Utricularia etc.
- Root hairs are absent or poorly developed.
- Root caps are poorly absent in *Eichhornia* and these caps are replaced by root pocket.
- Roots, if present are generally fibrous, adventitious, reduced in length, unbranched or poorly branched. In Leena roots act simply as balancing and anchoring organs.
- In there some floating aerial roots also in addition to normal adventitious.
- In Jussiaea repens two types of roots develop when the plants grow on the surface of water, some of them are floating roots which are negatively geotropic having spongy structures. The floating roots keep the plants afloat.

Stem: In aquatic plants, stem is very delicate and green or yellow in colour. In some cases, it may be modified into rhizome or runner, etc.

- In the submerged forms as Hydrilla, Stem is long, Slender, spongy and flexible.
- In Free-floating forms, it may be slender, floating horizontally on water surface as in Azolla



Leaves

- In floating plants leaves are generally long, circular, light or dark green in colour, thin and very smooth. Their upper surfaces are exposed in the air but lower parts are generally in touch with water. In lotus plant petioles of leaves show indefinite power of growth and they keep the laminae of leaves always on the surface of water.
- In submerged forms, leave is thin and are either long and ribbon shaped as in Vallisneria or long and linear as in Potamogeton
- Floating leaves are large, flat and entire as in Nelumbo with their surface coated with wax: their petioles are long, flexible and cover with mucilage.
- Submerge leave are generally translucent.
- Emergent form as Ranunculus and Sagittaria show heterophylly with submerged, floating and aerial leave.

Anatomical modification

Roots

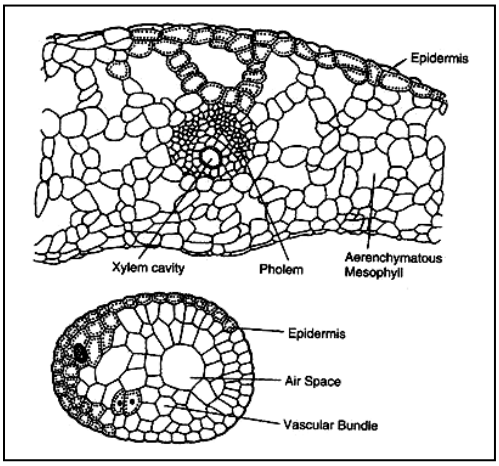
- Cuticle is totally absent in the submerged parts of the plants. It may be present in the form of very fine film on the surfaces of parts which exposed to atmosphere.
- Epidermis is usually single- layered made up of thin walled Parenchymatous cells.
- Epidermis in hydrophytes is not a protecting layer but it absorbs water, minerals and gases directly from the aquatic environment.
- Epidermal cells contain chloroplasts; thus, they can function as photosynthetic tissue, especially where the leaves and stems are very thin, e.g., Hydrilla.
- Hypodermis in hydrophytes is poorly developed. Its cells are extremely thin walled.
- Cortex is well developed, thin-walled and parenchymatous, major portion is occupied by well-developed prominent air cavities as aerenchyma.
- Vascular tissue is poorly developed and least differentiated in submerged form potamogon with thin-walled elements.

Stems –Distribution of various tissues in stems of hydrophytes become clear from transverse section of stem of Hydrilla

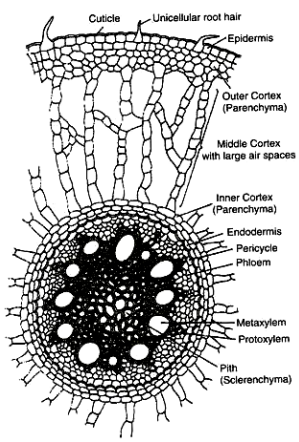
- Cuticle is either absent or poorly developed and thin.
- Epidermis is usually single layered made of thin walled parenchymatous cells.
- Hypodermis is completely absent in submerged forms of hydrilla.
- Cortex is well developed, thin-walled and parenchymatous, extensively transverse by air cavities in roots.
- Endodermis is generally distinct especially in rhizomes and similar organs.
- Vascular bundle generally lacks bundles sheaths.

Leaves:

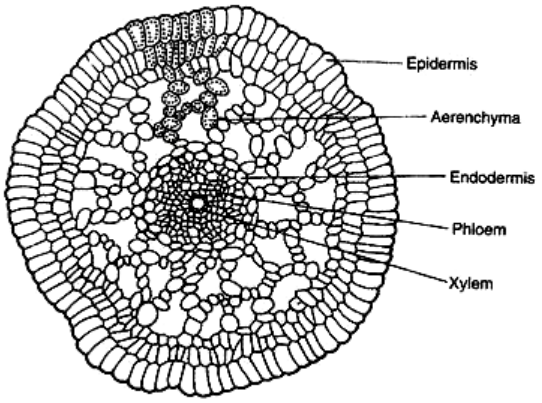
- Cuticle is usually absent in submerged forms as Anacharis and potamogeton. In floating form as Nymphaea, Stomata are confined only to upper surface of leaf.
- Epidermis is singled layered, made of thin-walled cells
- Mesophyll is undifferentiated in submerged leaves.
- Vascular bundle tissues are very much reduced and sometime difficult to differentiated into xylem and phloem as leaves of submerged forms like Anacharis.
- Mechanical tissues are absent.



T.S. of submerged leaves; A. *Vallisneria* and B. *Ceratpphyllum*



T.S. of root of *Typha latifolia* (monocotyledonous) showing air space in cortical region and sclerenchymatous pith



T.S. of *Hydrilla* stem

FOREST FIRE

Forest fire is mostly an anthropogenic phenomenon which burns valuable flora and fauna and sometimes also involves villages and structures. Every year, the world faces extreme wild fires, which affect million hectares of forest leading to effects on biodiversity, ecosystem functioning and landscape stability It is very common in all the ecosystems and plays an important role in ecosystem dynamics, biodiversity, soil and microbes.

Observation-

Segments	Observation way of fire effected sites
Forest tree/ crop	**A. Species:** The tree/ crop species with thick corky bark are comparatively less damaged than those with thin bark. The broad leave tree is less effected than confer tree. **Highly sensitive to Fire** …… …… **Low sensitive to fire** …… ……
	(B) Age of tree/crop: The younger trees, due to low height and lesser diameter, are greatly damaged on account of
	Their height is only up to 5 or 6 m and even normal fire dries them up
	Due to less diameter, the smaller poles get broken down from lower portion of stem.
	(C) Condition of trees/ Crops: the condition pertains to dry or green position of the tree/crops. The dryness or green condition affects the damage by fire. Burning of bark and cambium layer is a usual damage.
	• Rupture in tissues
	• Reduces the volume of sawn timber
	• Fire cause wounds on the stem.
	• Reduces the vitality of stem/tree itself.
	• Tree may liable to attack of insect-pest and fungi.
	• Effect the growth of trees adversely.
Productivity of forest	• The problem of degeneration may be crop up.
	• Replacement of superior quality species from fired site.
	• Having the poor/ less increments in the trees.
	• Declared position of forest.
	• Very less economic returns.
	• Severely effect the micro-organisms in soil.
Regeneration Problem	• Regenerated forests are enormous effected
	• In absence of coppicing power, the regeneration is completely destroyed.
	• The fire in artificial regenerated areas/ or plantations of such species have destroyed.
	• Repeated fire delays the completion of regeneration so much.
	• The area of regeneration is to kept closed to grazing for longer period.
Reduce the protective function of forest	• Protective function of forest against Soil and water erosion.
	• Protective function of forest Catchment of rivers and streams.
	• Protective function of forest as protection of watershed.
Soil and Microorganism	• Soil sustains life and provide shelter to plants and soil micro-organism
	• Ground or surface fire, it destroys all the vegetation
	• In fire area, soil erosion begins resulting in loss of top fertile soil
	• Soil micro- organism are severally affected
	• Disturbance of soil and micro-organism possess several problems to the forest ecosystem and whole system is spoiled
	• De-structure of organic matter effects the soil structure
	• Nitrogen reserves of soil are depleted
	• It makes soil compact and impervious
Air quality	• Smokes effect the respiratory system of wildlife.
	• The smokes come out and spreads the traces of ash on the adjoining vegetation
Wildlife	• The fire effect as burns the eggs
	• It causes destruction of young ones
	• It destroys the habitat the wildlife
	• Ruins the grazing grounds
	• Ash and other impurities mix with of water
Effect of Forest fire	• Due to forest fire, Loss of scenic beauty
	• It creates ugly appearance
	• It gives scary appearance

FOREST TREE SPECIES

Common Name	Botanical Name
Shisham	*Dalbergia sissoo*
Chilbil/Papdi/Kanju	*Holoptelea integrifolia*
Arru	*Ailanthus excelsa*
Safed siras	*Albizzia procera*
Kala siras	*Albizzia lebbeck*
Neem	*Azadirachta indica*
Khair	*Acacia catechu*
Desi babool	*Acacia nilotica*
Reunja	*Acacia leucophlea*
Jungal jalebi	*Pithecolobium dulce*
Vilayti babool	*Prosopsis juliflora*
Kanji	*Pongamia pinnata*
Subabool	*Leucaena leucocephala*
Dhauri/Siddha	*Lagerstroemia parviflora*
Aonla	*Emblica officinalis*
Jamun	*Syzygium cumini*
Arjun	*Terminalia arjuna*
Bel	*Aegle marmelos*
Lasoda	*Cordia mixa*
Asna	*Terminalia alata*
Harra	*Terminalia chebula*
Salai	*Boswellia serrata*
Desi babool	*Acacia nilotica*
Dhak	*Butea monosperma*
Gamhar	*Gmelina arborea*
Haldu	*Adina cordifolia*

Jhinghan	*Lannea coromandelica*
Baurang/Bhurkul	*Hymenodictyon excelsum*
Kusum	*Schleichera trijuga*
Dhau	*Anogeissus latifolia*
Karar/Kurlu	*Sterculia urens*
Kardhai	*Anogeissus pendula*
Khaja/Kasai	*Bridelia retusa*
Kaitha	*Feronia limonia*
Phaldu/Kaim	*Mitragyna parvifolia*
Chiokar	*Prosopis spicigera*
Tendu	*Diospyrous melanxylon*
Kathsagon	*Haplophragma adenophyl*lum
Piyar/Chironji	*Buchanania lanzan*
Padal	*Stereospermum suaveolens*
Domsal/Kari	*Miliusa velutina*
Pula/Kapsa	*Kydia calycina*
Kala kikar	*Acacia ferruginea*
Duddhi/Kurraiya	*Holarrhena antidysenterica*
Parsidhha	*Hardiwickia binata*
Bakain	*Melia azedarach*
Vijaisal	*Pterocarpus marsupium*
Bahera	*Terminalia belerica*
Mahua	*Madhuca indica*
Ber	*Zizyphus mauritinia*
Sonjhari	*Acacia auriculiformis*

SHRUB/HERB/CLIMBER & CREEPER SPECIES:

Common Name	Botanical Name
Satawar	*Asparagus racemosus*
Aloe vera	*Aloe barbadensis*
Adusa	*Adhatoda vesica*
Karaunda	*Carissa spinarum*
Kareel	*Capparis deciduas*
Jharberi	*Zizyphus nummularia*
Thuhar/Senhur	*Euphorbia nivulia*
Nagphani	*Opuntia dilloni*
Safed madar	*Calotropis procera*
Dhatura	*Datura somnifera*
Kareel/Tenti	*Capparis deciduas*
Gokhru	*Tribulus terrestris*
Peelu	*Salvadora persica*

Jangli pyaj	*Urginea indica*
Nirgundi	*Vitex nirgundi*
Hingota	*Balanites aegyptica*
Giloe	*Tinospora cordifolia*
Shikakai/Aila	*Caeselpenia dicapetala*
Ashwagandha	*Withania somnifera*
Safedmusli	*Chlorophytum tuberosum*
Kalimusli	*Curcuma orchioides*
Gurmar	*Gymnema sylvestre*
Kalmegh	*Andrographis paniculata*
Nirgundi	*Vitex negundo*
Harjor	*Cissampelos pareira*
Mulethi	*Glycyrrhiza glabra*
Brahmi	*Bacopa monerii*

GRASS SPECIES

Common Name	Botanical Name
Khus grass	*Vetiveria zizanoides*
Citronella grass	*Cymbopogon winterianus*
Lemon grass	*Cymbopogon flexuosus*
Dinanath	*Dicanthium annulatum*
Anjan	*Cenchrus ciliaris*
Stylo	*Stylosanthes hamata*
Ghamur	*Panicum antidotale*
Doob	*Cynodon dactylon*

Gurla/Chikuwa	*Chrysopogan fulvus*
Palmarosa/Jarakus/ Raathar	*Cymbopogon martinii*
Kush	*Desmostachya bipinnata*
Parwa	*Heteropogan contortus*
Chota pakhwa	*Aristida hystricus*
Babru	*Sorghum halepense*
Donda	*Dichanthium annulatum*

FOREST ECOSYSTEM

Abiotic component: These are the inorganic substance present in the soil and atmosphere. In addition to mineral present in forest. We find the dead debris---litter accumulation, chiefly

Biotic component: The living organisms present in the food chain occur in following manner

Producer – these are mainly tree that show much species diversity and greater degree of stratification, find in tropical moist deciduous forest. There are also present shrubs and grass species on forest floor.

In Bundelkhand region member flora, **the producers** are such as trees as follows

Common Name	Botanical Name
Shisham	*Dalbergia sissoo*
Chilbil/Papdi/Kanju	*Holoptelea integrifolia*
Arru	*Ailanthus excelsa*
Safed siras	*Albizzia procera*
Kala siras	*Albizzia lebbeck*
Neem	*Azadirachta indica*
Khair	*Acacia catechu*
Desi babool	*Acacia nilotica*
Jungal jalebi	*Pithecolobium dulce*
Vilayti babool	*Prosopsis juliflora*

Kanji	*Pongamia pinnata*
Subabool	*Leucaena leucocephala*
Arjun	*Terminalia arjuna*
Bel	*Aegle marmelos*
Harra	*Terminalia chebula*
Salai	*Boswellia serrata*
Desi babool	*Acacia nilotica*
Dhak	*Butea monosperma*
Tendu	*Diospyrous melanxylon*
Piyar/Chironji	*Buchanania lanzan*

Consumers

Primary consumers.

Size	Nature of feeds	Primary consumers.
Micro organism	feeding on tree leave	Ants, flies, beetles, leafhoppers, bugs and spider
Macro-organism (large animals grazing)	Feeds on shoots and fruits of the producer	Elephant, nilgai, deer, moles, squirrels, shrews, flying foxes, fruit bats mongooses.

Secondary consumers

Primary consumer as feeds materials	Secondary consumers as
Rat	snakes,
beetles, leafhoppers, bugs	birds,
Ants, flies	lizards

Decomposers: Rate of decomposition in tropical and subtropical forest more rapid than in Temperate one.

micro-organisms	Example
Fungi species	*Aspergillus, Coprius, Polyporus, Ganoderma, Fusarium, Alternaria Trichoderma etc.*
Bacteria species	*Bacillus, Clostridium, Pseudomonas and Angiococcus*

CROPLAND ECOSYSTEM

The ecosystem is natural in the sense that all operate as self –regulating system without direct interference and manipulation by the man on the way. When man is very much involved in their operation as called Cropland ecosystem. A cropland ecosystem is an artificial ecosystem having the aim primarily to grow a single species of one's choice**.**

Abiotic component: These are the inorganic substance present in the soil and atmosphere. In addition to mineral present in forest. We find the dead debris-litter accumulation, chiefly

Biotic component: The various living organism in food chain in Maize cropland ecosystem occurs

Producers: The dominant plant species would naturally be *Zea mays*. Beside maize, a number of weeds like *Cynodon dactylon, Launea nudicaulis, Euphorbia hirta, Cyperus rotundus, Digitaria* spp. *Alysicarpus* sp. Also contribute to primary production of the field.

Consumer:

Primary consumers: These are the herbivores represented a variety of animals, big as well as small.

Name of primary consumer	Nature of foods
Aphids. Thrips, beetles	Feed and lay eggs on leave
Rabbit, rats, birds, and man	Feeding on maize

Secondary consumers: These are carnivores like frogs and some birds that eat insect.

Tertiary consumers: These are carnivores like snake and hawk which feed on secondary consumers frog and smaller birds.

Decomposers: These are microbes present in soil as well as air, that decompose the dead matter of plant and animals these are bacteria, actinomycetes, and fungi, responsible for decay, decomposition and humidification, making the minerals available again to the producers

HYDROSERE

Hydrosere originating in a pond starts with the colonization of some phytoplankton which is pioneer plant community, and finally terminates into forest, which is a climax community together with component of vegetation.

Phytoplankton stage.

- They constitute the pioneer community.
- Blue green algae, diatoms and bacteria etc are the first organisms to colonise the primitive medium of the pond
- The soil is very much reduced with a pH value of not more than 5.00.

- They grow multiple and grow for some time.

Rooted submerged stage:

- As the result of death and decomposition of phytoplankton and their mixing with the silt, brought from surrounding land by rain water and by wave action of pond water.
- There is develop a soft mud at the bottom of the pond.
- This new habitat which tends to be a bit shallower and where light penetration may be now occur easily becomes now easily become now suitable for growth of the root submerged hydrophytes example- Hydrilla Myriophyllum, and Elodea.
- These plants bring about further build-up of the substratum as a result of their death and decay.
- When the water level, decrease making the pond shallower.
- This new habitat is replacing these plants way to another type of plants which are floating leave type.

Rooted floating stage:

- Water depth is almost 2- 5 feet.
- These plants colonise the habitat with rhizomes.
- They all are rooted hydrophytes with their large leave floating on water surface
- Example Nelumbo, Aponogeton, Trapa and Monochora.
- Free floating species as Azolla, Lemma wolffia, Pistia and spirodella are also become associated with rooted plants due availability of salt and other minerals in abundance.
- Due the shallowness of pond, the decomposition of organic matter formed due to death of these plants bring about further build the substratum.

Thus, floating species sooner or later disappear from the area.

Reed- swamp stage

- In this stage, plant community are rooted but most parts of their shoots remain exposed to air e.g., Typha, Scirpus and phragmites.
- They have developed the rhizome and form a dense vegetation.
- The water level is by now very much reduced and finally becomes unsuitable for the growth of amphibious.

Sedge-meadow stage:

- Due to successive decrease in water level and further change in substratum, the species like Carex, Juncus and Eleocharis colonise the area.
- They form a mat like vegetation towards the centre of pond with help of their much-branched rhizomatous system.
- AS the high rate of transpiration, there is much rapid loss of water and sooner or later the mud is exposed to air as a result of which nutrients like ammonia and sulphide become oxidised to nitrates and sulphates.

Thus, mesic condition approaches the area and marshy vegetation disappears gradually.

Woodland stage:

- By the time of disappearance of marshy vegetation, Soil become drier for most of the time of year.
- This area is now invaded by terrestrial plants Example Salix and cornus as shrub and Populus and Almus as tree.
- By this time, there is much accumulation of humus with rich flora of micro-organism.

Thus, mineralisation of the soil favours the arrival of new tree species in the area.

Forest stage:

- This is the climax community.
- The woodland community is rapid invaded by several trees.
- In tropical climate with heavy rainfall, there develop tropical rain forest.
- In temperate regions there develop mixed forest forests of *Almus, Acer and Quercus.*
- In region of moderate rainfall, there is develop tropical deciduous forest or monsoon forest.

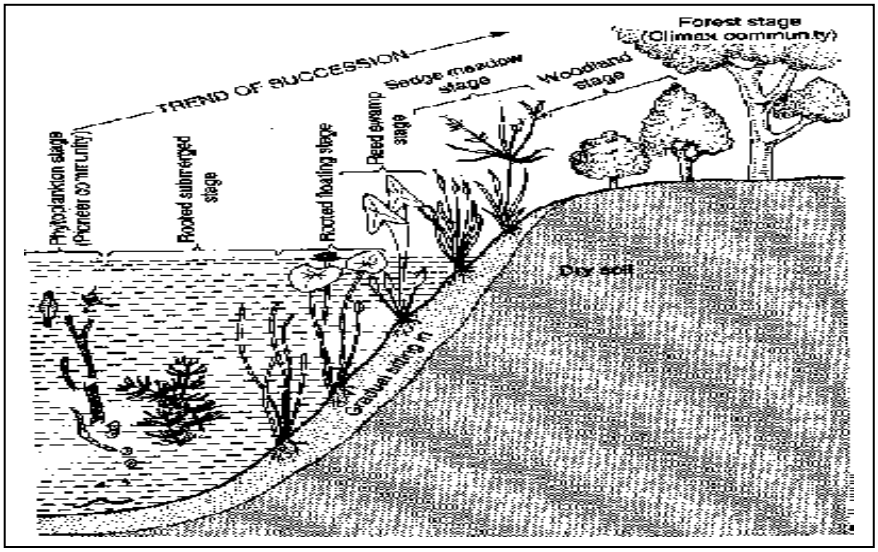


Diagram showing different plant communities appearing at different stage of hydrosere in a pond (the gradual decrease in water level and successive development of the soil in area to give finally a terrestrial habitat for forest community)

XEROSERE

Xerosere originating on bare rock surface the original substratum is deficient in water and lacks of organic matter, having only minerals in disintegrated unwanted state, the pioneer to colonise this primitive substratum is crustose type of lichens and through a series of successive seral stage of succession finally terminates into forest which constitute the climax community. The succession initiating from the dry land is called as Xeroarch. Xeroarch or Xerosere is further categorized

into Lithosere, defined as the succession sequence which begins from the rock surfaces. The succession sequence in the growth and development of lithosere community includes following stages

Crustose Lichens stage:

- In this stage, the substratum colonized by this pioneer is very poor in moisture and organic matter, subjected to extreme temperate.
- The pioneer community is composed of lichens species such *as Rinodina, Rhizocarpon and Lacanorma*. This stage is also called as **Crustose** and the species of this stage can tolerate desiccation.
- These above-mentioned species produce acids which bring about weathering of rocks.
- The dead organic matter of lichens becomes mixed with the small particle of rock.

However, this process is very slow. These lichens are then replaced by foliose lichens,

Foliose lichen stage:

- This initial formation of soil in depressions of rocks supports the growth of lichens called **foliose lichens** such as, *Parmelia Dermatocarpon* etc., which have large leaf like thalli.
- The above lichens species can absorb and remain water and are able to accumulate dust particles which help in the further buildup of the substratum.
- These above newly invaded foliose lichens aggregate more soil particles as well as water leading to formation of thin soil layer on rocks.

Moss stage:

- The development of thin soil on rock surface especially in the crecices, favours the growth of some xerophytic mosses.
- *Grimmia and Polytrichum* are the moss which invades in an area due to the thin layer of soil on rock surfaces.
- After some time, these mosses will accumulate more soil particles, water and organic matter and leads to colonization of moisture loving mosses such as *Bryum, Hypnum* etc. and thus called as moss stage of succession.
- After their successful growth, they compete with lichens.
- Due to death and decay, there is further addition of organic matter in the soil.

And, the thickness of soil layer now increases.

Herb stage:

- Moss when decomposed into organic matters forming a mat over fragmented rock and provide a substratum for the seed germination of annual grasses such as *Aristicla, Eleusin, Poa* etc.
- The death and decay of these grasses leads to replacement of the vegetation by perennial grasses such as *Heteropogon, Cymbopogon* etc.
- Invasion of small animals were also encountering at his stage of succession.

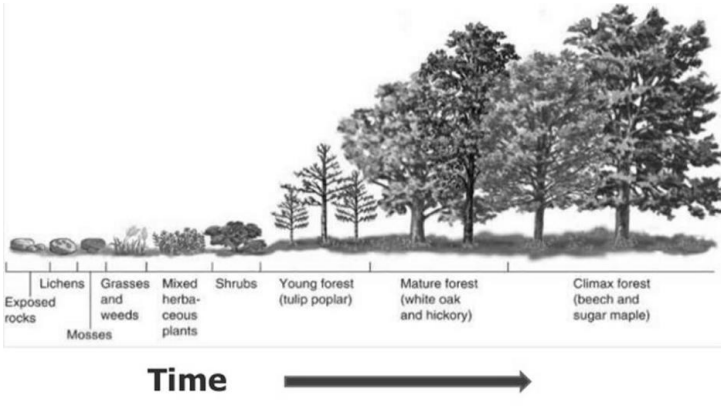
Shrub stage:

- Due to much accumulation of soil,the habitat becomes suitable for shrubs which migrating in the area.
- Colonization of shrub such as *Zizyphus, Caparis and Rhus* are favourable of rock weathering and mineralization.
- Shrubs are larger than herbs in size with deep root penetration and further leading to soil formation *via* rock weathering.
- The soil is further enriched by the dense shrubby growth. these in turn are finally replaced by trees which makes climax community.

Forest stage:

- The environmental is now favourable for the colonization of hard and stunted trees requiring sunlight for growth.
- Mesophytic type of vegetation is supported by the environmental factors and thus leads to an equilibrium, stable and steady state of succession between biotic community and environment.

There develops finally a forest community,



Ecological Succession – The progressive change in species composition of an ecosystem over time

Different stage of Lithosere/xerosere

FOREST COMPOSITION

Forest composition refers to all plant species found in a stand or landscape, including trees, shrubs, forbs, and grasses. It also refers to forest communities at the stand or landscape level whose canopies may be dominated by a single tree species or contain a mixture of species.

Objective: the main objective of study forest composition is to study the effect of anthropogenic activity on the composition of forest of that area;

Classification of forest base on composition: On the basis of the number of species present, the forest is classified into –

1. **Pure forest:** Pure forest is defined as a forest composed of almost entirely of one species, usually to the extent of not less than 80%. It is called pure crop or stand.
2. **Mixed forest:** Mixed forest is defined as a forest composed of trees of two or more species intermingled in the same canopy; in practice, and by convention, at least 20% of the canopy must consist of species other than principal one. the species composing the mixture may be distinguished as principal, accessory and auxiliary.
   a) **Principal species:** the species first in importance in a mixed stand either by frequency, volume or silviculture value.
   b) **Accessory species:** a useful species of less value than the principal species, which assists in the growth of the latter and influences to a smaller degree the method of treatment.
   c) **Auxiliary species:** a species of inferior quality or size, of relatively little silvicultural value or importance, associated with the principal species.

MINIMUM SIZE OF QUADRAT

Required material: A piece of string, scale and four nails hammer, graph sheet, Herbarium sheet cello tape.

Procedure: With the help of string piece and three nails make a 'L' shaped structure in the field. With another piece of string and a nail make a squire of an area of 10 x 10 cm^2. Note down the various species present within the area. Now increase the area to 20 x 20 cm^2 and Note down the number of species present in this area. Thus, go on increasing the area i.e., 30 x 30 cm^2; 40 x 40 cm^2 and so on (As shown in fig.) each time recording the number of species occurring in that area. Continue the process till there is no further increase in the total number of species with the increase in size of the Quadrat. Fix specimen of each species recorded on the herbarium sheet. This is to be done in all the exercises that follow in the study of structure of community.

Preparation of "Species-Area curve": Take a graph sheet and plot the number of species on Y-axis and against the area X- axis as shown in the figure. Thus, a curve would be obtained, known as Species -area curve. Note the point at which this curve starts flattering up (as shown with the mark in figure (B). From this point find out the area of the Quadrat that would be the minimum size of the Quadrat to be taken for further study.

MINIMUM NUMBERS OF QUADRAT

Quadrat of definite size (Minimum size as determined in previous exercise), graph sheet herbarium sheet & cello tape.

Procedure: Lay down 25 to 50 Quadrat of the definite size randomly in the field at different sites. List down the different Species present in each quadrat as shown in the given table. With the help of data in the table, find out the accumulating total of the no. of species for each quadrat. Now, take graph sheet and plot the no. of quadrat on x-axis against accumulating total no. of species on y-axis. A curve would be obtained and at the point at which the curve starts flattering up would give the minimum no. of quadrat to be laid down in the field.

ECOLOGICAL POPULATIONS

A **population** is a set of individuals of the same species living in a given region or habitat. Populations are examples of ecological systems. As such, they exhibit both structural and functional properties.

key traits of population structure

- Total number of individuals in a population
- Age distribution of those individuals
- Sex ratio of adults
- Probabilities of survival (or mortality)
- Rates of fecundity

Life history tables, or life tables: These are a method of quantifying population structure that addresses all of the above population traits. Life tables provide age-specific information on survival and fecundity rates for a particular population. An ecologist can collect two very different types of life history data for individuals in a population.

Horizontal (dynamic or cohort) life tables require ecologists to follow all the individuals of a single cohort in a population from birth to death. Construction of horizontal life tables frequently depends on the recapture of marked individuals for mobile species or repeated, representative samples of sessile species. Since individuals must be followed from birth to death, the horizontal life table technique is not well suited for the study of long-lived individuals.

Observation:

Anatomy of life tables: A life history table contains information on age classes (x), the total number of individuals in each age class (n(x)), survival rates for each age class (l(x)), fecundity rates for each age class (b(x)), and the number of offspring produced per individual at each age class (l(x)*b(x) and l(x)*b(x)*x). The following is an example of a **horizontal life table:**

Age in Month X	Number/Age class N(x)	Survival rate l(X)	Fecundity b(X)	Offspring/indiv. l(X) * b(X)	Age-weighted fecundity l(X) * b(X)*X
0	134	1.000	0.00	0.00	0.00
1	117	0.873	0.00	0.00	0.00
2	82	0.612	6.28	3.84	7.69
3	64	0.478	9.60	4.59	13.76
4	52	0.388	12.10	4.70	18.78
5	43	0.321	13.60	4.36	21.82
6	23	0.172	17.40	2.99	17.92
7	13	0.097	13.50	1.41	9.85
8	3	0.022	15.00	0.34	2.69
9	2	0.015	0.00	0.00	0.00
10	1	0.007	8.30	0.06	0.62
11	0	0.000	5.00	0.00	0.00
SUM				22.28	93.13
		R0 22.28 offspring **G** 4.18 months **R** 0.74 ind/month **Optimal age for sexual maturity** 5 months			

Calculation: When using cohort information, calculate the **survival rate for an age class (l(x))** as the number of individuals in that age class (n(x)) divided by the number of individuals alive in the first age class [n(0)]. In the above table, survival at age class 0 (l(0)) is n(0)/n(0) or 134/134 = 1.000.

At age class 1, l(1) = n(1)/n(0) or 117/134 = 0.873.

Next, use the provided fecundity data to calculate the offspring produced per individual

in each age class (l(x)*b(x)) and the age-weighted number of offspring for each age class (l(x)*b(x)*x). Once the horizontal life table is completed, you can calculate the net reproductive rate (R0), mean generation time (G), and intrinsic growth rate (r) of the population.

Net reproductive rate (R0) is the sum of the l(x)*b(x) column. It represents the expected number of offspring an individual will produce over its lifetime in the population.

If R0 >1, then population size increases. If R0 < 1, then population size decreases, and if R0 = 1, then population size does not change. In the population described by the horizontal life table above, an individual is expected to produce 22.28 offspring over its lifetime.

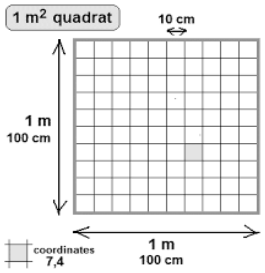
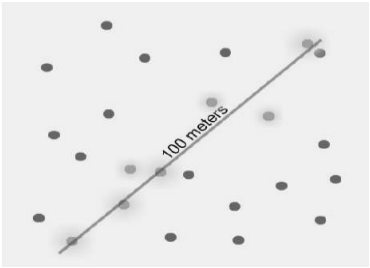
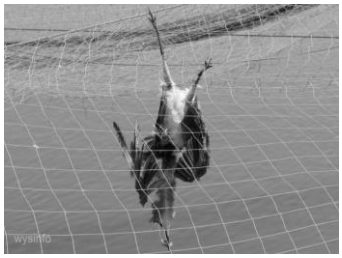
Mean generation time (G) is the sum of the l(x)*b(x)*x column divided by the net reproductive rate (R0). The intrinsic growth rate (r) is an estimate of population growth; it is equal to the natural log of the net reproductive (R0) divided by the mean generation time (G): $r = \ln(R0) / G$.

The optimal age for sexual maturity in the population corresponds to the age class with the greatest age-weighted fecundity (l(x)*b(x)*x).

MEASUREMENT OF DIVERSITY OF PLANTS AND INSECT (Biodiversity)

Biodiversity: It is the number and variety of organisms found in a specific c region. Part of biodiversity also includes the variety of Earth's ecosystems. In order for biodiversity to remain high, diverse ecosystems need to remain sustainable. Recall that nutrients and energy cycle through ecosystems, and that what happens in one ecosystem can affect cycles in other ecosystems and in Earth's three other spheres. Preserving and protecting individual species and the ecosystems they inhabit are critical to maintaining biodiversity on Earth.

Various methods	Picture
Canopy fogging 1. Canopy fogging is an effective way of collecting information about the biodiversity of insects. 2. low dose of insecticide is sprayed up into the top of a tree. When the insects fall, they are collected on a large screen, shaped like a funnel. 3. Scientists may keep and observe some insects. 4. It is helps scientists learn more about the life cycle of these insects.	

Quadrat sampling 1. Quadrat is a known square area that is marked using a pre-made square of plastic, or stakes and string. 2. Quadrats can range in size from 1 m^2 to 20 m^2, depending on the type of habitat surveyed. 3. Different species and their numbers within the quadrat are counted. 4.Counting is repeated many times in different places throughout the habitat to get an accurate representation of biodiversity.	
Transect sampling 1.Transect sampling is done using a transect line. 2. transect line is usually a rope or measuring tape that has been marked at set intervals, such as every metre. **3.**The line is unrolled within the habitat. At every interval, the type and number of species along the line are recorded.	
Netting Line mesh nets are used to capture birds and bats in terrestrial ecosystems, and fish and other organisms in aquatic ecosystems. 1. captured, an organism is identified. 2. addition, it may be measured, blood may be taken for genetic analysis, and it may be tagged. 3. In many cases, the organism is then released.	

PLANT DIVERSITY

To study the status of plant diversity in RLBCAU, Jhansi, campus. Area is divided into different aspects (North, South, East and west). In each aspect 10 quadrates of size 10 m × 10 m for trees were laid out randomly Within each quadrate (10 m × 10 m), one sub-quadrates of size of 5 m × 5 m for shrubs and 1 m × 1 m for herbs were laid out. Density of trees was calculated by counting trees in each sample plot. Diameter of each tree in the sample plot was determined by tree calliper or tap. Density of shrubs was calculated by counted plants of different species in each sub-plot. The diameter of shrub was calculated by using digital calliper. While in case of herbaceous vegetation, each quadrate was segregated species wise and identified with the help of herbarium at IGFRE and Forestry experts, FRI Dehradun scientists, Journals and research books.

Parameters which are studied under floristic composition assessment are:

Basal Area (m^2 ha^{-1})

The cross-sectional area of shrubs and herbs falling in the recording unit was determined by the formula as below:

Basal area = $\pi d^2/4$ …….. (1)

Where: d = Diameter

***Per cent frequency (% F)*:** This term refers to the degree of dispersion of individual species in an area and usually expressed in terms of percentage occurrence. It was studied by sampling the study area at several places at random and recorded the name of the species that occurred in each sampling units. It is calculated by the equation:

$$\text{Percent frequency (\% F)} = \frac{\text{Number of quadrates in which the species occurred}}{\text{Total number of quadrates studied}} \times 100 \text{ ----- } \ldots\ldots\ldots\ldots \text{ (2)}$$

***Density (No. ha^{-1})*:** Density is an expression of the numerical strength of a species where the total number of individuals of each species in all the quadrate is divided by the total number of quadrate studied. Density is calculated by the equation:

$$\text{Density (D)} = \frac{\text{Total number of individuals of a species in all quadrates}}{\text{Total number of quadrates studied}} \text{ --------- (3)}$$

***Importance value index (IVI)*:** This index is used to determine the overall importance of each species in the community structure. In calculating this index, the percentage values of the relative frequency, relative density and relative dominance

are summed up together and this value is designated as the Importance Value Index (IVI) of the species (Curtis, 1959).
IVI = Relative Basal Area (RBA) + Relative Density (RD) + Relative Frequency (RF) - (4)

Relative density: Relative density is the study of numerical strength of a species in relation to the total number of individuals of all the species and can be calculated as:

$$\text{Relative density (RD)} = \frac{\text{Number of individuals of the species}}{\text{Number of individuals of all species}} \times 100 \quad \text{--------- (5)}$$

Relative frequency: The degree of dispersion of individual species in an area in relation to the number of all the species occurred.

$$\text{Relative Frequency (RF)} = \frac{\text{Number of occurrences of the species}}{\text{Number of occurrences of all species}} \times 100 \quad \text{--------- (6)}$$

Relative dominance (Relative basal area): Dominance of a species is determined by the value of the basal cover. Relative dominance is the coverage value of a species with respect to the sum of coverage of the rest of the species in the area.

$$\text{Relative basal area (RBA)} = \frac{\text{Total basal area of a species}}{\text{Total basal area of all the species}} \times 100 \quad \text{--------- (7)}$$

The total basal area was calculated from the sum of the total diameter of immerging Stems. In trees, poles and saplings, the basal area was measured at breast height (1.37m) and by using the formula πr^2, but in case of herbaceous vegetation it was measured on the ground level by using calipers.

PARAMETER WHICH ARE STUDIES UNDER DIVERSITY INDICES

Similarity (S) and dissimilarity (D) indices: Indices of similarity (S) and dissimilarity (D) were calculated by using formulae as per Mishra (1989) and Sorensen (1948).

$$\textbf{Index of Similarity (S)} = \frac{2C}{A+B} \quad \text{--------- (8)}$$

Where, A = Number of species in community A
B = Number of species in community B
C = Number of common species in both the communities

$$\text{Index of Dissimilarity (D)} = 1-S \quad \text{--------- (9)}$$

Species richness, diversity and dominance indices: The Species richness was calculated by using the method 'Margalef's index of richness' (D_{mg}) (Magurran, 1988)

$$D_{mg} = (S-1) / \ln N \quad \text{--------- (10)}$$

Where, S = Total number of species.
N = Total number of individuals per hectare.

Species diversity and dominance were evaluated by using the following methods. Shannon's diversity index and Simpson's index of dominance was calculated using important value index (IVI) of the species.

Shannon-Wiener (1963) Index of diversity: The formula for calculating the Shannon-weaver Index of diversity is

$$H = -\sum pi \ln pi \quad \text{--------- (11)}$$

Where, H = Shannon Index of diversity
pi = the proportion of important value of the i^{th} species
(pi = ni/N, ni is the important value index of i^{th} species and N is the important value index of all the species).

Simpson (1949) index of dominance: The equation is used to calculate Simpson's index was

$$D = \sum (pi)^2 \quad \text{--------- (12)}$$

Where, D = Simpson index of dominance.
Pi = The proportion of important value of the i^{th} species (pi = ni/N, ni is the important value index of i^{th} species and N is the important value index of all the species).

POPULATION

Population is a set of individuals of a particular species, which are found in a particular geographical area.

Population ecology is the study of populations in relation to the environment, including environmental influences on **population** density and distribution, age structure, and **population** size.

The population that occupies a very small area, is smaller in size, such a population is called local population. A group of such a closely related local population is called meta-population.

Population Attributes:

Population Size or Density: It is the number of individuals of a species per unit area or volume

$$\text{Population Density (PD)} = \frac{\text{Number of individuals in a region (N)}}{\text{Number of unit area in the region (S)}} \text{PD} = \frac{N}{S}$$

Birth Rate (Natality): It is the rate of production (birth rate) of new individuals per unit of population per unit time. For example, if in a pond, there are 20 lotus plants last year and through reproduction, 8 new plants are added, taking the current population to 28. Then, birth rate = 8/20 = 0.4 offspring per lotus per year.

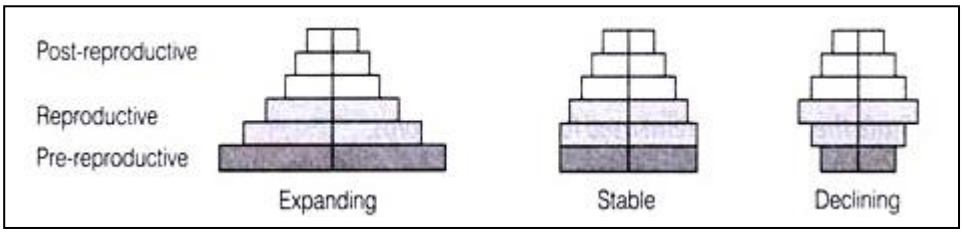
Death Rate (Mortality): It is the rate of loss of individuals (death rate) per unit time due to death or due to the different environmental changes, competition, predation, etc. For example, if individuals in a laboratory population of 40 fruit flies died during a specified time interval. Then, the death rate = 4/40 = 0.1 individuals per fruit fly per week.

Sex Ratio: An individual is either a male or a female but a population has a sex ratio like 60% of the population are females and 40% are males.

Age Pyramid: Population at any given time is composed of individuals of different ages. When the age distribution (per cent individuals of a given age or age group) is plotted for the population, this is called age pyramid.

The age pyramids of human population generally show the age distribution of males and females in a combined diagram. The growth status of the population is reflected by the shape of the pyramids.

(i) Expanding
(ii) Stable
(iii) Declining.



Representation of age pyramids for human population

Population Growth: The size of a population for any species is not a static parameter, it keeps changing with tim. There are following two models of population growth:

Exponential Growth: Availability of resources (food and space) is essential for the growth of population. The unlimited availability results in population exponential. The increase or decrease in population density (N) at a unit time period (t) is calculated as (dN/dt)

Let dN/dt = (b – d) XN
Let (b-d) = r, then, dN/dt = rN

Where, N is population size, b is birth per capita, d is death per capita, t is time period and r is intrinsic rate of natural increase.

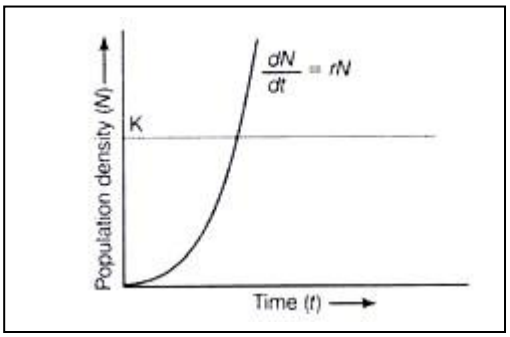
r, is an important parameter that assess the effects of biotic and abiotic factors on population growth. It is different for different organisms.

It is 0.015 for Norway rat and 0.12 for flour beetle. The above equation results in J-shaped curve as shown in graph.

Integral form of exponential growth is $N_t = N_0 e^{rt}$

Where,

N_t = Population density after time t,
N_0 = Population density at time zero (beginning),
r = Intrinsic rate of natural increase,
e = Base of natural logarithms (2.71828).



Population growth curve showing exponential growth

Any species growing exponentially under unlimited resource conditions, without any checks can reach enormous population densities in a short time.

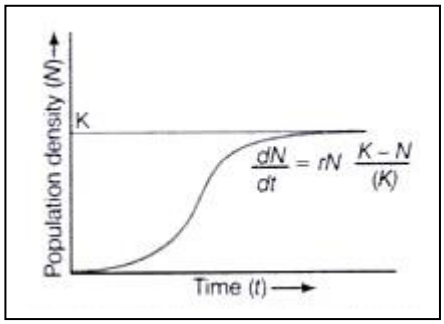
Logistic Growth: Practically, no population of any species in nature has unlimited resources at its disposal. This leads to competition among the individuals and the survival of the fittest. Therefore, a given habitat has enough resources to support a maximum possible number, beyond which no further growth is possible.

This is called the carrying capacity (K) for that species in that habitat. When N is plotted in relation to time t, the logistic growth shows sigmoid curve and is also called Verhulst-Pearl Logistic Growth and is calculated as

$dN/dt = rN (K – N/K)$

Where, N is population density at time t K is carrying capacity and r is intrinsic rate of natural increase.

This model is more realistic in nature because no population growth can sustain exponential growth indefinitely as there will be completion for the basic needs.



Population growth curve showing logistic growth

Human population growth curve will become S-shaped, if efforts are being made throughout the world to reduce the rate of population growth and make it stationary.

Population Interaction in the Ecosystem: The environment consists of both abiotic (physical) and biotic (biological) factors. Nutrients in the soil, carbon dioxide, water, temperature, atmospheric pressure, wind and osmotic balances are some of the physical aspects required for a living being. Along with these abiotic factors of the ecosystem, the population can be very much affected by their interactions.

Following are the main modes of interaction between populations.

Competition: As the name suggests, it is a relationship when two or more species compete for the same limited resources at the same time, which may be food, water, light, or any prey. All these things are crucial for any organism's growth and survival.

Predation: This is a relationship where one species depends entirely on the other for its food and survival. The species which feeds on other species is called predator whereas the one that is fed upon is called the prey. This entire relationship is called Predation.

Predator is usually stronger than the prey, and hence it consumes preys during its entire life cycle. In some food chains and food webs, a predator can also fall prey as all living organisms develop a kind of defense mechanisms after a certain period of time. The words 'predator' and 'prey' are not always limited to animals. They are implied on the relationship between animals and plants as well. For example – rabbit feeding on carrot, bear eating berry and grasshopper and leaf.

Camouflage: Camouflage literally means 'to disguise'. It is the phenomena where an organism or a species develops structural adaptation that helps them to blend with their surroundings is known as camouflage. This helps them avoid getting detected by predators.

Symbiosis: It is a Greek term which means "living together." In various relationships among two or more species or organisms, both the parties depend on each other for food and survival. It is a relationship where one organism lives on another with mutual stereotypic behavior.

There are three types of Symbiosis:

Mutualism: Where both species are benefitted. It is the ecological interaction between two or more species where each species is benefitted from the other. It is the most common type of ecological interaction and describes that mutual dependence is necessary for social well-being. It is dominant in most of the communities worldwide.

Commensalism: Where one species benefits without harming the other. This is a type of ecological interaction where one organism is benefitted from the other organism without harming or benefitting it e.g., cattle egrets and livestock, birds following army ants, barnacles and whales, etc. all exhibit commensalism.

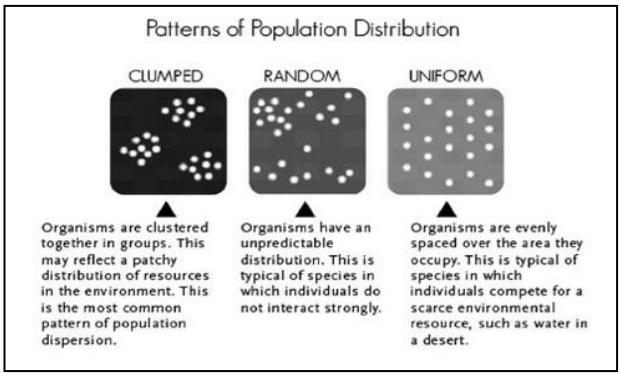
Parasitism: Where one species benefits by harming the other. Parasitism is a one-sided symbiosis, where one organism lives on or in another organism. The one that feeds on the other organism is called the parasite whereas the one that is fed upon is called the host. The parasite survives and multiplies using the host cell machinery and therefore, harms the host.

POPULATION DISPERSION

The spatial distribution at any particular moment of the individuals of a species (typically plant or animal). Under natural conditions, organisms are distributed either by active movements, or migrations, or by passive transport by wind, water, or other organisms. The act or process of dissemination is usually termed dispersal, whereas the resulting pattern of distribution is best referred to as dispersion.

Dispersion is a basic characteristic of populations, controlling various features of their structure and organization. It determines population density, that is, the number of individuals per unit of area, or volume, and its reciprocal relationship, that is, mean area, or the average area per individual. It also determines the frequency, or chance of encountering one or more individuals of the population in a particular sample unit of area, or volume. Therefore, ecologists study not only the

fluctuations in numbers of individuals in a population, but also the changes in their distribution in space. Individuals may be distributed in a uniform, random, or clumped **pattern**. Uniform means that the **population** is evenly spaced, random indicates random spacing, and clumped means that the **population** is distributed in clusters.



BIODIVERSITY CONSERVATION ORGANIZATIONS

There are a number of international and national organizations, agencies and programmes in different aspects of environment, forestry, wildlife and other related fields. Some of the important bodies of them are given below:

Earth scan: It is an agency developed by UNEP in 1976 which commissions original articles on environmental matters and sells them as popular features to newspapers and magazines, especially in developing countries.

Convention on International trade in Endangered Species (CITES): It is an international forum, whose membership for agreement is open to all nations. For India, the Ministry of Environment & Forest acts as nodal agencies for participation in such type of International agreement.

Environmental Protection Agency (EPA): This is an independent federal agency of the United State Government established in 1970. It deals with protection of environment by air, water, solid wastes, radiation, pesticides, noise etc.

European Economic Community (EEC): It is a community of 12 European countries, with political, economic and legal base. The community has joint agricultural, scientific environmental and currency programmes among the members. It has also programmed of farming and implementation of coordinated policy for environmental improvement and conservation of natural resources. India has recently taken up a EEC funded project on air quality monitoring.

Human Exposure Assessment Location (HEAL): This project is a part of Health-Related Monitoring Programme funded by WHO in cooperation with UNEP. This project has three components viz. (i) air monitoring (ii) water quality monitoring (iii) food contamination monitoring on a global basis.

International Council of Scientific Union (ICSU): It is an NGO, situated in Paris, that encourages the exchange of scientific information, initiates programmes requiring international scientific co-operation and studies reports on matters related to social and political responsibilities in treatment of scientific community.

International Union for the Conservation of Nature and Natural Resources (IUCN)

IUCN is an autonomous body established in 1948, with its Headquarters at Morges (Switzerland) that initiates and promotes scientifically based conservation measures. It also cooperates with UN and other intergovernmental agencies and with sister bodies of World Wildlife fund (WWF).

International Marine Consultative Organization (IMCO): This Organization regulates the operation of ships from marine water pollution viewpoint.

South Asia Co-operative Environment Programme (SACEP): It is recently set-up programme for exchange of professional knowledge and expertise on environmental issues among member countries- Afghanistan, Bangladesh, Bhutan, India, Iran, Pakistan and Sri Lanka.

United Nations Educational, Scientific and Cultural Organization (UNESCO): It is established in 1945 in Paris to promote the scientific research and training aspect of forest genetic resource conservation, notably through men and the biosphere programme. The WHO (UN World Health Organization) and UNIDO (UN Industrial Development Organization) both of which are UN specified agencies have recently joined forces with their interest in the conservation, processing and use of medicinal plants and in case of UNIDO the use of plant biotechnologist in industrial development.

United Nations Environmental programme (UNEP): It was established in 1972 in NAIROBI, Kenya, UNEP mandates include the encouragement and coordination of sound environmental practices, raising of global awareness of environmental issues.

World Commission on Environment & Development (WCED): This is a 23-member commission, set-up in 1984 in pursuance to a UN General Assembly resolution in 1983 to re-examine the critical environment and development issues and also to formulate proposals for them. This is a call for political action to manage better environment resources to ensure human progress and survival.

Earth Watch Programme: It is a worldwide programme, established in 1972 under the terms of the Declaration on the Human Environment. It monitors trends in the environment, based on a series of monitoring stations. Its activities are co-ordinated by UNEP.

Men and the Biosphere Programme (MAB): This programme is the outcome an International Biological Programme (IBP) that has already concluded its activities, MAB was formally launched by UNESCO in 1971. Approximately 14 project areas of comprehensive research under this programme.