PART I

PRINCIPLES OF PLANT ECOLOGY

PART I
PRINCIPLES OF PLANT ECOLOGY
CONTENTS

WHAT IS ECOLOGY

WHAT IS ECOLGY ?

No living organisms (plant , animal or man) can exist in complete isolation, animals depend upon other living organisms, mainly plants, for their food supply . Animals also depend upon the activities of plants for a continued oxygen supply for their respiration . Apart from these two basic relationships , an animal may be affected directly or indirectly by other plants and animals living around it . In like manner, the animal will produce its own effects on the surrounding plants and animals: some it may eat or destroy, thus damaging the balance between competing species, for others it will provide food or it may influence the texture and fertility of the soil etc . On the other hand , though plants manufacture their own food by photosynthesis, yet they are dependent upon animal respiration for at least CO_3 which they use as raw material . Supply of mineral salts which they use to build up their substances can only be maintained through the activities of fungi and bacteria breaking down the organic matter left in the soil by other living creatures . Again, many plants are entirely dependent on animals and man for pollenation and for dispersal of their seeds . Man breeds and eats both animals and plants, also cuts trees to make use of its wood , thus disturbing the balance of the environment .

Plants are found all over the earth growing in various kinds of situations . They are found on the tops of high mountains which are covered with snow for the greater part of the the year and in hot springs ,they grow on the moist banks of streams and in the dry sand of deserts or even on dry rock and in rock crevices . In fact, there is hardly a place in this earth where plant life of one type or another is not met with . But the plant species that inhabit earth vary from place to place . It is com-

---

M.B. The origin of the term ecology in the Greek Language is as Follows : Eco = Oikos which means Home or the Dwelling Place and Logos = Science or study .

mon knowledge that water plants are wholly absent from neighbouring-dry land . In like manner , the trees of mountains are not represented among the plants that grow in the water or plains .

The distribution of plants on this earth is not haphazard . The differences in the vegetation species of different places are primarily due to the differences in the environment . Environment means every thing outside the plants which influence in any way their life, e.g. light , heat , soil , water , grasses , man , other plants etc . Habitat , on the other hand , is the particular place or situation in which a plant grows e . g . bank of stream , slopes, sand embankments , plains, water , etc . Habitat is more specific in meaning than envitonment as a whole . The branch of botany that deals with the specific study of the relationships of plants in relation to their environmet is called **Plant Ecology** . It explains why certain plants grow and are associated together in a particular habitat under specific environmental factors and why they do not grow in others.

The reason why plant species are not uniformly.distributed over the earth's surface is that environments differ from place to place and so do the plants . Plants growing in any particular habitat are adapted to live in this habitat . In other words , they are in harmony with the factors of the environment . The adaptation of a plant species to its surrounding (environmental factors) is called **Epharmony** . A species that cannot adapt itself to the natural conditions under which it lives must disappear from the environment . The same thing happens when the environment undergoes a change to which a species cannot adapt itself . It is thus the environmet that determines the fate of a plant , it determines whether it shall survive or not .

Epharmony may be achieved in a number of different ways . Thus species may adapt itself to a dry habitat by means of a dense coating of hairs , others may not have a single hair but may develop waxy cover on the leaves or else reduce its foliage , still others may assume a succulent form or else are ephemeral in its life history and thus evade dry seasons .

Plant ecology or the study of the reciprocal relationship between a plant (or plants) and its (or their) environment has two aspects : **au-**

tecology and **synecology** . Autecology is concerned with the study of individual species and its environmental factors, while synecology (phytosociology) is the study of plant populations (communites) and their complex of ecological (or environmental) factors .

Plants of the earth vary from place to place because of variations in the ecological factors . Regions having a similar set of ecological factors will have similar vegetation (plant cover) because the demands of the plants under similar conditions are similar .

Environmental factors are classified as :

1. a. conditions e . g . temperature , light etc .

   b. substances e . g . water , carbon dioxide , oxygen , nutrients etc . and

   c. forces e . g . wind , gravity etc .

or

II. a. climatic factors which are related to atmospheric surroundings of the plant and include : precipitation, temperature , light, wind , evaporation , dew etc .

b. edaphic factors which are related to the subsurface part of the plants and include soil structure , soil texture , soil water , soil salinity etc .

c. biotic factors that include the biotic elements : (man , animal , plant and microoganisms) affecting and are being affected by the aerial and subsruface parts of the plants, and

d. physiographic factors ,which are related to the form and behaviour of the earth's surface and include also the exposure to sun , slopes, surface , altitude etc (topography) and substatum .

Plant ecology , thus becomes more than a study , it is a way of looking at life , always attempting to understand the whole community . The plant ecologist must have deep knowledge about various branches not only of botany e . g . taxonomy , morphology , physiology , anatomy , flora etc . but also of other branches of sciences that help him to understand and explain the ecological phenomena in the study area e . g. soil science , climatology , geomorphology etc .

THE VEGETATION

THE VEGETATION

Vegetation is a mass of plants covering an area. It is formed by the coming together of individual plants and their interaction upon each other.Plants modify the habitat in which they live. They cause it to become wetter or drier, they may increase the richness of soil and decrease light intensity. In different ways, plants change the habitat and make it fit or unfit for various types of plants to grow .

Vegetation may be a forest with its trees, shrubs, undershrubs, bushes, herbs and forest floor with its lower plants (fungi, mosses, bacteria, lichens etc.). It may consist of grasses, marsh plants, submerged plants, sparse desert plants, crust-like growth of lichens on bare rocks etc. The type of vegetation in a particular area is controlled mainly by the environmental factors. Forests are present in areas where rainfall is high while deserts occur in areas in which rainfall is low. In other regions where environmental factors vary, different types of vegetation are present .

Vegetation is either : a) natural, b) artificial or c) semi-natural. By natural vegetation we mean vegetation primarily due to nature rather than to man. i.e. vegetation that comes out as a result of the environmental factors without man's interference e.g. forests, grasslands, deserts etc. Artificial vegetation is that one which is formed mainly by man's interference and it includes all sorts of agriculture, horticulture, and afforestation. Semi-natural vegetation, on the other hand, is a natural one in which man interferes partially only. The degree to which man has influenced on apparently natural community varies very considerably and has often to be made the subject of special investigation. Continued selective felling of trees in a natural wood, and especially the constant cutting out of certain kinds only, will for instance, gradually alter the proportional compsition of the wood and sometimes its whole character. Again the opening of the whole canopy and the consequent letting in of light will kill certain woodland plants and promote the growth of other. It will also allow the entrance of herbs and grasses which could not grow in the deep shade and these will tend to suppress the true shade plants of the woodland floor which have survived and to compete with the species whose growth has been stimulated, so that the constitution of the ground vegetation may be entirely altered. Pasturing and burning of grassland or heath will destroy some species and severely check the development of others while certain species will shoot again quickly after being grazed or burned, thus altering the composition of the herbage. All these effects and others of a similar nature, have constantly to be taken into account in studying seminatural vegetation .

EVOLUTION OF VEGETATION

Any vegetation either forest, grasslands, desert, marshes etc. has its origin i.e. it devlelops and finally matures in a process called " evolution of vegetation ". The origin of a vegetation begins with invasion when propagation organs (germules, propagules) like spores, seeds, rhizomes etc. leave the parent place and arrive in a bare area by **migration** through the agency of wind, water, animals and man. Many of these migrants disappear because the environmental conditions are unfavourable . Those for which the conditions are favourable germinate in the new area and some of them continue their growth into mature plants i.e. migrants make themselves at home. The process by which these pioneer migrants establish themselves in the new area after germination of seeds to give seedlings, growth of seedlings to give mature plants and reproduction of mature plants to give a new generation is called **ecesis.** Ecesis is, thus, the adjustment of plant to a new home (environment), and it is completed only when the new invaders, the pioneer, produce a new generation. Seeds may germinate to give seedlings which then disappear or the seedlings may grow to give mature plants which cannot reproduce. In these two conditions ecesis is not completed .

Ecesis results into **colonisation** of the new area after which further propagation and reproduction lead to grouping of plants in a process termed **aggregation**. Aggregation sooner or later results in **competition** which occurs usually where two or more plants make demand for light, space, nutrients or water in excess of the supply. Competition increases with the increase of population. In other word, competition is essentially a decrease in the amounts of water, nutrients, space or light available for each individual plant. It is consequently greater between individuals or species which make similar requirements upon the same supply at the same time. The outcome of competition is the reduction in number of size of the individual or the total disappearance of one or more species. Only the stronger plant survives and continues its life cycle and the weak plant dies. The surviving plants react upon the place in which they grow in a process called **reaction**, i.e. effects of the established plants on the environment. This is not to be confused with the impress which the environment makes on the plant. The plants interact on the habitat and modify the environment. Once well lit areas are more or less densely shaded. Humus accumulated and dry areas become moist, wet areas become drier by the absorption and transpiration of large amount of water by the plants. Owing to the shade caused by the plants, the temperature becomes lower and the air becomes humid. The changed conditions become less favourable for the early pioneers and more favourable for new invaders. Thus, shrubs may replace herbs in consequence of shading them, trees may be able to start under the shelter of shrubs and once fairly established, cause the disappearance of their benefactors i.e. shrubs in turn be ousted by trees .

Reaction is not an indefinite process but a point is reached where the vegetation is in equilibrium with the environment and the dominant plant in the area is obvious. In this way , a gradual process of evolution of vegetation takes place as a results of the phenomena of migration, ecesis, colonisation, aggregation, competition and reaction. At last the environment becomes stable because it cannot be modified indefinitly . It is now the climate that determines what will be the final type of vegetation . If precipitation is low and evaporation is high , only enough water may be present for the growth of drought tolerant plants and their associates . On the other hand , if rainfall is high and evaporation is low , forests will prevail . The vegetation that develops at the end will be more or less permanent and will be in equilibrium with the climate i.e. a stage of **stabilization** is reached . This is the highest type that habitat can support under the prevailing climate and is called climax vegetation . In this stage reaction is not completely stopped but it goes on to a very small extent and its effect is not detected .

Climax is defined as the final stage of vegetation development which being in harmony with the environment is more or less permanent . The main climaxes of the plant cover of the world are regional and depend upon climate. These main types of vegetation are characterized by the life-form of the dominant species and include : tropical forests, warm rain forests with evergreen plants, deciduous summer forests with dominants losing their leaves in winter , tundra - treeless vegetation of arctic and alpine regions , grasslands of various types dominated by grasses or grass - like plants such as sedges (often with scattered trees or shrubs forming savannah) , semi-desert shrubby vegetation , manglal vegetions of the tropical sea shore-lines , desert vegetation of the arid areas with scanty and widely spaced plants etc .

The development of vegetation may be arrested in the subfinal stage of succession as a consquence of repeated burning , cutting , grazing , flooding and other causes . This imperfect stage of development by natural or artificial factors , other than climate is termed **subclimax** . On the other hand , vegetation more advanced than the surrounding climax due to locally more favourable conditions obtaining in its limlited area is termed **postclimax** .

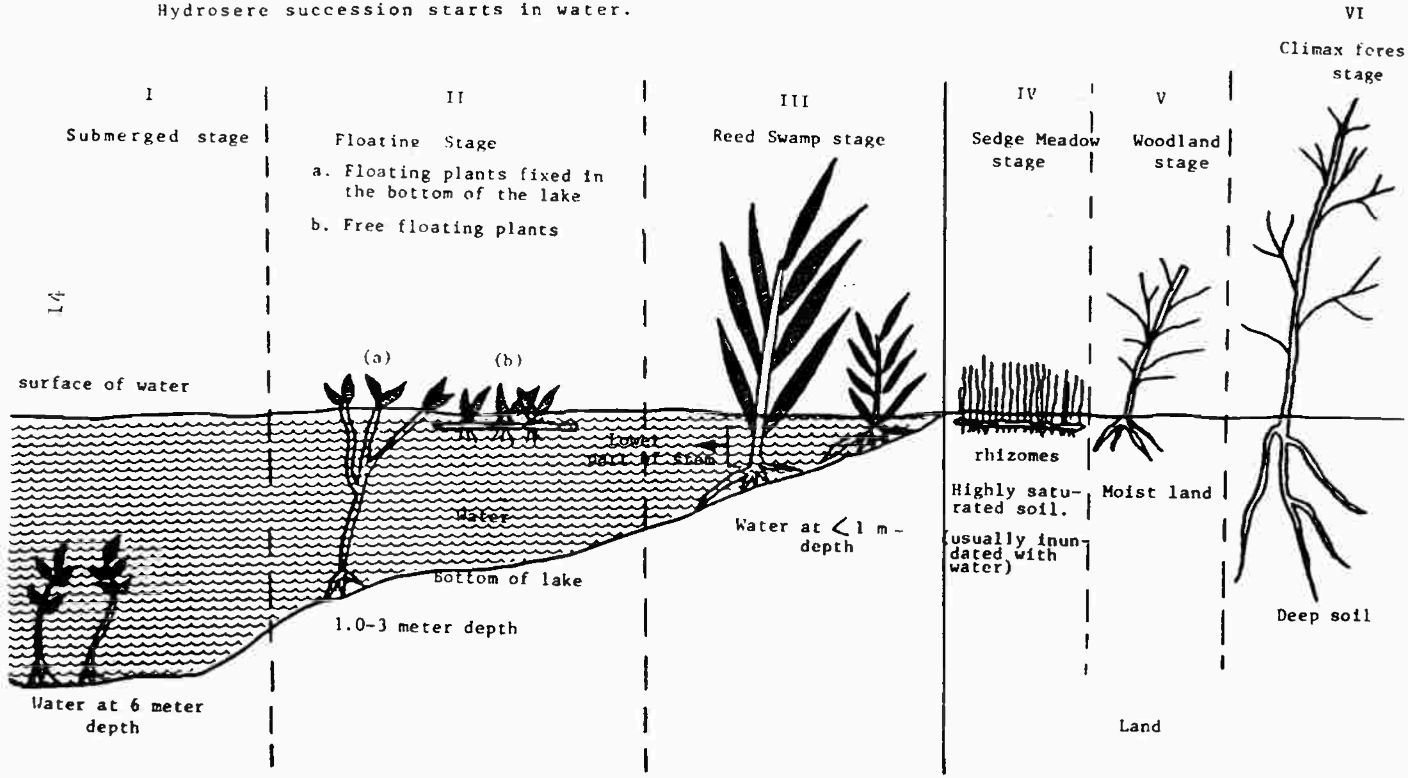
SUCCESSION OF VEGETATION

One of the most fundamental characteristics of vegetation is its susceptibility to change . The plant communities of which it is composed varies in relation to variations in the complex of environmental factors that occur from place to place. But the composition and structure of any given community also reflects the interaction between its component members and between them and their habitat through time . Any environmental changes must inevitably result in correspondingly minor or major changes in the associated plant community . They will tend to make the habitat less favourable for other species . Some may not be able to tolerate the new conditions , or to survive the competition of those better adapted to them . Som species will tend to disappear from the habitat , some will decrease others will increase in number , while yet others , formerly not present will be able to establish themselves in the community . The result of changes in a particular habitat , will be that one assemblage of plant species will be replaced or succeeded by another of different structure and composition . This process whereby one community replaces another on a given site , as a result of environmental changes , is called **Vegetation (or plant) Succession** . Change continues untill the establishment of stable climax vegetation . This means that , vegetation of an area has a life-history just as an individual plant or animal has . It is born ,develops and matures . An area to be occupied with plant life starts as a lake to be filled in with sediment or a mountain of rock to be eroded into soil . The same area is eventually occupied successively by a series of different plant communities untill a final stage (or climax stage) is developed . The intermediate stages in the process of succession are called **seral communities** and together constitute a **sere** . Successions beginning in watery habitats (e.g. pond , lake , swamp etc.) are called **Hydrarch** and the different stages of development constitute **Hydrosere** . Succession beginning in a dry situation is called **Xerarch** and the different stages of developme constitute **xerosere**. Xerosere which begins on bare rock is called **Lithosere** while that beginning on sand is termed **psammosere**.

HYDROSERE SUCCESSION

A hydrosere succession may begin in a pond , lake or swamp. The water is deep in the middle and becomes progress-ively shallow towards the shore . The various stages and processes that lead to the development of a climax vegetation in such a situation are: **submerged** , **floating** , **reed swamp** , **sedge meadow** , **woodland** and **climax forest** (Fig.1) .

Diagrammatic Representation of the six successive stages of the Hydrosere succession starts in water.



14

1. Submerged Stage

Near the shores of a lake , if water is less than 6m in depth , may be found many species of plants growing entirely submerged . These are the pioneers of the hydrosere succession. Easily seen among them are several species of flowering plants such as water weed (*_Elodae_*), pond weed (*Potamogeton*) hornwort (*_Ceratophyllum_*) and naiads (*Najas_*) etc . The plants grow at various depths , mostly rooted in the muddy or sandy bottom. They often form dense massess of vegetation especially in late summer when ther fully grown , so that boating may become difficult if not impossible .

The growth of this submerged vegetation year after year has a very marked effect upon the habitat . Material eroded by streams and transported into the lake is deposited about the plants because they form a direct obstacle to its advance . Moreover , when the plants die , their remains sink to the bottom where , because of insufficient oxidation , the vegetation debris and the dead animals associated with it are converted into humus which also settles down cementing the soft muddy soils . As this process of building the lake bottom proceeds , the water becomes shallow and less fit for the submerged species and more suitable for the new floating invaders . Obviously , the process of building up the bottom of the water by the submerged plants is disadvantageous for them and ultimately they are forming a reduced water depth and a rich substratum suitable for the new invaders .

2 .Floating Stage

As a result of the process of shallowing water , the habitat becomes suitable for the floating plants . When water is only 1 - 3 m deep , various floating plants invade the area previously occupied by the pioneer submerged plants . The floating plants are of two types : -

a . Plants rooted at the bottom but which have stems or leaf petioles rising nearly to the top of the water so that their leaves float at the surface e . g . *Nymphaea* , *Patamogeton* etc .

b. plants not rooted at the bottom but which have stem (rhiozomes , stolons etc .) with adventitious roots come under water surface while their leaves are floating over the water surface e.g. *Eichhornia* ,*Pistia* , *Wolfia*, *Spirodela etc* .

At first , the floating plants are associated with the submerged species , particularly those that grow best in shallow water. But as the invaders increase in number(aggregation) , gradully spreading year by year , their leaves occupy more of the water suface and the light for the submerged plants is decreased . The latter , finding , the conditions unfavourable , might migrate into deeper water .

Because of the dense tangle of stems much water - born sediment is deposited in the floating plant zone , while the debris formed by the decay of these rather massive species rapidly builds up the substratum , i.e. the floating plants continue further the process of building up the lake bottom which becomes shallow and unsuitable for them . The shorewared margin of the floating plant zone is eventually invaded by swamp plants . Water that is too shallow is distincty unfavourable to floating species .

3 . Reed Swamp Stage

With the continued shallowing of water , invasion becomes possible for plants that root at the bottom and are partly submerged but the major of their foliage is raised above the surface of water . The tall cattail (*Typha domingensis* . *T. elephantina*) and reeds (*Phragmites australis*) may invade the territory occupied by the floating plants where water is less than one meter deep . All have profusely beranching rhizomes and where establishment of seedlings is successful , invasion is still possible . Like the preceding plants , the tall body of the reeds and their dense growth exert a controlling influence . Obviously , the floating plants are at a great disadvantage as regards light . As reed swamp community develops , they largely or entirely disappear moving into deeper water .

The reaction of reed swamp plants is not only to shade the surface of water but also to build up the lake shors by retaining the sedimentary materials washed into the lake and by the very rapid accumulation of palnt remains . Thus , the water depth is gradually decreased and the habitat becomes less fit for most species of the reed swamps .

4 . Sedge - Meadow Stage

The substratum now changes to a marshy soil with water table at the surface or it may sometimes be covered with a few inches of water. Such a habitat is too dry for the reed swamp plants and is invaded by various species of rushes e. g. *Juncus* etc.and Sedges e.g , *Carex* , *Cyperus* etc . All these react upon the habitat in several ways . They transpire enormous quantities of water absorbed from soil and build up the soil by accumulating the remains of dead plants and catching water - carried and wind - born soil . The soil gradually becomes too dry for plants that need excess water in soil and by the addition of more humus every year finally the marshy sedge meadow habitat becomes unfavourable for water - loving plants to thrive . They are gradually replaced by species of another vegetation . In dry climates , this may be grasslands or some other xeric climax , but in more moist ones , woodland .

5 . Woodland Stage

The pioneers of this stage will be those that can tolerate partially water - logged conditions around their roots . These woody plants react upon the habitat by shading the area , making the soil dry by their vigorous transpiration and catching windborn soil and accumulating plant remains. The sedgemeadow plants now disappear being replaced by shade enduring herbs which grow among the trees and shrubs . Examples of shrubs that belong to this stage are : *Salix* , *Cornus* , *Cephalanthus* etc .

6 . Climax Forest

As humus accumlates and the moist soil becomes filled with bacteria, fungi and other microorganisms which enrich it , many other trees make their appearance . Mixed forests of *Salix* , *Alnus* , *Populus* , *Celtis* , *Ulmu* etc . with their accompanying characteristic shrubs and herbs may result . Under the canopy of these trees the air is humid but their shade will make conditions unfavourable for the pioneer sun - loving species of shrubs and trees . After a few generations the pioneers will be replaced by the trees and undergrowth of the most shade tolerant plants . Plants of medium water requirements (**mesophytes**) have , finally replaced the **hydrophytes**

Thus , the area once covered by deep water becomes transformed into a forest , a phenomenon clearly conceivable when one follows the actual process of development . The whole developmental process in action may be found about lake margins where each stage is shown as a definite zone .

The climax of the hydrosere will be forest if the climate is wet . In dry climates xeric grasslands may be the climax .

XEROSERE SUCCESSION

A xerosere succession may begin on bare rock where it is called **lithosere** or on sand where it is called **psammosere** .

Lithosere succession includes six stages namely : crustose lichen , foliose lichen , moss , herbaceous , shrub and climax forest (Fig . 2) .

1. Crustose Lichen stage

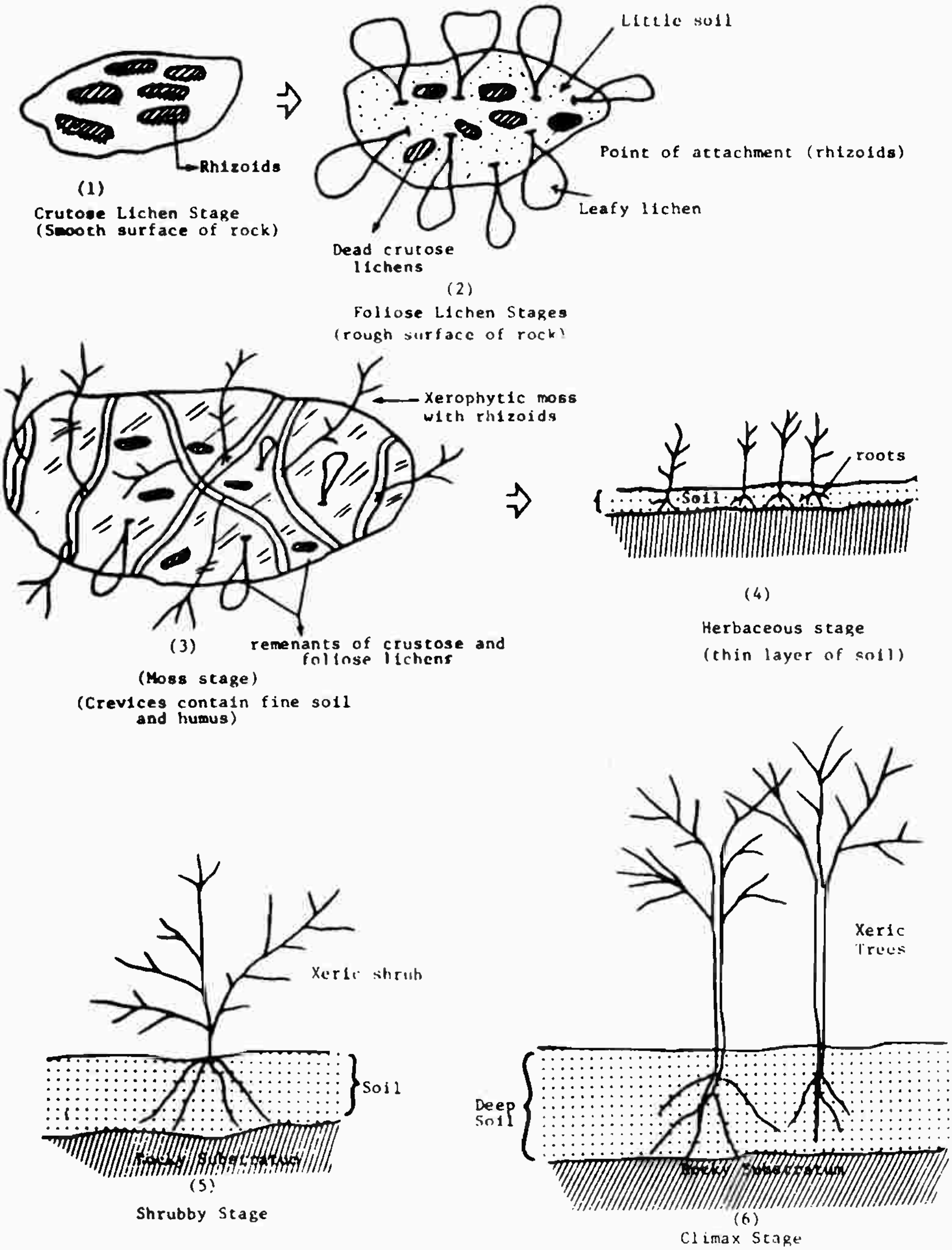
On the smooth surface of bare rock , which is extremely xeric , water and nutrients are extremely scarce and the conditions become even worse by exposure to sun , wind and extremes of temperatures . The first pioneers on such habitats are the crustose lichens . They are very slow growers and can stand extreme desiccation . Whenever there is rain , these lichens can absorb water like a sponge and flourish very quickly , i . e . they flourish during periods of wet weather and remain in a state of desiccation for long periods during drought .

The fungus living symbiotically with the terrestrial algae secures its carbohydrates from the host which , in turn , is protected by the crust - like fungus growth from extreme drought .

Mineral nutrients are obtained by the secretion of CO_2 which with water forms a weak carbonic acid that slowly eats into the rock into which the rhizoids sometimes pentrate for a distance of several millimetters . Nitrogen is brought in by rain or by wind - blow dust . Thus all the life requirements of these simple crust - like species are met .

Migration to distant rocks takes place either by wind carried spores or spores or lichen fragmentation , i . e . soredia . Thus , species of *Rhizocarpon* , *Leidea* etc , come to colonize these bare areas and play an important part in converting the rock into soil . Th crustose lichen , which is attached to the rock with its whole body , does not only exert an influence at the contact of thallus and rock , but also the corroding effects of carbonic acid and perhaps the other secretions extend beyond the thallus margins during moist weather . Thus , lichens help corrode

Fig. 2. Six Successive Stages of the Xerosere (Lithosere) Succession Starts On Rocky Substratum.



and decompose the rock , i.e. change the smooth surface of rock to be rough helping the other forces of weathering . By mixing the rock particles with their own remains , they make conditions possible for the growth of other vegetation .

The rapidity by which a minute amount of soil will form is controlled very largely both by the nature of the rock and by the climate . On quartzite or basalt in a dry climate , the crustose lichen stage might persist for hundreds of years . But limestone or sand - stone in a moist climate , sufficient change to permit the invasion and ecesising of more developed plants of the second stage (foliose lichen) may occur within a life - time .

2 . Foliose lichen Stage

Foliose lichens appear as soon as a little soil has accumulated . Unlike the crustose lichens , foliose ones are attached to the substratum at a single point or along a single margin . These lichens slowly replace the cruatose form on the more weathered portions of the rock and also in the depressions or other slightly less exposed situations . Their leaf - like thalli overshadow the crustose form , thus cut off the source of light . The crustose species will die and decay .

Water has a better chance to collect and to be absorbed about the folioceous invaders , evaporation is greatly decreased , and wind - and water - borne lichen fragments and dust particles and humus are more rapidly accumulated because of its less rapid oxidation . The acid produced by the living and decaying plants eats constantly farther into the rocks . Indeed , it is probable that the change from crustose to foliose lichens is a change of habitat as great as happens anywhere in the sere . Examples of foliose lichens are : *Dematocarpon* spp . *Parmelia* spp . , *Umbilicaria* spp . , etc .

The reaction of foliose lichens results in a thin layer of soil collected on the rock surface and this prepare the way for the xerophytic moss .

3 . Moss Stage

As soon as a sufficient amount of soil and humus has accumulated in the minute crevices and depressions of the rocks, the habitat becomes favourable for the invacies of black moss (*Grimma* spp .) , hair moss (*Polytrichum* spp .) and twistedmoss (*Tortula* spp .) . Their rhizoides compete with those of foliose lichens for water and nutrients and the erect stems often exceeds the latter in height, cutting light from it.

Soil rapidly accumulates among the erect stems as the plants, dying below but continuing above, build up the substratum and constantly increase its depth. The depth of soil under the cushion - like moss mats, often an inch or more, contrasts with the thinner layer under the foliose lichens and the hard substratum under the crustose lichens

4 . Herbaceous stage

The mosses increase the soil thickness and the death and decay of the older mosses often produce a film - like mat on the rock surface. This mat has a great waterholding carpacity. Seeds of various xerophytic herbs, especially shortlived ephemeral or annuals, and later biennials and then perennials, are able to germinate and the plants to mature. Because of drought and sterility the first generation makes only stunted growth. Their roots continue the process of rock disintegration and each year the humus from their decaying remains enriches the soil. Gradually, thickness and richness of soil are increased, and plant coverage, shading the area, decreases the evaporation and increases humidity, and drought periods are shortened. Bacterial, fungal and animal population of soil increase and condititons become less xeric. The intensely xerophilous, shallow rooted grasses e. g. *Aristida* spp. *Poa* spp., etc. prevail and react upon the habitat.

5 . Shrub Stage

Soil has now been prepared by the pioneers of lithosere, namely : lichens, mosses and herbs and consequently xeric shrubs now appear. The shaded herbaceous plants tend to disappear. The roots of the shrubs further corrode the rock which is now more or less completely covered with soil. The soil is further enriched by humus formed from fallen leaves and other plant remains, Massive networks of roots fill the soil. Wind movement is retarded, humidity is higher above the decaying leaves and evaporation from soil is greatly reduced. All of these conditions, coupled with the enriched soil with its greater capacity for holding water, furnish an excellent nursery for tree seedlings and are unfavourable for the former possessors of the land which disappear leaving the area for trees and their associate species that can grow under shade.

6 . Climax Forest

The first speceis of trees to appear are xeric . Their growth is stunted and they are far spaced . As weathering processes continue and the soil deepens , trees increase in both number and vigour . The trees now become taller and their growth is densed . Under their increasing shade , the light demanding shrubs and earlier trees give place to more shade tolerant and mesophytic species of trees . A new herbaceous and shrubby vegetation adapted to the humid air and a moisten and richer soil develops in the shade of the forest floor .

Conclusion

From the above described hydrosere and xerosere (lithosere) succession , we may conclude that succession leads to less extreme conditions . In xerosere as hydrosere the habitat has changed from one of extreme to one.of medium water relations . In other words , plants tend to make it favourable to more plants by reduction of extremes reflected in improved moisture conditions . Thus , xeric habitats become wet and hydric habitats become drier by plant reaction as succession progresses . The vegetation at first adaptes to xeric or hydric conditions has developed into a mesophytic forest . The deciding factor is the climate and the type of climax stage is in harmony with it .

WATER - DROUGHT AND VEGETATION

Drought is an extremely difficult term to define , for it has special specific connation for plant ecologists . Generally, drought is expressed in terms of the weather and climate of a particular region and is often referred to as a period of abnormally dry weather sufficiently prolonged to cause serious water imbalance in the affected area . The vegetation of an area is usually adapted to the average conditions of that region and it will suffer severely when the deviation in precipitation is both intense and prolonged .

Drought is generally related to water which of all the factors of the environment is the most impotant . Water is an essential substance and a sufficient quantity of it is vitally necessary for all plants . Besides being the major constituent of protoplasm and cell sap ; it forms the solvent in which the gasses and mineral nutrients are absorbed by the plants and moved from cell to cell within the plant body . Translocation of food materials and most of the metabolic reactions in the plant body take place in aqueous solution . Water is one of the raw materials in the process of photosynthesis . It keeps the cells and the plant organs in turgid conditions . No growth is possible without water . The resistance of plants to heat or cold is largely determined by the amount of water present . It is , therefore , no wonder that water is the most important single factor of the environment which has a great influence on plant structure and function and most of the other environmental factors influence on plant -water relations. Apart from that , water also determines to a very great extent the distribution , vigour and densities of plants . In general , forests occur in regions where there is adequate rainfall during all seasons of the year , accompanied by warm climate . Grasslands are found in regions characterized by high summer rainfall and low winter rainfall while deserts occur where there is low rainfall both in winter and summer . The water relations of plants are dtermined primarily by two processes namely : absorption from soil and transpiration of plants . The former depends on the amount of available water in the soil and the latter depends upon such factors of climate as temperature , humidity and exposure to solar radiation . The process of transpiration is of significance to the plant because of its cooling effects . Yet the greatest danger to plants comes from excessive loss of water . For normal growth and healthy development the plant should have a favourable water balance : transpiration should exceed absorption .

Plants are found growing all over the world in all sorts of conditions with respect to water supply . They live on rocks where supply of water is always doubtful matter , others grow on the banks of rivers and canals , still others are found growing in water .Plants growing in these and other habitats are not all alike . They differ from place to place . This is primarily due to the difference of water relations of the different habitats . There are places where water supply is scanty and all the atmospheric conditions are such as greatly enhance the loss of water from aerial parts. Such an environment , especially characteristic of hot desert , sand hills and mountains , is called **xeric** . Plants inhabiting xeric habitats are called **xerophytes** . There are places which are entirely under water such as lakes , ponds and other water bodies . Such habitats are called **hydric** and the plants inhabiting hydric habitats are called **hydrophytes** . Between these extremes are places which are characterized by a medium water supply . Habitats where is neither so deficient nor in excess are called **mesic** and the plants inhabiting these mesic habitats are called **mesophytes** . Plants of **halic** (saline) habitats are called **halophytes** .

XEROPHYTIC VEGETATION

Xerism may be the result of inadequqte water for plant absorption or excess of water loss by transpiration , or in some severe cases may by due to a combination , of both of these factors . Deficient absorption of water may be due to an actual shortage of water in the soil when the soil is said to be **physically dry** or it may be **physiologically dry** where it does contain plenty of water but this water is not readilty available to the plants . This is the case in the following :

a . cold - water in which soil water is changed to ice,

b . water - logged soil in which roots of plants fail to absorb water due to the reduction of air contents of soil as water fills the capillary and non - capillary pores of soil and roots cannot respire fresh air , c . acidic and highly saline or alkaline soils where soil solution is highly concentrated relative to cell sap of roots and hence absorption is stopped .

In the latter three cases , though the soil is rich in its water content , yet water is not available to plants and the soil is then physiologically dry .

Xrophytes are found in the deserts and in all habitats where soil is poor in water and the air temperature is high increasing the water evaportion from soil . The most intense xeric conditions are met with in saline soils where arid conditions are combined with a soil containing an excess of soluble salts which makes water absorption extremely difficult . This means that the soil is dry both physically and physiologically

In xeric habitats live those plants which can either economise in the use of water or else have the capacity of drought tolerance . Xerophytes meet these conditions in number of ways . There are **ephemerals** which live only for a few weeks during the short rainy season . Many of these plants emerge from their seeds in early spring , bear leaves , develop flowers and fruits within a few weeks when there is enough water in the soil and the air is humid . When the dry season comes , their seeds have already ripened and the plants die , or more correctly the roots , stems , branches and leaves of ephemerals die leaving the seeds in soil . Seeds can withstand the severe dry conditions and they will germinate again in the next rainy season . This means that ephemerals evade drought and pass the dry period in the form of seeds which are not easily affectes by drought . **Annuals** and **biennials** also belong to this category . In the unfavourable periods of drought , their aerial parts die and they remain buried in the soil where they are comparatively safe from the effect of drought . Thus , we may conclude that ephemerals , annuals and biennials are drought escaping rather than drought resisting or drought tolerating plants (photo 1) .

The second important group of xerophytes is that of **succulent** plants . Succulence is an important adapation to decreased water supply under arid conditions . There is a preponderance of thin - walled parenchyma elements over the thick - walled tissues . The parenchyma elements remain turgid . Low water content causes the conversion of polysaccharides into pentosanes which have a high water - binding property . These together with the nitrogenous compounds of the living cells bring about great hydration of the protoplasm that results in succulence

Photo 1 : Ephemeral vegetation after rainy season, Eastern Desert Egypt .

Succulents are of two types , narmely : a) stem succulents and b) leaf succulents . In the first category are the cacti and cactus - like Euphorbias , (plants that belong to family Euphoriaceae having succulent stems looks like cacti) . They are characterized by succulent stems with reduced or spinelike leaves . The stem has strongly cuticularized epidermis , the stomata are few and mostly closed so that transpiration is greatly reduced . The roots are spread near the soil surface and whenever there is a little rain (or dew) , the roots rapidly absorb water from the superficial soil strata . The water is stored in the succulent stem as a reserve and is used very economically in time of drought . (photos 2,3) .

The second category of succulents are plants like *Aloe* and *Agave* in which the leaves become succulents and the stem is reduced . The leaves are vertically erect and their epidermis show special features . The cell layer of the outer epidermal wall is very thick with heavy cutinisation and a thick cuticle . Inside the epidermis are several rows of chlorenchyma with abundant chloroplasts followed by large water storage tissues in the pulpy interior . The stometa are sunken . The highly developed cuticle greatly reduces water loss when the stomata are closed . In general , succulent plants are **drought resistant** rather than **drought tolerant** .

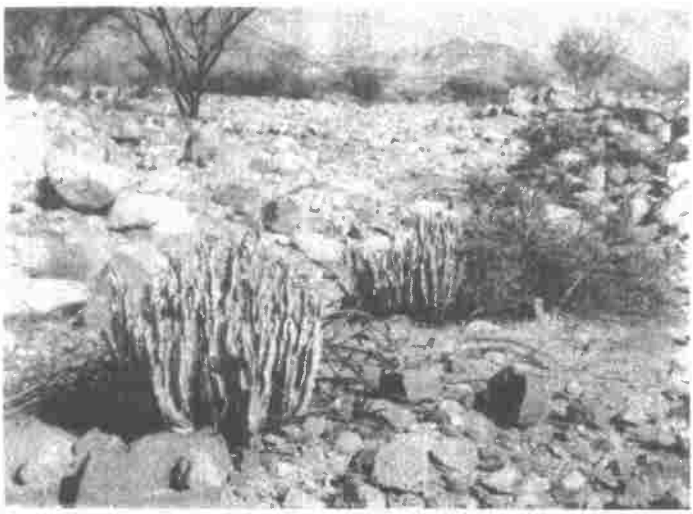


Photo 2 : Caralluma retrespiciens, a succulent xerophyte growing in the rocky substratum of Gebla Eiba area , Red Sea coastal Desert , Egypt .

Photo 3 : Thin xerophytic vegetation , Siwa Oasis , Egypt : **Zygophyllum cocineum** , succulent xerophyte , dominates .

The interesting group of xerophytes are the desert plants or **true xerophytes** which include perennial herbs as well woody shrubs and trees (Photo 4) . The plants are usually with small aerail parts and an extensive root system which may grow deep and reach the water table or spread profusely thus commanding large area of the soil for water absorption . The root hairs are abundant . often extending far back from the root tip .

Photo 4 : Xerophytic thin vegetation, Eastern Desert Wadis, Egypt .

The chief object of xerophytes is to get as much water as possible . Their well developed root system is extensively branched and often approaches the water table . The xylem elements are very richly developed in xerophytes so that internal resistance to the conduction of water is reduced to a minimum .

The desert habitats of the xerophytes include a variety of landform : rocky plateau , desert wadis , desert mountains , gravel desert and desert plains .

a) Rocky Plateau

The rocky plateau is the initial type of the erosion cycle . The rocky substratum provides little possibility for plant growth and that is further reduced by exposure and represent in fact extreme aridity . The micro - relief may , however , allow for the accumulation of water and soil notches or depressions . In these an ephemeral plant cover may appear in the favourable rainy season . Upon the approach of summer the scanty soil will dry up and the plants will have finished their life cycle e. g. *Aristida* spp . , *Diplotaxis acris* etc .

The run - off water may produce , in the surface of the rock , furrows which are usually lined with waste of fine texture This is another habitat that is possible for ephemeral plant growth e.g. *Trigonella stellata* , *Anastatica hierochuntica* , *Pteranthus dichotomus* etc .

The above mentioned furrows may lead into certain longitudinal depressions that are shallow - not exceeding 2 cm in depth . These shallow trenches contain and lead the run - off water . The bottom is usually bare of soil cover , but certain perennials may be found sending their roots into the crevices and trapping some soil around their bases . Among these species are : *Echinops spinosissimus* , *Reaumuria hirtella* , *Iphiona mucronata* , *Asteriscus graveolens* , *Farsertia aegyptiaca* , *Calligonum comosum* , *Diplotaxis harra* , *Ephedra* spp . , In the wet season , certain ephemerals and annuals appear in these trenches e . g . *Trigonella stellata* , *Mesembryanthemum forskalei* , *Diplotaxis acris* , *Plantago ovata* , *Erodium cicutarium* , *Zygophyllum simplex* , etc . These trenches are not real wadis but are , perhaps , the initial stage in the formation of wadis .

b) Desert Wadis

Desert wadis represent one of the habitats of the xerophytic vegetation . The term wadis is variably used to designate dried stream - beds in a destert area . A wadi may be transformed into a temporary water - course after heavy rains . The wadis are organized into systems , each with a main channel and branched tributaries .

The development of the bed of a wadi includes the gradual accumulation of transported materials , that is the gradual building up of the soil . This cumulative process entails substantial changes in the composition of the plant cover .

The bed of the wadi would be rocky . The habitat of the rocky bed of a wadi differs from that of a rocky plateau . It is more protected , has a more creviced substratum and receives more water . **Chasmophytes*** plants of rock crevices (Photo 5) will be able to exploit the habitat at this stage . By the gradual accumulation of soil plant cover may by established . The shallow soil may be moistened during the winter season . This will allow the appearance of ephemerals , annuals , biennials and perhaps a few perennials that will fail to complete their normal life cycle . The soil will be dried up by the approach of the summer season and the shallow roots will consequently be desiccated .

Photo 5 : Rock-crevices at the Eastern Desert where **Stachys aegyptiace** xerophyte grow .

The gradual building up of the soil proceeds until its thickness will allow the creation of a deeply seated permanently wet soil layer which underlies an upper layer subject to desiccation in the dry season . At this stage , the plant cover will assume a more permanent nature : perennials will find a favourable habitat .

A stage will be reached when the soil becomes so thick that shrubs and trees will find it possible to establish themselves . The natural climax of the habitat would be *Acacia*_, *Balanites* and *Tamarix*_scrub , or plant cover with comparable structure , (Photo 6 , 7) . In certain areas , the trees of these genera are fetched for fuel and / or their branches are

* Chasmophytes : Plants capable of growing in rock crevices .

badly browsed by animals . The result is that most of the mature wadi vegetation is a deflected and the natural climax is deprived of desert shrubs and trees as dominants (i . e . subclimax stage is present) .

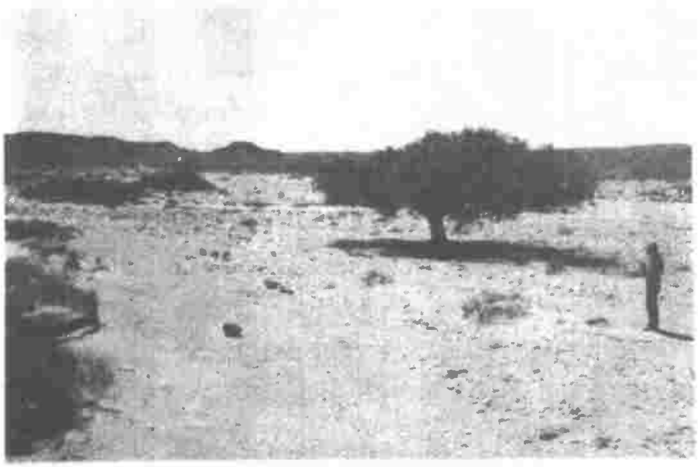


Photo 6 : Tamarix aphylla tree and shrubs , Red Sea Wadis, Eygpt .

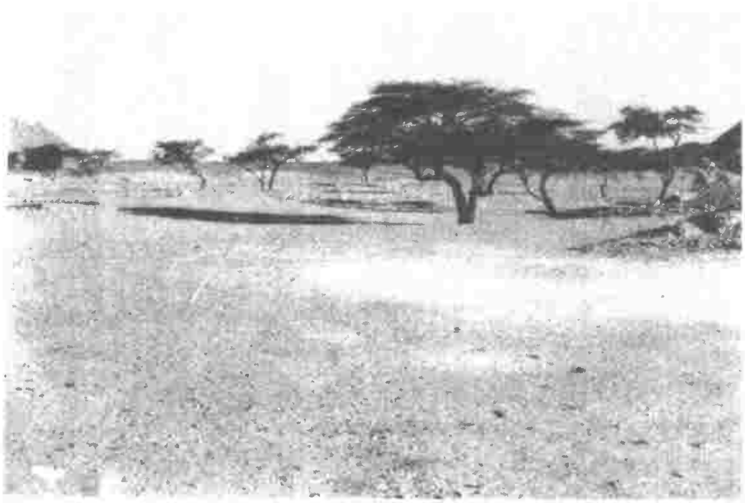


Photo 7 : Xerophytic shrubs and trees of **Acacia,** Eastern Desert, Egypt

At all stages of wadi development, the habitat is subject to accidental torrents that may destroy the vegetation and wash away the soil. This explains the complex and confusing pattern of the plant cover in many of big wadis : the vegetation may be locally and repeatedly destroyed and may be at various stages of regeneration and development.

c) Desert Mountains

Desert mountains may consist of ranges or may be isolated into solitary units and represent in sedimentary formation, an advanced stage in the desert erosion cycle. The sides of the mountains may slope more or less gently or may be stepterraced but are always veneered with rock fragments. The plant cover on the mountain sides varies according to height: the lower levels receive more water and are less exposed to winds than higher levels. Also, the plant cover varies from one mountain to another, and the contrast is obvious between sandstone mountains and limeston ones . This is true in so far as the floristic composition is concerned, other features of the vegetation may be comparable. Xerophytes living in this habitat include : *Capparis decidua , Cleome africane , Acacia ehrenbergiana , A . tortilis* etc. (Photos 8 , 9).

Photo 8 : Capparis decidua shrubs, in a Wadi of the Red Sea Coastal Desert .

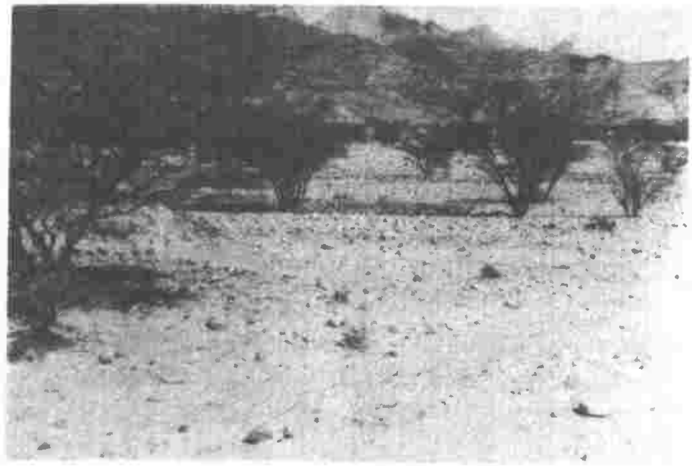


Photo 9 : Acacia tortilis, Red Sea Coastal Desert, Egypt .

d) Gravel Desert

Gravel desert habitat is common in arid land countries where fluviatile deposits abound e . g . Egypt and Saudi Arabia . In this habitat the ground surface is coverd with gravels commonly made of pebbles , globose in shape and dark brown in colour . In such formations , the softer deposits have blown away leaving a covering of "lag gravel" on the surface . This gravel cover , once established , protects the soil beneath from further transportation , and is , for this reason , called "desert armour" The gravels are so closely strewn that they provide a concrete - like layer impenetrable to plant roots . Botanically speaking , the mature gravel desert is a sterile habitat , save for certain desert lichens and algae on the lower surfaces of the few white translucent gravels . In certain localities the development of gravel cover is incomplete and we may call it premature gravel desert . Ephemeral vegetation appears in this type of habitat during the rainy season and persists during the spring . In the dry years this type of vegetation fails to appear . This include : *Aristida spp., Senecio spp., Centaurea spp., Trigonella spp., Schismus spp., Aizoon canariense etc* .

certain species e . g . *Heliotropium* spp., *Fagonia* spp., *Farsetia* spp., and also ephemerals may grow in this habitat in rainy seasons .

On the flat portions of a gravel desert wind-borne materials may accumulate producing sheets of sand . The gravl layer , which is impenetrable to the roots , confines root growth to a layer of sand usually limited in depth . Although the plant cover includes a number of perennial species that are elsewher evergreen , the vegetation is distinctly deciduous . This may be due to the soil being so shallow that it does not allow for the storage of water in deeply seated layers . The roots are thus seem to be subject to desiccation during the dry summer . The characteristic dominants of this habitat include : *Hamado elegans* . *Panicum turgidum. Anabasis articulate, Farsetia oegyptiaca. Indigofera spinosa* etc .

e) Desert Plains

Desert plains are flat expanses where deep alluvial deposits are found . These represent a very late state in the arid erosion cycle . The original desert plateau has been completely removed and replaced by a flat terrain at a lower level . The soil is comparable to that in the channels of the main wadi , but the habitat is , however , deprived of the wadi's protection . These plains are subject to occasional sheetfloods as they almost always lies at the feet of some desert mountain .

The alluvium surface may be covered with sheets of sand or the plants may accumulate around themselves baby sand dunes (mounds , hummocks or hillocks) . see photos 33, 43 , 41 , 57 , 58 , 95 , .

Desert plains are favourable habitats for many community types lominated by xerophytes e. g. *Salvadora persica. Cassia senna. Dipteygium glaucum . Rhazya stricta . Leptadenia Pyrotechnica* etc . (phoos 10 , 11) .

Photo 10 : Cassia senna (Sena miky) plants growing in one of the Wadis of the Eastern Desert , Eygpt .

Photo 11 : Leptadenia pyrotechnica xerophytic shrubs, growing in a Wadi of the Eastern Desert, Egypt .

HALOPHYTIC VEGETATION

Halophytes , or the vegetation of saline (halic) habitats , may be considered as highly spcialized plant growth , characterized by the possession of great tolerance to salt . their salt tolerance can be appraised in at least three ways , namely :

a) their ability to survive on saline soils , b) their absolute yield on saline soils , and c) their relative high yield on saline soils compared to non-saline ones .

The adaptability of halophytes to salinity takes place through different modifications . Some are excretives , i . e . possess glandular cells, capable of excreting ecxcess salts e . g . *Tamarix* spp., *Limonium* spp., *Limoniastrum* spp., etc . Other halophytes are succulents having succulent leaves and / or stems that overcome the rising of salt concentration by an increase in their water contents e . g . Suaeda spp., Salicornia spp., Zyophyllum album, Arthrocnemum glaucum , Halocnemum strobilaceum. Halopeplis perfoliata etc (Photos 12 , 13 , 14) . A third group of halophytes are capable of accumulating excess salts in certain parts of their bodies . These are the cumulative halophytes e . g . *Junus* spp., etc . Mangrove plats e.g. *Avicennia* spp., etc (Photo 23) . are also halophytes growing in the shallow waters of the tropical seas . These plants belong to the exclusive halpohytes which exclude unwanted salts . The salt tolerance of halophytes , in general , increases both during their growth and development from one generation to the next . This adaptation is possible due to the features and properties which arise during evolution .

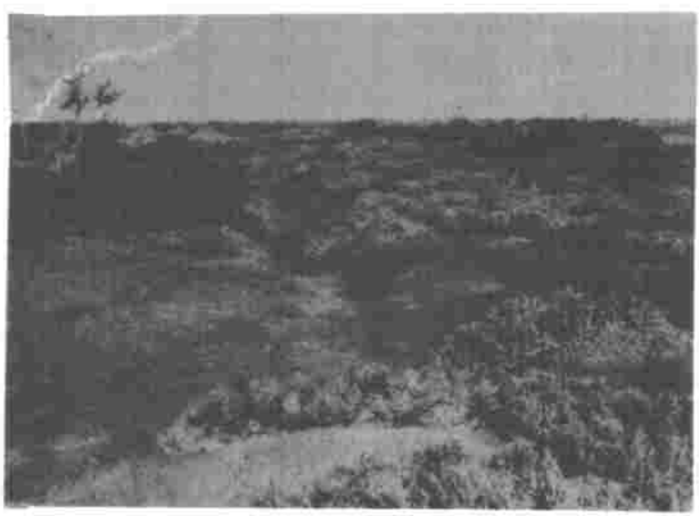


Photo 12 : Salt Marsh vegetation dominated by **Arthrocnemum glaucum** , Red Sea Coast , Egypt .

Photo 13 : Salt marsh vegetation domiated by **Halocnemum strobilaceum** Littoral Salt Marsh, Red Sea Coast, Egypt .

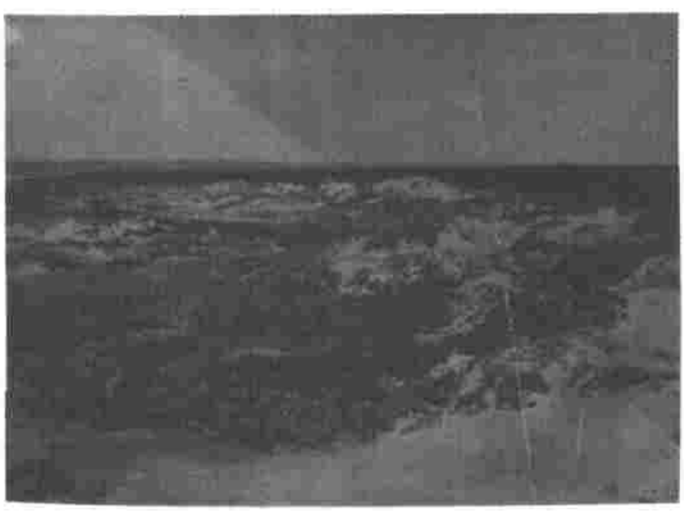


Photo 14 Salt marsh vegetation domiated by **Halocnemum strobilaceum** Littoral Salt Marsh, Red Sea Coast, Egypt .

Photo 15 : Mangrove Plants, foreground : **Rhizophora mucronata.** background : **Avicennia marina,** Red Sea shore-line , Egypt .

Salt marshes , or the habitat of the halophytes , are of two types : littoral and inland . Littoral salt marshes occupy the lands adjacent to maritime influences , i . e . periodic tidal flooding , seawater spray , sea water seepage etc . Their formation takes place through the silting up of lagoons or shore-line areas protected by sand or shingle bars . The inland salt marshes , on the other hand , are far from the reach of the maritime influence and are usually present in the oases and depressions of the the inland desert which are characterized by a shallow underground water table . In certain areas the underground water is exposed forming lakes of brackish or saline water . In both littoral (coastal) and inland salt marshes , the lands are liable to be flooded with water (of the sea or underground) . As this water evaporates , it leaves its salts behind leading to salt marsh formation .

Zonation is a universal characteristic feature of the salt marsh vegetation . Several factors (tidal movement and inundation , land relief , soil depth , soil salinity , depth of underground water , sea water spray , wave action etc .) seem to play certatin roles in the zonation pattern of salt marsh vegetation , but their individual effect varies . The dominant halophytes of seaward zones of the salt marsh differ from those of inland ones , and in many instances , a few inches increase in ground level may result in a profound change . The ideal example of the zonation pattern of salt marsh (halophytic) vegetation can be seen in the Red Sea littoral salt marshes . The mangal (mangrove) communities occupy the first zone which is permanently covered with sea water . Seeds , seedlings and lower parts of mangrove trees and shrubs (*Avicennia marina*) are adapted to sea water inundation . The second zone is characterized by saline soil which is covered with sea water during high tide and is dominated by *Halopeplis perfoliata* in certain areas or *Halocnemum strobilaceum* and / or *Arthrocnemum glaucum* in others . The inland zones are successively dominated by : *Limonium axillare* , *Aeluropus massauensis* , *Sporobolus spicatus* , *Zygophyllum album* , *Nitraria retusa or (Suauda monoica) and Tamarix mannifera* .

Soil features are apparently one of the main factors influencing the plant cover and distribution and also zonal pattern of the halophytic vegetation . Climatic conditions have a pronounced effect on the edaphic characteristic of the salt marsh . Aridity of climate increases the rate of evaporation . This, when associated with low precipitation , leads to the formation of surface salt crusts , and accordingly the surface layers of arid land salt marshes contain the highest proportion of soluble salts which considerably decreases in the lower layers . For example , in the community type dominated by *Halopeplis perfoliatat* of the Saudi Red Sea Coast (Thuel Area) , soil salinity drops from 45.7% in the surface layer to 9.6 % and 8.5 % in the subsurfsace and third layers respectively .

Salt marsh soils have abundant water but the plants are faced with great difficulty in the matter of water absorption on account of the high percentage of salts in the soil . Such soils are physiologically dry . Halophytes posses very high osmotic pressures that overcome this problem . But, new generation of halophytes (seedlings) usually appear after rainy periods during which excessive salts of upper layers areas are leached downward .

HYDROPHYTIC VEGETATION

Hydrophytes are plants which grow wholly or partly submerged in water . They are uniform, and there are fewer adaptations in aquatic plants than in xerophytes .

The hydrophytes are either: a) submerged e.g. *Ceratophyllum demersum*, *Potamogeton crispus* ,*P . pectinatus*, *Ottelia alismoides*, *Halophila stipulacea*, *Elodea canadensis*, *Cymodocea major* ,*Zostera noltei* etc., b) free floating e.g. *Eichhornia crassipes*, *Pistia stratiotis*, *Lemna spp.*,*Spirodela* spp., etc. or c) rooted floating having roots fixed in the mud e.g. *Potamogeton nodusus* etc. The rooted hydrophytes are better adapted as they obtain mineraly from mud at the bottom of water.

The two factors which have the greatest influence on plant life are the supply of water and the regulation of transpiration. In the case of hydrophytes,in general, water is easily accessible and in the case of submerged plants transpiration is out of question. The absorbing and conducting tissues are, therefore, reduced to a aminimum . The roots are poorly or not at all branched. In some cases, they are absent. The xylem, being less in demand, is poorly developed and reduced . In the submerged leaves, the stomata, through which transpiration occurs , are absent and when present are functionless . The floating leaves bear stomata on the upper surface only. Unlike the xerophytes, the epidermis of the hydrophytes is thin and the cuticle is almost absent . In the submerged plants, excretion of water takes place by **guttation** through water pores or **hydathodes** not through stomata (transpiration). Osmotic pressure in hydropytes is very low and the plants rapidly wilt when removed from water .

Hydrophytes, like other plants, need oxygen for respiration and carbon dioxide for photosynthesis. They have solved this difficulty by an extensive development of a system of air spaces or air chambers (aerenchyma) in their tissues especially in the submerged parts and all the tissues obtain enough oxygen for respiration by internal circulation.

Emersed hydrophytes are plants inhabiting shallow water.Their roots, rhizomes, lower parts of their aerial stems and a portion of their lower leaves are under water but most of the shoot system is aerial . These plants (emersed hydrophytes) are adapted to living partly in water and partly in air . Reed swamp plants come into this group. A swamp is marshy land where the water table is just near the soil surface. Growing at the edge of water, these plants e.g. *Typha* spp., *Phragmites* spp., *Cyperus* spp., etc . have well developed and rapidly spreading rhizomes fixed in the mud by adventitious root. . Like the mesophytes the emerged parts of these plants have well developed conducting and mechyma and a system of air chambers for internal aeration of the submerged parts . Accordingly , emersed plants can be considered as a transitional vegetation type between the aquatic and terresrrial types .

MESOPHYTIC VEGETATION

Mesophytes are plants of mesic habitats which are neither extremely dry nor very wet . The soil solutions are dilute and the soil contains enough oxygen supply for roots . Many of the cultivated crops and garden plants belong to this group .

Mesophytes are intermediate between xerophytes and hydrophytes in thier structural characteristics and ecological requirements . They are often classified into **sun** and **shade** mesophytes . The soil in which mesophytes grow contains an adequate amount of water and their roots are very developed . The volume of roots often equals or exceeds that of aerial parts . The foliage is very richly branched and the leaves are large and thin . The epidermis is thin and the stomata usually occur on both surfaces of the leaves . Cutinisation of epidermal walls is very moderate .

Mesophytes are not tolerant to drought and readily wilt under conditions of slight water deficit . Their osmotic pressure is low as compared to xerophytes and halophtes but high as compared to hydrophytes . Mesophytes are also sensetive to increased salt content in soil .

SOIL FACTOR

SOIL FACTOR

Definition

Soil is the unconstant outer layer of earth's crust ranging in thickness from a mere film to some what more than 10 feet , which through processes of weathering and incorporation (accumulation to form bodies) of organic matter , has become adapted to the growth of plants . It is underlained usually by the parent material into which the deeper roots of plants may extend . The true soil or **solum** is generally made of the same parent material which it covers .

Origin and Components

The chief component of most soils is derived from rocks . More than 90 % by weight of ordinary air - dried soil consists of rock fragments . The mineral matter derived from the rock material constitutes the matrix of the soil , it is very stable .

A true soil has five constituents :

1 - The mineral particles of various size and in different stages of chemical decomposition .

2 - Organic matter in various stages of decomposition ranging from raw litter to well decomposed humus .

3 - Soil solution of various inorganic salts

4 - Soil atmosphere occupying interspaces not filled with soil solution .

5 - microorganisms both plants and animals .

Why Soil is important to plants ?

Nearly all plants, except parasites , epiphytes and free floating hydrophytes are rooted in soil . The vegetation plays remarkable role in the formation of soil in which plants are fixed and from which they obtain their water and nutrients . A plant rooted in the soil is in direct contact with it , the roots branch and exploit large area in the soil which may some time increase than area occupied by the shoot .

Soil may affect plants in the following :

1- germination of seeds
2- growth of seedlings
3- branching of roots
4- depth of plants
5- vigour of plants
6- number of leaves
7- number of flowers
8- yield of fruits
9- Quality of yield .

The types of plants are affected mainly by the type the of soil . There are the halophytes growing in saline soils , the lithophytes growing in rocky soils , the chasmophytes growing is rock crevies etc .

The present chapter will account ; on the following :

1 - Soil parent matterial
2 - Soil devloment
3 - Soil profile
4 - Soil physical properties
5 - Soil chemical properties
6 - Soil Organic matter
7 - Soil Organisms

SOIL PARENT MATERIAL

This is the solid fraction of the soil which has been developed by the weathering of rock and it acts as the frame work of the soil . Along the spaces in between the particles or on the surface of the particles all the activities in the soil are performed . It depends on the nature of the rock from which the soil is derived and depends on the way it changed to form the soil .

The parent materials , may be

a) residual and / or   b) transported

a) residual parent materials :

In this case the soil has developed in its place from the rock below and has suffered little transportation . It has usually suffered long and often intense weathering . The change in its physical and chemical properties are highest in the surface . The change gradually decreases downwards untill the soil pass to the bed - rock from which the residual soil has been formed .

b) transported parent materials

In this case the parent materials have been transported from the original rock to the place where they are deposited . Transportation is achieved by different means :

1 - gravity , 2 - water , 3 - glaciers and 4 - wind .

1- **Gravity** : This means of transportation is carried out in the mountainous region . The transported rocks are called **colluvial parent material** . A piece of rock may be separated and thrown where it lies . Boulders different in size may fall form a colluvial parent naterial . Some times the soil may contain fine particles as well . In sloping areas slow movement of soil may occur .

2 - **Water** : Here , the transported rocks , the **alluvial parent material** , are characterized by

a) the particles are commonly rounded in outline because of continual fraction when carried with water .

b) the particles are arranged in layers or horizons . Each layer is characterized by a range of particle size . Fine particles and some times rocks and boulders are present in definit layers , They depend on the spead of water carrying the particles . The alluvial parent material may be present in :

(i) Flood plains (ii) terraces and

(iii) deltas

(i) Flood plains : The water current deposits its sediments on the valley when flood occur . Year by year the alluvial soil is formed . High flood covers the plains which becomes in case of submergence while in low flood the plains are exposed .

(ii) Terraces : The terraces are elevated soil along a water course creek or valleys which were previoualy reached with high flood water . But as the water channel become more deep they has been raised above the reach of water forming terraces that are often high in oraganic matter and mineral nutrients .

(iii) Deltas : Much of the finer sediments carried by streams are not deposited in the flood plains but are carried by water current downward by river , when the later pass to sea or a lake , the fine materials deposit and accumulate forming deltas e . g Delta of the Nile .

3 **- Glaciers :** Glacial parent materials are found in the cold areas . Glaciers are masses of ice pass crushing rocks in their way and a soil may be formed according to that . Particles of various sizes ranging from boulders to fine clay may be present without any arrangment . The chemical nature of the soil depend on the rocks on which the glacial have passed .

4 - Wind : The rock particles carried by wind are called aeolian parent matrials . These are either in the form of : dunes or loess .

(i) **Dunes** always formed mainly of sand and they are of three types :

a) coastal dunes that are present near the coasts of the sea e . g . dunes along the Mediterranean Sea.

b) plain dunes which are formed on fload plains and they are usually in cone shaped .

c) desert dunes in the inland desert e . g . duns of the Oases .

(iii) Loess is formed of finer paricles usually silt and they have a yellowish - buff colour carrying large amount of humus . Loess is usually met with around rivers e . g . Mississippy and Missouri river valleys where the deposits reach 100 ft thick . It is believed that loess blown out of the river valley as it is found that it is coarser and deeper near the river and shallower and finer farther from it .

Classification of Soil Parent Materials

The rocks found in the earth's crust are commonly classfied as

(1) ingneous (2) sedimenatary (3) metamorphic .

(1) The igneous rocks are formed from molten lava and include such common rocks as granite , basalt .... etc .

They are composed of primary minerals such as :

(a) quarts SiO_2 .

(b) Feldspars $K_2O\ AI_2O_3\ 6\ SiO_2$ and

(c) dark coloured minerals including biotite: $KAl\ (MgFe)_3\ Si_3O_{10}\ (OH)_2$ and augite : $Ca_2\ (AIFE)_4\ (MgFe)_4$ Si6 O2 4 .

granite $\xrightarrow{\text{weathering}}$ Quartz $\xrightarrow{\text{Cement}}$ sandstone

(2) The sedimentary rocks are resulted from the deposition and recementation of weathering products of other rocks . For example , quartz sand weathered from a granite and deposited in the bottom of prehistoric sea , may through geological changes have become cemented into a solid mass .This would be called a sandstone. Also limestone is a cemented calcite CaCO3 or Dolomite CaMg (CO3) 2 .

(3) The metamorphic rocls are those which have formed by the meamorphism or change in form of other rocks . Igneous and sedimentary masses which have been subjected to tremendous pressures and high temperature have succumbed to metamorphism . For examples , quartz SiO2 gives quartizite (metamorphic rock) calcite CaCO3 gives marble (metamorphic rock) Clay H4 A12 Si209 gives slate (metamorphic rock) .

The following table includes the minerals founds ion soil

Name	Formula	Name	Formula
1 Qurtz	SiO2 (sand stone)	7 Calcite	Ca Co3 (Lime-
2 Microline oth-	K Al Si3 O8		stone)
3 er Biotite	K Al (Mg.Fe)3	8 Dolomite	Ca Mg (CO3)2
	Si3 O10 (OH)2	9 gypsum	Ca SO4 . 2 H2O
4 Augite	Ca2 (AlFe)4	10 Gibbsite	A1203 . 3h20
Limointe Fe2	(Mg.Fe)4 Si604	11 Cly mineral	Al Silicates H4A2
5 03.3H20			Si12 04
Hematite Fe2		12 Feldspars	K2O . A12 03 .
6 03			6Si)2 .

SOIL DEVELOPMENTS

Three basic Processes are concerned in soil development :

1- Mechanical (disintegration) processes .

2- Chemical (decomposition) processes and .

3- Biological processes .

1-Mechanical process (disintegration) :

Forces responisble for disintegration bring about a decrease in size of rocks and minerals without affectintg their compostion . Rocks are formed of a mixture of minerals which have different expansion coefficient .Variations of temperature geatly influence the disintegration of rocks . During the day rocks become heated and at night often cool . Therefore differential stresses are set up which evantually produce crackes and rifts (opening) . Water aids the processes of weathering . It freezes and liquifies (water expands on freezing) causig cracking of the rocks . Wind has always been an important carrying agent and when armed with fine debris exerts an abrasive action also .

2- Chemical processes :

These include process of axidation , reduction , hydration, hydrolysis , carbonation and solution .

(a) Oxidation

Oxygen is quite an active element , and it combines with many other elements freely . A considerable amount of iron in the rocks is in the reduced or ferrous form F++ which is easily oxidised by oxygen to ferric Fe +++

$$4 FeO + O_2 \text{ -------- } 2 Fe_2O_3$$

Ferrous oxide + O2 ---- Hematite

Sulphur (S) is likewise readily oxidised in soils to form sulphuric acid .

(b) Reduction

Reduction is the opposite of oxidation and is encoureged wherever oxygen , common electron acceptor in soils , is in short supply . In a water logged soil , ferric iron could accept an electron and be biologically reduced , at the same time some carbon may be anaerobically oxidised . This process then , is active at lower depths in the earth's crust under poorly drained conditions where water occupis much of the air space of the soil . The evolution of CO2 from rapidly decaying matter may reduce oxygen supply and result in reduction .

(c) Hydration

The union of water with soil minerals is illustrated by .hydration of iron oxide :

$2Fe203 + 3H2O$ ---- $2Fe2O3 . 3H2O$ Hydrated Hematite

Hydration is a common process in rocky decay . Not only does the iron in mirerals oxidize and become hydrated , thus increasing in size and softness , and so lead to further mineral breakdown , but also many other compounds like SiO2 and $Al_2 O_2$. Hydration also operates to physically disintegrate rock because the hydrated compounds occupy more space and play an active role in weathing .

(d) Hydrolysis

Water is a very active chemical reagent . The hydrogen ion in water tends to change places withe positive ion (cation) in many compounds , thus forming new compounds . This process goes on extensively with minerals containing strongly basic elements parts of which are exchanged for Hydrogen.

$CaSiO3 + 2HOH$ -------- $H2 SiO3 + Ca (OH)2$

$KAl Si_2 O_8 + HOH$ ---------- $HAl SiO_8 + KOH$

This exchange is known as hydrolysis , and it is a very effective reaction in changing the chemical composition of many minerals .

(e) Carbonation

The decomposition of organic mater in the soil and the respiration of plant roots liberate large quantities of CO_2 in the soil air . This gas readily combine with bases , producing carbonates or bicarbonates . For example Ca (OH $)_2$ and KOH librated by hydrolysis reaction just shown readily combins with CO_2 as follow :

$Ca (OH)2 + 2 CO2$ -------- $Ca (HCO3) 2$

$2 KOH + CO2$ -------- $K2 CO3 + H2 O$

This process is known as carbonation and it is one of the most effective in decomposing soil minerals.

(f) Solutions

Solutions occur in soil in the form of acids , e . g . HNO_2 , H_2SO_4 , HCO_3 etc . These acids are developed in soil through chemical and biological agencies . Seldom do these acids occur in more than traces , but their continued formation results in considerable decomposition of minerals .

Solutions of salts have a greater solvent action for many mirerals than has pure water , and hence in soil where soluble salts are abundant the process of solution may be accelerated .

3 - Biological Process

Simple plants such as lichens , mosses etc . grow upon exposed rock where they catch dust until a thin film of highly organic materials accumulate. They decompose the rock to fine particles . Bacteria and microorganisms presents in soil may assimilate and fix N and produce many products during their activities which affect the nature of the soil .

Roots of higher plant affect the chemical nature of soil as well as the physical properties . Roots absorb mineral elements from the soil , they respire and produce CO2 and their remains are decomposed to form organic increment . Roots of grasses in particular , change the physical properties of soil especially its structure .

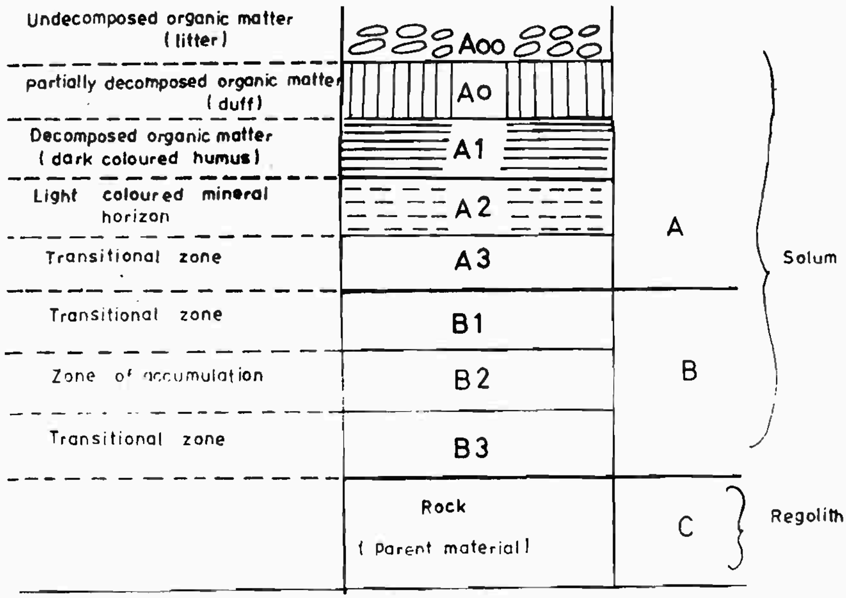
Animals, e . g earthworms, have great effect on the chemical process in soil . Particles of soil are swallowed by earthworm and grind up with their principal food which is a decomposed plant material . The excreta of worms are deposited in soil usually on the surface of ground in spiral heaps . Also , by their burrows the earthworms penetrate downward the soil to a maximum depth of 7 m , opening the lower layer of soil . Earthwarm by this manner not only futher loosening the soil , but they render the nutritive substances of the soil more easily available for plants . Their excreta is rich in nitric acid and calcium carbonate .

Remains of animals , including man , and insects which are full of nitrogen and organic content are also important , their decomposition affect the processes of weathering .

SOIL PROFILE

As parent meterial is disintegrated mechanicully , decomposed chemically , and molded biochemically into soil , a more or less deffinit layering develops . A section down through the varius layers into the less weathered parent material is called the profile .

The layers resulting from soil forming processes are grouped under three (A, B and C) layers :



Sketch Showing An Ideal Soil Profile

Defintion

soil profile = super imposed layers of soil which have undergone the processes of weathering and could be distinguished in three zones : A, Band C (parent material)

Description of the horizons of the soil profile

The first zons is known as "A" horizone . It is divided inton Aoo where there is accumulation of leaf litters , Ao where the litter undergoes partial decomposition , A_1 layer is a dark coloured horizon containing a relatively large amount of humified organic matter thoroughly mixed with inorgainc matter, A_2 layer is a light-coloured mineral horizon resulting from a leaching and bleaching action it is a well developed layer . A_3 layer is a transitional Zone which is often absent , when present it is more like A_2 than B .

The second zone is known B herizon (zone of decomposition) . is divided into : B_1 = transitonal zone , usually absent , when present it is more like B than A. B_2 = zone of accumulation especially of silicates , clays , iron , and aluminium compounds i . e . enriched zone , B_3 = transitional zone usually absent .

The third zone is known as C horizon or the unconsolidated parent material similar to that from which the solum has developed . This may come from the bedrock below i.e residual or it may has been transported from elsewhere and deposited on the bed rock i.e transported .

SOIL PHYSICAL PROPERTIES

The physical properties of soil have much to do with its stablility for the many uses to which man puts it . These include : soil texture , soil structure , soil temperature, soil air and soil water .Texture is perhaps the most permanent characteristic of soil and will be discussed first .

Soil texture :

The mineral component of soil is fromed of particles of different siz classes . The proportions of these give evidence on the soil texture . The international soil science society proposed the following siz particles :

Soil Particles	Diameter (mm)
Gravel---------	> 2.00 mm.
Fine gravel (very coarse sand)	2.00-1.00 mm.
Coarse sand ------	1.00-0.500 mm.
Medium sand -----	0.5-0.25 mm.
Fine sand --------	0.25-0.10 mm.
Very fine sand ------	0.1-0.05 mm.
Silt ---------	0.05-0.002 mm
Clay --------	< 0.002 mm.

The process of separation of soil particles is known as Mechanical Analysis. Coarser particles could be determined by the screens (sieves) while fine separates are determined by sedemintation processes. The pipette and hydrometer methods are quite convenient .

Properties of Soil Separates

1 - The gravel is the larger soil particle which is not active.

2 - The sand having large particle size, is not active as a soil separete.It has no chemical and little physical activities.

The sand serve as a frame work on the surface through which the fine particles are arranged. The surface of the sand is smaller than the surface of finer particles of the same weight.

3 - Silt : Coarser silt like fine sand, is inactive both chemically and

physically. Finer silt may have little chemical and physical activities . Particles of silt are relatively large as not to allow to coherence to each other, they do not stick to each other. Clay particles, especially the colloidal clay, can stick on the silt particles while not sand.

4 - Clay : Clay is distinguished into coarse clay (mineral inorgaric) and colloidal clay (organic) . The clay partilces constitute the base of all chemical and physical activities of the soil. The fertility of soil depends on the clay fraction and especially the colloidal clay .

The surface of clay particles is larger than the surface of coarse particles of the same weight . The particles can adsorb ions , and thus change of ions is possible on the colloidal clay particles. Clay particles stick together to from a paste.

Texture Classification of Soil

According to the proportions of the different soil separates the soil is classified to certain classes such as : sandy soil, loamy soil, silty soil, clay soil . In sady soil , the sand is above 80% . If clay is above 30% it is caly soil . If there are almost equal proportions of sand (35%) silt (45%) and clay (20%) the soil is loamy (35% sand+ 45% silt+ 20% clay : = loamy soil) . The soil is silty when the silt is above 60% and clay less than 20% .

Soil Structure :

Soil structure refers to the arrangment of the particles to each other. The soil may be simple in structure when it is formed of coarse grains like sand where the particles function more or less separately. They occur where there are insufficient cementing colloide to bind the particles together. A very complex structure is represented in clay where the soil granules are composed of many particles bound together by colloidal or gum like material originating from the finest clay form a nucleus about which the still smaller particles aggregate into granules (or flocules) in a process termed floculation , a microstructure is formed when the granules (or flocules) are invisible by nacked eye while a macrostructure is formed when th flocules are noticed by nacked eye .

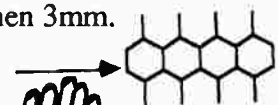
Forms of Soil Structure

The coarse textured soil e.g. sand , is structurless while the fine textured soil e. g. , clay , has definite structures . In the following are some forms of the soil structures :

1- Nutlike : The flocules (granules) are large and diameter is above 6 mm . 

2- Blocky : same as nutlike but diameter is between 3 - 6 mm .

3 - Granular : as nutlike but diameter is less then 3mm.

4 - Prismatics : the granules are prism like 

5 - Collumnar : ,, ,,, ,, coloumn like 

i.e the top of the granule is rounded.

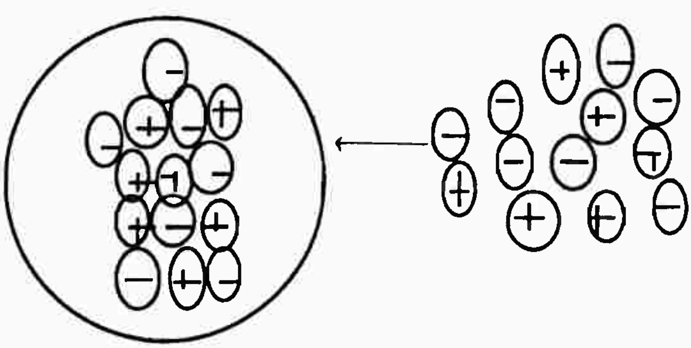
In both the prismatic and collumnar structures,the granule, are elongated, the long axis is vertical.

6 - Platy or plate-like in which the groups of granules are arranged in relatively thin horizontal plates .

7 - Laminer same as platly but the plates are thinner.

Floculation (= coagulation of the dispersed particles) . The process of granulation (or floculation)is aided mainly by the soil colloids which include clay colloid (inorganic colloid) and humus colloid (organic colloid) exist in close intermixture . The upper limit in size of the mineral colloidal particles is less than 0.001 mm or one micron (μ).

Floculation takes place as a result of a fact that colloidal particles bear negative charges , and in the presence of water wich is positively charged , orientation of soil particesl takes place due to the attraction between the opposit electric charges . By the reduction of the water in the soil , the soil particles adher to each other and unit of structure is formed . The well structured soil is good aerated while bad structured soil is



badly aerated .

Importance of Soil Structure and Soil Texture To Plants :

The structure and texture of soil are important to the growth of palnts , as they elucidate the difference between the soil types . This is shown in the followings :

1 - Root penetration

A coarse texured soil is easy for root penetration while a fine textured soil is difficulty penetrated . Well structured soil is easily penetrated by roots while bad structured soil shows resistance for root penetration .

2 - Water infiltration

A coarse textured soil is easily (quick) to water infiltrartion while the fine textured one shows slow infiltration of water . A well structured soil shows neither quick nor slow infiltration but good infiltration .

3 - Water holding capacity

This is smaller in sandy soil and higher in fine textured one as clay . Good structured soil shows relatively high water holding capacity .

4 - Fertility

Fertility depends on soil texture . Coarse soil is not fertile or of low fertility while clay soil (fine) is of high fertility .

5 - Soil aeration

Soil aeration is high in coarse textured and good structured soils . Bad aeration is found in clay and highly saturated ones .

The coarse textured soil has, thus, wide spaces full of air which is responsible of transmitting temperature . The reverse is true in fine textured soil .

Soil Temperature

Soil temperature affects the biological , chemical and physical processes in soil . It influences the rate of absorption of water and solutes , the germination of seeds , the rate of growth of roots and all underground plant parts as well as the activities of microorganisms . It is a great accelator of all chemical reactions and affects many physical proceasses taking place in soil .

Soil receives its heat directly from sun's rays and from decaying organic matter . In summer , the surface layers in which roots exist have a primary significance . The daily rangs in temperature of surface soil may be very great . Sometimes it reaches 30^{o} C - 40^{o} C , a temperature that may hurt the plant . Surface temperature above 38^{o} C often prove fatal to seedlings .

When soil surface becomes warmer than the deep layers , a heat wave is propogated downwards . It moves slowly , and at a depth of a few inches below the soil surface , temperature are not so high or fluctuations so pronounced .

Factors affecting soil temperature

Among factors that directly affect soil temperature are : colour , texture , structure , humus content , water content , slope of soil - surface with respect to sun as well as the presence and absence of vegetation cover · Out of all these factors , water content is the important one for the reason that water has a specific heat aboute five times greater than that of the solid constituents of soil . This explains why wet soils are colder than drier ones . Clay and peat soils are colder than sandy or loamy soils , largely because of their greater water content . A dark - coloured soil absorbs more heat and so warms more rapidly than the lighter coloured one which reflects the rays .

The degree of slope had a marked effect upon the amount of radient energy receives by soil . A slope of 5 degrees may be equivalent to a latitudinal distance of miles . The soil warms more quickly , vegetation starts earlier , and crops , like wheat , may ripen several days earlier on south than on north exposures .

Plant cover has considerable effect on soil temperature . Soil is cooler in summer under a cover of vegetation such as grass which intercepts most of the radient energy . It is warmer in winter than similar bare soil , since the cover acts like a blanket of poor conductivity , thus reducing the rate of loss of heat .

Measurament of soil temperature

The daily range of temperature in the surface of soil may be considerably greater than that of air above and for a study of surface conditions the thermogteph is essential . It consistes of a metal bulb (1) an inch diamater and 12 inches long fillid with liquid which is expanding or contracting according to the increase or decrease of temperature . The bulb records the change upon a metal dise (2) to which it is connected by a long flexible tube (3) . A pen (4) connected to the disc , records the temperature upon a chart which is marked off in degrees , hours and days and is attached to an 8 days clock that causes the drum (5) to make one complete revolution every week .

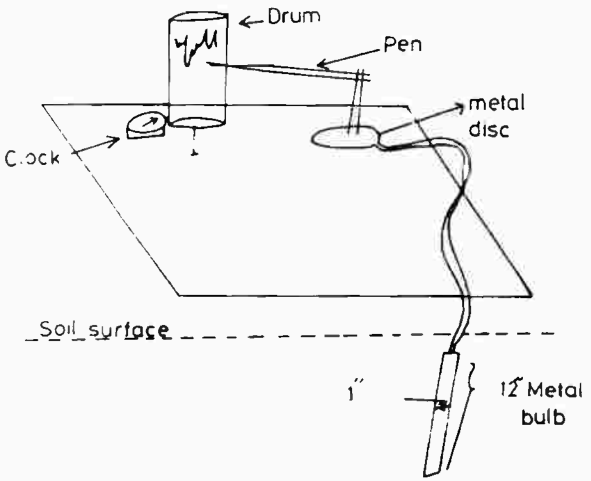


Fig . 4 Thermograph

The depth at which the bulb is buried varies with the purposes of readings . If temperature for seed germination is desired , it should be shallower than that of the study of root develompent of seedlings .

Soil Aeration (porosity)

Appoximately one half of the total volume of a representative mineral surface soil is occupied by solid materials . The remaining nonsolid or pore space is occupied by water and gases . If the spaces are filled completely with water , the soil is saturated . Always , in a soil a certain volume is occupied by air necessary for root respiration and activities of soil organisms . A well aerated soil may be define as "a soil in which gases are in the proper proportion to encourage optimum rates of the essential metabolic processes of these organisms ". Soil poposity depends mainly upon its texture and structure.

Soil Water (moisture)

Large quantities of water must be supplied to soil to satisfy the evapo-transpiration requirements of growig plants . Furthermor; this water must be available where the plants need it and most of it must come from soil , second , water acts as the solvent which together with dissolved nutrients make up soil solution .

Soil water may be classified into :

1- gravitational water
2- Capillary water
3- Hygroscopic water
4- Water vapour
5- Combined water .

1- Gravitational Water :

It is the amount of water which could be percolatd under the effect of gravity . It is of no use to plants except when rain occurs frequently and separated by narrow intervals . If this warer does not drain it will injure the roots due to the lack of oxygen and accumulation of carbon dioxide . The grvitational water is of light direct value to most plants .

2- Capillary Water :

This is the fraction of soil water which is hold by surface forces as film around soil particles and in carpillary pores . Immdiately after gravitational water has drained away , the capillary water is at its peak and soil is then said to be at its field capacity . Much of this film of water is hold loosely and is readily available to plants , but some of which is held by colloidal material and which is in the smaller pores is relatively unavailable . Capillary water is held against the gravity force. It is the main source of water for placts .

3 - Hygroscopic Water :

This is a very thin film of water held on the surface of soil particles by surface forces and moves only in the form of vapour . The moisture remining in air-dry soil is usually considered as hygroscopic water and is generally unavilable to plants . Distinction between this and unavailable capillary water is difficult . Hygroscopic water is held on the fine fractions , i . e . Colloidal fractions . It could be separated be heating the soil to 105 C^{O} .

4 - **Water Vapour :**

Water in form of vapour is present in soil atmospher (or soil air) . It is not used directly by plants , only , it makes the soil cool .

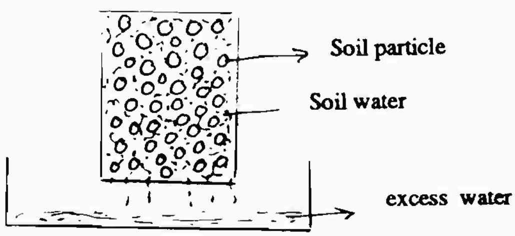
5 - **Combined Water**

This is the water combined chemically with some soil minerals as silicon oxide , aluminium oxide and iron oxide . The combined water is not separated by heating up to 105 C^{O} .

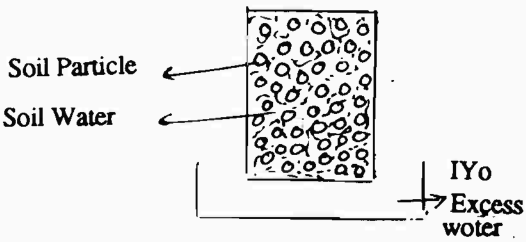
Soil Moisture Constants :

Soil moisture characteristics or soil hydrophysical characteristics , are determined under certain fixed conditions that are called " Moisture Constants " given in the following :

1 - **Maximum water holding capacity :** This is the water hold by a saturated soil . It may be determined by weighing a unit volume of soil before and after it has been immersed in water for 24 to 48 hours , i . e . a case of saturation with water, the excess water drains to a plate .



2- **Field capacity :** This is the amount of soil water remains (or holds) after all gravititional water is drained away in the dield . This value may be reached after a heavy irrigation from few hours to 3 days .



3 - **Permanent Wilting Point :**

Plant growing in soil absorb water and reduce the quantity of moisture remaining in soil . Some of water will be translocated from roots to leaves where most of it will be lost by transpiration at the leaf surfaces : A second important avenue of loss is evaporation directly from soil surface which will aid materially in the removal of soil moisture . Both of these losses are taking place simultaneously and are responsible for a markedly rapid rate of water loss from soil .

As soil dries out , plants will begin to show the effects of reduced soil moisture . Leaves of plants begin to show signe of permanent wilting . Although not dead , the plants are now existing in a permanently wilted condition and it will die if water is not added . The percentage of water that remains in a soil when permanent wilting is called the " permanent wilting percentage or wilting coefficient " . It varies between 1-15% depending upon texture of soil and include all the hygroscopic water plus a portion of the capillary water .

4 - **Available water :**

This is the range of moisture content between field capacity and the permanent wilting point . It is small in coarse-grained soil (sand) , sometimes less than 1% but higher in silt , loam or clay soils and may amount to 20% or more .

5 - **Unavailable water :**

The water holds in soil at permanent wilting point is unavailable to plants . Such water (moisture) includes hygroscopic water and the portion of capillary water which is removed too slowly by plants to prevent wilting .

Measurement of soil moisture

For ecological purposes it is of prime importance to know how much soil water is available for plant use and often to be able to follow its variations from day to day throughout a growing season . Any experssion of soil moisture should preferably refer to a unit volume of sample obtained in an undisturbed conditions .

Methods used for the measurements of soil moisture are of two types : 1) determining of actual content of water and 2) Measuring of moisture tension of soil , i.e. the condition of moisture in a soil using tensiometer

1- The actual content of water is determined by weighing soil samples before and after drying to constant weight in an oven at 105 C . The loss in weight represents the water content of soil and it is expressed as a prcentage of dry weight .

2- Moisture tension means the suction necessary to remove or deplete water from a thin column of soil . The measurement is carried out using tensiometer . The tensiometer consists of a porous pot set in soil and connected to manometer by a tube of small diameter .

Water in the pot makes connection through it with soil water, from which equilibrium tension is transmitted to the mercury of the manometer . As soil dries , it tends to draw water from the buried porous pot until the the suction force is balanced by the mercury column in the capillary tube . Since the height of mercury column indicates the tension in soil , the manometer can be calibarated from a wide range of soil moisture values and readings can be taken at any time and translated directly into values for available water .

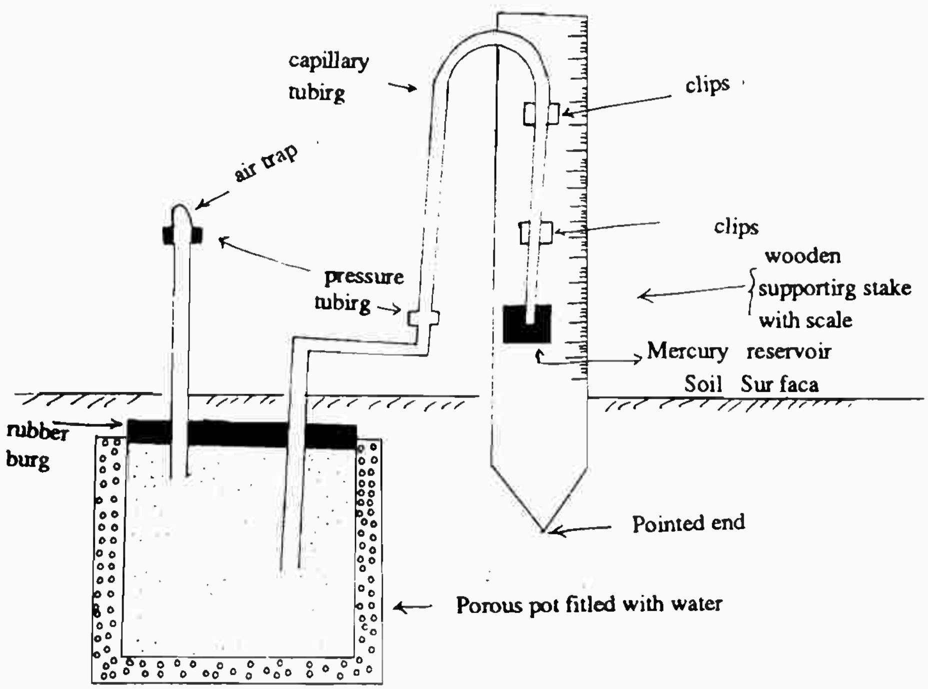


Fig . 5 Tensiometer

Soil water movement :

Movement of water through a soil , except downward percolation when soil is wet beyoned field capacty , is extremly slow . Even in soils in contact with a water table, the upward movement by capillarity is not great. The distances to which water rises (water column) by capillarity are only few cm and vary according to the soil types (35 cm in coarse sand, 70 cm in fine sand and 80 cm in heavy loam). Lateral capillary movement of water is also confined to small distances.

Water moves downward in quantity during and immediately after rain or irrigation. Later it may move upward or laterally to some extent when evaporation and use by plants reduces the movement near the surface .

Movement of gravitational water through soil is controlled by number, size, and conductivity of non-capillary pores through which it percolates. Drainage is rapid in coarse-textured soils but in clay soil movement is slow since the pores are small and may be blocked by swelling of colloidal gels or by trapped air.

Generally moisture movement takes place from moist soil to dry one .

SOIL CHEMICAL PROPERTIES

The chemical nature of soil may be determined by detecting the percentages of minerals and their constituating elements such as : Si, Fe, Al, Ca, p , K , ...etc.

soil type	Mineral Constituents (%)							
	SiO_2	AL_2O_3	FeO_3	CaO	MgO	K_2O	Na2O	P_2O_5
Fine Sand	94.3	2.1	0.7	0.07	0.03	0.03	0.01	0.01
Clay	55.7	6.6	5. 7	0.7	0.8	2.2	1.06	0.1

These elements are usually determined as oxides : SiO_2 , $Fe2O_3$, CaO , P_2O_5 ..... etc. In the following table are example fore the chemical analysis of two types of soil:

It is abvious that the amount of silica (SiO_2) is highest in both soil types followed by $Al2O_3$ then comes iron oxide, Ca02, Mg0, K_20, Na_20 and P_20_5 .

Chemical nature of soil depends on types of minerals present and it affects the charcters of soil related to nurition of plants . A soil rich in elements especiallly Ca, K, and P is more productive than soil poor in those elements .

The chemical study of soil includes , Ion exchange, soil reaction (pH), saline and alkaline soil, and acid soils.

A) Ion Exchange

Ion exchange is an important chemical reaction occuring in both inorgainc and orgaine colloids of soil. Colloidal nucleus or " **Micelle** " is negatively charged and has the power to adsorb cations of calcium, magnesuim, sodium, hydrogen and other elements . Any cation can be replaced by another cation and thus go into solution and be made available for absorbtion by plant toots .

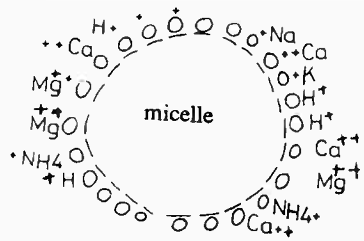


Fig . 6 The Colloideal Nucleus

The ions differ in their replacing capacity or power . The efficiency of an ion to replace onother depends on :

1 - **Concentration of ion in solution :**

The more the concentration the higher is the replacing power .

2 - **Number of charges on ions :**

The divalent ions have larger power of replacing than the monovalent ions .

3 - **The spread of ion movement :**

This depends on the volume of ion , Hydrogen is the most quicker of all ions . The ions may be distributed according to this order : H, Ca , Mg , NH4 and Na .

Each clay colloidal particle has a definit capacity of ion exchange . If the whole capacity is made of hydrogen ions the particle is known as unsaturated . If hydrogen ions are replaced totally by Na , K, Ca, etc . then it is saturated . Clay saturated with sodium is known as sodium clay , clay saturated . with potassium is known as potassium clay . Ion Echange capacity : The maximum amount of exchangeable ions (anions of acid and cation of base) a soil can hold .

Cation Exchange

The cation exchange takes place by exchange of cations such as Ca++ , Mg++ , Na+ , K+ and NH4 + with H + ion .

The cation exchange capacity is expressed in terms of equivalents of more specifically , as milliequivalents per 100 gms soil . Milliequivat ent = one milligram of hydrogen or the amount of any other ion that will combine with or displace it . Thus , if a clay has a cation exchange of 1 milliequivalent (1 m.e. / 100 gm) , it is capable of adsorbing and holding 1 milligram of hydrogen or its equivalent for every 100 gm of dry substance . The term equivalent indicates that other ions also may be expressed in term of milliequivalents . For example , let us consider calsium . This element has an atomic weight of 40 compared to 1 for hydrogen . Each Ca ++ ion has two charges and thus is equivalent to 2 H+ ions . Therefore , the amount of calcium required to displace 1 milligram of H+ is 10X 2 or 20 mgm the weight of one milliequivalent of calcium . If 100 mgs of a certain clay are capable of adsorbing a total of 250 mgm of calcium the cation adsorption capacity 250/20=12.5 m.e . / 100 gms .

Anion Exchange :

The anion exchange takes place by anion such as : sulphates, nitrates, phosphates ... etc . exchange with OH group . This occurs in a very narrow scale comparing to the cation exchange .

Soile Fertility :

The more colloidal clay in a soil, the more its fertility level and also the higher the capacity of a colloideal clay for inonic exchange, the higher the soil fertility .

The addition of manure fertilizere to a soil as : calcium, potassium etc. is of prime importance . The ions such as Ca ++ , K+, Mg ++ etc. replace H+ ion and are stored on the micelle to be utilised later, So, the clay micelle in a soil acts as a store house for plant nutrients .

B) Soil Reaction (pH)

Soil may be acidic when the H ions exceeds the OH ions, when the reverse occurs it is alkaline. Soil is said to be neutral when the H ions and OH ions are equal in concentrations (pH = 7) . Reaction is usually expressed as pH .

Humid climate favours acidic soils while in arid zones alkaline soils are favoured. Acidity in soil is a function of the colloidal fraction .

Acid soils may be formed as a resulkt of the decomposition of igneous rock and/or litter. These are also formed as a result of metablism of soil organisms. Basic soil reaction is due to the presence of excess salts which yield strong bases on hydrolysis e.g. Ca and Na carbonates . The pH of the acidic soil is less than 7, while the pH of the basic (alkaline) soil is more than 7, the neutral soil has pH value of 7 .

The pH varies widely from one habitat to another and even in the same habitat at different levels. Usually, the upper layers of soil are more acidic than the lower ones owing to the pressence of relatively abundant organic matter and the washing of bases by rain from the upper layer. In warm dry climates, soil varies from neutral to strongly basic.

In agriculture, acid solis are treated with limestone ($CaCO_3$) which supplies soil with Ca^{++} that neutralize the acids. Basic soils are improved by the addition of sulphur, which upon oxidation yields sulpuric acid that tends to reduce soil alkalinity .

$$Na_2CO_3 + H_2SO_4 \dashrightarrow CO_2 + H_2O + \underset{\text{(leached)}}{Na_2SO_4}$$

C- Saline and Alkali soils

The saline and alkali soils (pH more than 7) are those in which the salt concentration is high enough to produce salinity and alkalinity and decreases the productivity of soil .

In arid regions where drainage is very slight as well as in marshes ... etc . adjacent to seashores and other bodies of salt water , the soil salts may accumulate to such a degree that they are distinctly harmful to most plants . The salts may have been present originally in the parent materials and not leached as they are under heavy rainfall . More commonly salts occur in poorly drained places or seepage areas where they accumulate upon the evaporation of water that leached them from adjoining land .

Saline and alkali soils may be classified into three types :

a- Saline soils .

b- Saline - alkali soils .

c- non - saline alkali soils .

a) **Saline soils (solonchak)**

Saline soils are commonly named white alkali soils . In these soils there is a high percentage of neutral soluble salts suffcient to be seriously interfer with the growth of most plants . The cations are commonly , Na + , K + , Mg ++ and Ca ++ while the anions are mainly chlorides and then sulphates, nitrates , carbonates and bicarbonates in less extent . The pH of these soils is less than 8.5 because the souble salts present are mainly neutral and the amount of exchangeable sodium is small (less than 15%) . The salts may be in the form of white crusts at the soil surface or crystals of salts may be found in upper layer mixed with the soil mineral constituents . Reclamation of these soils may be achieved by good drainage and washing . The salts which are soluble will be leached downwards without rising in pH . The character of these soils is that sodium represents about 50 % of the soluble cations and the adsorbed Na to the colloidal fraction of soil is less than 15 % .

b - **Saline - alkali soils**

These soils contain also high precentage of neutral soluble salts that are seriously injured the plants . The pH seldom exceed 8.5 but rises when the soil is leached .

Once the neutral saluble salts are removed it is readily hydrolyses and thereby markedly increase in OH ions concentration in soil solution occurs . The cations of these soils are of Na+ , Ca++ , K+ and Mg ++ , but the soluble Na percentage is less than 50 % and the percentage of adsorbed Na is more than 15% .

Reclamation of these soils is difficult . If the soil is washed with water, the soluble salt will be leached downwards and the soil will be transformed to non - saline alkali soil (third type) , unless Ca ++ (usually $CaSO_4$) is added to such soils to replace Na from the colloidal complex or on the surface of the colloidal complex .

3- Non - saline alkali soils (Solontz)

These soils do not have so high concentration of soluble saltes as do those of the two preceding types . Their soil solution contains only small amounts of Ca ++ and Mg ++ but larger quantities of Na+ . The anions include SO 4 , C1 , HCO3 and small quantity of CO3 . The exchangeable Na + which accupies more then 15 % of the total exchange capacity of these soils , is free to hydrolyse . Consequently , the pH is above 8.5 and often rising to 10 .

These usually named " **black alkali soils** " . The dark colour of the salty surface crust is due to the dissolved organic matter.

Reclamation of this type of soils depends on the addition of lime ($CaCO_3$) .

Salinity in soil is produced as the under ground warter rises by capillarity , or the rain water comes down slopes accumulates in low places without drainage and in both cases high temperature increases the rate of evaporation of water leaving crusts of salts above soil surface .

Why salinity is harmful to plants :

Saline soil is harmful to plants in a number of ways . A concentrated soil soltion , due to excess of salts and to loss of water by surface evaporation may delay seed germination either temporarily or indefinitely by hindering water absorprion . The seeds of most halophytes probably germinate only when soil solution is diluted by rains , If germination is successful , later concentration of salts may cease the movement of water from the root hairs to the soil . This gives risre to a condition of **plasmolysis** (skrinking of the protoplasm) , absorption is inhibited and wilting and death of plants may result . Even if the plants can grow , their nutrition is stopped unless they have become adapted to excess supply of ions into which the salts are dissociated (like the halophytes) .

Injury due to excess salts is often show by **chlorosis** . The bark of plants may be corroded at the soil surface by salts , especially by the carbonates concentrating in soil surface during drought . In this way the bark be so thoroughly destroyed that the passage of food from leaves to roots is prevented .

Salinity may moreover , affect soil structure by dissolving out the humus and deflocculating the clay and producing impervious colloid through chemical reaction .

Many saline soils are underlained by a hard pan which is impervious to both water and roots .

Reclamation of saline and alkali soil

Various methods of reclaiming saline and alkali soils are emplyoyed . Among these are 1 - scraping the salts from the surface when they have accumulated 2- plowing them under , 3 - leaching them from the furrow bottom into the subsoil and preventing their accumulation at the surface by efficient mulches (decaying materials) . etc . The most satisfactory and permanent method is to add sufficient water to leach and drain out the excess salts and thus entirely to free soil from them . When sadium carbonate is present , addition of gypsum $CaSO_4$ with subsequent flooding may be effectively employed or sulphur may be added to the soil . The latter slowly forms sulphuric acid which neutralise the sodium carbonates . Moreover , calcium is brought into solution as calcium sulphate which exerts a further benificial effect .

$Na_2CO_3 + H_2SO_4$ -------- $CO_2 + H_2O + Na_2SO_4$ (leached) .

d) Acid Soils

In humid regions soil is frequently acid . The causes of soil acidity (pH = less than 7) are complex . It is due primarly to the leaching of soluble basic salts especially calcium carbonates . In soils of organic origin , calcium carbonate orginally occured only in small amounts . When basic salts, are present in only very small proportions , soil develops more or less marked acidity , most generally as the result of the accumulation of humus under conditions of poor aeration but sometimes by the setting free of acid from the mineral constituents of soil . Either mineral or organic acid may occur . Nitric acid may be produced by nitrifying bracteria , sulphuric acid by the oxidation of sulphur bearing compounbds , hydrochloric acid by the interaction of salt water and soil in the vicinity of the saline areas , and carboinc acid is continually present in soils . Numerous organic acids : oxalic , lactic and acetic are formed by the decompostion of cellulose and other organic compounds , and certain organic acids are actually secreted by roots in poorly aerated soils . Amino acids are also formed by decay of materials of organic origin . It is believed that both the inorganic and organic colloids of soil adsorb various substances . Hydrogen ions are among the substances adsorbed . A neutral salt in soil e . g . calcium choride may replace some of the adsorbed H ions and the latters goining into soil solution increase acidity .

SOIL ORGANISMS

Soil is not a mass of inert inorganic material but it is the home of certain animals and plants . The plant life is represented by countless billionions of microorganisms (bacteria , fungi , algae) roots , and rhizomes of higher plants . The animal life is represented by microscopic one- celluar protozoa , nematodes , earthworms , insects , burrowing animals (moles , gophers , rates ... etc) .

A) Soil Microorganism

Among this vast assemblage of soil dewelers , certain groups deserve special mention since they are concerned very directly with supply of nitrogen, a constituent of the protoplasm and a substance most indispensible to plants , these are the soil microorganisma or soil microbes . A single gm . of loam from surface soil may contain 4,000,000 to 58,000,000 microbes .

A soil microbes are responsible for many chemical changes occuring in soil , e . g . 1) Decomposition of organic matter , . 2) Fixation of atmospheric nitrogen . 3) Changes in mineral constituents of soil . etc . These three processes can be described as follows :

1- Decomposition of Organic Matter

The plant remains and also animal residues are subject to continual decomposition by the activity of soil microbes . This takes place by the aid of enzymes in these microbes .

The soil microbes are present in larger extent in the surface layer of soil , i . e . in "A" horizon . The organic content is a factor of great importance in soil productivity . A soil with high organic contents contains more nutrient , than soil devoid of organic matter .

The pocess of decomposition goes on in many steps . The plant remains (orgabic matter) when decompose are transformed to several intermediate compounds or products . The starches (carbohydrates) fats ... etc decompose and finally the products are exidised to $CO2$ and $H2O$ which are easily used by plants . Compounds containing N decompose to $NH3$ and other intermediate products in a process called Ammonification that takes place as follow : the proteins break down into less complex proteoses , peptones and amino acids . The bacteria use part of nitrogen for themseleves and in so doining , they release ammonia as a waste . Few plants can use ammonia directly and many are injured by its accumulation in soil .

Proteins → proteases → peptones → { Acid amides ; $NH_3+CO_2+H_2O$; amino acids }

Ammonification is followed by nitrification in which a group of nitrite bacteria (nitrosomonas) convert the ammonia to nitrite by partial oxidation . The nitrites are further oxidised by other bacteria (nitrobacter) to nitrates which is the form of nitrogen most favourable to green plants .

2- fixation of atmospheric nitrogen

Certain bacteria (e . g. *Rhizobium* spp .) living free in many soils, entre the root hairs of most leguminous plants and produce a proliferation of cortical cells sufficient to appear as a small nodule on the root . Although the plant provide food for the bacteria and produces the nodules in which the bacteria multiply , the relationship is truly symbiotic . These nitrogen fixing bacteria (*Rhizobium* spp .) are able to take free nitrogen from the air , and to combine it with other elements to form compounds that can be used by plants during its life time . After plant death , the accumulated nitrogeneous compounds are released in the soil and are used by other plants growing there .

Apart from the nodule forming bacteria there are other types of bacteria in the soil that fix the atmospheric nitrogen . This type is not symbiotic (nonsymbiotic) which , under suitable aeration , fixes nitrogen and changes it to nitrites and nitrates . This type is called azotobacter . Under conditions of insufficient oxygen supply (anaerobic) it is called *Clostridium* bacteria

3- channges in mineral consituents of soil

By the effect of soil microorganisms , acids is produced from the mineral constituents of soil e .g H_2SO_4 , HNO_3 together with organic acids . These act on the minerals of soil , dissolve insoluble materials such as phosphates , carbonates , Mg compounds , Ca compounds ..... etc .

B) Animal life in soil

Protozoa are largely beneficial to soil because they are fed on pathogenic bacteria and keep important group of bacteria in youthful state for a longer period of time by consuming the older bacterial cells, thus stimulating specific bacterial processes .

Nematodes are beneficial and harmful in the same time. They improve soil aeration and aid in bringing an intimate mixture of minerals and organic matters in soil and in breaking down organic materials. On the other hand, the root of a great number of plants, such as tomato, carrot, peas etc. are attacked by certain species of nematodes and great deal of damage is often done. They also puncture the roots of plant facilitating the entrance of other parasites .

Earthwarms are very important in soil. These organisms may pass several tons of soil through their bodies annually and in so doing bring about an increased availability of plant nutrients. Plant nutrients contained in both the mineral and organic portions are relessed, the nitrogen of the organic matter being affected particularly. Holes left in of soil by earthworms bring appreciable quantities soil from the lower to the upper horizins, resulting in considerable soil mixing and develop the aeration of soil .

Other large animals inhabiting soil namely : rodents , ants , snails, spiders, insects. etc. are beneficial for most soils. As result of their activity considerable quantity of soil are transferred and some disintegration of soil particles occurs. Their activities tend to increase aeration and imporve drainage of soils. Some of these animals cause various chemical changes in soil either directly by their digestive processes or indirectly by influencing the activites of soil bacteria, fungi ... etc . Although soils may be directly benifited by the activity of these animals yet they may prove unfavourable to agriculture nuder certain conditions . Much damage is done to certain crops by representatives of these groups especially by some of the insects .

ORGANIC MATTER AND HUMUS

The organic matter exert a controlling influence on soil properties, including productivity and without it the surface layar of the earth could hardly be correctly designated as a soil .

Sources and kinds of soil organic matter :

Both plants and animals contribute to the organic matter of soil. Some of the material is derived from dead roots and soil organisms and is, therefore, well distributed through the soil from the first. On the other hand, much organic matter is deposited up on soil surface as leaves, twigs, wood ... etc . and becomes incroporated into mineral material only through the activities of organisms . In dense forests as much as several tons of litter may be deposited on the ground annually .

Because roots and soil organisms inhabit chiefly the upper soil layers, and because all materials derived from plant shoots are deposited upon the surface, soils generally show a rapid decrease in orgaic matter from the surface downward . All organic plant debris which have has fallen to the ground is called **litter** or the Aoo layer. Just beneath the fresh litter may be found material derived from the preceding season's litter in which decay is well advanced and this is the **duff** or Ao layer . Uder certain types of vegetation both these forms of suface debris are present but elsewhere one of both of them may be abset at least at certain season . After the normal biologic processes of decay , the duff is decomposed imparting a dark colour to soil . Such finely divided amorphous organic matter is called **humus,** and the process leading to its formation is called **Humification,** Humus denotes soil organic matter which has undergone extensive decomposition . It is not homogeneous compound with no definite chemical composition . It is a dark heterogeneous mass consisting of the residues of plants and materials together with the synthesized cell substaces of soil organisms . Humus is not static but dynamic in soil , it is continually undergoing change . A part of humus is in a colloidal state and thus has active chemical and physical properties . The chemical nature of humus in uncertain as it is continually subjected to changes by decomposition , oxidation . etc .

The humus content affects the physical propties of soil such as soil structure, water holding capacity etc . Humus swills in water like the spong and thus it increases the water holding capacity of soil . Being dark , the humus affect soil temperature .

Chemically humus act in soil as store house of nutrients . The plant food minerals are retained in humus and gradually released from it by new plants . The colloidal humus acts as micelle with higher cation exchange capacity than the colloidal clay . The micelle of humus is organic in nature and composed mainly of C, H, O_2, S, P. In cases of the colloidal clay it is composed of Si, O_2, H and Fe. The humus micelle has more negative charges than the clay micelle and thus affects greatly in the conditions of soil fertility .

By the decomposition of humus under the effect of microorganisms, CO_2, and H_2O (i.e carbonic acid $CO_2 + H_2O$ ----------- H_2CO_3) is Produced . The cardonic acid produced is active in dissolving minerals and salts .

Soil may be classified according to the content of organic matter into :

1 - Mineral soils , contains 0 - 20 % humus (or organic matter) .

2 - Muck soils , contains 20 - 30 humus (or organic matter) .

3 - Peat soils : contains more than 30 % humus (or organic matter) .

Soil Solution

All the water contained in a soil, together with its dissolved solids, liquide and gases is termed soil solution . Of the 15 or more elements essential for plant nutritin all but C, H and 0 are derived from soil . and it is believed that practically all substances taken up by roots must be contained in soil solution .

Plants cannot live normally when any of these nutrient elements are present in amount too small or in combination too complex for absorption . Neither can they live normally if soil solution contains a harmful excess of one or more solutes such as acids, bases, salts, organic toxines or even fertilizers . It is only when soil solution has neither too little nor too much of any solute that soil can be considered fertile .

PHYSIOGRAPHIC FACTORS

PHYSIOGRAPHIC FACTORS

The chief physiographic factors of the enveronment are : (1) Topography and (2) Substratum .

1- Topography

It refers , to the configuration of the earth's surface; the hills , the valleys , the mountains , the shores , their slope angles and directions facing sun and winds and their elevation . Since the earth's surface is continually being pushed up and eroded down , the relatively flat areas are in the minority . But even , e.g. in desert wadis the microtopography produces micro-environmental differences of great importance to growth and distribution of the inhabiting plants .

Topohraphy does not directly affect the organisms but it works through other factors . The north - and south - facing or the east - and west - facing slopes , of any ravine (wadi) affect plant disribution and growth by their being shaded or sunny , respectively , or by their being of barren shallow or deep soils etc .

2- Substratum

The earth's crust is made up of many types of rocks , each with its own particular mineralogical composition and other characteristics . In many places these rocks are the parent material of the soil and lie as a substratum immediately below the soil . Over large areas , however , the rocks are burried under glacial deposits , alluvium and dune sands . In such places , the substrata of ecological importances are those unconsolidated deposits that act as the parent material of the soil.

Soils are the products of climate and vegetation acting upon a substratum . However , with a given climate it is the substratum that causes much of the variation in soils and vegetation . Even in quite different climates , certain kinds of rocks such as limestone , have pronounced chemical characteristics , which result in restriction of certain species of these chemically distinct areas . Other species with different requirements may be excluded from the unusual rock . Among the sharpest biological boundaries are those where different rock types come in contact .

The effect of a substratum on soil and vaegetation is most marked in extreme dry or cold climates . Here , soil development is slow, so that the particular mineralogical composition of the parent material often predominates in the thin soil cover . The availability of water in dune sand , salty plays and rocky soils may be so different that different vegetations occupy them in the same desert climate . However , in the desert , one can literally step from one community to another over the contact zone between two rock types . Rock differences are the responsible facor for the two vegetation types .

Whatever the climate , roks that have an excess or lack of certain minerals tend to cause the greatest biological restriction or exclusion of species . These are limestone , dolomite , and any rock that have been chemically altered by e.g. hot-spring or volcanic actions . By contrast , rocks of mixed mineralogic-decomposition , no matter what their origin , tend to have similar vegetations in the same climate . Alluvium is the substratum developing into the most productive soils in any climate .

BIOTIC FACTORS

BIOTIC FACTORS

The biotic factors (Bio = Life) of the environment are those which depend directly upon the action of living organisms on the vegetation . With regard the whole complex of living organisms , both animals and plants, naturally living together as a sociological unit which has been called the **Biome** . The Biome includes soil algae , bacteria , earthworms , insects , parasitic fungi , rabbits , mice and other rodents , cattle , sheep , man etc .

Biotic factors could be divided into three categories as follow :

A) Relations between plants and plants .

B) Relations between plants and animals .

C) Relations between plants and man .

A) Relations Between Plants and Plants

There are two social relationships betweem plants and Plants : I Dependent Union and II Commensal Union

I. Dependent Union

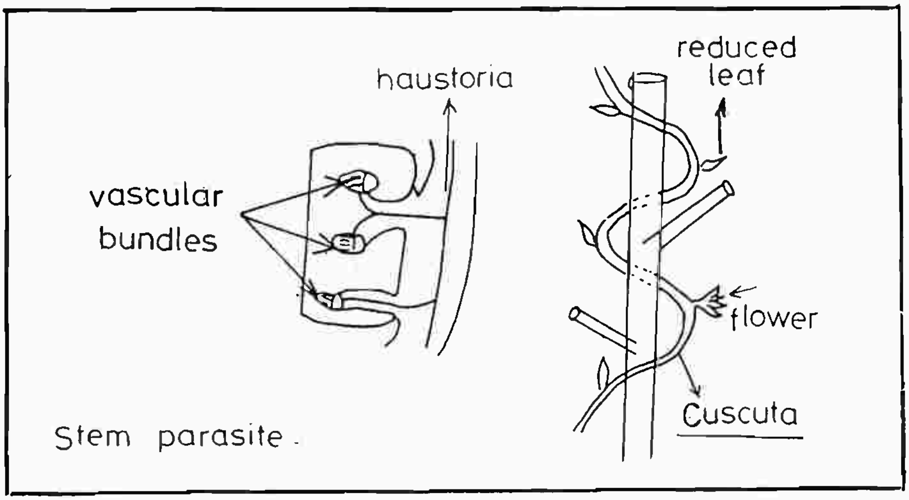
A plant depends upon another for its life in diferent ways . It may depend totally (Parasitism) , Simply (Epiphytes and Lianas) or both depend upon each other (Symbiosis) .

A) Parasitism

The parasitc plant being devoid of chlorophyll depends wholly on its host . The parasite suck the nutrients from its host causing harm to the latter .

There an two types of parasitism :

a) Stem parasite and b) root parasite . Example of stem parasite can be studied by *Cuscuta* . which is a typical stem parasite . It is an annual parasite on many hosts , e . g . *Trifolinm* spp . *Cuscuta* has a thread-like stem which entwines the host sendig haustoria in the tissues of the latter through which nourishment is absorbed . Green leaves are absent but a mumber of minute scales devoid of chlorophyll appear on the stem . The stem bear rosette-like bunches of white or pink flowers . Owing to the production of a great number of minute seeds the risk of a host not being found is minimized , since one or more seeds are very likely to germinate near a suitable plant .



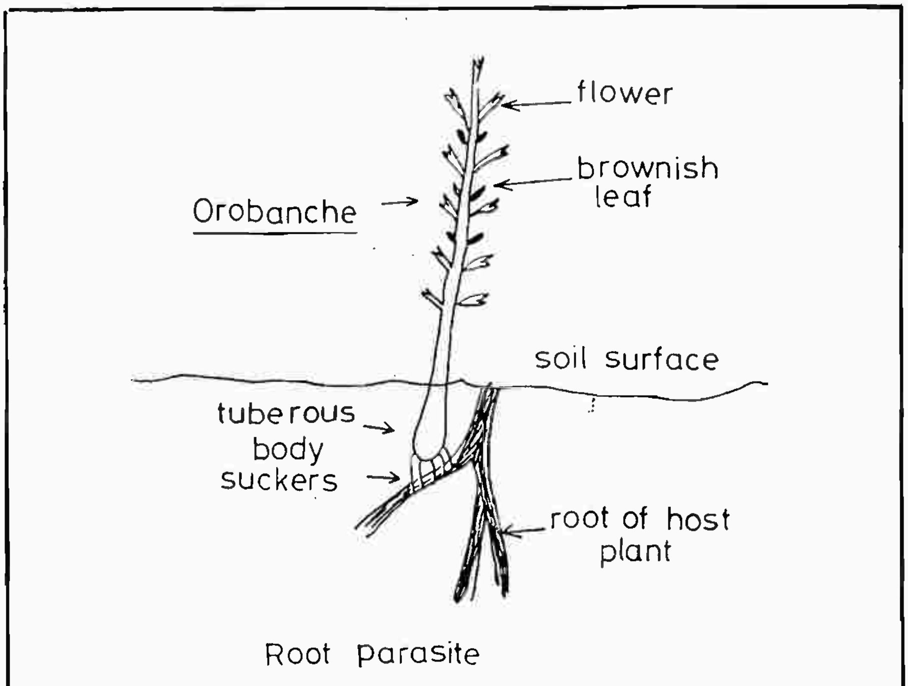


Fig .7

The haustoria develop from the stem as outgrowths which become flat when coming in contact with the host. A peglike outgrowth arises from the center of the haustorium, penetrate the cortex and finally, expands as it reaches the vascular tissues of the host. Then the tissues of the haustoria become differentiated into phloem-like elements which come in contact with the xylem of the host. In this manner the photosynthetic products and absorptive system of the host become available for the parasite.

Orobanch is a typical exemple for root parasites. The orobanch is a plant that shows greater modification of shoots which attaches itself on growth of the root of a host developing a brown tuberous body without leaves and shut off from light. By means of suckers it burrows with a broad surface into root of host plant and establishes a close relation with its conducting tissues. The flowering shoot appears above ground carrying browndish leaves and numerous flowers.

B) Symbiosis

Symbiosis is the living together of dissimilar organisms (e.g. algae, fungi, bacteria, root of higher plants etc.) with benifit to both. The nitrogen fixing bacteria on the roots of leguminous plants, the mycorrhizal fungi on the root of trees and the lichens are typical examples of symbiosis between plants.

a) Lichens

A lichen is an organism formed by the close association of one or more fungi with one or more unicellular green or blue green algae. The algal cells are enmeshed within the fungal mycelium. The fungus gets all its food from the algae. The algae may benifit from certain excretions of the fungi and the latter also protect the algae during time of drought.

b) Symbiotic N Fixation (Bacteria and Root of plant)

Roots of most leguminous plants produce ball-like nodules or *bacteriorrhizae* inhabited by bacteria (*rhizobium* spp.) which fix atmospheric N into compound that eventually benifit the legumes. The legume in turn furnishes the bacteria with foods and water.

Legume-nodule bacteria gain entrance into root through hairs and are purely parasitic in early stages of nodule formation. In well developed nodules the bacteria make use of N to synthesize amino-acids .

c) **Mycorrhiza** (fungi and root of plant)

Root of many plants regularly grow in close association with the hyphae of fungus . The term mycorrhiza is applied to this association . When fungus is present outside root tissue of plant , the mycorrhiza is known as ectotrophic . This type of mycorrhiza occurs in many trees e.g. beech , oak , pine etc.. The fungal hyphae cover the root and form a complete investment when full developed . They do not penetrate the cells of the root and replace the root hairs acting as absorptive filaments . As regard the importance of this type of mycorrhiza , there is evidence that in some types of soil the tree does not flourish unless the mycorrhizal association is properly developed .

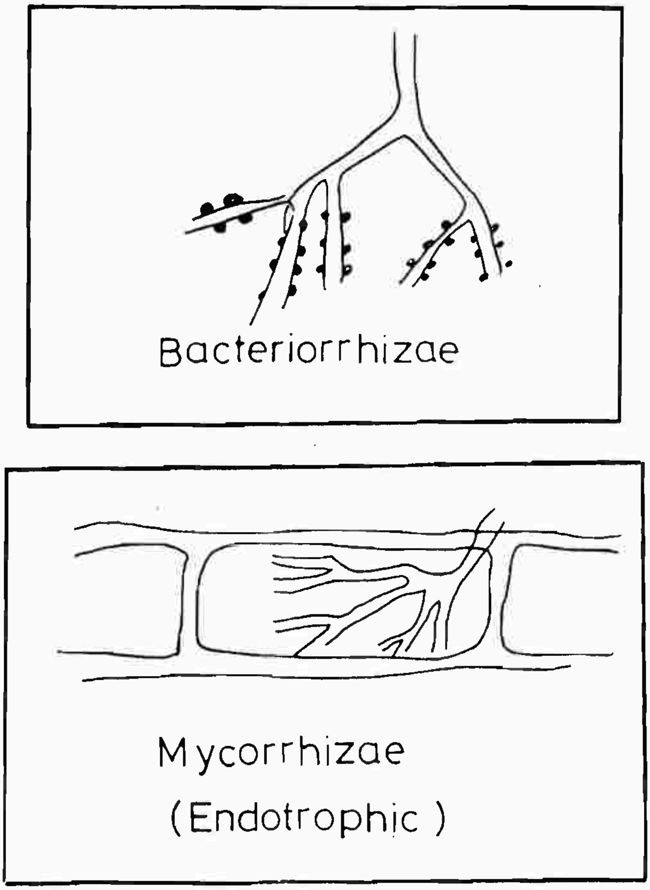


Fig .8

When the fungus penetrate and lives inside the cortical cells of root of higher plant as in orchid root , the mycorrhiza is known as **endo-trophic** . In this type the fungal filament come into intimate relation with the protoplast of higher plants . These internal hyphae are connected with the external hyphae found on root surface . There is change of nutrients between the fungus and the higher plants . By this way the two organisms can tolerate the severe environmental conditions .

C) Simply dependents

These include the epiphytes and lianas .

a) Epiphytes

Epiphytes are plants growing on other plants which differ from parasites in not deriving water or food from the supporting plant and from lianas in ont having soil connections . Of all ecological classes of palnts these are the most directly dependent on precipitation for their water supply and unless rains are heavy dew fall at frequent intervals , they must able to endure drought . Their nutrient supply is derived in part from rainwater , which always contain some dissolved substances , in part from accumulated wind-borne particles , and in part from the decayig bark surface of the supporting plants .

Epiphytes may grow on trees and shrubs . They occur on the trunk , limbs and sometimes on the upper leaf surface of woody plants .

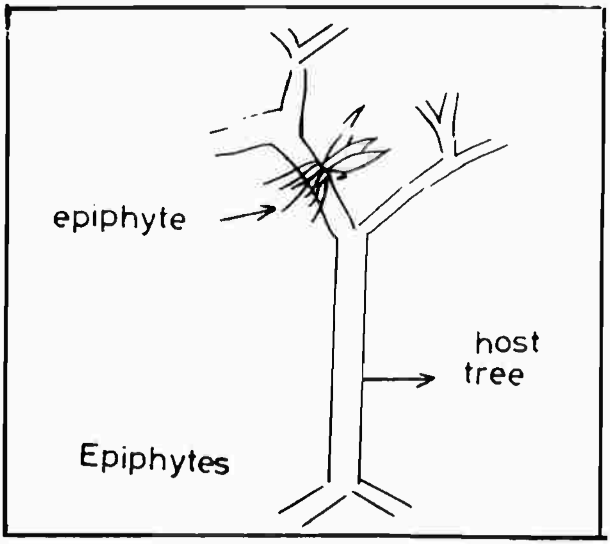


Fig .9

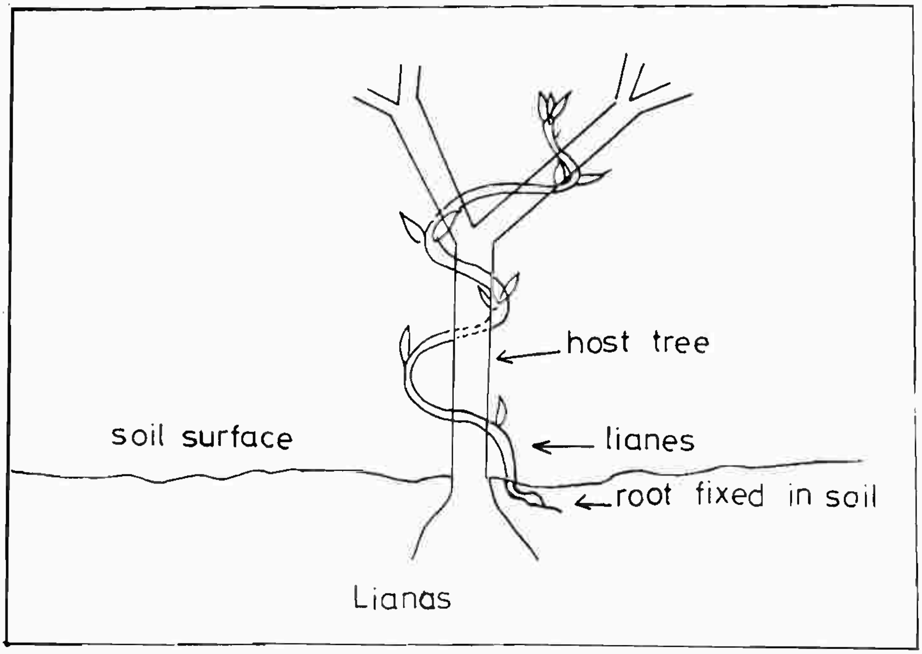


Fig .10

b) **Lianas**

Vascular plants that are rooted in ground and maintain their stem in a more or less erect position by making use of other objects for support are called lianas . This habit of growth has the advantage of enabling plant to get better light with a maximum economy of supporting tissue These lianas that climb over other plants , are in a sense , parasitizing the other plants supporting tissue but there is no direct nutritional relationship between true lianas and trees upon which they grow .

Anatomically , lianas stem exhibits two peculiarities , the woody cylinder occurs as strands separated by vertical partitions of parenchymatous tissues , and the xylem vesseles are long and wide .

Lianas may be classified into the following :

1- Leeners : Those plants have no special devices for holding into support , e . g . *Plumbago* , *Cocculus* etc . (Photo 16) .

2- Thorn Lianas : Lianas possessing thorns which are hardly specialized for the function of climbing e . g. *Bougainvillea and Rosa* spp .

3- Twinners : Lianas in which the entire stem twins about the support . These are mostly herbaceous plants , e . g . *Ipomoea, Phaseo-*

lus etc .

4 - <u>Tendril Lianas</u> : Lianas possessing special organs , the **<u>tendril</u>** which are modified to facilitate climbing either by twining about the support (*Vitis*) or by adhering to its surface (*Hedera helix*) Tendrils are generally weak organs untill they become attached . Tendrils may be a part of leaves such as the modified terminal leaflet of a compound leaf (*Pisum* , *Vicia* etc .) or the petiole which takes a twin about the support (*Clematis*) . In Vitis the tendril is of a stem origin .
Adventitious roots emerge from the stems of *Vanilla* to serve as tendril .

Photo 16 : Plant - Plant Relationship , **Cocculus pendulus** (White trunk) is climbing on the strong trunk of **Acacia raddiana** tree, Eastern Desert, Egypt .

II. <u>COMMENSAL UNION</u>

The presence of plants nearer to each other make them compete to get their needs of light and nutrients . Competition is at its maximum state when competators are of one species and are inneed for the same nutrients while competition is at its minimum state between the plants that are inneed for different nutrients and also between those plants that have their aerial parts in different levels of air or their roots are in different layers of soil and so they take their water and untrient solution freerly . Competition may be also mechanically between strong and weak plants.

In desert regions , where plants are very few and scattered in very wide areas and their roots are far from each others , competition is very weak or practically not present while in the forests competition is very strong .

RELATIONS BETWEEN PLANTS AND ANIMALS

The relations between plants and animals are represented by : Grazing of plants by animals (herbivorous animals) , Pitcher Plants (carnivorous Plants) , animal pollination , seed and fruit dissimination by animals .

1- Grazing And Browsing (Herbivorous Animals)

Grazing refers to the use of unharvested herbs or forage by animals , browsing refers to a similar use of shrubs and/or trees .

For each kind of animals the plants available to it may be classified in a sequence from those that are very palatable to those that are strictly avoided . Palatable species tend to be the most severly injured and unpalatable ones may escape injury and even may be benefited by the release from competition . Among the palatable species , differences in nutritive value must be taken into account in those planting and managment practices that benefit certain species at the expense of the other . Owing to differences in seasonal development , different types of plant cover may have different period , during which they are grazed to best advantage .

Grazing may injur a plant because the frequency or degree of removal of its photosynthetic organs cuttails its assimilation . On the other hand, plants the shoots of which are kept clipped to small size by continual grazing may be better able to withstand drought . The smaller plants make smaller demands on the supply of moisture stored in soil .

The effect of grazing on different species of plants depends to a large extent on life form (herbs , shrubs, trees etc..) . Annuals that are palatable quickly disappear from an area if grazed so much that they cannot set many seeds . Among herbaceous perennials, palatable grasses withstand grazing because their leaves are not destroyed as their basal meristems are not removed. In fact plants are stimulated by mild grazing . Shrubs are less easily injured by browsing than herbs are by grazing because browsing, which is generally confined to the new growth , removes but a small portion of shoot . Low shrubs, may be kept reduced ıo dwarf mats and tall shrubs and trees, if they can attain a height above ıhe reach of animals, finally become essentially free from direct ingury.

The aspect of vegetation may be markedly changed as a result of these difference in reaction of individual species to the grazing factor Grazing in shrubby vegetation often increases the numbers and sizes of shrubs by removing the competitive grasses that having a large share of water and nutrients available. Grazing in purely herbaceous vegetation generally results in a sparser plant cover consisting of fewer species which are unpalatable. The kind of animals that produces most of grazing influence is also an important factor . Sheep normally prefare forbs, horses and cattle prefer grasses and goats and deer prefer broad-leaved woody plants.

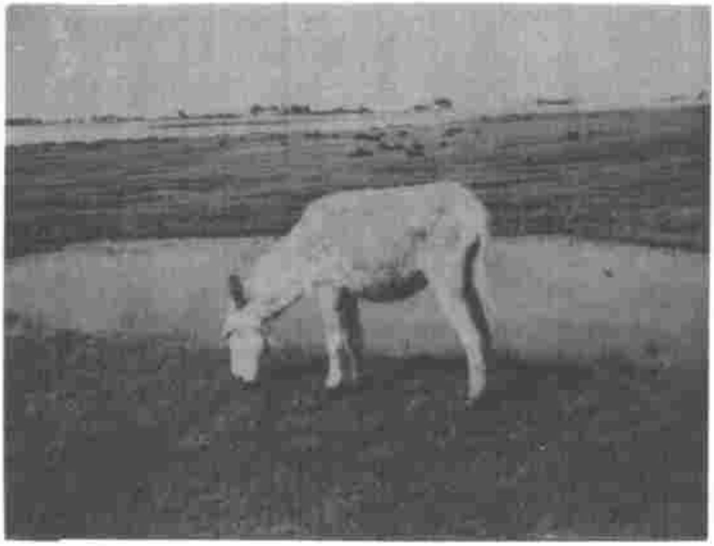


Photo 17 : Salt marshes dominated by **Cyperus laevigatus** . The Donkey is grazing the plant , Wadi El-Natru Depression , Western Desert , Egypt .

Animals ate also destructive factors for seeds and seedlings. The high energy value of the particular types of food stored in seeds makes them very satisfactory as a source of food for animals. Insects, birds, mice and other desert rodents annually consume tremendous quantities of seed. The amount of seed poduced by a particular type of plant varies considerably from year to year, and when the crop is small, seed-eating aninmals may destroy it entirely .

Not only seeds are consumed by animals, but during their first summer, seedlings remain so succulent that they are subject to attack by rodents. etc.

Seedlings of platable plants are also, and easily, damaged by the grazing of animals (photo 17) .

2 - Carnivorous plants

These plants are provided with certain arrangement which enable them to capture and retain small animals especially insects,and digest them with certain enzymes. There are different openions with respect to the benefits taken by plants from animals. Some workers are thinking that carnivorous plants absorb the resulting nitrogenous compounds from the digested animals, but other do believe that non of the carniverous plants seems on the least dependent upon its animal prey for nitrogenous compounds and the carnivorous habit is only an incidental feature of their nutrition.

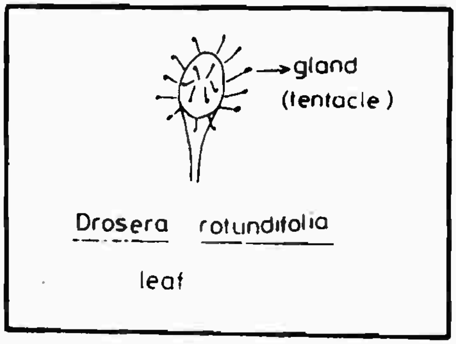
Three examples can be studied for the carnivorous plants , namely : *Drosera* , *Utricularia* and *Nepenths* .

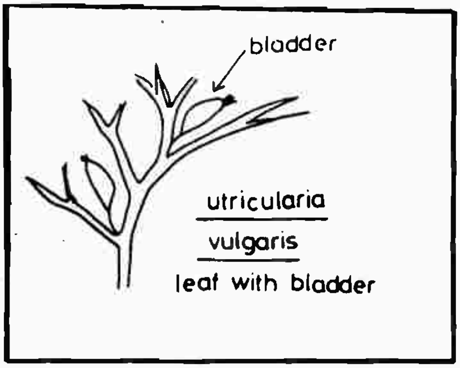
a) *Drosera rotundifolia*

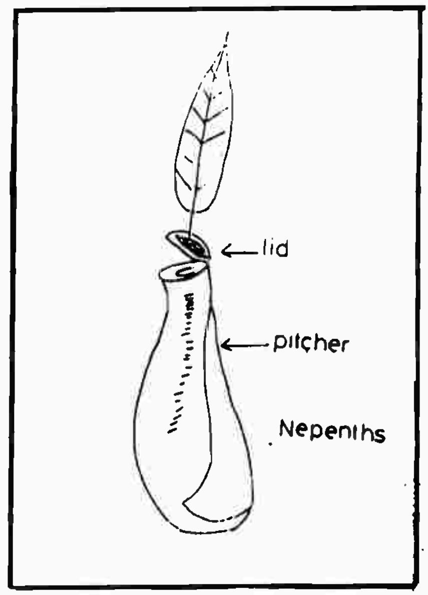
This plant has leaves covered with stalk - like outgrowths (tentacles) provided with glands at their ends which produce viscid acid secretion When an insect touch one of these tentacles , it is caught in the sticky secretion . As it struggles to release it - self , it becomes surrounded by other tentacles and held firmely . Also the leaf blade concave enclosing the insect . At this stage digestive evzymes are secreted attacking the insect's body and converting its soft parts into a soluble form when they are absorbed by the tentacles . After considerable time the tentacles take their notmal position leaving the undigested parts of insect .

b) *Utricularia vulgaris*

This is another example for the insectivorous (Carnivorous) plants which lives submerged in water . The plant carries many small-sac like structures called bladders on its depply divided leaf . Each bladder is provided with hairs surrounding a narrow aperture and a trap door which opens inwards . When a minute aquatic animals touch certain hairs around the aperture , the trap-door is released and water rushes in . The organisms carried by water are imprisoned in the bladder , and after being disorganized they are absorbed by forked hairs which arise from the internal surface of the bladder .







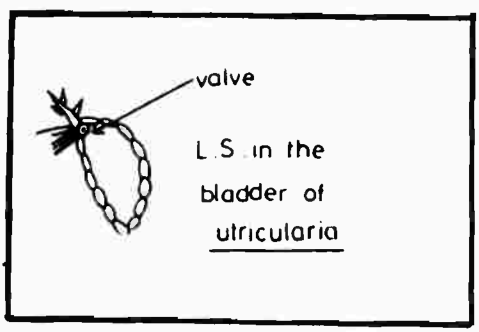


Fig. 11

c) ***Nepenths***

In this plant the leaf blade has a flat basal portion and its midrib is prolonges as a tendril which terminates with a pitcher (Vessel) . The later results from the hollwing out of the midrib . The pitcher has a lid which protects the contents from being flooded by rain . The secretion within the pitcher is excluded by numerous large button shaped glands upon its inner surface . Attracted by secretions of honey to the rim of the pitcher , and then slipping on the smooth surface below the margin , insects drop in the accumulating fluid . The dropping insects stimulate the short-stalked glands to secrete digestive enzymes which decompose their proteins converting them into soluble compounds easily absorbed by the cells of the pitcher .

3 - Pollination by Animals

The cross pollination by some flowers is secured by flying insects , chiefly bees , butterflies and flies . These insects are by far the most important group of animal pollinators , but other kids of animals occasionally perform this function . Bats and snails also appear to be the pollinaters of certain flowering plants .

Insect-pollinated flowers (entomophilous) are characterized by the presence of nectar pollen grains and by being very conspicuous with coloured perianth . Nectaries which produce the nectar may be situated on any protected part of the flower . They are often found on an enlargment of the receptacle called a disc . They may be located at the base of the flower , or at the top of ovary .

When the nectar is produced in large quantities it overflows from the depressions in which it is secreted . The sticky coat of the pollen grain facilitate its adherence to the body , whilest the stigma has a sticky receptive surface .

When pollinating insects descend on the perianth of flowers their bodies become dusted with pollens . The insects on visiting other flowers , the pollen adhering to their hairs covering their bodies is rubbed against the stigma .

4- Dissemination by Animals (Zoochory)

a) <u>Edible Disseminules</u> (endozoochors)

Seeds of berries and other small fleshy fruits asre encased in succulents tissues which are used by birds as food , get in many of these birds . Seeds have stick coverings and pass through the digestive tracts uninjures to be carried some distance before being excreted . The passage of seeds through the digestive tract facilitate germination in certain species .

b) <u>Inedible Disseminules</u> (**Epizoochors**)

Fruits of certain plants e . g . *Bidens* , *Cenchrus* , *Xanthium* etc are especially well adapted for clinging to the fur of animals which carry them some distance before chewing them from their fur .

Mud clinging to the feet of migratory water-birds, has been found to contain a wealth of tiny dissiminules of aquatic plants a fact that explains the appearance of body of water accumulates . Spores of many kinds including those of fungi causing important true diseases , have been isolated from the plumage of migratory aboreal birds . Many plant pathogens are carried from host to host by insects .

CLIMATIC FACTORS

CLIMATIC FRCTORS

The atmospher is essential to all life ; the absence of a comparable combination of gases is the main factor precluding the possibility of life as we know it from other parts of the universe . Not only is the atmosphere a renewable source of essential materials for plant growth but it acts as a " filter " through which sunlight or radiant energy reaches the earth's surface and it provides , as a result , an insulating or thermostatic medium wihout which variations between day and night temperatures would be too extreme for the survival of any known forms of plant or animal . Further it is the the agency by which water is circulated through and distributed to the biosphere .

Plants depend directly on the atmosphere for certain frundamental materials , and conditions , necessary for their successful growth and reproduction . In its gaseous composition the Free Atmospher is remarkably uniform and constant so that while oxygen and carbon dioxide are essentials , their proportions do not vary significantly enough to make marked differences in plant growth or distribution . On the other hand the actual or average physical state of the atmosphere - the weather or climatic conditions - varies considerably in time and place . Since a different species of plants vary in their minimum requirements for, or in their tolerance of , particular climatic conditions , these conditions play a major role in determining where a particular plant can or cannot exist . Climatic factors are the master of all environmental factors that control not only the growth of plants but also the development , distribution and densities of the vegetation of the earth . The plant cover (vegetation) of the earth is divided into number of units (Plant formations e . g . forests , grasslands, desert etc .) that are related mainly to the major climatic zones of the world .

The factors of atmosphere of greatest importance are those such as light , temperature , precipitation , humidity , evaporation and wind . All of these factors are essential and all of which vary in amount or intensity from one part of the biosphere to another . All these factors , however , interact one with the other and operarte in combination to produce those atmospheric conditions which will either permit the presence of certain palnts in or exclude them from a particular habitat . The condition of any one of these factors will obviously have a direct effect on that of the others; light intensity and duration will influence temperature and humidity are interrelated , humidity affect light intensity and so on .

Cimatic (atmospheric factors) may be modified by the edaphic and biotic factors of any habitat . For this reason it is difficult , and in many respects unrealistic , to try to isolate the independent effect of one particular climatic factor on plant growth or function .

In the following , a brief description of the climatic factors and their effects on plants will be discussed . These factors are : Precipitation, Temperature , Radiation and light, Humidity, Wind and Evaporation. A short note on the atmospheric gases is also described .

Climate : is a term refers to the atmospheric factors (precipitation , humidity , temperature , light , wind and evaporation) that prevail in a region , country etc . within a year or season . It can be expected .

Weather : is a term refers to combination of the above mentioned atmospheric factors in a day , hour or a moment i.e. short period of time . Weather is , usually unexpected and it changes quickly .

PRECIPITATION

Precipitation is the all forms of water whether liquid or solid that fall from the atmosphere and reach the ground . It is expressed in inches or millimeters of liquid water .

In all habitats except those where the supply of water is constant owing to the presence of springs , streams , ponds or other bodies of fresh water, the dependence of water content of soil is upon precipitation .

Precipitation occurs in two forms .

A- Liquid Forms : Rainfall and Dew

B - Solid Forms : Snowfall , Hail and Frost .

A- Liquid Forms Of Precipitation

1- Rainfall

Rain is the most important factor affecting growth , density and distribution of plant coverage in the different seasons of the year . Vegetation of any great region of the world is determined primarily by the amount and seasonal distribution of rainfall . Vegetations are of three types . Forests , grasslands and deserts . Heavy annual rainfall distributed through all seasons of the year produce forests . Heavy rainfall in summer and low rainfall in winter produce grasslands. Low rainfall in summer and winter produce deserets .

The vegetation type of any region is conditoned not only with the total amount of rain per year but also with its seasonal distribution . In desert regions , for example , in certain years strong and heavy showers may fall forming instant **torrents** as a result from **cloudburst** . This amount of water will increase greatly the annual amount of rainfall on that desert . Such rain is harmful to plant life , only it increases humidity of atmosphere for a short time . Relative small amount of rainfall over an area distributed seasonally will be very useful to plants than relatively larger amount fall within short period . This means that the total annual rainfall in an area is only rough indicator of moisture condition for plant growth . A light rainfall usually does not affect soil moisture , for most of it will be intercepted by vegetation , if there is , and/or will evaporate quickly . That which reaches soil will wet only the surface and likewise be lost to the air . Thus , such amount of rain may , therefore , be of no significance whether except to raise the humidity temporarily and reduce transpiration for a short time . If rain falls heavily for short periods much of it will be lost by runoff , the amount varying with steepness of slope , nature of soil and density and type of plant cover . Seasonal distribution of rainfall may be of much more importance than the total amount of the year . If rainfall is uniformly distributed throughout the growing season , moisture conditions may be far more favourable with 20 - 30 inches than they would with 40 - 50 inches if the growing season is interrupted by one or more dry spells . If precipitation is regularly seasonal , the type of vegetation may be definitely . For instance , grasslands characterize those areas where raifall in rather light and concentrated in spring and early summer . Winter rains with dry summer characterise several coastal regions , support the shrubby vegetation .

Rainfall is either convectional , orographic or from depressions .

a) Convectional Rain

Hot air with water vapour ascends as it becomes less dense . The rising air mass is called convection current . Such currents reach their climax in huge " tower " or " heap " clouds and fall in torrential thunderstorms when they mangle with cold air . Occasionally in hot desrts , these cloudbursts transform dried-up water courses (wadis) into torrents that may drown travellers .

b) Orographic Rain

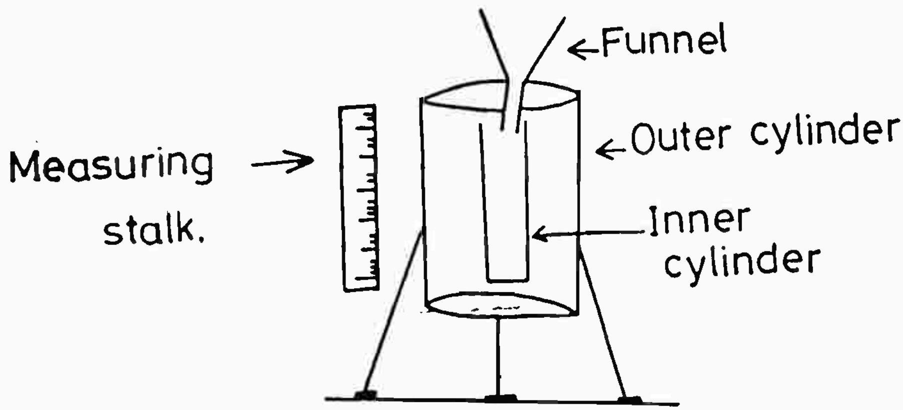
This type of rain occurs only in the mountainous countries. Orographic rains steadily from clouds caused by cooling of air as it blows up mountain side .

c) Rain From Depressions

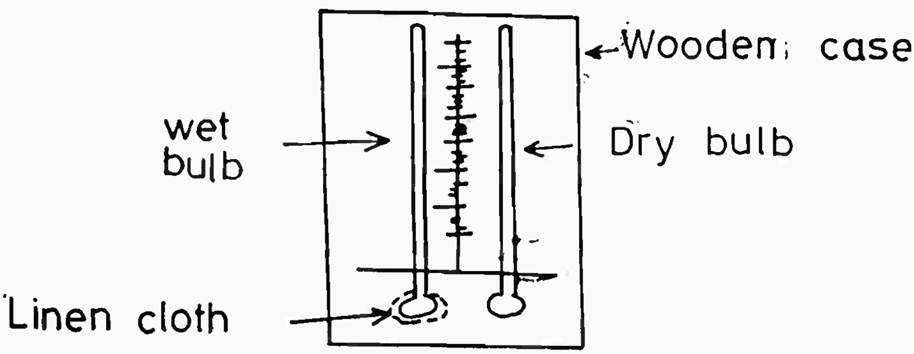
When warm , light , moist winds ride - up over the cold , dense dry air , clouds occur in between . The warm and cold winds causing rain . These encounters between warm and cold winds are called depressions

Measurement Of Rain Fall

Rainfall can be measured with the " Standard Rain Gage ". It is formed of a cylinder (8 inches in diameter and 20 inches high) which has a funnel built into the upper end that permit water it catches to run into an inner cylinder wih exactly one-tenth cross sectional area . As the ratio of the outer to the inner cylinder is 10 : 1 , the measurement of water collected in the tube must be divided by 10 if taken directly or it can be measured with a standard graduated stick . The purpose of the smaller inner tube is to increase the depth of water and permit for a more accurate readings . After a heavy rainfall when water from the inner tube has over flowed into the outer cylinder , firstly the inner tube is read , emptied and then the water from the outer one poured into it and the amount is recorded .



Standard Rain Gauge



Hygrometer

Fig . 12

2- Dew

Dew is the second type of liquid form of precipitation . It is formed by the condensation of water vapour of the lower layers of atmosphere on a cold surface Dew formation does not require saturated air , only it needs the presence of difference of temperatures of the surface and the air in touch with it . Dew starts to condense after sunset and may be late to midnight depending upon the temperature conditions but it stop on sunrise .

In humid areas where rainfall is high, dew is too small in amount to add diretly to the water content of soil . In these the evaporation of dew causes an increase in air humidity and thus decreases slightly the amount of water lost by evaporation from soil and transpiration from plants. However, in areas of low rainfall particular in the hot desert, dew may make an appreciable and vital contribution to rainfall. In these areas the total annual dewfall may exceed the total annual rainfall. For example, in Helwan Desert south of Cairo in Egypt it was found that the annual dewfall equal 50 mm whereas the annual rainfall rarely exceeds 30 mm. In these hot deserts,dew is considered the major source of water for xerophytic mosses, lichens , ferns and even for the ephemeral, annual and biennial flowering plants living there. In an experiment it was found that the moisture content of mosses increased by 20% during daytime and100% during night with heavy dew.

Unlike rainfall, dewfall is more or less unchangeable and that makes it as a continuous source of water for the minute plants especially under drought conditions.

Dew has two sources : (i) atmospheric water vapour and (ii) water evaporates from soil by capillarity.

Measurement of dew is carried out with Leich's Plates which are formed of perforated porcelain each has a surface area of one square decimeter and thickness of one centimeter. These plates resemble the soil. Dew can be estimated by weighing these plates within certain period and the differences between the weights give you the amount of dew.

B. Soild Forms Of Precipitation

1 - Snow

Snow is the atmospheric water vapour frozen in crystalline form whether in single crystals or aggregated in flakes . Snow is formed like rain but at temperature below freezing and under conditions that permit the crystals to fall before they melt. Snow is an important source of soil moisture. It does not only act as a cover to prevent evaporation but upon thawing (melting) it also enters soil directly as rain. Snowfall = the amount of snow falling in a given time.

2 - Hail

Hail is a frozen rain or grains of ice falling from clouds. It differs from snow being composed nearly of frozen water while snow is composed of frozen water vapour .

Hail falls usually in summer under exceptional conditions, it is of little importance to plants as a source of water. It may do serious physical damage, often stripping foliage completely from woody plants and damaging herbaceous structure beyond recovery.

3 - Frost

Frost is a state of freezing i.e temperature at or below the freezing point. It is the frozen dew but when occurs is harmful to plants particularly the ephemerals and small seedlings.

II TEMPERATURE

Temperature is like water in its action upon plants, that it has more or less to do with nearly every function but as a working condition and not as a material. Moreover,as well as being an indirect factor on plant growth, temperature has a direct effect on practically every plant function. All the chemical processes and metabolism and also many physical processes such as diffusion, precipition and coagulation as in cell wall formation, elongation of shoots and roots etc. are dependent upon temperature and are accelerated by its increase up to an optimum. Vant Hoff's Law that the spead of chemical reactions doubles with every temperature increase of 10 ^{o}C is applicable within limits, and up to a certain optimum, to the metabolic function of plants (and animals). With a descrease in temperature to a certain minimum, growth in size is retarded, at a lower temperature cell division and photosynthesis are also checked and at still lower temperature till the minimum values, respiration ceases and death happens . Although there are few places in the world where temperatures are continuously too cold or too hot for life , most of the biosphere operates within a range between zero ^{o}C to 50^{o}C. There are some algal plants that can grow and reproduce at temperature below zero and others which can tolerate temperature as high as 70-80^{o}C in hot springs. Thus, temperature is not only the working condition for all organisms including plants and controls the rate of their biological activity and process but also it furnishes the energy for some of them.

The habitat plays an important part in determining the influence of temperature upon each species. A particular species has been accustomed for countless generations to certain extremes of heat and cold as well as to certain seasonal sum of temperature. Temperatures beyod these extremes check (hinder) the plant's activity and this is usually true of the total heat available during the growing pereiods. These temperature adjustments become so deeply impressed in the protoplasm of a species that they result to a more or less fixed habit as regard temperature. Thus, in temperate regions, for example, low temperature in winter becomes a necessary experience to the trees of deciduous forests.

Temperature has a marked effect upon seed germination, growth of plants , opening of flower buds,fruit production i.e. upon plant reproduction. Consequently, temperature has not only great influence on the devlopment of individual plant but also upon the development of vegetion.

Measurement of temperature is carried out with the aid of accurate standardized glass thermometer. Air temperature is usually taken in the shade with thermometer exposed to wind and away from the influence of one's body. Continuous temperature record are obtainable with thermographs. The thermometers readings are either in Centigrads (^oC) or Fahrenheit (^oF) . Centigrade = having hundred degrees or divided into a hundred degrees. The centigrade therometer of 100 degrees had been constructed by Celsius (1701- 1744) in which the freezing point of water is zero and the boiling-point is 100^o . Fahrenheit, on the other hand, of a thermometer or thermometer scale having the freezing-point of water marked at 32^o and the boiling-point at 212^o . To convert degree Celsius (centigrades) to Fahrenheit, multiply by 9 and add 32. To convert degree Fahrenheit into Celsuis (or centigrade)substract 32 and mulitiply by 5 .

Thus:

$^oC = {^oF} - 32 \times \frac{5}{9}$ $\qquad$ $^oF = {^oC} \times \frac{9}{5} + 32$

$100^oC = 212^oF$ $\qquad$ zero $^oC = 32^oF$

$122\ ^oF = 50\ ^oC$ $\qquad$ $50\ ^oF = 10\ ^oC$

$1\ ^oC = 33.8\ ^oF$

For each species of plant there are maximum temperatures necessary for its various metabolic activities . These are called the **Cardinal Temperatures** The minimum (the " threshold" or the " base") temperature is that below which a function cannot operate; plants native to warm region e.g date palm, sorghums, melons etc . require minimum cardinal temperature of 15-18^{o}C for growth while plants native to cold regions e.g cereals, require minimum cardinal temperature of between- 2 ^{o}C and 5^{o}C ome evergreen conifers have minimum temperature for photosynthesis of - 3^{o}C An increase of temperature above the ncessary minimum will be accompanied by an increased rate of activty up to an optimum , thereafter the rate declines until a maximum temperature is reached above which activity ceases. Whether a plant will be able to grow in certain area or not will depend on whether the requisite amount of heat is available for a period long enough to allow the completion of its life cycle . While the degree and durartion of heat may be sufficient to allow vegetative growth, unlese are also sufficient for the production of seeds , a plant obviously cannot maintain itself .

Plants , in general , are subjected to a considerable range of temerature during their period of growth . They grow only when temperature remains within certain limits and mature and die or become dormant when it falls too low or become too high .

Temperature fluctuates both daily and seasonally . The amount of heat received depends upon the angle of suns rays and their consequent absorption . The actual temerature at the surface of earth are greatly modified by **Radiation** and **Convection** (transmission) . In consequence , the maximum daily temperature does not occur at noon " Sun Time " (as in case of light) but somwhat later , often at 2-3 p . m . The minimum temperature is not reached at midnight, but just before sunrise upon the following morning . The maximum temperature for the year does not occur at the **June Solstice** but a month or two later . Similarly , the minimum falls a month or more later or **DecemberSolstice** . Solstice is the time when the sun reaches its maximum distance from the equator : Summer solstice when it touches the Tropic of Cancer about 21st June and winter solstice when it touches the Tropic of Capricon about 21st December .

Variation of temperature occurs with changes in Latitudes and Altitudes . High latitudes receives sun's rays at a greater angle than equatorial one and the absorption of heat by the atmosphere is correspondingly greater, thus leaving less for soil surface . High altitudes (mountains) receive more heat than lowlands , but as loss by radiation is so much greater , the mountainous regions are uniformly colder than plains or low lands . Although air on mountain tops is colder than that of plains yet surface temperature on soil is often considerably higher .

Winds cause temperature to rise when they blow from warmer regions and to fall when they come from a cooler ones . Clouds reflect a considerable pertion of the insolation from their upper surfaces and consequently temperature at earth's surface is decreased . However , plant cover (dead or alife) reduces day temperature by screening out sun's ray and increases night temperature by retarding radiation .

III RADIATION AND LIGHT

Radiation is energy moving at or near the speed of light . Practically all the energy of an ecosystem originates as radiation from the sun , that is , Solar Radiation . Minor amounts of energy comes from beyond solar system e . g . volcanoes etc , but these do not contribute much to radiation provides the necessary energy to heat environment and to drive the ecosystem by means of energy storage at photosynthesis .

The solar radiation which penetrates upper atmosphere and reach the earth's surface consists of electromagnetic waves ranging in length from 0. 3 to 10 microns (m) , thus equals from 300 to 10000 millimicrons or 3000 to 100,000 A^{O} . It cosists mostly of visible radiation or light (wave length = 390-760 mmicrons) , inferared or thermal radiation (above 760 mmicrons) and ultraviolet radiation (below 390 mmicrons) .

Light is that radiation in which violet comes at the shorter end of the wave length span and red at the the longer end . It is visible to our eyes whereas other radiations are not . Light is the effective radiation in photosynthesis and is important to considerable extent in the heating of the environment . It makes up almost half of the solar radiation reaching the earth's surface , thus it is a determining factor for plant growt and vegetation development . It is from the radient energy of light the chlorophyll absorbs certain wavelengthes which enable the chloroplasts to manufacture food .

The series of wavelengths of light that exhibiting different colours is as follows : red = 760-626 mmicrons , orange = 626-595 mmicr , yellow = 595 = 574 mmicr, green = 574-490 mmicr, blue= 490-435 mmicr, violet = 435-390 mmicr . All these colours make up the visible spectrum affecting photosynthsis . The invisible spectra are : infrared and ultraviolet . The infrared radiation (longer wavelength) is of no value to plants and is not known to be harmful to them while the ultraviolet radiation is of shorter wavelength than those of sunlight and it has a pronounced bad injuries effect upon plants . Although green plants , with few exceptions , are the only organisms that can directly make use of light energy , they actually change only about 1% of the light they receive to potential energy .

Not all wavelengths are equally usable . Green light is reflected or transmittred while much more longer wavelengths , e . g red light , are much more effective in photoynthesis than the shorter lengths of yellow and blue . On the other hand , not all plant species are equaly efficient under equal illumunation . Some require certain intensities and some need certain lengths of day or season to function normally

Quality And Duration Of Light

Differences in latitude and altitudes cause variations in climate , light is a part of the climate . Thus , variations in photosynthesis and growth of plants are seen at different latitudes and altitudues . Differences in light intensity during the growing season has great effect on the plant growth . Plants of arctic regions , for example , have been shown to make carbohydrates continuously during 24 hours of summer in which sun contiue for 24 hours and produce amount of food as great as would be formed during the whole year of the plants of the temperate climate . Many species of evergreens are known to make photosynthesis in winter in sufficient large amounts to balance that oxidised in respiration .

The quality of light is modified by clouds , fogs , atmospheric water vapour etc . Water vapour in air absorbs a great deal of long wave length , particularly infrared . During winter a higher percentage of red light and a lower one of blue light reach earth than in summer . In general , the red end of spectrum permit excessive tissue and cell elongation, while the blue - violet light exerts retarding effect upon growth by keeping cell smaller .

In nature duration of light varies from 12 hours at the eqator to continuous sunlight or coninuous darkness throughout the 24 hours during a part of the year at very high latitudes . Thus , tropical plants are exposed to intense light during half of each year , while arctic plants grow in weaker light continuously or nearly so through the summer (short season) . Long summer days of high latitudes enable plants to develop rapidly and mature quickly . Photosynthesis is continuous under such conditions although lowest at midnight .

For each plant species there is a minimum light intensity essential for growth : this is the percentage of full day light necessary for photosynthesis to produce new food material at a rate greater than it is being used up in the process of respiration . Similarly there is an optimum intensity beyond which the rate of photosynthesis decreases and increased light intensity may be determinetal (harmful) to the plant . Minimum and optimum requiremnts for light intensity vary from one species to another .There are those which can only grow and attain full development in light of low intensity , i. e shade - loving plants or **Sciophytes** , others which require high light intensity or sun-lovivg plants or **Heliophytes** . Most trees , all cereal crops , many grasses and herbaceous weeds are heliophytes , while a great number of mosses and ferns , together with the herbaceous and shrubby plants of woodland habitats are sciophytes .

The particular length of day essential for the production of flowers and seeds of plant is called **photoperiod.** The response of plant to duration of daylight is called **photoperiodism**.There are short-day species e.g. *Chrysanthemum*, tobacco etc. which never flower until the day-length or photoperiod is less than a critical, i.e. less than 12-14 hours, these plants are called long-night (or short-day) plants. In contrast, the long-day (short-night) plants reqiure over 12-14 hours day light, e.g lettuce, beet, wheat, potato etc. In short-day plants daylengths in excess of critical period result in abnormally large vegetative parts. (giantism) and suppression of flowering . For these plants the shorter the photoperiod the shorter the life cycle. In long-day plants exposure to daylengths shorter than the critical periods tend to shorten the internodes to the extent that the plant assumes a rosette form and becomes stunted and flowering is suppressed in addition.

EFFECTS OF LIGHT ON PLANTS

Light has influences on : (1) the production of chlorophyll, (2) closing of stomata .

light is necessary for the formation of plant pigments. Plants with plastids produce chlorophyll only in light and the chlorophyll disappears in continued darkness. Although sometimes formed in darkness, chloroplasts cannot function in synthesis of carbohydrates without light.

Leaf undergoes the greatest modification as response to light than any organ of plant. Stems may be modified to some extent when they contain chloroplasts. Roots, not being exposed to light, show only indirect effect such as result from differences in growth due to an increased supply of photosynthate and the response to a well lightened or a moist shady habitat.

Thickness of leaf increased with light intensity. Plants grown under 1-20% light develop only one layer of palisade tissue; those under 70% have two distinct layers. Cells that normally form palisade in sun develop into spongy cells in shade whereas spongy cells under strong illumination develop into palisade. Leaves that contain an excess of sponge tissues are relatively broader while those in which the palisade is preponderant are relatively thicker.

Light is the most important factor modifying stomatal movement that has a profound effect upon transpiration and respiration of plants. In nearly all plants, stomatal opening is correlated with the presence of light when other conditions for opening are favorable.

LIGHT INTENSITY

Intensity of light varies according to several factors, the most important ones are : the atmosphere, the latitude, layers of water, suspended particles, laryers of vegetation and topography.

1 - Effect of Atmosphere

Atmospheric gases, chiefly nitrogen and oxygen absorb and disperse a small portion of the shorter wave lengths of light as it passes through the gaseous layer enveloping the earth. It is due to this absorption that ultraviolet wavelengths shorter than 290 mmic. never reach the earth's surface. The higher the elevation of a surface above sea level, the thinner the layer of air remaining above it and the brighter the light. Mountain summit extending to an elevation of 2 miles are exposed to light intensity of 129,000 L whereas only 107,000 L are received at sea level. All moisture contained in air,visible as well as invisible vapours,exert a

---

L = International standard unit for expressing light intensity, a unit of photometry (Luxes or foot - candles) using photoelectric meters { Luxmeters or Photometers }.

powerful screening effect . For this reason the intensity of light is much greater in dry than in humid climates and is very low when cloud and fog are abundant. On a cloudy day, light may be reduced to 4% of the normal intensity. Light scattered by gas molecules and water droplets becomes <u>Diffuse Light</u> or <u>**Sky Light**</u> as contrast with <u>**Direct Light**</u>. On clear day, diffuse light comprises but 10-15% of total light,whereas in shady days (cloudy) it may comprise up to 100% of the total

2 - Effect Of Latitude

Latitudinal variations in light intensity due to height of sun obove the horizone are very important. In equatorial region light is not most intense and contains the highest proportion of direct sunlight. Progressive toward the poles the intensity decreases and the percentage of diffuse light increases.

3 - Effect Of Layers Of Water

Submerged plants are subjected to weaker illumination than terrestrial ones, for part of the light is reflected back at the water surface and of the remainder much is absorbed by the upper layers. The greenish or bluish colour of bodies of water indicates that the principal wavelength reflected are at the short end of the spectrum, especially between 420 and 550 mmicr.

As light penetrates water, the intensity decreases as depth of water increases. Even in perfectly clear water only 50% of the light penetrates as deep as 18 m and at 50 m depth there may be scarcely sufficient light for feeble photosynthesis.

Light penetration through snow is sufficient to allow hardy plants (plants able to bear cold) to begin growth before the snow cover melts in spring. Photosynthesis may take place under as much as 40 cm of snow.

4 - Effect Of Suspended Particles

Solid particles dispersed in air (dust,smoke) or in water (clay, silt, plankton etc.) have screening effect.

In industrial areas smoke may cut off 90% of the light. Even more damage are the effects of smoke particles which settle out of the air and accumulate as films on plant surface. This not only cuts down the amount of light available to the chlorenchyma but also plugs partly the stomata. Plants with sticky or hairy surfaces suffer the most.

5- Effect Of Layer Of Vegetation

Leaves transmit about 10% of the light fall on them, so that most of light penetrates through foliage passes between the leaves as sky light. In a complex plant community, the height of any plant in relation to its neighbours determines to a large extent the amount of light it receives. In a forest, only the mature plants (trees) of the tallest species ever receive full insolation. Undershrubs receive reduced illumination, herbs and other shorter plants grow in still weaker light. When in full leaf, the canopy of very dense forest may reduce light to less than 1% of full sunlight.

6 - Effect Of Topography

The direction and slope of land surface cause marked variations in the intensity and daily duration of insolation (light). To get the maximum possible sunlight, a plant must grow where neither topographic nor other features of its surroundings are near enough or high enough to interfere with light from any direction.

IV HUMIDITY

What is Humidity ?

Humidity is the mount of moisture in air in the form of vapour. It is one of the most important factors since it directly affects the rate of transpiration. The amount of water that a plant loses frequently determines whether it can or cannot grow in a given habitat .

Absolute Humidity is the actual amount of water present in air. It is expressed as grams per cubic meter of air. The amount of water vapour in the atmosphere taken by itself does not determine the dryness or wetness of a climate. The climate which is recognized as dry is not necessarily has less actual moisture since even in desert region the amount of moisture in a given unit of space may equal or even exceed that in other district commonly considered as moist. Warm air can hold more water vapour than cold air. In fact the capacity of air for holding invisible water vapour doubles with each increase of 20^{O}F in temperature. In desert, the humidity is very low and water exposed quickly evaporates. Conversily, in areas of low temperature the amount of vapour that can remain in air is lessened and the air is more saturated.

Relative Humidity is the ratio expressed as a percentage of water vapour actually present in air (unit of space) at a certain temperature to the amount necessary to saturate the same unit of space under similar coditions. For example, 50% relative humidity means that the space contains one-half the amount of water vapour necessary to saturate it (100%) .

The lower the relative humidity at a given temperature the more rapidly the air will take up water from transpiring leaf or from a moist soil surface.

Factors Affecting Humidity

Humidity is affected by temperature, wind, exposure, cover, evaporation and other climatic factors.

High temperature increase the capacity of air for moisture and consequently lower the relative humidity. At low temperature, air will hold less moisture and consequently its relative humidity increases. With a given amount of water vapour in air, transpiration from plants and evaporation from soil are increased with a rise of plant and air temperatures .

Wind has a powerful effect upon humidity, dry winds lower the amount of air moisture by removing the moist air about plants and mixing it with dry air. This has the effect by keeping the humidity low and promoting transpiration.

Exposure, i.e the position of a slope with respect to the sun, affects humidity through the action of the sun and wind. Slopes that are exposed to sun's ray for longer time receive the most heat. Consequently, slopes with a northern exposure show somewhat lower humidities than those with southern exposure. The effect of wind is most pronounced upon those slopes exposed to prevailing dry winds.

Cover increases humidity by reducing the influence of both temperature and wind. In addition, a living cover (plants) supplies moisture to air in consequence of transpiration from plant that compose it.

Evaporation of the surface of moist soil increases humidity. This is particularly noticeable in forests and thickets of shrubs where air is sheltered from sun and wind . In general, air near soil surface is more moist than that near the top of a cover of vegetation.

The view that atmospheric pressure influences relative humidity by changing the density of the air and hence its power to hold moisture, might not be correct as the amount of water vapour required to saturate a given area is entirely independent of the pressure of the other gases present and is determined solely by the temperature of the vapour itself . However, low air pressure does increase the rates of evaporation and transpiration through a reduction in the density of the air.

Measurement Of Humidity

Humidity is measured by means of a wet and dry bulbs **Hygrometer**. It consists of a wet-bulb thermometers set in a wooden case. The dry-bulb thermometer is an ordinary thermometer, but the wet-bulb is a thermometer covered with a clean linin cloth which is moistened with distilled water. The dry-bulb thermometer indicates the normal temperature of air while the wet bulb one gives the reduced temperature resulting from cooling due to evaporation. If air is moist, there is a little evaporation, if it is dry evaporation is rapid and the result is a marked drop (depression) is the wet bulb. Evaporation produces a decrease in temperature depending upon the amount of moisture in air.

Tables have been prepared for almost all possible combinations of air temperaturees and wet-bulbs depressions,showing the corresponding relative humidy (RH).

Saturation Deficit

Saturation deficit is the amount of water vapour that the air can take up before becoming saturated. In an atmosphere completely saturated with moisture, water begins to condense and some of it is precipitated in the form of rain, dew or snow.In such an atmosphere, the air cannot take up more moisture and the rates of evaporation (from soil) and transpiration (from plants) are negligible . In comparatively dry air, transpiration is rapid because the air, being unsaturated, can take up more moisture.

Saturation deficit is influenced by temperature . An appa rently dry air such as that of a desert may actually contain more moisture because of its high temperature with the absolute humidity of the air remaining constant, its saturation deficit increase with rise in temperature and falls with the lowering of temperature. When the temperature falls very low, some of the moisture may condense in the form of liquid water as happens in dew formation .

V. WIND

Definition

Wind is a climatic factor which though not essential for plant growth yet it can exert a considerable inflence on the form of the plants. Even under conditions of plentiful soil moisture,wind may put a strain on the plant's water balance as sever as that in completely arid region. In areas exposed to high wind force, as along the sea coasts and at high altitudes, the height to which plants grow may be limited by their ability to absorb and transport water upwards rapidly enough to replace that loss by transpiration

Effects Of Wind

Wind has both a direct and indirect effects on plant life. The direct effect of strong winds is mechanical and consists in uprooting trees and breaking off branches and twigs. Strong winds also cause permanent curvature in plants on exposed places where the trees usually have an asymmetrical appearance with few branches and leaves on the windward side.Grasses and other low plants or those with well developed rhizomes are less susceptable to winds. Though winds helps in seed and fruit dissimination, yet they do much harm in blowing fruits or blossoms from plants by preventing insects from working among flowers . It is an important agent in the distribution of weeds and spores of many diseases producing fungi. By means of whirl-winds, spores are carried high into air and over large distances. Viable spores have been caught at height of more than 11,000 feet. Wind has a beneficial effect in drying the soil in spring and milden temperature on leeward sides of large bodies of water ..

Wind velocity increases with height , above ground , thus the plants with prostrate habit with their leaves near the soil surface are safe from the drying effect of wind while the tall trees are the greatest suffers from excessive transpiration . The strong winds in the upper strata of air cause the upper shoots to dry off and inhibit growth in length . In exposed areas , therefore ,. the wind action often limits the height to which tress can grow. In such places latter trees grow to a uniform height called " **the general vegetation limit** " . The force of wind may be modified by windbreaks , by sowing grains in furrows and by strip planting which reduce its effect , since all times a part of the soil in the field is protected by a cover of vegetation .

The indirect effect of winds is physiological . Transpiration makes the air surrounding the plants moist . Winds remove this moist air and bring in dry air and thus increases transpiration . Consequently , the rate of transpiration is higher in places where winds blow than in still air. Winds blowing from the sea and other large water bodies bring in moist air and hinder transpiration . Winds has also an indirect effect on **Relative Humidity** by moving the fogs , clouds , carrying hot or cold air masses from places to places . They also change the sea coast's temperature as well as mixing the humid air with the dry one .

Mobilization of sand and building up of sand bodies (mounds , hummocks , hillocks and dunes) are mainly carried by winds . The arrangement of sand masses in regions of scant vegetation is also subjected to the influence of wind . If sand movement comes slowly , vegetation may save itself from burial by growing up through sand and binding it . These are the sandbinder species , not all plants are sand - binder only the psamophytes are those species that can build sand formations .

Wind movement is measured by **Rotating Anemometer**. It is composed of three half - balled cups connected together with mobile arms that move by the effect of winds . The arms are fixed on vertical stand on which there is a recorder to record wind velocity . The data are recorded as kms of wind movement per hour .

Experiment to show the effect of continuous wind velocities of 5 , 10 and 15 miles/hour on the transpiraton of sunflower was conducted . The soil was containing the optimum water needed for the plant . After the first week it was found that the rate of transpiration increased with increasing wind velocity . At the end of 6-7 weeks the three plots of plants were using water at rates about 20% , 35% and 50% respectively higher , per unit area of leaf surface , than control plants grown in still air . There was a decrease in leaf area and in height and diameter of stem with inreasing wind velocity . The dry wight was reduced one-half to two third under a velocity of 15 miles/hour . Water requirement increased, maximum increament observed being about 50% under the highest wind velocity . Wind has the same relative effect at night as during day , causing approximately the same percentage increase in transpiration rate .

VI. EVAPORATION

Definition

Evaporate means to fly off in vapour , to pass into an invisible state , to depart or to vanish . Evaporation is the act of evaporating or passing off in steam or gass . It is the process by which a substance changes into the state of vapour.

From the climatic point of view , Evaporation is an important factor . It is the desiccating power of the atmosphere that effect greatly vegetation . Evaporation Stress is affected by the other factors of the atmosphere , namely : precipitation , humidity , wind, temperature , sunshine etc .This means that the Rate of Evaporation reflects the combind effects of the other climatic factors .

In its wider mean, Evaporation is a process by which more water molecules leaves a surface , any surface , than enter it e.g . soil surface, water surface , leaf surface . etc .

Evaporation And Vegetation

As surface layers of soil , where plants grow , dry out , evaporation from these layers ceases because they form a dry barrier through which little soil water moves . At this point , major water losses from the soil takes place through the leaves of plants i.e . through transpiration . From the soil the plants take water by the roots and they lose it through leaves . Perennial xerophytes are drought tolerant plants having long root system that penetrates deep in soil deeper than the surface layers of soil where evaporation occurs , to reach the permanent wet layer of soil from which it takes its water . Ephemerals and annuals , however, cannot grow in such a habitat with dry surface soil layers . These plants have short roots that take water from surface layers only .

Evapotranspiration is the total loss of water by evaporation from soil and transpiration from the plants constituting the vegetation of such a soil . It is measured by the use of weighed Lysimeters containing an appropriate soil cores as follows :

1- In two similar lysimeters (A and B) put equal amounts of soil of the same type (sand , silt , clay , etc .) . Get the weights of the lysimeters + the soil .

2- put in each lysimeter equal numbers of plants of the same species and almost the same form . Get the weight of lysimeters + soil + plants . 3- Water the plants of the two lysimeters with equal amounts of water . Get the weights of the two lysimeters + plants + water (A_1 and B_1) .

4- Cover the soil of lysimeter "A" with plastic cover to prevent evaporation and leave the soil of lysimeter "B" uncovred, i. e. evaporation takeas place normally .

5- Leave both lysimeters in open air for a known period . Take the weight of each at the end of the experiment (A2 and B2) .

6- The amount of water loss by evapotranspiration (ET) $= B_1 - B_2 = B_3$

7- The amount of water-loss by transpiration (T) $= A_1 - A_2 = A_3$

8- The amount of water loss by evaporation (E) $= B_3 - B_3$

Since evaporation determines to great extent the efficiency of rainfall in a great measure , especially in areas where rainfall is less than 100 mm/year , the ratio of precipitation to evaporation (P:E) gives the nearest approach that is yet possible towards an annual index of the external moisture or water relations of plants . This ratio is more indicative of the vegetation type of an area than is either parameters : precipitation or evaporation considered independently . Thus , we may find that two areas may have nearly indentical rates and same pattern of distribution of precipitation , but the evaporation rate in each area may be different owing to the differences in pervailing wind and temperature variability . The plant cover of the two areas will, consequntly , vary . Also, similar evaporation rates but variations in the amount and/or distribution of precipitation can make , for example , the differences between grassland and forest types of communities.

What is the meaning of arid - areas ?

Arid areas are those where the amount of water required for evapotranspiration is less than the actual amount of water present in soil which is greatly affected by precipitation .

Measurements of Evaporation

Ecologists found that a measuring instrument known as " **Atmometer** " invented and designed by Livingston on 1915 react to external factors in a manner somewhat similar to plant body . The evaporation surface of the atmometer is a porous clay cup fed from beneath from water reservoir . When water is evaporated , the level of the reservoir falls and the amount of water evaporated is known either from changes in surface level or by the different intervals and expressed in cubic cm per hour or per day from the standard . For example , if the evaporad water is 30 cm^3 in certan period , the evaporation rate = 30 x the standard value (e.g 0.70) = 28 cm^3 /period .

Rate of evaporation can be measured also by Piche Evaporimeter which gives quick readinges and can be used in the plant communities . It is a simple instrument easy to use and is suitable for limited periods . It consists of a glass-standerd-measuring test tube connected from its lower-end with a paper disc which is moisten all the time from the water of the tube . The amount of water evaporated is measured by reading the tubes at known intevals e.g 30 minutes or 60 minutes . The results are expressed in cm^3/hour piche .

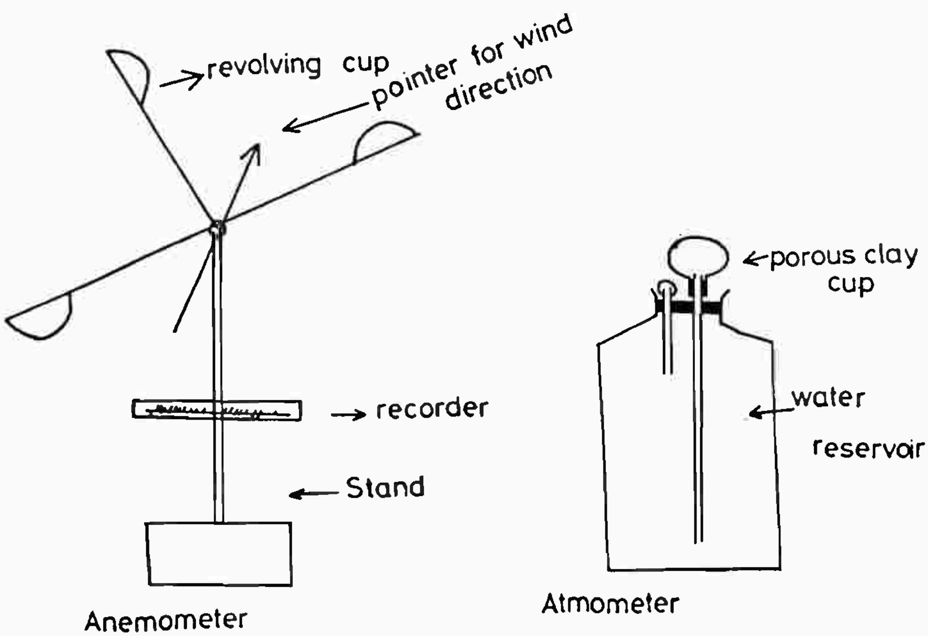


Fig . 13

ATMOSPHERIC GASES

The present concentation of CO_2 (0.03 % by volume) and oxygen (21% by volume) is somewhat limiting to many higher plants . It is well known that photosynthesis in many plants can be increased by moderate increase in CO_2 concentration , but its is not so well known that decrcasing the oxygen concentration experimentally can also increase photosynthesis .

The situation in aquatic environments is quite different from that in the atmospheric environment because amounts of oxygen , carbon dioxide , and other atmopsheric gases dissolved in water and thus available to organisms are quite variable from time to time and place to place . Oxygen is an A - I limiting factor , especially in lakes and in waters with a heavy load of organic materials . Despite the fact that oxygen is more soluble in water than is nitrogen , the actual quantity of oxygen that water can hold under the most favourable conditions is much less than that constantly present in the atmosphere . Thus , of 21% by volume of a litre of air is oxygen , there will be 210 cc . of oxygen per litre . By contrast , the amount of oxygen per litre of water does not exceed 10 cc . Temperature and dissolved salts greatly affect the ability of water to hold oxygen , the solubility of oxygen being increased by low temperatures and decreased by high salinity . The oxygen supply in water comes chiefly from two sources : By diffusion from the air and from photosynthesis by aquatic plants . Oxygen diffuses into water very slowly unless helped along by wind and water movements . Therefore , Important daily seasonal and spatial variations may be expected in the oxygen concentration of aquatic envionments .

Carbon dioxide , like oxygen , may be present in water in highly variable amounts , but its behaviour in water is rather different . Although present in low concentreations in the air , CO_2 is extremely souble in water , which also obtains large supplies from respiration , decay and soil or underground sources. Unlike oxygen , CO_2 enters into chemical combination with water to form H_2CO_2 , which in turn reacts with available limestones to form carbonates (- CO_3) and bicarbonate (- HCO_3) .

CLIMATE AND VEGETATION

There is a definite pattern of correlation between natural vegetation and the elements of temperature and rainfall. It is not a perfect relationship for soil variation and other factors are also important. Nevertheless, this tie-in has led to many classifications aimed at a climate vegetation link.

In hot areas , adequate moisture will lead to a rainforest but if a short dry spell occurs, a deciduous forest, with a vegetative resting period, will result. As rainfall decreases, the forest will give way to a thron woodland, savanna, scrubland, desert grasses and finally desert. In temperate zones, the wettest parts will support a deciduous forest and as the dry season increases, sclerophyllous woodland (summer drought), prairie, steppe and desert occurs in this order. In cool zones, sufficient rainfall will give rise to the taiga or northern coniferous forest and, as temperature decreases, the tundra region and perpetual snow and ice follow.

Climate is the biggest overall factor determining plant distribution and the main world types of climate are related to vegetational features. Study of climate (climatology) is accordingly, fundamental to plant ecologists especially when we know that within the life time of a particular plant , climatic factors do not often change appreciably.

Climatology deals with light, temperature, precipitation, evaporation, humidity and wind. Additional factors include radiation and cloudiness, and stroms may also be considered. These components are often interdependent,their various combinations giving us the characteristic climates of different parts of the world, which for our purposes may be divided broadly into three regions ,namely: **Polar, Temperate**, and **Tropical**. These regions are primarily temerature zones. Beside these three categories , there are the more localized climates of : high altitudes, Monsoon and Mediterranean types with warm and damp seasons alternating with dry ones , oceanic climates and widely extreme continental types. To the first three climatic groupings the main vegetation belts of the world largerly correspond with local variations of the localized climates and other factors.

The climates of temperate and adjacent lands are mostly fairly warm and moist at least in the favourable periods. They exhibit marked seasonal and diurnal fluctuations and also vary greatly from place to place .

The mean of the warmest month each year is normally above 10^{o} C and the annual precipitation is often more than 762mm. There are marked differences between winter and summer in light, temperature and precipitation. The vegetation tends to be fairly luxuriant at least in favourable situations with trees and shrubs widely dominating though herbaceous plants usually exceeding them in number and variety. Most areas having a mediterranean type of climate with hot and dry summer but other seasons that are damp and cold their vegetation being often dominated by leathery-leafed (sclerophyllous) shrubs and include many bulbous and ephemeral herbs.

The climates of polar lands and high altitudes are mostly severe with the mean of the warmest month usually below 10 ^{o} C. Preciptation is mostly in the form of snow and often less than 254mm. annually, though owing to the prevailing low temperature the relative humidity may be high and evaporating power low. There are wide seasonal fluctations in most polar regions and wide diuranal ones in most alpine areas. In the higher latitudes there is continuous light in summer and darkness in winter. The vegetation is mostly low and scant and comprises dwarf shrubs, herbs,lichens and mosses.

The climates of tropical and adjacent lands are warm and widely humid with the mean temperature of the coldest month usually above 17.8^{o} C. The rainfall is often heavy (more than 625 mm) and widely equable with often little or no seasonal variation. The vegetation ranges from the world's most luxuriant rainforest to various scrub, grassland and desert communities as the available water decreases. Most monsoon areas of alternatively wet and dry seasons are commonly dominated by deciduous trees and shrubs.

PHYTOGEOGRAPHY

PHYTOGEOGRAPHY

Geography is the study and description of the differentation and distribution of earthly phenomena embracing all that composes or affects the earth's surface including its physical features, climates and products whether living or inert . A major part is biological geography or biogeography , which for practical purposes is divided along the main line of division of living things into two kingdoms : plant geograpohy and anilmal geography . Plant geography is called phytogeography .

Phytogeography deals with the distribution of plants on the surface of the earth and in water , therefore it is one of the widest and most interesting subjects with which botanists especially taxonomists and ecologists , are concerned . This matter of distribution should be concerned with both the individual species and their various and complex assemblages that make up vegetation .

The ultimate purpose of phytogeography is the study of the differences in areas which make up the the world . Plant floristic and vegetational features as far as possible on world basis and for recording and illustration makes use of maps as one of its main tools . This illucidates the economic importance of phytogeography . It shows us a clear picture of plant cover of the world which provides us with much of our food , clothing housing , fuel industrial raw materials (drugs , oils , papers , textiles , plastics , scent , rubber , resin gum , wax etc .) , as well as oxygen .

Geographical distribution of plants on the earth depends mainly upon :

a. the agents that carry the plants (or parts of plants) from one place to another in process called dispersal ,

b. the barriers that hinder the distribution of plants and restrict their presence to certain area (or areas) of the world .

DISPERSAL

Dispersal (migration) merely involves dissemination from the parent and distribution to a new area . Thus , dispersal is a necessary fore runner of ecesis . In nature , only a small proportion of the plant bodies which become dispersed and which may conveniently be termed disseminules (migrules) actually become established and affect ecesis . Not only do many of them die prematurely or fall on "barren ground" or come to rest where they cannot even start a new life , or fail to survive the struggle with stronger competitors but also the ecological conditions and physiological reactions have to lie within narrow limits for ultimate success . Therefore , the vast great majority of the disseminules are doomed (die) .

The disseminules are most often reproductive structures such as spores , seeds or fruits . In numerous instances they are special structures of a vegetative nature or unmodified parts of plants or even group of plants (e.g. water hyacinth) . Often the same plant species or individual will produce mor than one type of disseminules , thereby increasing its chances of effective ecesis , e.g. *Phragmites australis* , the most widely distributed vascular plant in the world has the multiple advantage of wind-dispersed plumed fruits and water dispersed buoyant rhizomes .

Agents of Dispersal

Dispersal is carried out by wind , water,animals and man in addition to mechanical dispersal .

1. Wind Dispersal

Air currents (winds) are important in the dispersal of many different plants . Not only do winds blow leaves but they obviously transport some seeds and fruits for considerable distances . The more efficiently adapted of these have bodies that are so light that they float in a light breeze and may be transported far from the parent . The microscopic spores of fungi and bacteria are even more effective in their dispersal by air current . Such dispersal may take place over distance that in numerous instances have been proved to run into many hundereds of miles without losing their power to resume active life on regaining suitable conditions .

The main organs and plant bodies which are especially modified for the purpose are :

a. Spores

These are the main disseminules of most of the groups of plants up to , and including , the ferns which are often produced in fantastically great numbers . Thus, a single specimen of *Agaricus campestris* has been estimated to produce l, 800,000 spores , while a large specimen of mushroom (*Coprimus comatuc*) may produce 5,240,000,000 spores . Although externaly variable in size and form , spores are commonly minute and easily blown about by the wind-being frequently borne by upward air - eddies rising to the upper atmosphere from where they may be transported to vast areas . Indeed they are probably sometimes blown around the world without settling to earth . Bacterilal and some other minute cells may belong to the same category as spores in the matter of size and aerial buoyance . These spores are often extremely resistant to low temperatures and desiccation which in fact appear to prolong their life , so that many caught in most remote situations are alive, able to germinate when given suitable conditions and so we say " viable " . They may live for many years and , apparently , often withstand the radiation effect of high altitudes

b. Dust seeds and minute fruits

The seeds of many plants such as the members of the Orchid family (Orchidaceae) and the one seeded fruits of some of the mainly tropical parasitic familiies e.g. Balanophoraceae are also minute and extremely light, as well as sometimes winged, and so tend to be blown away and about in much the same manner as spores.

c . Plumed seeds

These usually bear a light tuft of silk hairs at one end and are liberated from a capsular fruit ,on splitting releases them gradually, often one by one .The plants involved are usually herbs or climbers, e.g. *Asclepias* and they generally occur in open situations in, or from, which they can travel for hundreds of miles.

d . Plumed fruits

These include the familiar "Parachutes" e.g. *Taraxacum* spp. Their appendages cause them to be detached by wind and float away, often for very considerable distances. The plants concerned are usually herbs and grasses.

e . Winged seeds

In these , usually a thin portion of the seed-coat forms a wing that catches in the wind when they are liberated, often in considerable numbers. They chiefly occur on trees, shrubs and lianas (woody climbers) and so are liberated some distance above the ground. Good examples are offered by species of *Bignonia* , and other members of the family Bignoniaceae.

f . Winged fruits

Again chiefly occurring on trees and shrubs, these are to be borne at least out of the immediate sphere of influence of the parent plant. Often the flight is a spinning one and not very efficient in terms of distance e.g. fruit of *Machaerium* spp .

g .Long haired seeds and fruits

These are sufficiently alike to be considered together, their main feature being that the surface is covered with long silky or wooly hairs. Such disseminules tend to be less efficient than plumed ones but are capable of travelling for some miles . The plants are trees or shrubs e.g. *Gossypium* seeds, *Salix* seeds and fruits of *Anemone* spp.

h . Jactitation

This is the slinging out of seeds from fruits such as the capsules of *Papaver* spp., which are held aloft on long stalks that are liable to bent with the wind and spring back subsequently to jerk out some more of the contents in the opposite direction.

2 . Water Dispersal

Any light disseminules may be dispersed by water up to the limit of their ability to float and retain the power of germination - that is until they become water-logged and sink or decay or until they are killed or, having begun to germinate, fail to reach a suitable habitat. Hence, the main requirements for water dispersal are sufficient buoyancy and impermeability, their degree of development in a particular disseminule being often the most important factor determining its success.

Among algae and many higher plants e.g. *Elodae_canadensis* which normally live submerged in water, there is no need for impermeability as the plant or special disseminule merely drifts with any water current, sometimes attached to floating logs etc. Such drifting appears to be the main mode of distribution of most sea weeds.

Free-floating plants such as *Lemna* spp., are widely dispersed and they float on the surface of water, though they may sink to the bottom during perennation. A fine tropical example is the water hyacinth (*Eichhornia crassipes*) whose dilated (enlarged) leaf-stalks act as floats

Floods may transport whole trees, as well as innumerable seeds and fruits that are deposited on the wet flood-plain when the water retreats.

The main modes (ways) of water dispersal are the following :

a . Sea Currents

These can cause very effective long-distance dispersal of suitably modified disseminules, in some known cases for over 1,000 miles. For this the body must normally be able to float for a long time without becoming waterlogged and must also belong to a littoral species that can establish itself under saline conditions on sandy, muddy or other sea-shores. Coco-nuts (*Cocos nucifera*) are so dispersed. Excellent tropical examples are afforded by characteristic dominants of mangrove swamps such as species of *Avicennia* and *Rhizophora*, the seedling of which float widely.

b . Rivers and Streams

These commonly transport fruits, seeds and other parts of plant, sometimes as far as from their source right down to the sea . Such dis-perersal is limited to the direction of the current and to the particular land. examples of flowering plants regularly dispersed by fresh water streams are many e.g. *Potamogeton* spp., etc .

c . Rainwash and Torrents

These not only splash out the seeds or spores from open organs but when forming a wash carry them much farther than other agencies. A considerable run-off may be noted in cold regions when the snow melts in spring but the ground remains frozen and impervious. It is not necessary that disseminules , in order to be washed away, should be able to float. Almost any plant or part of a plant may in certain circumstances be dispersed by drastic flood, sometimes for considerable distances , to be deposited in silty flood plain well-suited to the establishment of migrant plants.

3 . Dispersal by Animals

With their obvious mobility and life among plants on which they are largely dependent for food and in other ways, many animals are important agent of dispersal. There are two main categories:

a . those that are carried externally (ectozoic or epizoic transportation)

b . those that are carried internally after swallowing (endozoic tra - nsportation).

For this latter type of dispersal, the seeds, fruits or other disseminules are commonly modified by being attractive in appearance and particularly as food, for example by its bright colour and palatable flesh. This may be sweet and juicy when ripe as in peach *(Prunus persica)*, figs *(Ficus carica)* etc.. In addition, the embryo or other vital parts should be protected from digestion by a resistant covering, in which case germination is often hastened by passage through the animal. For ectozoic dispersal the disseminules are commonly adhesive by means of a sticky surface or more often, by their possession of hooks or other devices by which they catche on to the fur etc.

Birds tend to be the most important group of animals from the point of plant dispersal. They are not only abundant everywhere in the world and can fly for very great distances, but also they have the power to cross wide expanses of water.

Mammals, among animals, stand next in importance to birds as disseminators of plants. The mammals are important dispersal agents of many herbaceous plants with small seeds, which they swallow with the foliage etc., and are also the main transporters of plants with disseminules . Even though many herbivorous mammals effect such complete digestion that the vast majority of seeds and fruits which they take in their bodies are incapable of germination after voiding, there are nevertheless plentiful instances of disseminules being excreted unharmed. In case of stone-fruits, the pass through the intestines of the animals, not only unharmed, but much benefited by the treatment. Seeds so passed are known to germinate more quickly and produce stronger plants than those which have not been swallowed by birds or animals and acted on by the gastric or intestinal fluids.

Because of their frequently furry coats, mammals tend to be more commonly effective than birds in the ectozoid transportation of adhesive fruits, such as those with hooks or other devices for attachment. Many fur-coated mammals wander extensively or travel far on migration, some even crossing wide tracts of sea-ice in the arctic. Some seeds also adhere to animals by viscia glands, gummy exudation or owing to their wholly sticky nature , while the spikelets of many grasses do so by jagged parts (notched rough ends), or minutely toothed awns

Lower animals, e.g. reptiles, although most of them are carnivorous, some feed on fruits and may disseminate them.More important in this respect are fresh water fishes, many of which are vegetable feeders that swallow the seeds of aquatics and semi-aquatics and many of which can migrate overland, usually through wet grass.

Some of the larger aquatic mollusca and reptilia (creeping water animals) play a part in the dispersal of algae which grow epizoically upon these animals. Snails on land disperse seeds and spores that adher to their bodies or have been swallowed.Indeed, it is said, that the spores of some fungi will only germinate after passing through the intestine of a slug (type of animal). When the latter is eaten by a frog or bird the possibility of far more extensive dispersal occurs.

Insects are probably the most important of the groups of lower animals in the matter of plant dispersal, especially of very small bodies, such as fungal spores. Transport is commonly by swallowing and "passing" in the excreta. Locusts are said to afford examples of the first method, sometimes over considerable distances and ants frequently transport seeds with edible appendages. Flies and many other insects often carry spores of cryptogams adhering to their bodies, especially when the latter are densely haired. Further instances are the well-known transmission of fungi and bacteria carrying diseases, by insects.

4 .Dispersal by Human Agency

Man is evidently the most active agent of vegetational changes-including plant dispersal-of modern times. He is the greatest dispoiler of forests and causer of erosion, dispersing weeds as well as growing crops. As he (man) travels about the world in greater and greater numbers and with ever increasing speed and ease, he is always transporting the disseminules (or sometimes transporting whole individuals or groups) of plants. Also, of vast importance is his indirect effect, through the pasturing of his domestic animals or his disturbance of natural of com munities of herbivorous animals. As a result, there are few parts of the world where the vegetation and its component flora do not bear the stamp of human interference.

The following are some of the main methods by which man introduces plants to new areas and often new countries and even continents. In addition to international transport of desirable plants for agricultural, horticultural, silvicultural or other purposes, weeds are often dispersed inadvertently (without intending) with the seeds of vegetables , cereals and garden flowers, as well as with pot plants. Seeds of these weeds are further dispersed in this case eventually by wind or water transportation.

Some seeds may pass through the human digestive tracts unharmed, the spontaneous growth of tomato plants in sewage farms bears clear testimony.

5 . Mechanical dispersal

Although it is usually effective over only short distances, mechanical propulsion or even extensive growth can be a distinct advantage in migration . Particularly, mechanisms of some fungi, usually on sudden rupture relieve stresses and may shoot their spores or spore-producing organs in some instances as much as 15 feet.

However, in the case of tiny (small) distance takes them into the free air and is often sufficient to launch them into atmospheric currents that may carry them particularly anywhere. Seed may shot out for distances of as much as 65 feet (about 20 metres) from fruits of *Ecballium elatorium* . when the fruit ripes , it breaks from the stalk and through the hole the seeds are eijected .

Many species of the genus *Viola* in which the fruit splits into three-shaped valves, shoot out their seeds for up to 15 feet as a result of unequal drying of the layers of the fruit wall. This dryness causes curving of the sides of the valves and the consequent pressing of the seeds.

BARRIERS

When we reflect that in many species of flowering plants,such as *Sisymbrium* and *Amaranthus*. a single individual may produce a million or more seeds in one summer, and that som cryptogams e.g. *Lycoperdon,* may produce as many as several million spores, and yet none overuns the world, it is obvious that only a small proportion of plant disseminules produced ever attain their real biological strength. To realize its full potentiality,a propagule must develop into an adult, which in turn reproduces . This stupendous (great) mortality of propagules is due to the action of various types of barriers to dispersal or to actual establishment (ecesis)

.Barriers are of four types:

1. Physiographic ,
2. Climatic ,
3. Edaphic , and
4. Biotic .

1. Physioraphic Barriers

These are due to features of the eath's surface . The most obvious of these for terrestrial plants are expanses of water and for aquatic plants , bodies of land . Other physiographic barriers are chains of mountains both directly by constituting mechanical impediment and indirectly by changing climatic conditions .

2. Climatic Barriers

These involve different conditions of temperature , humidity . light and other climatic factors . Owing to the close dependence of plants on climatic conditions , zones of vegetation and climate tend to correspond with one another , the climate commonly determines the general limit of a plant's distribution . A change of climate often constitutes a real barrier - not only as a whole but as to one or other of the climate's component factors , which may react in a particular way on the plant's physiological make - up .

3. Edaphic Barriers

Due to features of soil these are again various , involving structure , chemical compsition , moisture content , temperature conditions , or even content of living organisms ; any one of these can prevent a disseminule from establishing a plant in new area , even if it germinates quite successfully . Edaphic conditions tend to limit the distribution of plants (and vegetation) rather drastically within the main climatic belts . Absence of a suitable habitat or at least of the required conditions , is apt to constitute an insuperable (impossible) barrier to successful migration .

4. Biotic Barriers

These relate to living organisms , including other plants . The competition for space , light , water , nutrition etc ., involving other plants already established in an area and growing in reasonable equilibrium with local conditions , is apt to constitute an insuperable barrier to successful establishment of new comers . Impact of grazing or other disturbance by animals (including man) could prevent establishment . Consequently , widespread migration is largely limited to more or less " open " areas such as cliffs , sands and disturbed ground , where other sets of barriers come into play .

Barrier to Wind Dispersal

As we have mentioned , wind dispersal operates on free air - buoyant spores , seeds etc . It is thus expected to find an unusually large proportion of the native plants with wind - borne disseminules in the treeless high alpine and arctic regions . In dense forests and other sheltered areas wind is less effective . Wind - dispersal plants are also rare on oceanic lands ' oceans act as barrier that cannot be overcomed (insuperable barrier) by disseminules that cannot float for long protracted periods . Dense forests may have a barrier effect similar to oceans , though of a less limited nature .

Mountain ranges also prove an intercepting barrier in many instances . This is evidenced by the fact that at the foot of such obstacles a wide range of wind - borne seeds and fruits are often to be found germinating , having been stopped in their flight and fallen down .

Barriers to Warter Dispersal

These include absence of water , and obstacles to water movement . Interchange between salt and fresh water represents another barrier to water dispersal .

TYPES OF PLANT DISTRIBUTION

Distribution of plants is of two types .

a. Continuous inter-continental range

b. Discontinuous range

a. Continuous inter-continental range .

Of continuous inter-continental range of plant distribution on the earth we may consider four main types .

1. Cosmopolitan
2. Circumpolar
3. Circumboreal
4. Pantropic

1. Cosmopolitan distribution

This means world-wide distributed. In reality no species is truely so, or probably found in all edaphically or waterly similar and hence potentially suitable habitats. The correct definition of a cosmopolitan plant species is that one which tends to have wide range of geographical distribution or is panendemic (pan=not) . They should at least occur in all of the 6 widely inhabited continents .

2. Circumpolar

These are species distributed around the north and south poles . It applies to plants which reach the arctic (north pole) or antarctic (south pole) polar regions .

3. Circumboreal

The boreal zone lies next to the arctic and antarctic zones and may be considered as extention to the border of the sub-tropics .

4. Pantropic

Extending practically throughout the tropics and subtropics or at least widespread in the tropical regions of Asia, Africa and America e.g., Palm trees .

b. Discontinuous range .

In discontinuous ranges the plants are separated by wider gaps than the dispersal capacity of their propagules would normally bridge. The main causes of discontinuity are usually environmental in being due to particular topographic, climatic, edaphic or biotic characteristics which lead to areas being separated from each other by tracts of different characters .

The chief types of discontinuous ranges are :-

1. Arctic alpine

Distributed in the arctic region and in the mountain system of temperated or even warmer zones .

2. North Atlantic

Distributed in North America and Europe and sometimes locally in Asia .

3. North Pacific

Distributyed chiefly in North America and Eastern Asia, sometimes elsewhere .

4. North and South America

Distributed in North and South America, but lacking continuity between .

5. Europe - Asia

Distributed in Europe and Asia, but lacking continuity in between .

6. Mediterranean

Various types including the European and African shores of the Mediterranean Sea or the Mediterranean Basin .

7. Tropical

Distributed in two or more separate tropical regions .

8. South Pacific

Distributed in south America and New Zealand , often in other pacific Islands and in Australia .

9. South Atlantic

Distributed in south America and Africa (including Madagascar) .

10. Antarctic

Distributed on the antarctic mainland (usually as fossils) and in the South America and New Zealand .

ENDEMISM

Physical and ecological isolation has given rise to the phenomenon of endemism. Endemic plants are those (whether members of a family, genera or species) peculiar or exclusive to a particular area. They are plants which have either evolved with a particular area or plants which, becausc of barriers having been created subsequent to their migration, have become confined with a particular area. The degree of endemism, i.e. the number of endemic species (expressed as a percentage of the total of all species in an area) depends largley on how effectively and for how long an area has been isolated. Areas surrounded by oceans, extreme climatic conditions or extensive mountain ranges - limited by well - marked obstacles to migration - have been most favourable to endemism. Off-shore " continental " islands, within easy reach of the mainland, and often (as in Britain) , only recently separated fron it, normally have a few endemic species. Areas of characteristically high endemism are the isolated oceanic islands and mountain areas. The latter can, in fact, be considered as isolated " climatic islands " which in addition, because of marked variations in local relief and climate, often contain a great number of small endemic areas within them .

The general meaning of endemic in biology is that of being confined to, or indigenous (native born) in a certain region, as an endemic plant or animal .

In contrast with plants exhibiting various types of discontinuous ranges, and which may be widely scattered, are those whose range in each case is confined to a single restricted area, not extending beyond one region, island or other circumscribed tract. Such plants are called endemics .

The term endemic is very useful as it is commonly used in reference to political and larger geographical units. A plant may be said to be endemic to a certain state, to a country or to a continent .

In a study of the families of flowering plants, it was found that certain ones are confined to large continental masses i.e. endemic to them. The world is divided into 4 large continental masses and it was recognized that 33 families are endemics to the Americas, 16 to Europe-Africa, 7 to Asia and 5 to the Australia .

The number of endemics and the percentages of them vary widely from one region to another, depending largely on the history and conditions of the region. The conditions of endemism in islands is probably best known. The flowering plant species of Hawaiian Islands are nearly 82% endemics, that the genera are about 20% endemics an that many of them altogether lack close relatives. The follwing is a list of endemic percentages for certain islands :-

Island	Location	% of Endemics
Corsica	Mediterranean Sea	58
Madagascar	Indian Ocean	66
New Zealand	Pacific Ocean	72
Hawaii	Pacific Ocean	82
Canary	Atlantic Ocean	45
St. Helena	Atlantic Ocean	85

Mountains on land are in many respects like islands in the seas, because their isolation is relatively complete for reasons of climates and climaxes. In Ceylon, for exaamle, the flora contains over 100 species confined to one or a few hill tops rising from a plateau. In continental regions and large islands, it appears that endemism tends to be high in mountaneous area, In Egypt and Saudi Arabia the number of endemic species is high in the mountaineous areas e.g. Sinai and Gebel Elba mountains of Egypt and in the mountains of the Red Sea coast of the SW region of Saudi Arabia .

RELIC AREAS

These are areas occupied by relic species (often called relicts) which in the phytogeographical sense are remnants of an earlier flora that have been " left behind " when surrounding areas have been vacated. Thus, relic areas themselves normally constitute remnants of once - extensive areas, being usually isolated , (photo 18) .

The determination of whether a species in really a relic is not always an easy and definitive matter , and the same , consequently , applies to relic areas . lThe finding of fossils (ancient remains of a plant) in surrounding areas where it does not grow will demonstrate its relic nature and idicate from that period of time its local occupation dates .

Photo 18 : Relic hillocks previously dominated by **Tamarx** sp. in Wadi Qena , Eastern Desert , Egypt .

We may distinguish three main classes of relic on the basis of the type of natural habitat - change which has isolated them . These are :

1. Formation relics
2. Geomorphological relics .
3. Climatic relics

1. Formation Relics

These are the relics that occupy limited areas within the boundaries of major plant communities which have undergone considerable changes in composition e . g . the residual wood tracts that are sometimes found in extensive grasslands.`

2. Geomorphological Relics

These are the relic plants concentrated in their preferable habitat with particular ecological conditions , but that , owing to edaphic or allied changes , are no longer provided with the conditions of growth to which they are accustomed . Familiar examples include marine plants inhabiting lakes and shore plants growing along the edgs of dried up gulfs .

3. Climatic Relics

These are the relics that give evidence of having originated and formerly flourished under other climatic conditions than those in which they now grow . Examples are the mesothermic plants to be found in some boreal areas that have cooled at least since the " Post glacial optimum " when such plants are thought to have migrated to these areas .

Apart from the preceding classification of relic plants , the latter can also be classified on the basis of their age and origin as :

1. Pre-tertiary
2. Tertiary
3. Glacial
4. Interglacial
5. Post-glacial

HABITAT TYPES

Habitat refers to the place (locadlity or station) in which an organism or community lives . It is made up of many and various environmental factors having any kind of influence upon life within it .

Apart from air , which is the habitat of cerain microorganisms, hapitats range from dry land to open water .

A. Terrestrial Habitats

These are separted from the aquatic habitats by water conditions , and their main subdivisions often depend upon the relative availability of water . Leaving aside plants that grow on the sea margins and spend most of their life sub-merged , we have seven types of terrestrial habitats . These are :

1. Marginal habitats of the sea shore that are charcterized by salt spray or occasional inundation .

2. Lake and stream sides where the bed is shallow and shelterd , " reed swamp " . Most of the reed swamp bodies are aerial .

3. Various tropical swamps and mangroves .

4. Silty marshes (whether salty or not) which are abundantly supplied with water (but not covered) .

5. Less aqueous land habitats that are of many different types . Here , all manners of variation of climatic and edaphic conditions from place to place give rise to a great variety of different habitats usually supporting different types of forest , arable or pasture lands .

6. Deserts , which are areas where conditions are too unfavourable to allow the support of any extensive continuous development even of short grasses or scrub .

7. Mountainous habitat , where water conditions vary with altitudes and zonation of different vegetation types is a dominant feature .

B. Aquatic Habitat

Even when we divide these into the two main groups of saline and fresh water habitats , there are left intermediate " brackish " ones , which seem best considered with salt water . The degree of salinity can affect the habitat and attendant community .

Light , being essential for photosynthesis , sets limits to those depths in water where plant life is possible . In lower depths enough light does not penetrate and only specially adapted organisms can grow . Some red algae seem to be adapted in this way to live in depths of nearly 200m . The larger brown algae on the other hand , do not seem to be able to grow at such depths . Vascular plants in fresh water usually extend no deeper than 10 m . However , in the Mediterranean Sea , one flowering plant namely . " *Posidonia* " is reported to extend down to depths 80 m . or even 100 . in clear water .

Aquatic plants are often limited to sheltered bays to protect themselves from the wave and current actions .

As regard the content of dissolved substances , this can range from ocean or even more extreme salinity down to varying degrees in fresh water . We can distinguish three types of such water bodies .

a. Oligo - trophic or water poor in dissolved minerals in which only microscopic - one - cellular algae (desmids) grow but which may support a narrow zone of rooted plants because of the hardy bottom .

b. Dystrophic with water also poor in nutrients but rich in humus and acidic in reaction , often coloured and containing desmids and bog mosses (swampy mosses) .

c. Eutrophic with commonly silted shallow water which is poor in humus , low in number of species but richer in number of individuals . It is rich in combined N , P and Ca typically contains plentiful blue - green algae , rooted pond weeds and luxuriant reed - swamps .

Water pH whether acidic or alkaline , is commonly important to water plants . Lack of Oxygen is a limiting factor deep down in sheltered situations .

Tidal activities are also an important factor in limiting the zones of vegetation on the littoral salt marshes .

LATITUDINAL & ALTITUDINAL DISTRIBUTION OF PLANTS

The major and most obvious segregation of the plant life of the world is classified into three latitudinal zones , namely : **Polar** , **Temperate** and **Tropical** . These , owing to the shape of the earth and its position in relation to sun , are symmetrical about the equator . For most practical purposes , this zonation is scarcely detailed enough and it is usual to incorporate a fourth zone namely subtropical .

Recently , new classification of the zones of vegetation of the globe has been suggested as follows :

1 . Equatorial zone

Areas of the latitudes 0.0-15^{o} north and south of the equator .

2. Tropical zone

Areas of the latitudes 15 - 23.5^{o} north and south of the equator .

3. Subtropical zone . Areas of latitudes 23.5-34^{o} north and south of the equatar .

4. Warm Temperate zone

Areas of 34 - 45^{o} north and south of the equator .

5. Cold Temperate zone

Areas of 45 - 58^{o} north and south of the equator

6. Sub - Arctic zone

Areas of 58 - 66.5^{o} north and south of the equator .

7. Arctic

Areas of 66.5 - 72^{o} north and south of the equator .

8. Polar

Areas of 72 - 90^{o} north and south of the equator .

This would be satisfactory and accurate indication of the major distri bution of plants but it ignores one factor namely : the influence of eleva tion of land . It is well - known that at any altitude a sufficient vertica rise from sea level epitomises in a very short distance the climatic zona tion which is to be observed at sea level between the latitude in questio and the nearer pole . In general , temperatures get lower and lower a the land level rise . Since climate and vegetation are closely correlated i follows that a vertical rise similarly epitomises , the botanical change which are to be observed between the latitude and the nearer pole . This is illustrated by the familiar fact that as one asscends a mountain the plant changes with increase in elevation . If the rise is sufficient , a condition charcteristic of polar latitudes is reached ; so that the highest mountains , even on the equator , have permanent ice and snow at their summit (alpine) .

The vegetational zonation of mountain (altitudinal zones) and especially of tropical mountains , has been much studied . The following is an example . On a high mountain situated in the equator of the tropical zone , the lowest levels , namely between sea level (zero) and 600 m high are occupied by a truly equatorial vegetation characterized by palms and bananas . Above them comes a tropical but less equatorial kind of vegetation in which figs and tree ferns grow . Beyond , there is a third zone of sub - tropical types of plants e . g . murtles , and above them another warm temperate zone of evergreen trees . The fifth zone is occupied by deciduous trees , such as those familiar in temperate regions . Then a zone of coniferous trees . Alpine shrubs predominate in the seventh zone , then finally , there is a zone of alpine herbs . Above this , there is no appreciable vegetation as the mountain summit is covered with ice and snow . This zonation may be summarized as follows (Fig . 14) .

1. 0 - 600	meters	=	zone of palms and bananas
2. 600 - 1250	"	=	zone of figs and tree fern
3. 1250 - 1900	"	=	zone of myrtles
4. 1900 - 2600	"	=	zone of evergreen trees
5. 2600 - 3200	"	=	zone of deciduous trees
6. 3200 - 3800	"	=	zone of coniferous trees
7. 3800 - 4450	"	=	zone of alpine shrubs
8. 4450 - 5050	"	=	zone of alpine herbs
9. Above 5050	"	=	permanent ice and snow with no vegetation .

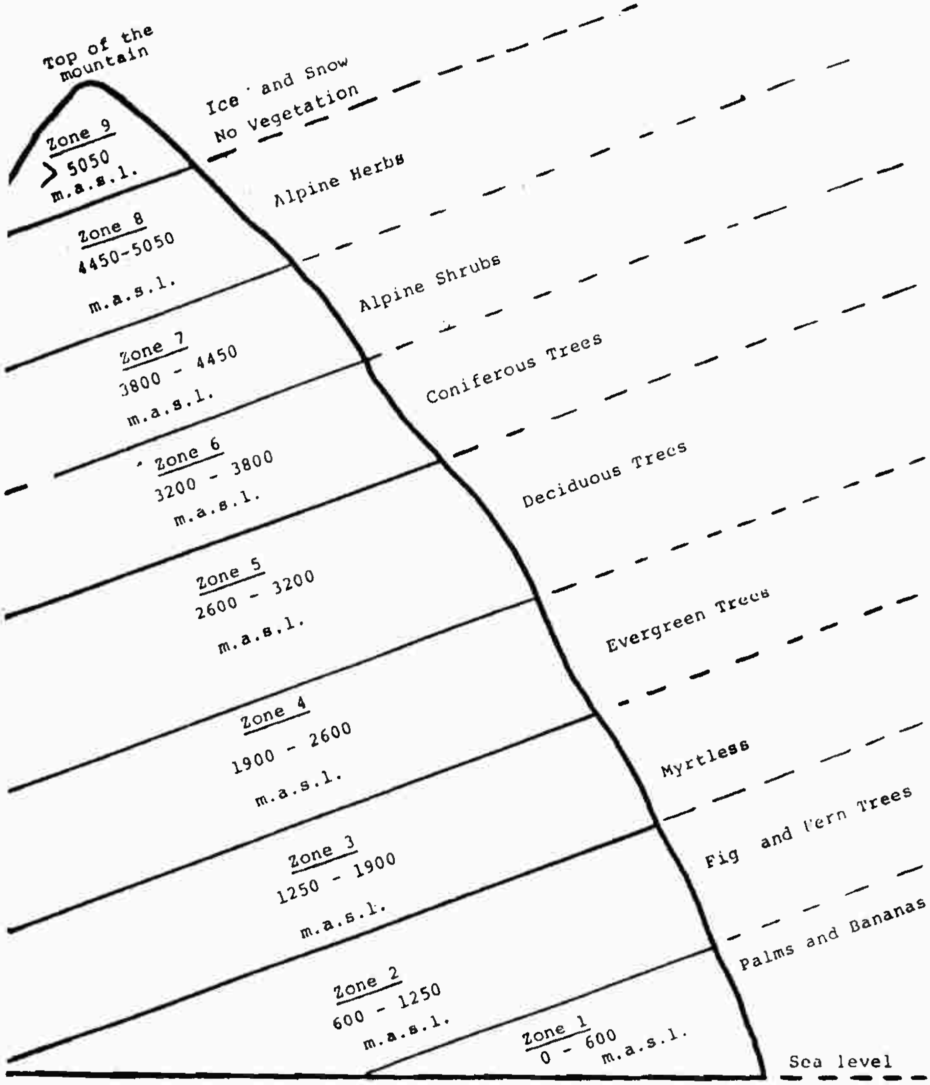


Fig 14 : Altitudinal zones of the vegetation

THEORY OF TOLERANCE

There are six fundamental prinicíples that control the geographical distribution of plants in the globe these are :-

1. Plant distribution is primarily controlled by the distribution of climatic conditions

2. Plant distribution is secondarily controlled by the distribution of edaphic factors .

3. Great movements of species and of floras have taken place in the past and are apparently still continuing .

4. Plant movement , especially in its largest aspect of plant migtration , is brought about by the transport of individual plants during their mobile phases .

5. There have been great variations and oscillations in climate , especilly at higher latitudes .

6. At least some variation has occurred during the same period in the relative distribution and outline of land and sea .The theory of tolerance of plants may be summarized in the following terms .

" Each and every plant species is able to exist and reproduce successively , only within a definite range of climatic and edaphic conditions . This range represents the tolerance of species to external conditions " .

" The tolerance of a species is a specific cheracter subject to the laws and processes of organic evolution in the same way as its morphological characters , but the two are not necessarily linked " .

" Change in tolerance may or may not be accompanied by morphological change , and morphological change may or may not be accompanied by change in tolerance " .

" Morphologically similar species may show wide differences in tolerance , and species with similar tolerance may show very little morphological similatity " .

" The relative distribution of species with similar ranges of tolerance is finally determined by result of the competiton between them " .

" The tolerance of any large taxonomic unit is the sum of the tolerance of its constituent species " .

ARIDITY AND ARID LANDS

ARIDITY)AND ARID LANDS

Arid lands are found over a wide range of latitudes and come under the influence of nearly all the major wind and pressure belts . Aridity affects the relationships between the water that is naturally available and its exploitation by plants and man . It therefore decides the basic potential of any land surface , whether it be a rocky (mountain face) or a deep alluvial soil , since it influences the ultimate behaviour of the soil and the ecosystems associated with it .

What are the causes of aridity ?

There are three distinct causes of aridity namely :

1. Separation of the region from an ocean either by topographical barriers like mountain ranges or by distance , as in midcontinental regions ;

2. Prevalance of the dry stable air masses and resistance of convective currents whose turbulance normally promotes rain formation ;

3. Lack of storm systems which must lift the air before rain fall .

Each different causes of aridity can exist on its own , or in combination with one or both other causes . The Arabian , Australian and Saharan desert zones are found between major wind belts with their associated storm systems .

Characteristics of Aridity

In order to understand the processes infuencing desert ecosystems , it is essential to appreciate aridity , and particularly its intensity . This can only happen if accurate climatic data is available . However , any measurements made are detailed value only in the location where they originate , since microclimate influences can significantly alter the overall shape of the data .

Because the availability of water and consequently the volume of water held in the soil , is of prime concern , there are three elements which need to be considered in detail to establish the patterns or characteristics of aridity ; these are :

1. The volume of rain , its frequency and rate of fall .

2. The range of temperatures with particular reference to their maximum values .

3. The relative humidity of the atmosphere .

The sporadic nature of dry - land rainfall is more pronounced where extremely arid lands are found , and its regularity improves on the semi - desert frings . As rainfall becomes more erratic , it comes characteristically in the form of thundestorms , which can form " Flash floods " . The nature of the soil determines how water runs off over the gorund and collects in wadis or streams . The more regular rainfall of the semi - arid areas is not so closely connected to cloudursts and in this case , the soil is not subjected to such great flood forces and is able to absorb great volumes of water as a consequence .

Evaporation rates in arid lands are commonly 15 - 20 times as much as the annual rainfall and have been known to reach 30 times the volume of available water . Even such high rates can be exceeded , should exceptionally strong drying winds occur . No depression of evaporation rates can be expected from cloud cover , since this is usually extremely low , except perhaps in coastal desert .

The soil's texutre will influence the rate of water movement within it and therfore influences the upward movement of moisture attracted by the evaporative forces . The finer the mixture , the greater the loss of water , where large soil-air spaces are found , resistance to these forces is greater .

World Arid Areas

There are five major zones , two in the northern hemisphere and three in the southern one , and each is separated from the others by either oceans or wet equatorial zones (Fig . 4) . The northern hemisphere contains deserts which are considerably larger in total area than those of the southern hemisphere ; the zone stretching from West Africa to China is larger than all the southern deserts combined .

Since climate is the predominant element influencing the morphology of the land and therefore the soils , it will be considered together with the description of location .

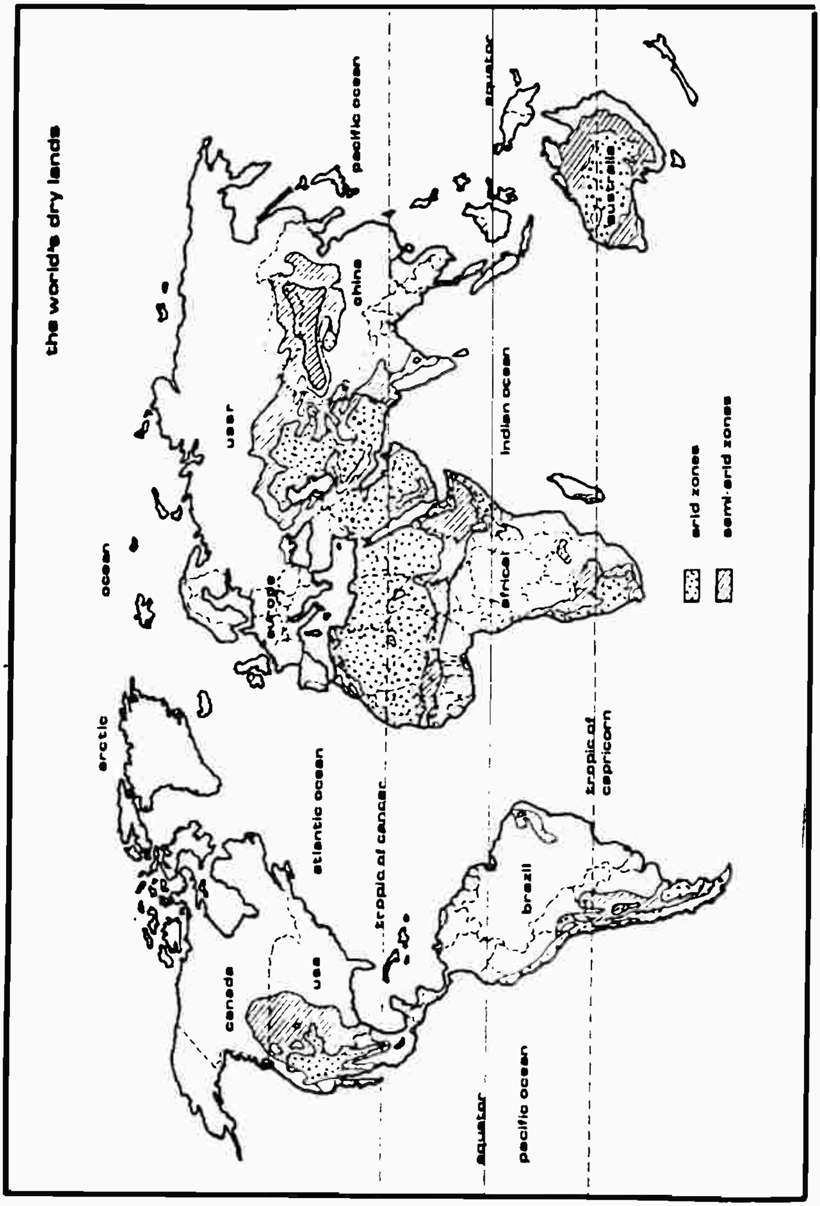


Fig 15 : The Dry Lands of the world

1- Northern Hemisphere Desert (Arid) zones

There are two major desert (arid) systems in the northern hemisphere ; the North African - Eurasian zone and the North American Desert zone . Owing to their magnitude , their formation has been influenced by a number of climatic factors , as can be seen from their enormous spread

A. The North African - Eurasian zone .

This is the largest of all the desert zones , starting in northern Mauritania in Western Africa and stretching to China (Figs . 5 , 6 & 7) . The Sahara is the world's largest desert and stretches across North Africa , encompassing Mauritania , Morocco , Tunisia , Algeria , Libya and Egypt . The desert zone continues on the eastern side of the Red Sea into Northern and Central Arabia , to the Northern Arabian states as far as the Arabian Gulf . Over the Gulf , the desert zone passes through Iran , including within its boundaries The Great Salt Desert , one of the world's least hospitable and least explored areas , on through Afghanistan and Pakistan and into Northern India .

The climate of such an enormous zone is extremely complex , as would be expected , and it includes 6 major climatic systems viz : the Mediterranean , the south Sahara , the Somali ,Chalbi and Southern Arabia , the Thar , the Turkestan , and Talka and the Gobi .

1- The mediterranean Climatic System

Principally , the Mediterranean climate influences the northern coast of North African , and eastern coast states of the Mibdle East . It can be subdivided into the following :-

a) The Northern Sahara :

This region can be further divided into the area influenced as it goes southwards from the North African coast . The typical pattern of the hot dry summer is replaced by extreme heat and very low winter rainfall . The zone extends from Morocco to Egypt and its limit coincides with the 100 mm . rainfall isohyet (the mapping line linking areas of equal rainfall) . One quarter of the total area of the Sahara receives less than 20 mm . of rain in a year. Even when the 50 mm . isohyet is reached , plant cover is till very poor especially in the north , north west and parts of Western Shara . Vagetation can be found in the center of theSahara , but is restricted to the Wadi beds : the rocky outcrops and hillsides are barren .

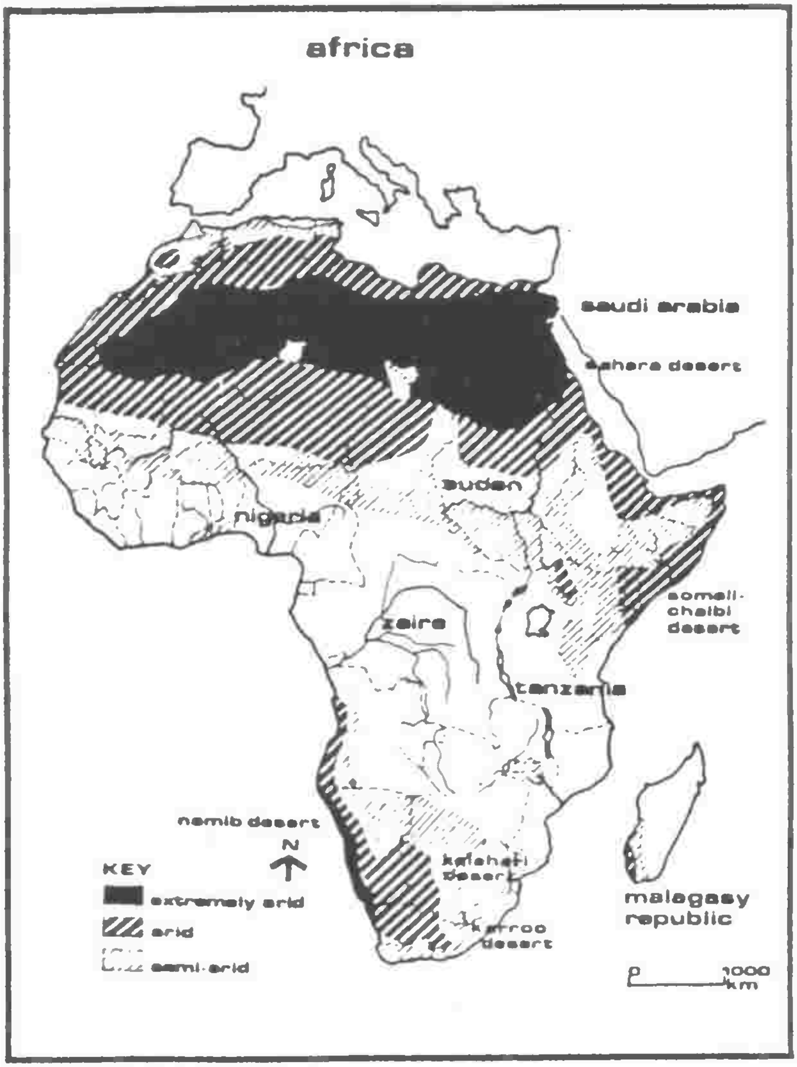


Fig 16 : Desert Areas of Africa .

b) The Northern Arabia

This zone is the eastern coastal zone of the Mediterranean and including Syria , Lebanon , Palestine , Jordan , Northern Saudi Arabia , Iraq and Kuwait . Its climate is typified by hot dry summers and winter cyclonic rains , coming off the Mediterrranean . Three types of desert have been distinguished within this zone : the " **rain deserts** " where vegetation , though sparser than the Northern Mediterranean flora with which it has affinities , is nevertheless supported by rainfall ; the " run-off deserts " where the rainfall can only support plants in depressions ; and " **absolute deserts** " where there is no rainfall .

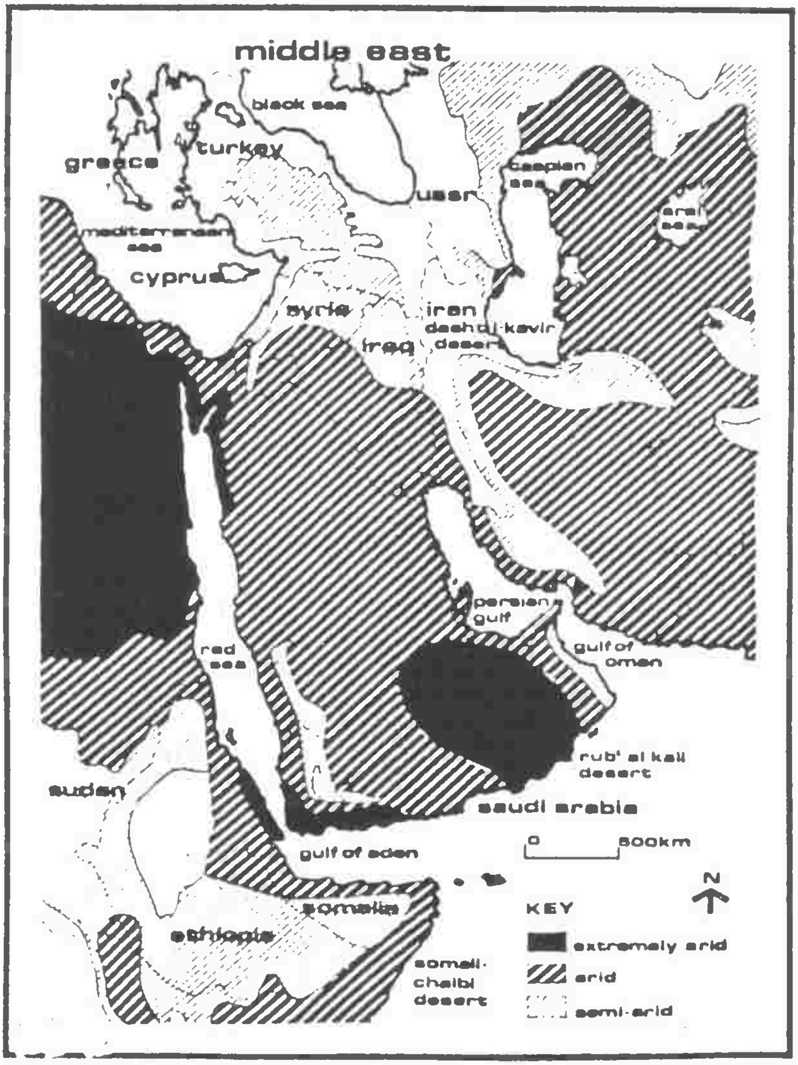


Fig . 17 .

North of the Tropic of Cancer , the Mediterranean Sea strongly influences the flora of the Red Sea area including Northern Saudi Arabia , Jordan and Palestine and even more so in Syria , where the total rainfall can reach 350 mm . year . In the northern and central desert of Palestine , the rainfall is between 75 mm . and 100 mm . but further north the scanty rain is augmented by 100 mm . of dew .

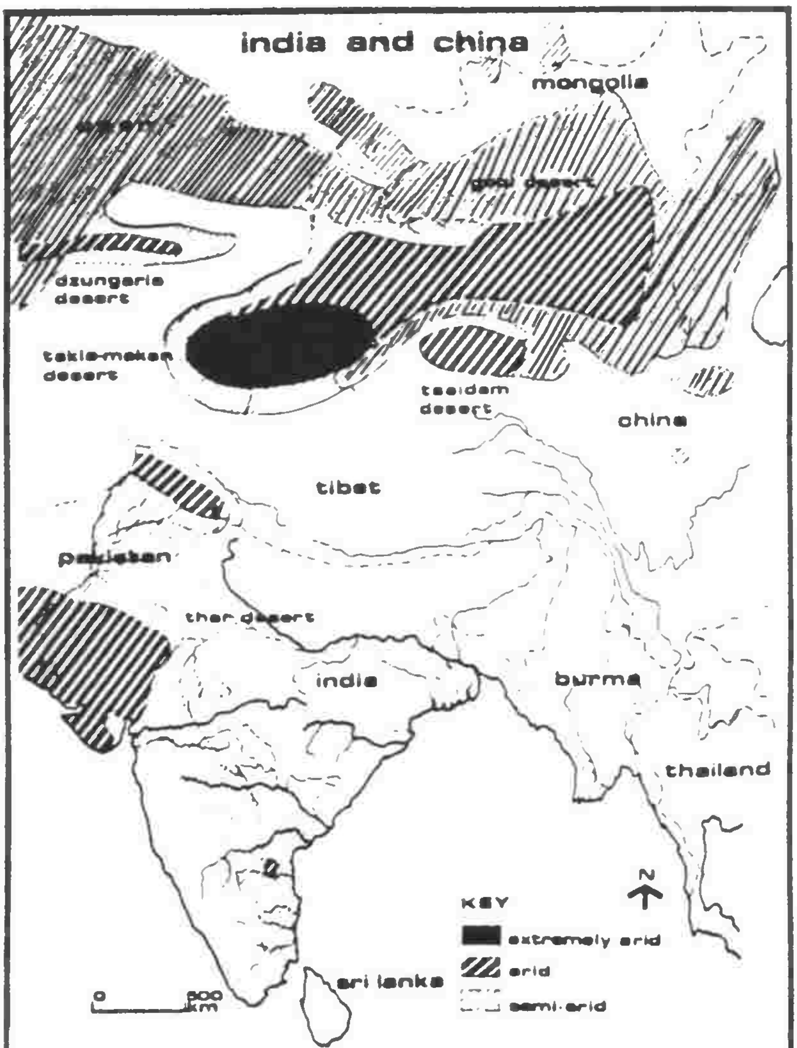


Fig . 18 .

2- The Southern Sahara

This area is the desert zone south of the major central expanse of the Sahara . Tropical weather systems have the greatest influence and the midlatitude systems are considered to be of peripheral significance only

The zone (Sudano - Sahelian belt) stretchs from southern Mauritania to the Sudan and includes on its southern borders Mali , Upper Volta , Northern Nigeria and Cameroons . Its climate is part of the tropical system which defines the weather of the area by the shifts of the intertropical convergence zone . Rainfall can be expected in summer and reaches 250 mm .

3- The Somali - Chalbi and Southern Arbian Climate System

This area includes the very variable geographical features of both Ethiopia and Somalia , with influences into Kenya and Tanzania as well as Southern Arabia and the states of the United Arab Emirates . Its climate is complex affected by topography , thermal low pressure and coastal upwellings as well as the Indian Monsoon . Its southern fringes come under the Tropical Climate Systems and there is a very rapid transition from pure desert to equatorial rain forest . A particularly interesting feature of the reastern Somali coastal area bordering the Red Sea is that this area was under the sea in recent geographical history , and is of great academic value in the study of plant colonization and the process of erosion .

4- The Thar Desert

The Thar (Indian) desert includes the arid portions of Western India and Eastern Pakistan . It is a transitional zone between major wind belts . Midlatitude cyclones produce moderate amounts of winter precipitation in the northern and western portions , while the eastern portion receives its rainfall from the monsoon circulation that dominates the subcontinent in the summer . The monsson of air terminates in Western India , resulting in a small and irregular rainfall in Thar .Summers are hot and winters are warm throughout the area .

5- TheTurkestan Desert

Except in the north , the Turkestan Desert has a Mediterranean type of moisture distribution but with colder winters than in typical Mediterranean climates . Throughout the area , winters are mostly cold and the summers are hot (very hot) . The average precipitation ranges from 75 to 200 mm , falling in winter or spring , leaving the summer months without precipitation .

6- The Takla - Makan and Gobi Desert

This is the largest desert of Asia and it lies in outer Mangolia and mainland China's Inner Mongolian Autonomous Region . This desert is separated from major moisture sources by orographic barriers or by great distances . The Tibetan plateau , roughly 3000 km in length with a mean elevation of about 4000 m . , form an effective barrier to moist air moving northward from the Indian ocean . It is an area of hot summers and cold winters with no particular seasonality for the scanty precipitation . A large portion of the Takla - Makan is extremely arid . The remainder of the area is arid .

b) The North American Desert zone

This zone extends southwards from central and eastern origin , embracing nearly all of Nevada and Utah except the higher mountains into SW Wyoming and Western Colorado , reaching westwad in southern California to the eastern base of the Sierra Nevada , the San Bernardino Mountains and the Cyamaca Mountains (Fig . 8) . From southern Utah , the desert extends into NE Arizona and western and SW Arizona . Desert areas extend southward along the eastern coast of northern Bajq California , in the lee of the mountain ranges of Sierra de Juarez . South of these ranges it extends across the peninusla as far south as the northern end of Sierra de la Giganta : farther southward it is limited to the Pacific coast . On the mainland it occupies the lowland of the state of Sonora , Mexico . The desert area extends into low elevations in New Mexico and Western Texas . In Mexico it extends through eastern Chihauhua and nearly all of Coahuila and southward into Central Mexico .

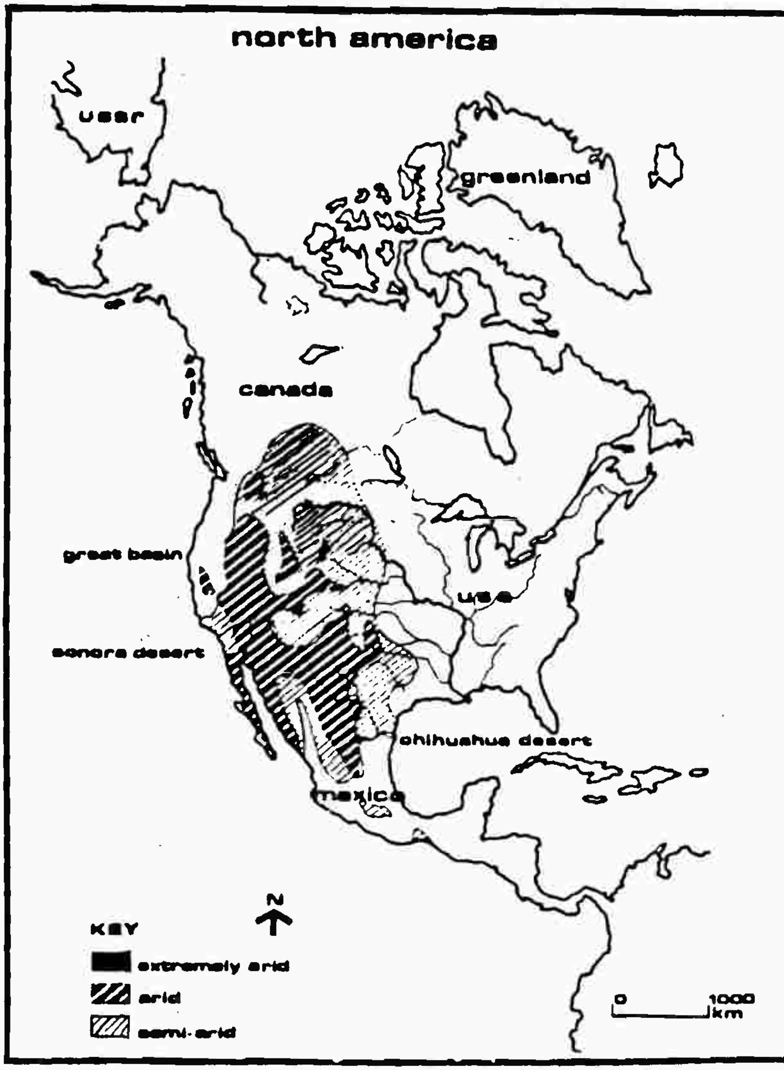


Fig . 19 .

II - Southern Hemisphere Desert zones

In the southern hemisphere , three major desert systems have been recognized . These are : the desert areas of South Africa with three distinct zones , South America with two distinct zones and Australia (Figs 5 , 9 and 10) .

1. The South African dry provice consists chiefly of the narrow elongated coastal desert of the Namib , the Karroo and Kalahari and Steppe uplands .

Fig . 20 .

2. The Australian dry province occupies a large proportion of the continent , with hot climate prevailing in the northern half and mild climates in the southern one . Five separate desert areas have been identified in Australia , namely : the Gibson and Great Sandy Desert in the west , the great Victoria Desert in the south , the Simpson Desert in the northern territory to the east of Alice Springs and the Sturt Desert in the west of grey Range on the borders of Queens land and south Australia .

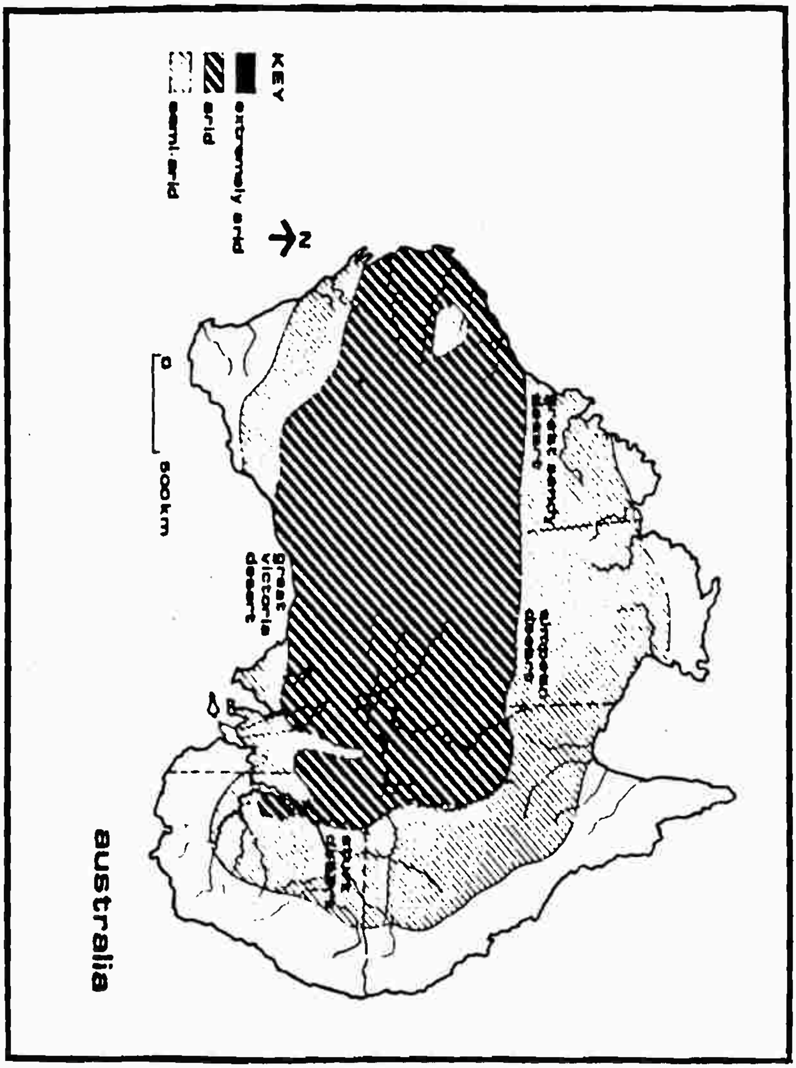


Fig . 21 .

3. The South American dry province is confined to a strip along the west coast and on the east side of the Andes toward the southern portion of the continent . It includes two main desert regions (arid and semi - arid) , namely : The Atacama - Peruvian and The MonteBatagonian Deserts .

Although it seems abvious that the desert areas of the world can be clearly distinguished by both appearance and vegetation , there has been considerable discussion as to how to define desert boundaries in climatic terms . from the previous pages one may say that the desert boundary has been previously defined as being limited by either 100 mm . or 150 mm . isohyts or the 250 mm . isohyets and even the 600 mm . isohytes in Australia . Although these are regional variations , it is now generally accepted that the border between arid and semiarid land is defined by the 250 mm . rainfall isohyet and that the boundary of the semi - arid zone is 500 mm . This definition does not include the Northern Arabia , the Northern Sahara and the Eastern Mediterranean countries where the lower 100 - 150 mm . or even lesser limits were set . It therefore seems appropriate to suggest that rainfall records cannot be used on their own to delineate desert boundaries , but that they should be used in combination particularly with temperature and wind

UNITS OF VEGETATION

UNITS OF VEGETATION

Plants typically occur together in repeating groups of associate plants . These groups or units are called communities and they are best described by noting the identity and growth form of the most abundant species , the largest species or the most characteristic species of the particular community the dominant species .

A plant community can be defined as " an aggregation of plants living together , having mutual relationships among themselves and their environment with one (or two) species that has (or have) large cover and great effect (reaction) on the enviroment , i . e . **the dominant** or controlling species . Any community includes , usually , many separated **stands** . The stands are more or less similar bits of plant cover found in nature representing the community type . The larger the number of stads investigated the more truthful will be the resulting picture of the community .

Dominance refers to the extent of area covered , space occupied or degree of control of a community by one or more species . The dominant species exerts some influence over the associtate organisms and it affects the soil structure and soil chemcial and physical characteristics . The dominant is highly successful ecologically in its relations to the environment and with other species . Cover and density are the chief qualities determining dominance and the number of dominants varies depending upon the environmental conditions in the different regions . In the deserts, salt marshes and grasslands, the dominant species are few, while in the tropical rain forests they are many. Thus, communuity is not described by simply listing all species which compose it, as though all species will be of equal importance. Instead, a community is characterized by detailing those species which contribute most to its unique structure and composition.

A community (or vegetation in general) is not equivalent to the flora of an area. In its simplest form, flora refers to a list of species or to the plant taxa occurring in that area. A flora in document form may range from a floristic checklist to a complex taxonomic treatment with keys-morphological and nomenclature information. Floras, as a rule, do not give information in which the species occur in nature, nor do they comment on their abundance, importance or uniqueness-all species have equal weights.

Phytosociology (plant sociology or vegetation ecology) is concerned not only with identifying the plant communities that form the vegetation of an area but also with determining how they (the plants) are related to one another and to the environmental factors.

How to recognize a plant community?

Because groups of plants form communities, many plant ecologists assume that plants in a community have some influence upon one another and /or that they have something in common with their environment.

For practical purposes, plant communities may be considered subdivisions of a vegetation cover. Wherever the plant cover shows more or less abvious spatial changes, one may distinguish the different communities with different dominants. These changes may be caused by spatial changes in species composition, changes in spacing and height of plants, changes in growth form (or life form) of plants or seasonal plant responses of vegetation properties, which in turn may correspond to spatial changes in their environment.

Spatial changes in species combinations are often obvious even to the casual observer. He may notice that certain species combination changes are related either to an increase in soil moisture in local depressions or to spatial changes in climate, land relief etc. In more extreme habitats such as salt marshes and coastal dunes, plant life-forms and species combinations are often so different from the adjacent plant cover that are self-evident as different communities.As properties vary transitionally or abruptly, plant communities may be self-evident to the investigator on first inspection. Communities that are non-evident to the unexperienced ecologist may be self-evident to the experienced investigator. Rcognition and definition of plant communities is a skill that can be learned by several visits to the study area .

A plant community can be understood as a combination of plants that are dependent on their environment and influence one another and modify their own environment. They form together with their common habitat and other associated organisms an ecosystem which is also related to neighbouring ecosystems and to the macroclimate of the region.

Plant Society

Within an area of vegetation under the control of a dominant or group of dominants, certain sub-dominant species may exert local control . A society is a community charcterized by one or more sub-dominants, i.e. species of different life-form from those of the regional dominants . The latter strongly influence and sometimes largely determine, especially by shading, the rest of the species belonging to the community.

The species forming the society are very abundant overportions of an area, i.e. local domination within a general domination already marked by the dominance of a community. That is, the society is a localized grouping of subdominants within a general domination.

Two kinds of societies may be distinguished, one is seasonal aspects the second is layering. The most casual observations show that in a climate with marked seasons.different species of a community make their vigorous growth, flower and fruit at different periods of the growth season. Species tend to fall into rather distinct groups, the flowering of each group giving a distinct of the community.Layering or layer society are best devloped in forests with a canopy of medium density.Under the most favourable conditions as many as five or six layers may be recognized. Layers are almost lacking among widely spaced dominants of deserts, but other wise occur in the majority of communities.

Plant Formation

Plant formations are the major units of vegetation or the main natural vegetion types of the world, viz: tundra, steppes, prairies, conifer forests,deciduous summer forests, evergreen tropical forests, grasslands, savannahs, deserts, salt marshes, mangals etc. They are the product of the climate and are controlled mainly by it . Each formation is a complex and definite organic entity with a characteristic development and structure. It is designated as a climax or climax formation . The climax is not merely the response to a particular climate, but is , at the same, the expression and indicator of this climate. Plant formation includes groups of plant communities which are characterized by having dominant species of essentially the sam growth form. In the desert formation of e.g.Egypt and Saudi Arabia , the group of plant communities dominated by trees include : *Acacia raddiana . Balanites aegyptiaca' Zizyphus spina-christi* etc . , those dominated by shrubs include : *Acacia tortilis, A. ehrenbergiana , Leptadenia pyrotechnica , Maerua crassifolia, Calotropis procera.,* etc . while those dominated by undershrubs include : *Rhazya stricta . Hamada elegans . Anabasis articulata, Psiadia arabica* etc .

INTEGRATED LEVELS IN ECOLOGY

There are three main levels of intergration in ecology-that is three principal kinds of ecolgical systems:

1 - The individual

2 - The population

3 - The ecosystem

The individual plant (or animal) is a genetically uniform entity; normally, no subdivison or part can live independent of the rest of the organism for more than a short time. The individual and its accompanying environment make up an individual ecological system.

Most organisms are individuals and are distinct from their fellows . However, many plants have vegetative parts such as rhizomes or runners, which can produce new plants that remain attached to the parent plant and that are genetically indentical to it. With such plants. which reproduce vegetaively, it is often difficult to decide just what is an individual and what is a small population, or **Clone** , of genetically indentical individuals all somewhat connected by vascular tissues.

The ecology of individual (autecology) is concerned with the way that particular plant (or animal) interacts with its environment.

An individual plant or (animal) is related to other organisms in two ways : (i) genetically to other members of its species and (ii) ecologically to other plants or animals of its biological community. Any relatively isolated, interbreeding group of individuals is called a local population. A local population in a specific environment tends by natural selection to become genetically adabted to that environment by the survial of individuals with certain genes or gene combinations.

Individuals and pouplations do not live alone in nature but in association with at least a few , and usually a great many , other plants and animals . These aggregations of organisms are not haphazared accumulations , on the contrary , they are spatially ordered , machinelike organizations which utilize energy and raw materials , together with the environment that controls it , is called an **ecosystem** . Any ecosystem repesents the highest level of integration in ecological systems , it consists of many individuals systems and population systems . Since no matter what their genetic ties , individuals and populations exist and operate as parts of ecosystems , the basic unit of ecology is the ecosystem

Ecosystem can be of any size from a jar of water containing algae and protozoa in the laboratory window to the great Amazonian rain forest and even the earth itself . Whetever the size , an ecosstem operates as a whole unit , both its physical and biological parts are so enmeshed in their function that it is difficult to describe the system by neat , separate categories classified according to the roles these parts play in the machine . Indeed , all of the organisms play at least two roles : as parts of the living core of the system and as parts of the environment itself . Nevertheless , if we are to understand ecosystems , we must attempt to analyze their structure and the functions of their various components . It is well to remember , however , that there are not always sharp lines delimiting the roles of each component , and that even apparently sharp boundaries may shift with the seasons or over long periods of time .

We may begin by recalling that an ecosystem is made up of two large parts : the physical environment and the biological community . Within the biological community , biological environmental components are added to the physical ones . However , the environment itself , including both its physical and biological parts , acts as a whole , and the subdivision above is made mainly to differentiate between the origins of the environmental factors . In the ecosystem , the physical environment provides the energy , raw materials and living space that the biological community needs and uses for growth and maintenance .

The biological part of the ecosystem usually consists of four or five energy levels . These trophic leveles are based on how far the original energy has come through the community . In the following outline ; trophic level I is indicated as TI , trophic level 2 ax T2 , trophic level 3 at T3 and soone .

T_1=The green vegetation . This is the part of the community that captures and stores solar energy in photosynthesis and releases oxygen . The rest of the community is completely dependent upon this level . It is often called the **producer** level .

T_2 = The **herbivorous** which digest plant material from T_1 and derive their energy from this plant food .

T_3 and T_4 = The **Carnivorous** animals that get their energy by eating herbivorous; the energy is thus one more step removed from its original source . The animals at T_4 get at least some of their energy by eating Cariviorkous at T_3 . Although one might think of typical carnivorous ,ranging from insects and spiders to birds and lizards , weasels (animals eating , frogs , mouces etc .) and shrew (mouse like animal) . Man is **omnivorous** , sometimes eats palnt material and sometimes eats orther animals .

T_5 includes fungi , bacteria , some protozoa and other small organisms that use dead plant and animal materials as food . These **decomposers** break down organic structures , releasing compounds and elements back into the environment and also utilizing energy and carrying it another step or several steps beyond its capture .

In terrestrial ecosystems , most of the decomposers live on the surface or in the upper part of soil , converting dead material into humus and evenrually into minerals , gases and water . The importance of the decomposers is obvoius ; without them dead material would simply accumulate and raw material would by in short supply such as phosphorus , would be tied up in the remains of palnts and animals . The decomposers provide the necessary cycling mechanism in the ecosystem . Energy simply flows in one end of an ecosystem (at photosynthesis) and flows out (by respiration) everywher along the line .

At the level of individual , at the level of population and at the level of the vegetation , it is possible to speak of plant ecology . But the intetactions of ecosystem involve all kinds of organisms in the complex community whose understanding requires a broader view point than the ecology itself .

MAJOR ECOSYSTEMS OF THE WORLD

MAJOR ECOSYSTEMS OF THE WORLD

Nine major ecosystems can be recognized in the world namely :

1- The seas , 2- The estuaries and sea Shores , 3- The streams and rivers , 4- The lakes and ponds , 5- The fresh water marshes , 6- The deserts , 7- The tundras , 8- The grasslands and 9-The forests .
and their cortnectors are exteadiag cover approximately 70% of the

1- The Seas

The major oceans (Atlantic , Pacific , Indian , Arctic and Antarctic) and their connectors are extending cover approximately 70% of the earh's surface Since here are likely to be phytoplankton under every square meter and since life in some form extends to the greatest depths , the seas are the largest and thickest of ecosystems . They are also biologically the most diverse . Marine organisms exhibit an incredible array of adaptation ranging from floating devices that keep the tiny plants within the upper layers of water , to the huge mouths and stomachs of deep - sea fish that live in the dark , cold world where meals are bulky but few and far between .

Physical factors dominate life in the ocean . Waves , tides , current , salinities , temperatures , pressures and light intensity largely determine the make up of biological communities that in turn , have considerable influence on the composition of bottom sediments and gases in solution . The food chains of the sea begin with the smallest rnown autotraphs and end with the largest of animals (giant fish , squid and whales) . The study of the physics , chemistry , geology and biology of the sea are combined into a sort of sience called oceanography .

2- The Estuaries And Sea Shores

Between the seas and the continents lie a band of diverse ecosystems that are not just transition zones but have ecological characteristics of their own . Whereas physical factors such as salinity and temperature are muh more variable near shore than in the sea it self , food conditions are so such better that the region is packed with life . Along the shore line thousands of adapted species that are not to be found in the open seas , on land or in fresh water . A rocky shore , a sand beach , an intertidal mud flat and a tidal estuary are dominated by salt marshes .

The word estuary (comes form latin nestus = tide) refers to a river mouth or coastal bay where the salinity is intermediate between the sea and fresh water and where tidal action is an important physical regulator .

Estuaries and in - shore marine waters are among the most naturally fertile ecosytems in the world . These are at least five mechanisms and conditions that maintain biological energy flow at rates often considerably greater than in the adjacent sea or fresh water :

1- tidal action promotes rapid circulation of nutrients and food and aids in the rapid removal of the waste products of metabolism ,

2- a diversity of plant species and life forms provides a continuous photosynthetic carpet despite variable physical conditions , 3 - An estuary is often an efficient nutrient trap that is partly physical and patly biological , 4 - A year - round primary production by a succession of crops even in northern regions and 5 - close contact between autotrophic and heterotrophic layers .

3 - The Streams And Rivers

The history of man has often shaped by the rivers that provide water , transportation and a means of water disposal . Although the total surface area of rivers and streams is small compared to that of oceans and land mass , rivers are among the most intensively used by man of natural ecosystems . As in the case of estuaries , the need for " multiple use " demands that the various areas (water supply , waste disposal , fish producation , flood control etc .) be considered together and not as entirely separate problems

Form the energetic standpoit rivers and streams are incomplete ecosystems , that is , some portion , often in large portion , of the energy flow is based on organic matter imported from adjacent terrestrial ecosystems (or sometimes from adjacent lakes) .

4 - The lakes And Ponds

Distinct zonation and stratification are characteristic features of lakes and large ponds . Typically , one may distinguish a **littoral zone** containing rooted vegetation along shore , **limnetic zone** of open water dominated by plankton and a **deep - water profundal** zone containing only heterotrophs . In temperate regions , lakes often become thermally stratified during summer and again in winter , owing to differential heating and cooling . The upper part of the lake or **epilimonion** becomes temporarily isolated from the lower or **hypolimonion** by a **thermocline** zone that acts as barrier to exchange of materials . Consequently , the supply of oxygeon in the **hypolimionium** and nutrients in the **epilimonion** may run short . During spring and fall , as the entire body of water approaches the same temperature , mixing again occurs . Blooms of phytoplankton often follow this seasonal rejuvenation of the ecosytem .

Primary production in standing water ecosystem depends on the chemical nature of the basin , the nature of imports from streams or land and the depth , shallow lakes are usually more fertile than deep ones . Lakes are often classified into oligotrophic (few foods) and **eutrophic** (good foods)

5 - The freash - Water Marshes

Much of what was said about estuaries also applies to fresh - water marshes , they tend to be naturally fertile ecosystems . Tidal action of course , is absent , but periodic fluctuation in water levels resulting from seasonal and annual rainfall variations often accomplishes the same thing in terms of maintaining long - range stabilitiy and fertillity .

Rice culture is actually a type of fresh - water marsh ecosystem . The flooding , draining and careful rebuilding of the rice paddy each year has much to do with the maintainance of continuous fertility and high production of the rice plant , which , itself , is a kind of clutivated marsh grass .

6 - The Deserts .

Desert ecosystems occurs in regions with less than 10 inches of annual rainfall or sometimes in hot regions where there is more rainfall but unevenly distributed in the annual cycle .

The deserts are of two types : hot and cold . They are characterized by 5 very distinctive life forms of plants adapting to the desert ecosystem : (1) the therophytes (ephemerals , annuals) which avoid drought by growing only where there is adequate moisture , (ii) the desert shrubs with numerous branches arising from a short trunk and small - thick leaves that may be shed during dry period , the desert shrubs survive by their ability to become dormant before wilting occurs , (iii) the succulents such as the cactus or cacti like plants belong to family Euphorbiaceae e . g . **Euphorbia thi** which store water in their tissue and , (iv) Microflora such as mosses , lichens and blue - green algae that remain dormant in the soil but are able to respond quickly to cool in wet periods .

Animals such as reptiles and some insects are " preadapted " to deserts , for their impervious integuments and dry excretions enable them to get along on the small amount of water produced in the body as a result of the breakdown of carbohydrates .

7 - The Tundras

Between the forests to the south and the Arctic Ocean and polar ice-caps to the north lies a cicumpolar band of about 5 million acres of tree-less country called the **Arctic Tundra .** Smaller , but ecologically similar regions found above the tree limit on high mountains are colled **Alpine Tundra .** As in dreserts , a master physical factor rules these lands , but it is heat rather than water that is in short supply in terms of biologic function . Precipitation is also low , but water as such is not limiting because of the very low evaporation rate . Thus we might think of the tundra as an arctic desert .

Althought the tundras are often known as the " barren ground " and may be expected to have a relatively low biological diversity , a large number of species have evolved remarkable adaptation to survive this cold . The thin vegetation mantle is composed of lichens , grasses and sedge which are among the hardiest of land plants . During the long daylight hour (long photoperiod of the brief summer) the primary production rate is remarkably good where topographic conditions are favourable . The thousands of shallow ponds , as well as the adjacent arctic ocean , provide additional food of tundra food chains . There is enough combined aquatic and terrestrial net production , in fact , to support not only thousands of breeding migratory birds and emerging insects during the summer but also permanent resident mammals that remain active throught out the year .

8 - The Grasslands

Natural grassland occur where rainfall is intermediate between that of desert lands and forest lands . In the temperate zone this generally means an annual precipitation between 10 and 30 inches depending on temperature , seasonal distribution of the rainfall and the water holding capacity of the soil . Tropical grassland may receive up to 60 inches concentrated in a wet season that alternates with a prolonged dry season . Grasslands are one of the most important of terrestrial ecosystems , large areas occupys the interior of the principal continents .

Dominant plant - life forms of grasslands are the grasses which range from tall species (5 - 8 feet) to short one (6 inches or less) . A well developed grassland community contains species with different temperature adaptations , one group growing in cool part of the season (spring and fall) and another in the hot part (summer)

The grassland community builds an entirely different type of soil as compared to a forest , even when both start with the same parent mineral material . Since grass plant are short lived as compared to trees , a large amount of organic matter is added to the soil . The first phase of decay is rapid , resulting in little litter but much humus , in other words , humification is rapid but mineralization is low . Conseqently , grassland soils may contain 5 - 10 times as much as forest soils . The dark grasssland soils are those best suited for growing principal food plants .

9. The Forests

The open sea and the forests are , in comparative sense , the extreme ecosystem types in the biosphere in regard to standing crop biomass and the relative importance of physical and biological regulations . In any one forest region one may see a variety of vegetations that represent stages in succession as well as adaptations to varying soil and moisture conditions of the substrate . Because the range of temperatures that will allow forest development is extremely wide , a sequence of forest types replace one another in a north - southt gradient . Moisture is more critical to the tree life form , but forests occupy a fairly wide gradient from dry to extremely wet situations . The northmost forests which form a belt just south of the tundra , are characterized by evergreen conifers of the genera *Picea* (spruce) and *Abies* (fir) , species diversity is low , often with one or two species of trees forming pure stands . Deciduous forests are characteristic of the more southern moist - temperate regions , these forests have more pronounced stratification and a greater species diversity . Pines (*Pinus*) are found in both northern coniferous and temperate deciduous forest regions , often as seral stages . The third type , the tropical forests , range from broad - leaved evergreen rain forests , where rainfall is abundant and distributed throughout the annual cycle , to tropical deciduous forests that lose their leaves during a dry season . Two life - forms , the vines (lianas) and the epiphytes (air plants) , are specially characteristic of tropical forests . Species diversity reaches a maximun in tropical rain forests , there may be more species of plants and insects in a few acres of tropical forests than in the entire flora and fauna of Europe .

Human civilization has so far reached its greatest development in what was originally forest and grassland and temperate regions . Consequently , most temperate forests and grasslands have been greatly modifid from their primevel conditions , but the basic nature of these ecosystems has by no means been changed .

THE BIOTIC PYRAMID

THE BIOTIC PYRAMID

The biosphere is that part of the earth which contains living organisms- the biologically inhabited soil , air and water. These inhabitants range from plants and animals of microscopic size and simple one-celled structure to those of considerable proportions and complex form. That most visible part of the biosohere, composed of the larger plants and animals, is but a small proportion of the whole. A conservative estimate might put the total number of different species of plants at nearly half a million and that of animals three to four times as many,while the number of individuals in any one part of the biosphere can \be staggering. It has, for example, been estaimated that in a gram of rich soil there may be as many as 100,000 algae, sixteen million fungi and several billion bacteria.

In the complex inter-relations between the various members of the biosphere and between them and their environment, plants and more particularly green plants , occupy a key position . They do so by reason of their ability, unique among living organisms, to use solar or light energy in manufacture, from such simple inorganic elements as carbon, hydrogen and oxygen, highly complex organic substances which, in turn,provide the food and energy necessary not only for their own growth but for the maintenance of all other forms of life on earth. This process of photosynthesis (carbon assimilation or primaary production) can be summarised in the following simple manner:-

$$CO_2 + H_2O \xrightarrow[\text{chlorophyll}]{\text{Light}} \text{Carbohydrates } (CH_2O) + O_2$$

The carbohydrates (CH_2O) provid the basic "building block" from which other food materials such as proteins and fats can in combination with such essential mineral nutrients as nitrogen, phosphorus,potassium etc. be produced.Of the light energy absorbed by the green plants about a sixth is used during the process of photosynthesis; the remainder is converted into potential chemical or food energy bound into the plant tissues themselves . This produces the energy necessary on the one hand for plant metabolism and for herbivorous animals on the other. The potential food energy is released in the reverse process of respiration, in both plants and animals during which oxygen is used and carbon dioxide produced. Photosynthesis harnesses solar energy.Respiration makes it available for all living functions. Photosynthesis moreover constitutes the basic and fundamental difference between most plants and all animals. The nutrition of green plants is as a result of this process autrophic or wholly dependent on inorganic materials, while that of animals is heterotophic or wholly dependent on the organic or wholly dependent on the organic food materials produced initially by plants.

By the process of photosynthesis practically all but a very minute proportion of the energy necessary to sustain life enters the biosphere. Green plants are then the vital energy traper and converter and on their efficiency, and that of the earth's vegetation cover in this respect, depends the amount of primary food that the earth can produce and the amount of animal life it can support. this has become a matter of increasing concern in a world where the pressure of increasing human population is making ever increasing demands of the biosphere. It has been estimated that of the solar radiation reaching the earth's suface most is expanded in evaporation and in the heating of the atmosphere and the earth's surface. Only about 1% of the total light or about 2% of that of suitable wave-length, the visible white light which is absorbed by chlorbhyll, is involved in the process of photosynthesis. Of the total or gross amount of carbohydrate produced some is used in plant metabolism, the remainder which is built up into new tissues repesents the net photosynthetic production over a period of time. The ratio between the energy of the organic matter produced and that of either the light available (or the actually absorbed) is a measure of the plant's photosynthetic efficiency. The most recent and frequently quoted estimates suggest that the mean net photosynthetic efficiency for the earth's surface is somewhere in the order of 0.1% to 0.2% depending on whether calculations are based on total light available or that of suitable wavelength

Expressions of photosynthetic efficiency vary according to the measurements on which the ratio between light and food energy are based . The former may be total incident light , that available to or that actually absorded by plants ; the latter may be expressed in terms of either gross - or net - plant production . Further , expressions of efficiency will depends on the unit of time during which the amount of photosynthesis is calclated , (annual , growing season , monthly or daily) . For this reason most ecologists prefare to employ either gross or net primary production rather than efficiency when studying the conversion of solar radiation to plant material . The productivity of the photosynthesing plant or mass of vegetation is the rate at which energy is fixed . It can be measured either in terms of the rate of carbon dioxide absorption or oxygen production or the amount of organic matter manufactured . The latter is the easiest to detemine and the most frequently used . It can be expressed as :-

1. the dry weight of a plant or 2 . the amount of carbon assimulated by a plant or . 3 . the energy equivalent of the plant material . produces per unit area or per unit time .

The amount of photosynthesis carried out by a plant depends on the rate of assimilation which is grovened by such facts as light intensity , amount of carbon dioxide , availability of water , temperature conditions and on the photosynthesising areas (the combined leaf and green stem) capable of trapping available light . Productivity will be greatest when optimum conditions for photosynthesis and maximum environmental absorbing leaf area coincide . In this respect , and in terms of the total weight of organic matter produced , the photosynthetic efficiency of many crop plants is less than that of natural vegetation ; although their yield may be high it may be not higher and may be less than that of say a woodland cover growing under similar environmetal conditions .

The biosphere (organic world) together with its inorganic environment , forms what is refered to as a biotic complex , an ecological system or an ecosystem . Such a system or complex includes organic and inorganic elements , each influencing the properties of the other and both necessary for the maintenace of life as we know it . The basic components of the ecosystem are , thus :

1. inorganic (or abiotic) substances ,

2. producer orgnisms , the autotrophic or self nourishing green plants ,

3. consumers - the heterotrophic or other dependent animals , and

4. the reducers or decomposer , chiefly the micro - organisms (bacteria , fungi , actionomycetes etc .) which decompose or break down and effect the mineralization of organic matter .

Under natural conditions an ecosytem will be able to maintain and perpetuate itself when a balance is achieved between the supply and demand of nutrients and between energy input and energy loss . There will be a relative equilibrium between the members of different kinds of organisms and the energy of food supply available . Indeed , ecosystem is no more than a technical term to express what is meant by the nature and its operations as the balance of nature .

Since all the components of an ecosystem are so intimately intermeshed it can be easily appreciatesd that any change in the amount , condition , or rate of activity of one will have a repercussion on the whole . An increase or decrease in the amount of any of these substances such as oxygen , carbon dioxide , water or mineral nutrients , or a change in the light or temperature conditions necessary for efficient plant functioning , will directly affect plant growth and indirectly affect the animals dependent on them , For example , a decrease in the amount of water below the minimum requirements for a particular type of plant may result in its disappearance from an ecosystem , and with it the animals which feed on it , or these animals may as a result be forced to feed on another plant or disappear . The removal of these plants may also affect the other plants in the ecosystem by changing light , temperature , soil etc . coditions of the ecosystem .

Plants , however , are directly dependend upon , and affected by , the nature of the physical site , and in turn they exert a greater envinmental effect (reaction) than do animals . They determine the type and volume of the latter . As a result plants play the major and fundamental role in the composition , structure and function of most ecosystems , and because of their greater total mass or volume (biomass) , they determine the " appearance " of biotic communities . For this reason , terrestrial systems , in particular , are frequently characterized (or classified) on the basis of their plant components e . g . as forests , grasslands etc .

The greatest number of limiting factors influencing plant or animal growth , abundance and distribution are biotic in nature . Food supply for animals is one of these , and is the most common factor limiting the growth of animal population , either directly , through being short of requirements , or indirectly through behavioural responses to food shortage . The number of plant - eating animals in an area is ultimately limited by the abundance of the plants on which the animals feed . Furthermore , since the plants must survive and reproduce , there must always be a greater abundance of plants than what is actually needed to provide food for the animals . Most plants produce a surplus of vegetative growth and of seed , part of which be used by animals . However , each plant , in order to survive , must maintain a metabolic reserve - a minimum amount of leafage to permit it to store food for its own survival , or set seed for its own production .

Plant growth may be limted by competition from other plants of the same or different species each drawing on the same reserves of soil and water or shading one another from essential sunlight . Some plants secrete substances which inhabit the growth or establishment of other plants . A variety of organisms may prey upon plants , from the seed stage through the life cycle to the mature plant .

It is obvious that the number of carnivorous or meat eating animals in any area is limited by the availability of the prey upon which they feed . Also , there must be enough prey animals to enable the prey species to survive and reproduce ; the predator cannot eat all of the prey or both would become extinct . Most prey animals have developed behaviour patterns in relation to their habitat conditions that permit some of them to escape predators . Predators eat the most vulnerable and available prey , and usually do not hunt down and capture the moste elusive individuals . Often the individuals captured are either the very young and very old , or the most diseased or genetically least vigorous stok . Therefore , natural predation tends to have overall benficial effects on the population of a prey species .

The relationship of the abundance of predators and prey is sometimes illustrateds in the form of a biotic pyramid (Fig....) Green plants occupy the base of the pyramid and must always have a greater total volume or biomss than the plant eaters that feed upon them . The herbivorous form the second step in the pyramid , which must in turn be wider and represent a greater biomass than the third step representing the carnivorous animals that feed upon herbivorous . Furthermore , if there are carnivorous animals that feed upon herbivorous they must be fewer in number and contain less biomass than their prey . Each suc-

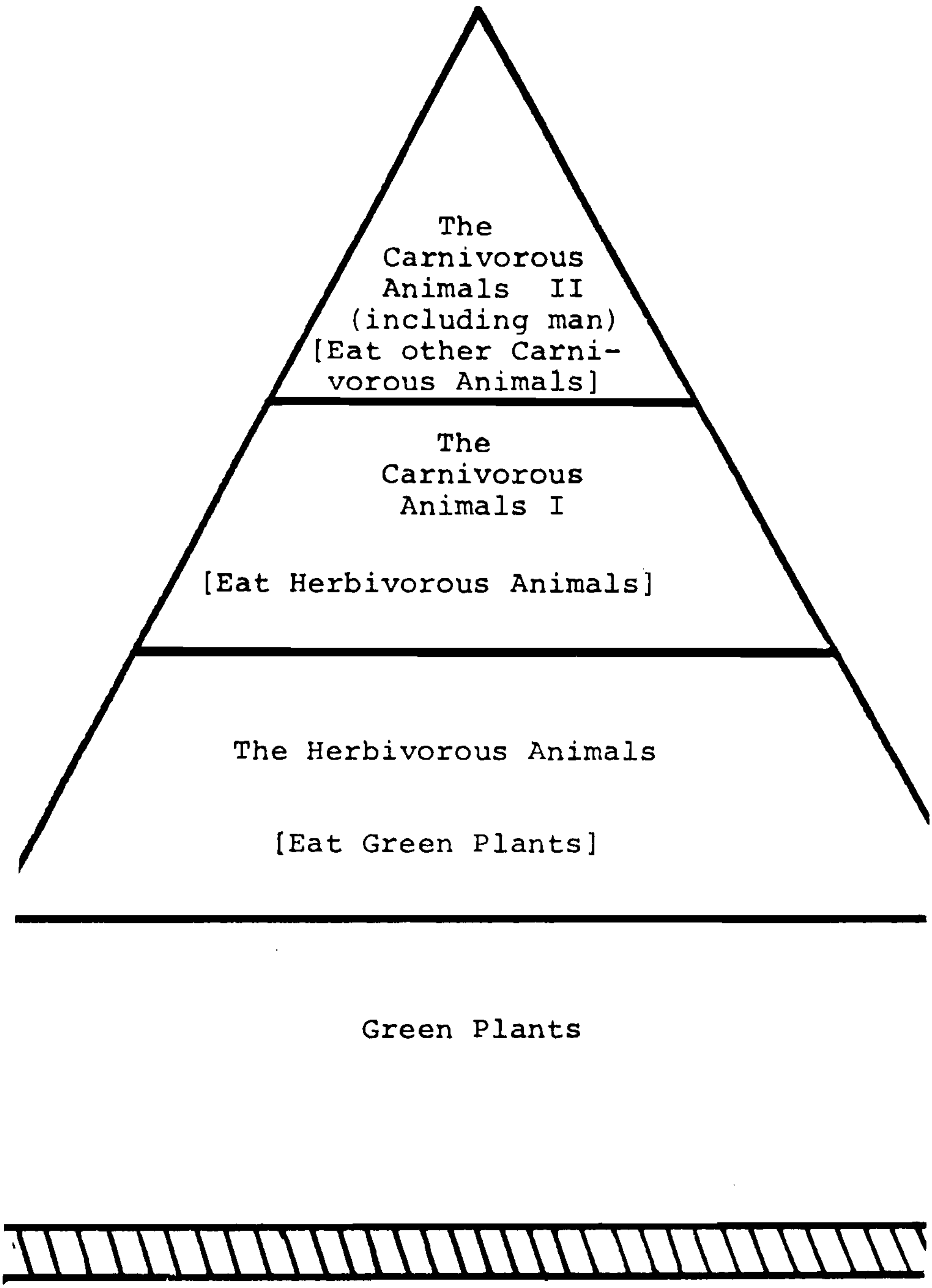


Fig. 22 . THE BIOTIC PYRAMID

ceeding level in the biotic pyramid also represents a consistent flow of energy from green plants to herbivorous to predators . Since at each transferr of energy from one level to another some energy is necessarily lost , more calories are available at the lower level of the pyramid than at any higher level .

The sequence of plants and animals feeding upon one another is called a **food chain** . Food chains are interconnected , since more than one herbivore may feed on a plant and more than one kind of carnivore may eat a herbivore .

As elements pass from soil (or atmosphere) to plants , and are then eaten by herbivorous and in turn by carnivorous , they are often connected in varying degrees by a process known as **biological magnifications** . Thus , the element iodine may be present in the soil in small quantities and taken up by plants as it goes into solution and reaches plant roots . It has little function in plants , but is essential to plant - eating animals . These must obtain enough iodine from the plants they eat and concentrate it in their thyroid glands , for the glands to function properly . The level of iodine in animal's thyroids is far greater , therefore , than in either the plants or the soil .

Although the number of herbivorous is limited by the supply of plants , and the number of carnivorous is determined by the numbers of their prey , the reverse is also true in varying degrees . The abundance and distribution of a plant can be limited by the presnce of herbivorous . If a plant is introduced into an area where there are no species that feed upon it , it can spread rapidly and become transformed into a weed or pest . For example , kalamath weed was itroduced into Australia and latter into the NW United States of America, rapidely became an importanty range pest . It was only controlled when one of the insects that normally fed upon it was introduced . Similarly the abundance and distribution of plant - eating insects and other animals in often controlled by a wide variety of diseases , insects or other predators that feed upon them . If the predators are destroyed , their plant eating prey can increase suddenly and explosively , since its reproductive rate in nature is adjusted to the need for survial under constant predation . Suden increases in number of rodents or other plant - eating mamals have often been related to the extermination of the predators that formerly held them in check .

Parasites and disease organisms play the role of minor predators . Frequently , they have a direct density - dependent relationship to the hosts upon which they feed . When the host animal is abundant , and praticularly when it is weakened by shortage of food , its parasites and diseases will often become more widespread and have more serious effects . Most animals are adapted to survive in the presence of a wide range of diseases and parasites and these have relatively small effects upon them providing that other conditions (e . g . food , space , climate etc .) are favourable . Organisms (animals , plants etc) introduced into a new environment , however , are particularly vulnerable to the diseases and parasites of that area to which the native animals (or plants) may have resistance or immuntiy . Similarly , diseases introduced into a new area can have drasting effects upon native species which have no immunity to them .

FIELD STUDIES OF VEGETATION

FIELD STUDIES OF VEGETATION

Vegetation , in general , is composed of different plant communities . Thus , the field study of any vegetation should involve the description and measurement structural characteristics of each of its plant communities .

The structural charactetistics of a plant community can be classified into " .

A. Analytic Charactetristics ... and

B. Synthetic Characteristics

A. ANALYTIC CHARACTERISTICS

The analytic characteristics of a plant community are qualitative and quantitative . The qualitative characteteristics are usually described while the quantitative ones are measured .

1. Qualitative Characteristics

These include the study of the floristic composition , periodicity and phenology , stratification , vitality and vigour and life-form of a community .

1. Floristic Composition

The floristic composition of a community is an indication of the kind of species occurring in the community . A complete list of species is the most essential charactetistic of a stand and in making of such a list is the first step in its study . In practice it is impossible to name all the organisms . Plant ecologists usually name only the vascular plants (Perennials , biennials , annuals and ephemerals) but they may include also lichens and mosses particularly in wet regions . In order to secure a complete list , inspection and collecting through the growing season are required so that all species appearing in different seasons will be included . The plants need to be correctly named , which often requires the aid of a well trained and competent taxonomist . Herbarium specimens should be collected representing all the plants listed . The list has to be accompanied wth accurate descriptons of the environmental conditions of the study area.

Floristic lists are valuable for charactetization because each species has its own range of ecological amplitude . Each one has its particular relationships to the environment and to other species , so the total number of species , as well as the average number per sample areas in each stand , tell much about the conditions of the habitat . A decline in the number of species from one area to another may indicate increasingly adverse conditions . For example , the number of species in the Red Sea mountains decreases with increasing elevation due to changes in climate and substratum .

2 . Stratification (Layering)

Stratification , or layering , is the occurrence of organisms , or their parts , at different levels in a stand . Stratifcation is readely seen above ground , but is present also in the unseen root systems and horizons . Stratification usually occurs because life forms (trees , shrubs , herbs , mosses etc .) differ in their requirements and amplitudes , and therefore grow at various levels which differ in light intensity , temperature , moisture conditions , organic content of the soil and other factors .

The number of strarta above ground varies according to the kind of community . In early stages of succession usually only one stratum is present , comprising lichens , mosses or annual herbs , but as succession proceeds additional strata appear so that in a mature grassland there may be three strata , the two highest comprising grasses and forbs , and the lowest short herbs , mosses , lichens and occasional algae . Five or seven strata may be found in forests : two or three of trees , one or two of shrubs , a herb or field layer and a ground or moss-lichen layer . Occasionally trees that project above the general canopy are called emergent or super canopy trees .

Stratification is well developed in tropical rain forests . For example , in Nigeria the top tree layer at 40 to 50 m . consists of relatively few species with wide spreading , umbrella shaped crowns as much as 27m in diameter that do not touch one another . The middle layer at 18 to 40 m contains many species with small , rounded crowns up to 11 m in diameter that occasionally come into contact .The lowest stratum , as high as 17 m is limited in the number of trees that are restricted to this level , but contains many young idividuals , belonging to species characteristic of the two upper layers . The crown are often small and conical with larger leaves than the taller trees and they form a closed canopy bound together by climbing plants . The herb layer not over 1 m high , is even more poorly delineated and in places in missing . The ground layer is missing entirely .

Stratification is obvious in the vegetation of the coastal deserts of , for example the Red Sea of Egypt and Saudi Arabia . Four layers are recognized as follows : -

1. Tree layer is represented by *Acacia raddiana* , *Zizyphus spinachristi* , *Balanites aegypytiaca* , *Tamariax aphylla* etc .

2. Frutescent (shrub) layer is represented by *Lycium arabicum* , *Acacia tortilis* , *Leptadenia pyrotechnica* , *A . ehrenbergiana* , *Periploca aphylla* , *Maerua carssifolia etc* .

3. Suffrutescent (undershrub and bush.) layer is represented by : *Hamada elegans* , *Rhazya stricta* , *Panicum turgidum* , *Dipterygium glaucum* , *Anabasis articulata* etc .

4. Ground layer is represented by ephemeral vegetation e.g. *Zygophullum simplex*, *Aristida* spp . , *Poa* spp. , *Cenchrus* spp., etc and some perennials e. g . *Fagonia* spp ., *Tribulus* spp. , *Cucumis prophetarum* etc .

It is not necessary that all of these four layers are present everywhere in the Egyptian and Saudi Arabian Red Sea coastal deserts . One or more may be absent depending upon the environmental conditions prevailing in that particular area , photo 19 .

The composition of the vegetation in each layer may vary from place to place so that distinct groups of plants similar in life-form ,called **synusiae** or **unions** are recognizable . Examples of sunusiae are stands of *Polytrichun* moss in the ground layer of an open oak forest and stand of *Vaccinium* spp . in the low shrub layer of a pine wood . Different synusiae may appear in the same layer , for example , mosses and lichens may form winter sunusial and *Antennaria* spp . summer synusiae in *Andropogon* stands .

Plants of the lower layers may increase in size and number when those in the upper layers are removed by grazing or cutting .

Apart from the aerial stratification , there is also underground layering of the root systems . This is caused by various factors such as differences in moisture content of soil , salt concentrations at various soil depths , type of plant , soil structure , soil texture , depth of underground water etc.

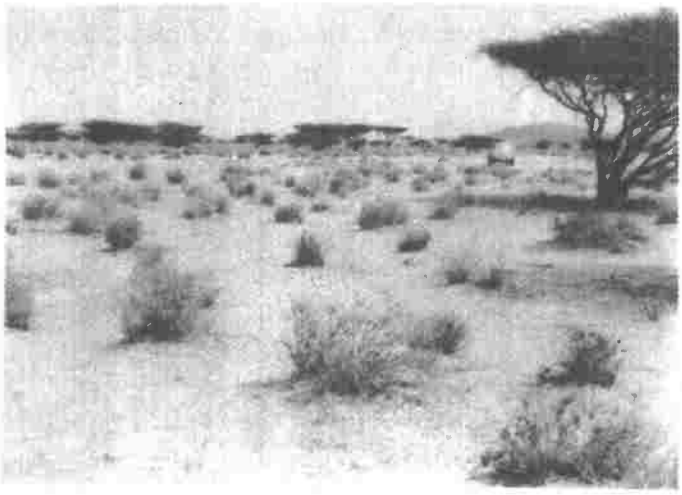


Photo 19 : Stratification of Vegetation .

3. Periodicity and Phenology

Periodicty is the period of the year during which a plant is vegetative , flowering , fruiting , leafless , its seeds are mature , dry , etc . such phenomena of changing the aspects of the plant are closely related to climatic changes . Periodicity refers to the regular seasonal occurrence of various processes such as photosynthesis , growth , pollination , flowering and ripening of fruits and seeds ; and the manifestation of these processes such as formation of leaves , elongation of shoots , appearance of flowers and dissemination of seeds . Periodicity results from inherent genetic characteristcs of each species under the influence of a particular combination of environmental conditions . It means partiularly the recurrence at certain time of these processes and their manifestations .

Phenology , on the other hand , refers more to the appearance of the manifestations at certain seasons of the year , rather than to their cyclic nature . It is , therefore, the actual appearance and recording of the . periodical phenomena of plants as leafy , flowering etc .

The seasonal aspects of an individual plant may proceed through the several phases including embryo period , leafy period , flowering period , fruiting period , leafless period etc . Not all species have these periods strictly . For example, most plants flower during spring , but the plants belong to chenopodiaceae usually flower during autumn .

Braun-Blanquet used the following signs of periodicity :

fol	=	foliage	s.fol .	=	leafless
dr	=	dry	b.	=	buds
fl	=	flowering	sdl	=	seedlings

It may be concluded that various expressions of periodicty and phenology of plants are means of adaptation to seasonal changes in the physical environment . Usually , in order to live in a given location , the plant must make full use of the favourable environmental periods and endure or tolerate , by one mean or another , the unfavourable periods

Most communities have definite aspects at different seassons of the year . The chief aspects are :

1. Prevernal or early spring
2. Vernal or spring
3. Aestival or summer
4. Serotinal or autumn
5. Hibernal or winter

It is interesting to keep records of phenological events such as the dates of appearance of certain kinds of seedlings in various years , the inception (beginning) of growth of perennials , the opening of leaf and flower buds on certain trees , the full expansion of first flowers , first ripe fruits , last flowers and the completion of the disemination of the fruits of seeds . Each species and each stage has its own specific rate of development and growth . The phenological phenomena have practical value in indicating many environmental factors , and can then be used to predict the time of harvest , when a range is ready for grazing and other practices .

4. Vitality and Vigour

Vitality relates to the condition of plant and its capacity to complete its lefe cycle .

Vigour refers to the state of health or development of a plant within a certain stage , e.g. a seedling of a plant may by vigorous but may not complete its life cycle up to fruiting stage , on the othe hand, another seedling of a second plant may be feeble but it may withstand the conditions and complete its life cycle .

Not all species found in a given stand need belong to the community . Unless the plants are reproducing , they are not completely adapted to the environmental conditions and may disappear . It becomes necessary , therefore , to know something about the vigour of the palnts such as the rate and total amount of growth , rapidity of growth (especially in height) , quantity or areas of foliage , colour and turgidity of leaves and stems , degree of damage by disease or insects ; time of appearance and number of flowers , rate of growth and extent of the root sustem ; appearance and development of new stems and leaves etc . The following calsses has been used :

Class I (V_1) : well developed plants which regularly complete their life cycle.

Class II (V_2): Vigorous plants which usually do not complete their life cycle or are poorly developed

Class III (V3) : Feeble Plants that never complete their lige cycles but do spread vegetatively .

Class IV(V4) : : Plants occasionally appearing from seed but do not increase in number such as ephemeral plants .

Changes in vitality of species are often indicators of community change or plant succession . Dominants decreasing in numbers and reproducing feebly indicate future radical change . Rapidly increasing numbers of species previously of little importance may suggest the new dominant to come .

5- Life Form

Life - form means the characteristic vegetative appearance such as the size , shape and branching . The life form of a species is caused primarily by its genetic constituion , and secondarily by the environmental conditions . Pronounced changes in the latter may cause great changes in the life-form .

The general appearance of a commuity is caused more by the life - of the most abundant or dominant species than by any other characteristics of vegetation . Raunkiaer's system is the most widely used one for the classification of different life - forms of plants . It comprises 12 main classes as follow (Fig . 23) .

1. Phytoplankton : microscopic plants suspended in air , water or in snow .
2. Phytoedaphon : microscopic soil flora .
3. Endophytes : Plants living wholly or partly within other plants as algae in lichens or parasitic fungi .
4. Therophytes : Annuals (or ephemerals) including algae , fungi , mosses ,many ferns and seed plants .
5. Hydrophytes : All water plants (except phytoplankton) with perennating parts submerged in water during unfavourable periods .

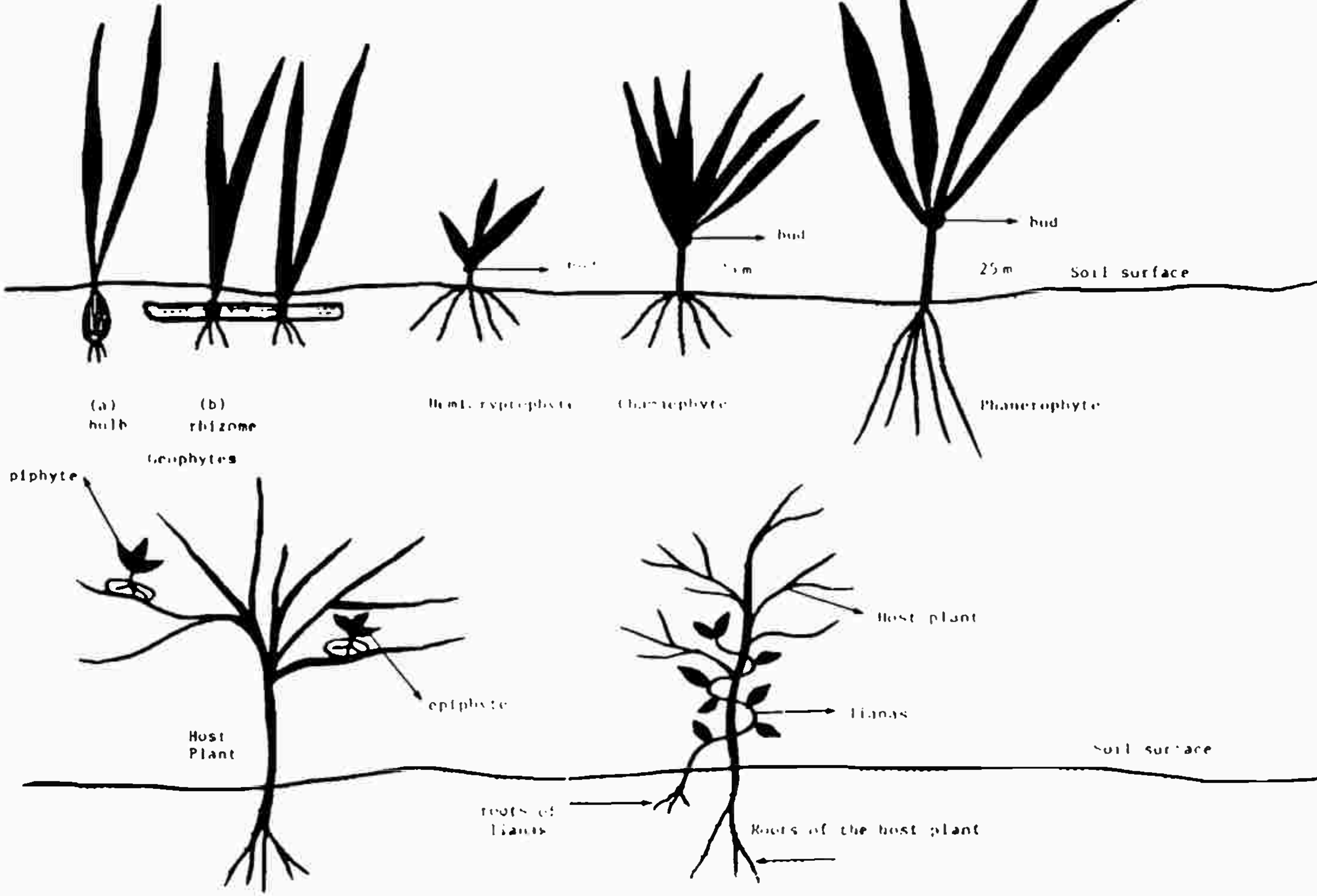
6. Geophytes :	Plants with perennating parts buried in the substratum , such as species with rhizomes or bulbs .
7. Hemi - cryptophytes :	Plants with perennating shoots and buds close to the surface , often cover with litter .
8. Chamaephytes :	Plants with buds located from the ground surface to 25 cm. above it.
9. Phanerophytes :	Shrubs , trees and vines with buds located on upright short at least 25 cm . above the surface .
10. Epiphytes :	plants growing on other plants not rooting in soil , without taking food from host plant , only support .
11. Lianas :	Plants rooted in soil but grow climbing other plants without taking food from host plant , only support .
12. Parasites :	Plants rooted in soil which depends upon host plant for food and support .

Growth - form refers to the development of the plants of the same species under different enviromental conditions .

Habitat - form bears the impress of the habitat such as *Cacti* in arid climates , *Elodea* Submerged in water etc . These forms are mainly ecological , and are of special value as indicators of environmental conditions . The most common classification contains these classes .

a. Hydrophytes :	Which include submerged , floating and swamp plants .
b. Mesophytes :	Which include sun and shade plants
c. Xerophytes :	Which include plants enduring drought .

Fig 23 : Diagrammatic repesentation of the life-forms of plants .



6. Sociability

sociability evaluates the degree to which plants in a stand normally aggregate . It refers to the proximity of plants or shoots to one another . It demonstrates whether the individuals of the species stand close together in mass formation and thus cover the ground in patches or are wholly isolated and stand scattered among each other . It depends upon the life form and vigour of the plants , habitat conditions and competition and other relationships between individuals . The scale for determining the sociability of a species , has been used in analysing vegetation is as follows :

S_1 (Class 1)	= Shoots growing singly . Small scattered
S_2 (Class 2)	= Small groups of plants
S_3 (Class 3)	= Small scattered patches or cushions
S_4 (Class 4)	= Large patches or patches of broken mats .
S_5 (Class 5)	= Very large mats or stands of nearly pure populations that almost completely cover a large area .

Generally , the shoots of some species are able to grow much closer than those of others . The plants that propagate by rhizomes , runners or roots forming very dense stand in which the shoots are separated by short internodes .

7. Association of Species

Association of species is the growing together of two or more species in close proximity to one another as a rather regular occurrence . Association of species may be brought about by the similarity in ecological amplitude of two or more species , similarity in geographic ranges ; difference in life - form (e.g . shallow or deep root systems) so that excessive competition can be avoided , dependence of one species upon another for shade or food as prasites , or dependence for protection from grazing as in grasses growing in dense clumps of cactus . Association may be so pronounced that a certain species may indicate the presence of other species in the stand , so that prediciton is possible to some extent , i .e . if species A is found in a certain area then species B is also be expected there .

When environmental conditions change, the species that are associated will vary . A species growing as a dominant in one stand usually has different associates when growing as a dominant or subdominant in another stand with different conditions .

The Associate Index has been used to measure the degree of interspecific association , for example , if species A occurs in 40 samples areas (A = 40) and species B occurs together with A in 30 of these sample - areas (B = 30) , then the Association I ndex of species A is $B/A \frac{30}{40}$ or 0. 75 or in three - fourth or the sample areas in which spcies A occurred it was asssociated with species B . At least 100 sample areas (stands) should be taken for these calculations .

II. Quantitative Characteristics

The quantitative characteristics of a community are those that can be readily measured and include the study of population - density and abundance , cover , height of plants , volume of plants and frequency of species present .

Before dealing with each of these parameters we must know the field methodes of studying plant commuity .

Methods of Field Studies

Plant community can be studied using one or more of these methods : -

A) Quadrat Method

B) Transect Method

C) Bisect Method

D) Enclosure and Exclosure Method

A. Quadrat Method

The quadrat is a square area of varying size marked off for the purpos of detailed study . By the study of numerous quadrats a knowledge of the structure of vegetation may be obtained . In its simplest form the quadrat is used in counting the individuals of each species to determine their relative abundance and importance . It is also employed to determine exact differences in the composition and structure of vegetation . By its use , changes in the development of vegetation from season to season and from year to year may be followed and recorded in detail .

Althoug a quadrat includes only a small area of vegetation , it reveals the exact structure of this small part . It is impossible , in fact, and unnecessary to study the whole area with same thoroughness . A number of quadrats located with care in places that appear to be different will reveal the entire range of structure . Quadrat methods work very well in all types of vegetation .

Kinds of Quadrats

A quadrat applies to a square unit or plots . Quadrats vary in both size and use . The size may vary from 100 sq. m . to 1 decimeter . The meter quadrat is used in grasslands and most other herbaceous vegetation . A square decimeter is employed in studying soil forming lichens and mosses on rocks. A quadrat may be a single unit or it may be diveded into subplots . Quadrats are also named with respect to their use . These are : list , count , basal area , cover , clip , chart , permanent and denuded quardrats .

Strips of steel or hard wood slightly more than a meter in length and centimeters wide are used in marking out quadrats .

1- List Quadrat

This is a quadrat in which the species are listed by name . A series of list quadrats gives a floristic analysis of the community and allows an assignment of a frequency index , but nothing else .

2- Count Quadrat

The number as well as the names of each species encountered are recorded . This method is widely used in forest survey work , but here additional information such as height , volume etc . also taken .

3- Basal Area Quadrat

Here , the basal area occupied by each species is estimated or measured . The total basal area of vegetation is also measured . The basal area is expressed in square feet per acre (or 10000 m^2) .

4- Cover Quadrat

The actual or relative cover is recorded , usually as a percentage of the area of the ground surface covered or shaded by vegetation .

5- Clip Quadrat

This method consists of securing the oven dry weight (60 - 65^oC)

of each species clipped at the soil surface or at a neignt or one or more inches . The total weight of vegetation and weights furnished by each species in the quadrat are ascertained .

6- Chart Quadrat

In this type of vegetation the position of each plant within the square meter and the areas occupied by bunches , mats or tufts of grasses , mosses etc . are determined and recorded upon a chart .

Vegetation is mapped on coordinate paper , a square decimeter in size , to a scale of 1 : 10 . where vegetation is dense , consisting of a great number of individuals in a small area .A large scale is often more convenient one of 1 : 5 usually being sufficiently large . This method, though tedious , provides a detailed picture of the vegetation .

7- Permanent quadrat

Any quadrat may made permanent by marking precisely the position of the original one . They are marked and protected in such a way as to permit study from year to year .

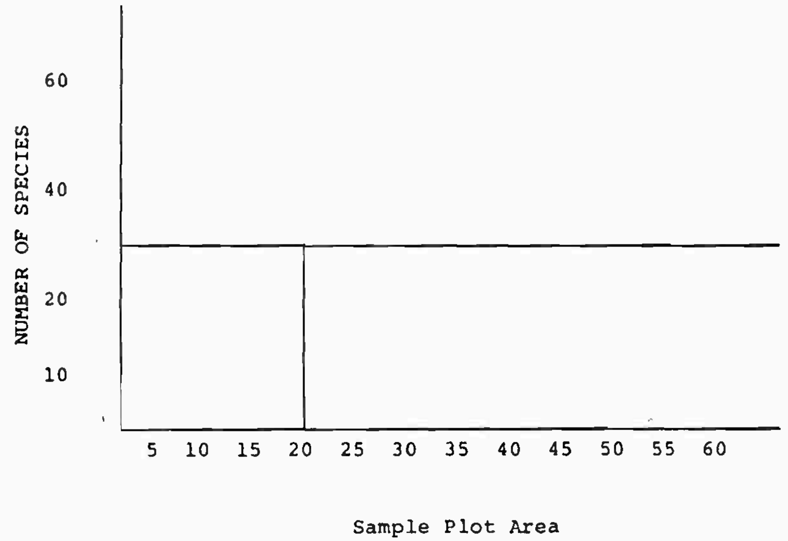
A permanent quadrat may yield much information even in a single year . If it is rechartd year after year in its original base area , it gives the complete story of develompent . The fate of seedlings , the time required for the survivors to mature and produce seeds , the methods , rate and success of vegetative propagation , as well as the length of life of the individual , make an interesting story (study) . One can see how the plants have aggregated , follow invasion of new migrants , trace ecesis , give much information about competition and how this results in the appearance of new species and the disappearance of others . One can see the changed conditions within the habitat resulting from reactions of the developing vegetation , and finally discover how it all ends in stabilization , i . e . through the aid of permanent quadrat one can follow the stages of the evolution of vegetation .

8- Denuded Quadrat

This is a permanent quadrat from which the vegetation has been removed in order that the manner which plants re - enter may be followed . Denuded quadrats may be used in experimental sowing or planting and are especially desirable in connection with artificial regeneration . It is a reliable mothed of determining rate of invasion and establishment of vegetation on badly depleted ranges .

Size , number and types of quadrat must be adapted to the charactistics of the community and the purpose of study . The richer the flora , the larger or more numerous the quadrat must be . To sample forest trees , the size of the quadrat must be larger than those used to sample shrubs . For grass and herbaceous plants , lm^2 is the usual size . The quadrat is usually square , but rectangular or circular ones may work better . Circular plots are the easiest to lay out because one needs only a center stake and string of desired length .

The number of sample units (subplots) varies with the characteristics of the community and objectives of the investigations . A species area curve can be deduced as follows :



This is obtained by plotting the number of species found in plots of different size (vertical axis) against the sample size (horizontal axis) .

The curve rises ar first because the number of new species found is large . As the sample plots size or number is increased , the quantity of new species added declines to a point of diminishing returns where there is little to be gained by continuing the sampling .

B. The Transect Method

A transect is a cross section of area used as sample for recording , mapping or studying vegetation . Because of its continuinty through an area , the transect can be used to relate changes in vegetation along the line with changes in the environment .

Transects are indispensible in studying zones and transitions of all kinds as they are continuous narrow strips that give cross sections of vegetation types , Transects are in two forms :-

a) Belt Transects

b) Isolated Transects

a. A belt transect is a strip of vegetation of uniform width and of considerable length . The width is largely determined by the character of the vegetation , just enough being included to reveal its true structure . In close herbaceous vegetation , the usual width is one decimeter , but it varies from 1 m to 10 m . in woodland . The one meter transect is emloyed for the shrubs and seedlings of the forests but for mature trees the 10 meter transect is used . Length of transect is determined by its purpose . It may be made permanent by marking the boundaries at intervals by stakes (stake = stick sharped at one end) . The plants are recorded as for the chart quadrat .

A belt transect shows a definite range of vegetation , and by making it permanent and re - charting at suitable intervals , change in vegetation along the line of the transect may be readily detected and measured . The factors causing the differences in the plant cover should also be determined wherever possible . The limits of zones may be shown on charts of a belt transect by a single cross line .

The belt transect can be set up as follows :

1. Fix the location of the transect , for statistically reliable estimates , the plots must be at random .

2. Determine the total area of the site to be sampled , then divide by 5 or 10 to obtain the total sample area .

3. Lay out a series of belt transects of a predetermined width and length sufficient to embrace the area to be sampled . Then divide the belts into equal - sized segments . These are sometimes called quadrats or plots but they differ from the true quadrat in that each represents an observational unit rather than a sample unit .

4. The vegetation in each unit is measured for some attribute , depending upon the problem at hand : abundance , sociablity , frequency , stem counts etc .

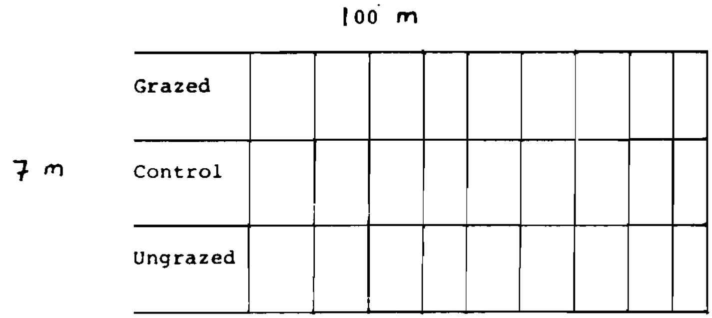
b- Isolated Transect transects are frequently used in grazing experiments . They usually consists of two strips , each 7 m wide and 100 m long with a protected strip between as a control .One is grazed and the other ungrazed . At the end of each year one unit of ungrazed area is opened and one of the garzed unit is closed . Hence , after , a few years , a history of the development of vegetation affected by 1,2,3 or more years of grazing may be seen , as well as its development for a similar series of years under protection . Thus , the influence of climatic cycles in terms of annual variations in density and volume may be measured .

C. The Bisect Method

The bisect is a line transect along which a trench (long narrow cut in the earth) has been dug to a depth greater than that of the deepest root systems . The underground parts such a rhizomes , corms etc , as well as roots of each plant are isolated and the position and extent of each is carefully measured and plotted to scale on coordinate paper . The whole root system may be drawn , but if the vegetation is all dense , only that part occurring in the first 15 cm of the trench will need be represented . This method reveals the form of the root systems of different species and show their relationship to each other and to different layers of soil etc . while a belt transect shows the structure of vegetation in two directions , the bisect supplements this by showing the third .

D. Exclosure and Enclosure Method

These are practically identical in as much as they are fenced areas of varying size and shape . The primary difference between them is reflrected in the terms , the exclosure keeping out one or more species of animals and enclosure restrcting them to a definite area . The chief purpose of exclosure is to provide protection against plant - eating animals , mainly rodents , and thus permit experimental study of the processes of natural recovery or artifical revegetation . Enclosure as a pasture affords the opportunity of determining the cause of overgrazing as well as a scale of overgrazing indicators . It is also employed to measure the coaction especially of rodents and grass hoppers upon natural species .



Parameters to be Measured Quantitatively

1. Population Density and Abundance

Population density refers to the number of individuals in a unit of space . When the measured unit area is divided by the number of individuals , the average area occupied by each individual is obtained .

Abundance is the total number of individual plants in a stand . The number of individuals of a species varies from place to place so that numerous areas are needed for reliable results .

To determine the abundance of species in a stand , a series of figures are used :-

Class 1 : +- When the species is very rarely recorded .

Class 2 : 1- When the species is rarely recorded .

Class 3 : 2- When the species is occsionally recorded .

Class 4 : 3- When the species is commonly recorded .

Class 5 : 4- When the species is abundantly recorded .

Class 6 : 5- When the species is very abundant or dominant .

Density is determined by counting the number of individuals of a species within a series of randomly distributed quadrats . Calculating the average number of individuals relative to the size of quadrats used fron the total sample .

2. Cover (Area Occupied)

Cover , or specifically herbage cover (plant cover) means the area of ground occupied by leaves , stems and infiloresence i . e . , the above ground parts of plants , as viewed from above . Each layer of vegetation is considered separately , since overlapping usually occurs , so that a tall plant is rated apart from one growing under it , i . e . the cover must be considered in terms of stratum to which the species belong .

For rapid estimation as well as for analysis of results , Braun - Blanquet proposed the following five classes for Cover :

Class I C1 = Cover less than 5% of the ground surface .

Class II C2 = Cover between 5 - 25% of the ground surface .

Class III C3= Cover between 25 - 50% of the ground surface .

Class IV C4 = Cover between 50 - 75% og the ground surface .

Class V C5 + Cover between 75 - 100 of the ground surface .

Cover as a measure of plant distribution in a community has been emphasized as being of greater ecological significance than density . The idea is based on the observation that cover gives a better measure of plant biomass than does the number of individuals . Plant biomass is the criterion of the structural classification of vegetation expressed by the spacing and height of plant . Plant biomass is an indicater of the capacity of a vegetation to accumulate organic material and it has a major influence on the stand climate in terms of light and temperature relations . It influences the water relations through rainfall interception and transpiration rate per unit area .

Plant biomass is evaluated through cover only in conjuction with a measure of depth and height . For descriptive purpose , this is accomplished by the stratification of a community into the various height layers . Therefore cover must be evaluated separately for each height layer or vegetation stratum .

Another advantage of cover as a qauntitative measure is that nearly all plant life forms , from trees to mosses , can be evaluated by the same parameter and thereby in comparable terms . This does not apply to density and frequency .

3. Height of plants

The height of plants is a good indicator of their condition or vigour and therefore can be employed as a criterion (standard) of the success of a species in various habitats . It can be also used as a measure of the favourableness of the environment and is much used by foresters as an index of the site and quality for various species of trees .

4. Weight of plants

Weight is one of the most important quantitaive characteristics of plant communities , for an increase in dry weight of plants is probably the best single measure of growth . The clipping of plants within sample areas to get green and / or dry weights has been widely used . In order to protect vegetation from grazing by sheep , fenced plots and movable cages varying from a square feet to several meters , are used . Cages may be located permanently , annually or for shorter periods depending upon the frequency and duration of the clipping operation .

5. Frequency

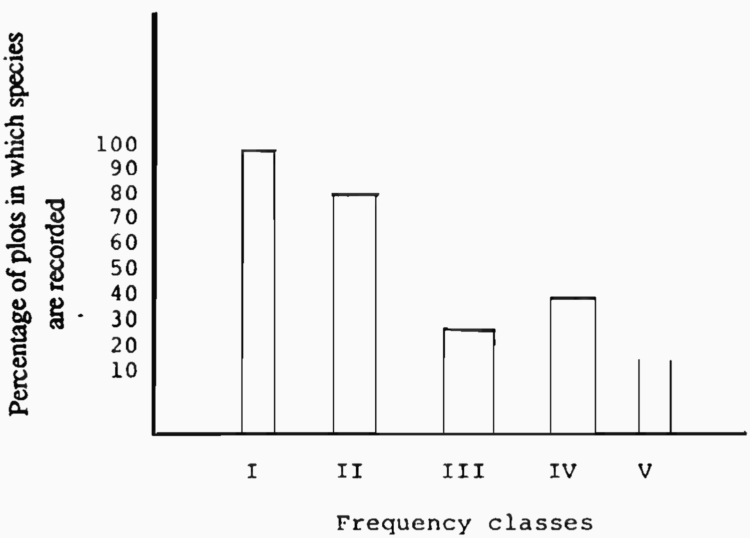
Frequency relates to the number of times a species occurs in a given number of repeatedly small sample plots (list quadrats) . It is an expression of the percentage of sample plots in which a species occur . No counting is involved , just record of species presence . It is measured by noting the presence of a species is sample areas . For example , suppose we have 10 sample plots (in quadrat or transect) in a community or vegetation , species A is recorded in 3 of these plots ; its frequency will be 30% . Frequency index (or percentage frequency) is formed for all the species present . Frequency is not concerned with the number of individuals of the species , but only its occurrence . If 30 individuals of species A are recorded in only one sample plot out of 10 sample plots , then the frequeny of species A will be 10% . On the other hand if each sample plot contains only one individual , the frequency of species A will be 100% . Frequency is an indicator for the distribution pattern of the species in the stands of a community which is rarely regular or uniform . Variation in distribution is caused by many influences such as microhabitat conditions or topography of soil , vegetation propagation , quantity and dispersal of seeds , time of invasion of one species as compared to others , grazing by animals etc . Accordingly , patterns may be present with centers of high percentage and greater abundance separated by areas of lower frequency and abundance .

The occurrence of species in an area are classified into 5frequency classes :

1. F I = 1 - 20 %
2. F II = 21 - 40 %
3. F III = 41 - 60 %
4. F IV = 61 - 80 %
5. F V = 81 - 100 %

The results of frequency classes may be expressed in frequency diagrams . The species of the highest frequency classes are often termed " local constants : or most frequent "

Species	Quadrats										Cover	Freq
	1	2	3	4	5	6	7	8	9	10		
A	4	4	1	2	3	5	6	7	3	1	2.6	100
B	-	-	2	3	6	7	2	1	3	5	1.3	80
C	1	1	8	-	-	-	-	-	-	-	1.4	30
D	-	-	-	-	2	3	-	-	5	3	0.5	40
E	-	-	-	3	-	-	-	-	-	-	0.6	20



B. SYNTHETIC CHARACTERISTICS

For a complete study of a community, its synthetic characteristics should be analysed. It is desirable to have information on as possible, at least enough stands to be representative of the whole. Synthetic characteristics are, generally, derived from data of analytic characteristics. They are:-

1 . Presence and constancy

2 . Fidelity

3 . Dominance

4 . Physiognomy and pattern

The difinitions and ways of deriving these parameters will be given as follow:

1 . Presence and constancy

Presence is the degree to which a species is represented in a series of stands of a community. In any given stand a species is counted as present if it occurs in that particular stand. When the species present in each of the stands of the community have been tabulated, the presence of each is expressed by the percentages of stands in which it occurs or by fine degree scale of presence classes, viz.,

I . Rarely present (in less than 20% of stands).

II. Seldom present (in 21-40% of stands).

III. Often present (in 41-60% of stands).

IV. Mostly present (in 61-80% of stands).

V. Constantly present (in 81-100% of stands).

IV and V indicate homogenity of the community.

Presence is used when the area of the sample plot (here stands) varies in area (not measured) from stand to stand.

Constancy is employed when equally measured sample plots (unit areas, quadrats) are used in each stand instead of the entire stands, for listing the species as for presence. There is thus no fundamental difference between presence and constancy.

2 . Fidelity

Fidelity is an indicative of the degree which a species is restricted to a particular kind of community. Species with low fidelity occur in a number of different communities, those with high fidelity occur in a few or in only one kind. This is because species differ in ecological amplitude(range) or in capacity to grow in a wide range of ecological conditions , or more species are able to associate with others or are prevented from doing so because of inability to compete. Other causes are dissimilarities in adaptations for migration and invasion, geographical dispersal etc. Fidelity and constancy (presence) are independent characteristics. Fidelity is concerned with the occurrence of a species in different kinds of communities, while constancy (presence) is concerned with various stands in the same kind of community Fidelity can be determined only by analyzing stands in several communities within a region while constancy can be determined by the analysis of several stands in the same community .

Braun-Blanquet classified the plant species into five fidelity classes :

Fid. I = Stranger: Species appearing accidentally i.e. either intruders from another community or relicts from an earlier stage of succession.

Fid. II = Companions (Indifferent): Species that occur without pronounced affinity or preference for any community.

Fid. III = Preferents : Species present in several communities but predominant in one of them.

Fid. IV = Selectives: Species present most frequently in one community but met with rarely in other communities.

Fid. V = Exclusive: Species found completely, or almost so, in only one community

Plant species have fidelity classes from III to V are called faithful or characteristic species.

Species of high fidelity may have considerable value indicating ecological conditions, e.g. restrictions. This is the indicator species.

3 . Dominance

Dominance refers to the extent of area covered, space occupied or degree of control of a community by one or more species is that one which has a high degree of dominance or control over a community .

The dominant is highly successful ecolgically in its relation to the environment and with other species. Cover and density are the chief qualities determining dominance, but frequency, height, life-form and vitality are also important.

The number of dominants varies depending upon the environmental conditions in the different regions. In the grasslands, in the salt marshes and in the deserts the dominant species are few while in the tropical rain forests they are many.

The synthetic tables in which kinds of species density cover and frequency are shown furnish an excellent aid in the quantitative determination of dominants. Also, analytic characteristics play a part in determining dominance. For example, in an area, the species that has higher cover and constancy, forms the top most layer and has a deep and dense roots system, that has a long growing season and possesses excellent vigour, best life-form (higher ones), and high degree of sociability, that forms almost complete foliage cover, has a frequency index of 100% and produces a large yield in dry weight, this will be the dominant species.

4 . Physiognomy and pattern

Physiognomy is the form or look and structure of vegetation, or the appearance of vegetation that results from the life forms of the dominant plant as well as its density, cover, height, socibility, stratification, colour and association of species. For example the physiognomies of *Rhazya stricta*, *Juncus rigidus*, *Hamada elegans*, *Tamarix mannifera* etc. communities are not the same.

Pattern in vegetation occurs in the form of groups or clumps of individuals or in any other non random arrangement of plants. Physiognomic contrast between groups such as shrubs in a grassland, or zones around a lake makes the pattern obvious, but slight differences in density,cover or frequency often require quantitative methods of determination before the pattern is detected.

Causes of pattern may be grouped under three headings:

a) Morphological: In which the growth of a propagative organ such as rhizomes is very important

b) Sociological : In which competition and association of species are of importance.

c) Physiographic: In which topographic variations, soil moisture, concentration of nutrients, soil texture and structure etc. are concerned.

In the initial colonization of an area the distribution of a species may be at random and without noticeable pattern unless som spots are more favourable for growth than others, but aggregation soon appears and results in morphological and physiographic pattern. Following this, competition, replacement of species and association of species lead to sociological pattern. However, as the climax is approached the pattern becomes less pronounced , but even in the climax, the three kinds of pattern usually exist .

Point - Centered Quarter Method

The point-centered quarter method is used in sampling trees in forests and is adopted in sampling grassland vegetation, and sand dune and salt marsh vegetation. The accuracy of the method increased with the increase in the number of sampling points, and a minimum of 20 was recommended. In applying this method to the vegetation,parallel lines were stretched at random across each stand of the community, and many points were randomly located along each line, making a total of 100 points. At each point, a pin with cross-pieces was placed vertically and the area around the points was divided into four equal quarters . In each quarter, the distance from the point to the closest living shoot of a perennial species was measured in centimenters, and the species and the distance were recorded. Thus, each sampling record consisted of four shoots and four measured distances. From the number of occurrence and number of shoots, the absolute frequency (number of occurrence/100 points) and the abosolute density (individual/m2) were respectively calculated.The line intercept method was used for estimation of relative cover. The lengths of intercept of each species in a stand were measured in centimeters. These lengths were then summed and expressed as relative value of total length of all lines. Relative density, relative frequency and relative cover were calculated for each perennial species and summed up to give an estimate of its importance value (IV) in each stand which is out of 300.

Dynamics of Communities

Vegetation is not static but it usually shows seasonal changes, i.e . it is dynamic . Within a growing season the aspect of a community changes from spring to autumn because of differences in the requirements and ecological amplitudes of the various constituent species , some growing rapidly and flowering early , others developing more slowly . The beginning of growth , flowering and fruiting of the same kind of plant comes at different times from year to year because the environmental condityions, particularly temperature and precipitation, vary. On account of drought, disease and other adverse factors, or old age, some plants may fail to produce seed or even die and the space they occupied may be taken by other species in the following year. Even the plants themselves modify the environment by reducing the light intensity, increasing the organic matter of soil, increasing or decreasing soil moisture etc. and consequently, in time they are replaced by another type of vegetation.

Some types of vegetation at first appear uniform over large areas, but close examination reveals variation from one place to another because the topographic and soil conditions change. The environmental conditions may change gradually in space, with corresponding alternation in the plant cover, forming a cline , or the change may be abrupt so that sharp transitions or discontinuities are produced.

It is evident that there are two kinds of changes that occur in vegetation; change in time and change in space.

a. Change in Time

This occurs in one area in the communities in which there is a loss of some of the present species and the invasion of new ones with accompanying increase in the complexity, as in ecologic succession where the change (directional) is from the less complex and less stable vegetation to the more complex and more stable ending in the climax or steady state, and ecologic retrogression is the reverse of this. Changes in time may be seasonal, annual or cyclic, successional or historic or genetic.

b. Change in Space

This occurs from one area to another such as gradual or sharp transition in vegetation-types among which are vertical and horizontal transitions, clines and discontinuities.

PLANT - WATER RELATIONSHIPS

WATER AND ITS PROPERTIES

When hydrogen and oxygen atoms combine the resulting molecule is stable and unreactive , this is the water molecule or H_2O .

At equilibrium , the product of the concentration of hydrogen ions and hydroxyl ions in pure water is constant , and a value of about 10 - 14 gram - ions per litre i . e one gram of ions in 10- 14 litres of water . Since the total number of hydrogen ions is exactly equal to the number of hydroxyl ions , each has a concentration of 10^{-7} gram - ions per litre . Pure water thus has a pH value of 7 , since pH is defined as the negative logarithm of hydrogen ion concentration , pH = - log [H^+] . The p H value of an aqueous solution is influenced by the presence of dissolved subdtances . Solutions in which the hydrogen ion concentration is greater than 10^{-7} gram - ions per litre (pH < 7) are acidic , whereas those in which the hydrogen ion concentration is lower than this (pH > 7) are alkaline .

Apart from the ordinary hydrogen and oxygen whose atomic weights are l and 16 respectively , natural water contains the hydrogen isotops , duterium 2 H and tritium 3H , and the oxygen isotops , O^{17} and O^{18} . The amount of these isotops present is relatively small ; the ratio of 1H to 2H isotops being about 6500 to 1 .

Water is such a familiar substance that its unique physical properties are usually taken for granted . Water is a liquid at most ordinary temperature , untill its melting point and boiling point are compared with those of other substances of similar molecular size .

Substance	Formula	MolecularWt	Melting point (°C)	Boiling point (°C)
Methane	CH4	16	- 184	- 161
Water	H20	18	0	+ 100
hydrogen fluoride	HF	20	- 92	+ 19
hydrogen sulphide	H2S	43	- 86	- 61

From such a comparision , it appears that water has a much higher melting point and boiling point , and this is attributable to the association of water molecules with one another , causing the substance to behave as if it has a much higher molecular weight than the simple formula (H_2O) indicates . If this were not the case , water would be gaseous at normal temperatures and life on earth could not exist .

Water also has the highest specific heat among the known substances . This means that it is relatively slow to heat up and cool down , a feature which is of considerable biological significance . Most liquides contract on cooling , reaching maximam density at freezing poit , but water has a maximum density at $4^{o}C$.

Water has the highest surface tension (73 .4 dyn / cm.) of all common liquids (except mercury) . It will rise by capillarity in glass tube , 0.03 mm in diameter , to a height of almost 4 feet (120 cm) . Consequently , water moves extensively by capillarity through narrow cavities in soil and in plant cell walls .

It is of consdirable importance to plants that liqiud water is almost colourless . The high transmission of visible light makes it possible for aquatic plants to photosynthesize when submerged at considerable depths , and for light to penetrate into deeply seated tissues of leaves . Water absorbs light to some extent , particularly at the red end of the spectrum , and this accounts for the blue - green colour of light transmitted through a thick layer of water .

From the above account , it will appear that water is ideally suited for its functions in plants .

THE IMPORTANCE OF WATER TO PLANTS

Without water , life as we knon , could not exist . living organisms orginated in an aqueous environment and are absolutely dependent on water in a variety of ways . Water is essential to plants for the following reasons :

(1) It is a constituent of protoplasm and comprises as much as 95% of the total weight . When porotoplasm is dehydrated it ceases to be active and below a certain water content it is killed .

(2) Water participates directly in a number of chemical reactions occuring in protoplasm . Hydrolysis and condensation reactions , in which water is added to , or removed from organic molecules , are important in various metabolic processes , such as the interconversion of carbohydrates e . g .

$$(C6H_{10}O_5)\,n + nH_2O \longrightarrow nC_6H_{12}0_6$$

starch glucose

It is the source of hydrogen atoms for the reduction of carbon dioxide in phoctosynthesis , and is a product of respiration .

(3) Water is a solvent in which many other substances are dissolved , and in which they undergo chemical reactions .

(4) Water maintain the turgidity of cells and hence of the plant as a whole .

(5) Water provides medium for the movement of dissolved substances in the xylem and phloem .

The water content of a plant , or its part , can be determined in several ways . The usual method is to dry the material in an oven (at 80 - 100°C) until it reaches constant weight . It is usually expessed as a percentage of either fresh weight or dry weight . Dry grains contain as little as 5% water as a percentage of the total weight , whereas the percentage of water in fruis is as high as 94.1 % (e . g Tomato) , in leaves 94.8% (e. g lettuce) , in stems 88.5% (e . g . Asparagus) , noots 93% (e . g Barley) .

NOVEMENT OF WATER IN SOILS

The movement of soil moisture (water) is relatively compelex because of the various directions and states in which it moves and the various forces operating to cause its movement . Downward movement (infilitration) occurs when the soil in being wetted by rain or irrigation , some upward movement (vertical capillarity) occurs when the surface is drying by evaporation , and a limited amount of lateral movement (lateral capillarity , seepage) may occur . Water moves as liquid in capillary films and in the larger , or noncapillary , pores from regions of lower to higher tension . Appreciable movement also occurs in the form of vapor along gradients from regions of higher to regions of lower vapour pressure . The forces that cause movement of liquid water are chiefly **gravity , hydrostatic pressure** and **capillary** forces .

Infiltration

Many studies have been made of the downwards entry of water in soil , a process commonly referred to as infiltration . Infiltation of water into the surface is the first step in wetting a soil , and the rate of infiltration into a given soil is a very important factor in determining how much of a given rainfall will be accumulated in the soil and how much will be lost by runoff " Infiltration rate = maximum rate at which a given soil , in a given condition , can absorb rain as it falls " . The rate of infilteration decreases rapidly in moist soils after only a few minutes exposure to rainfall . The wetted portion of a column of uniform soil , into which water was entering at the top and advancing downwards , appeared to comprise a transmitting zone through which water was transmitted , with little change in water content , from a saturated zone at the top to a wetting zone at the bottom , with a sharply defined wetting front at the lower end . Five zones are categorized as (1) a Saturation zone , a zone presumed saturated which reached a maximum depth of 1.5 cm , (2) a transition zone , a region of rapid decrese of water content extending to a depth of abount 5 cm , from the surface ; (3) the main transmission zone , a region in which only small changes in water content occurred ; (4) a wetting zone , a region of fairly rapid change in water content ; and (5) the wetting front , a region of very steep gradient in water content which represents the visible limit of water penetration . The decrease in infiltraion with time is largely caused by a decrease in the moisture potential within the transmission zone of the soil as the wet front moves futher below the surface . Other factors are the swelling of clay when it is wetted and the entrapment of air .

Soil suface

(1) Saturation zone
(2) Transition zone
(3) Transmission zone
(A) Wetting zone
(5) Wetting Front

Fig (24) Zones of Water Infiltration In Soil

Capillarity:

Is the movement of capillary water. Since so-called capillary water is the principal source of moisture for plants.its movement is of particular interest. Movement of capillary water is materially affected by soil texture, being most rapid in sandy soils and slowest in clay soils at saturation; but in drier soils the effect of texture are reversed, movement being slowest in sands and most rapid in clay. Height of capillary rise also depends on texture, being greatest in clay and least in sands . Apart from soil texture, the rate of movement of capillary water through the soil is influenced by soil structure and soil temperature. In addition , its mobility varies directly with the thickness of the water films. Very thick films can move in any direction, but as they become moderately thin they become immobile. The amount of lateral movement (seepage) of capillary water is never very great, and for this reason irrigation water must be applied close to the bases of the shoots if it is to benefit roots. For all practical purposes only the upoward movement of capillary water is important, and movement in this direction is significant only within a few feet of the water table.

In climates where the rainfall in scanty but the water table is not excessively deep, certain deep-rooted plants may be able to take advantage of water rising by capillarity from the water table upward. Likewise most species of plants that are essential confined to stream margins in lake shores are very dependent upon moisture rising from water table . At about 85 cm above the water table, the rise of capillary water becomes too slow to be significant in replacing transpiration rate. The zone of capillary water maintained by vertical rise is called the

Capillary fringe , and plants depending upon its moisture are said to be **subirrigated** . Plants of arid regions that depend upon maintining their roots in the capillary fringe are called **pheatophytes** , they are lavish (waste) users of water .

The moisture content of the soil in the capillary fringe is not uniform but decreases with height above the water table.

Movement of Water Vapour

As soil dries out, the water films become dis-continuous and capillary movement ceases. Any water movement in air-dry soils must be in the form of vapour. Movement of water vapour is along vapour-pressure gradients; hence it is affected by the relative temperatures and vapour pressures of various hoizons of the soil and of the soil and air.

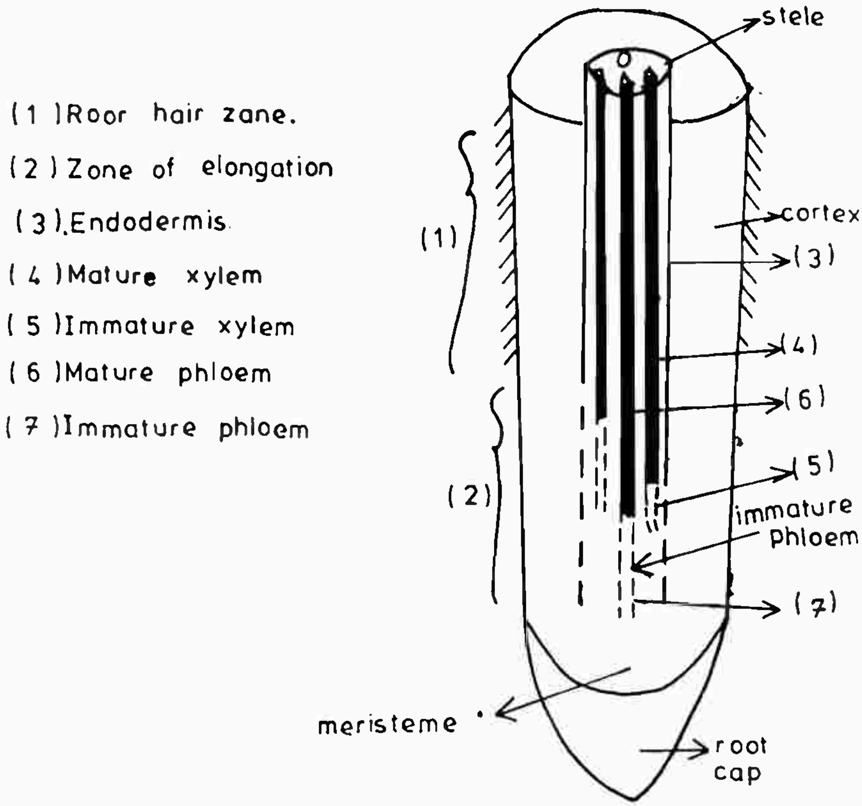
MOVEMENT OF WATER IN PLANTS

Water is absorbed by roots from soil mainly in the region of the root hairs. The root hair zone is a particularly favourable one for absorption because it presents a large surface area in intimate contact with water films surrounding the soil particles. Individual root hairs , probably for only a few days, being replaced progressively by others near the tip of the root as it grows. In this way the root-hair zone is brought progressively into contact with new regions of the soil.

Plants grown in solution culture commonly lack root hairs as do the roots of aquatic plants . In these cases, water absorption takes place over the whole surface of the root.

Functional root hairs and other surface cells of the root in contact with soil particles will absorb water as long as the potential of water in the vacuoles is lower than that of the soil solution. Absorption of water by the surface cells leads to an increase in their water potential which results in transfer of water to neighbouring more deeply seated cells having a lower water potential. If no other factors were operative the root would eventually come to equilibrium with the soil solution , when the potential of water in each of the cells was equal to that of the surrounding medium.

The actively elongating meristematic terminal zones of each root is composed of numerous, small, actively dividing; tightly packed cells, almost completely filled with cytoplasm. As the root extends through the soils, cell division at any one point ceases as the root progressively differentiates into three main tissue phases, the **epidermis** , the **cortex** and the **stele**, containing the vascular system . As the age of the zone under consideration increases, and its distance behind the continually extending root tip lengthens, cutinization and suberization of the epidermis occurs, root hair tend to disappear and secondary growth gradually commense. Secondary growth occurs commonly in dicotyledons and gymnosperms, but less commonly in monocotyledons, particularly annuals. It is associated with an increase in the diameter of the stele as cambial activity increases and, as a result, the cortex and epidermis are ruptured and break off.



Root tip showing various zones and the regions of xylem and phloem.

Fig . 25 .

Anatomical and physiological investigations of the absorbing zones of roots show that the zone of most rapid water absorption lies behind the merestematic region of the root tip it-self, and ahead of the region where suberization develops. In consequence, the zone tends to move through the soil with growth of the root system. The zone usually found 5-10 cm. behind the root tip. The length of the region depends largrly on the rate of root extension; in slow growing roots it is very restricted . Beyond the zone of rapid uptake, rate of absorption decreases rapidly as suberization develops.

The pathway of water movement from the root surface to the stele, in the zone of rapid absorption, invovlves transport across the epidermis, the root cortex and endodermis . The outer epidermal cell walls in this region, may be slightly cutinized but appear to be highly permeable to water. Many epidermal cells may develop root hairs, which are tubular extensions of the cells themselves, also of high permeability. The root cortex is generally composed of 5-15 layers of loosely-packed parenchyma cells with conspicuous intercellular spaces. Water may move through this zone through the protoplasts, from cell to cell, or outside the protoplasts, via the cell walls.

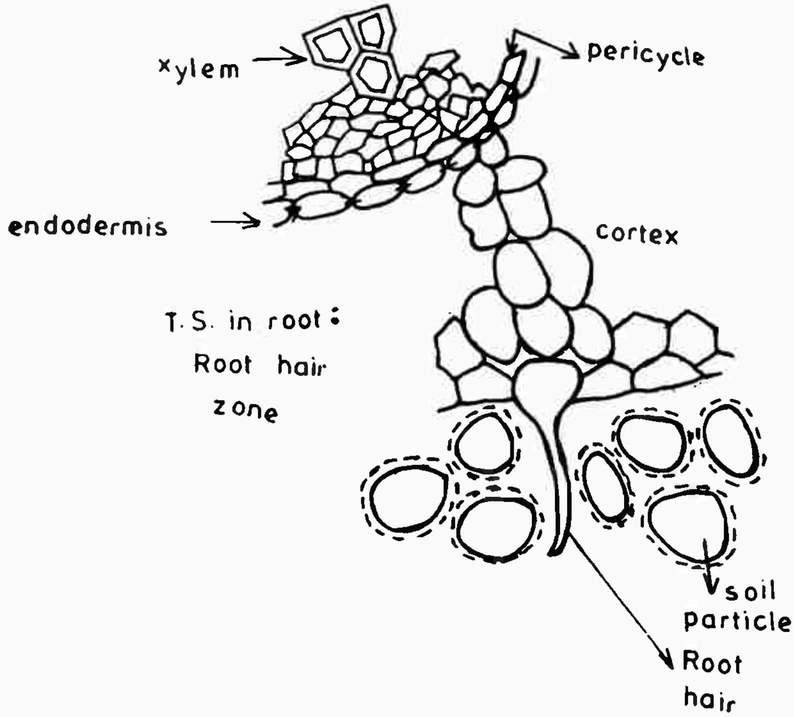


Fig . 26

The outermost layers of the cortex may differentiate into an exodermis of tightly-packed cells lying directly beneath the epidermis, but these cells do not become suberized at this stage. The innermost layer of the cortex, however, which forms the endodermis, contains suberin in a band-like layer which extends around each cell within the radial and transverse walls . This band, called the **Casparian strip** , constitutes part of the primary wall, rather than a simple wall thickening, and the suberin is deposited continuously across the middle lamella. Furthermore, the protoplast is firmly attached to the Casparian strip.

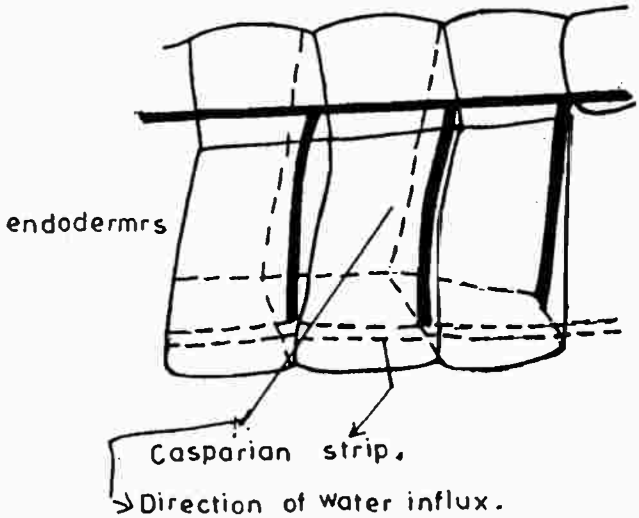


Diagram of Three endodermal cells showing casporian strip in transverse and radial walls.

Fig . 27 .

In consequence, the cell wall pathway for water, and ion movement is effectively blocked , and transport across the endodermal cytoplasm is necessary when casparian strip development is effectively continous. The endodermis, however, constitutes an important barrier to the free diffusion of ions.

With the vascular cylinder there appears to be little resistance to water flow from endodermis to xylem trachids or vessels. The cylinder consists of one or more layers of pericycle, and the vascular tissues. The pericycle generally consists of parenchyma and , in the zone of rapid absorption, the cells are thin walled without obvious regions of low permeability.

The pathway of water movement in suberized roots, in which secondary growth has occurred, the suberized outer tissue, consisting of a peripheral bark layer and layer of cork cambium, across or around the secondary phloem, and across the vascular cambium . None of these layers may constitute a single resistance barrier as great as the endodermis , but the outer suberized layers are heavily impregnated and can be expected to have very low permeability . There are , however , breaks in the tissue and there is some lenticel development , both possibly providing areas of low resistance .

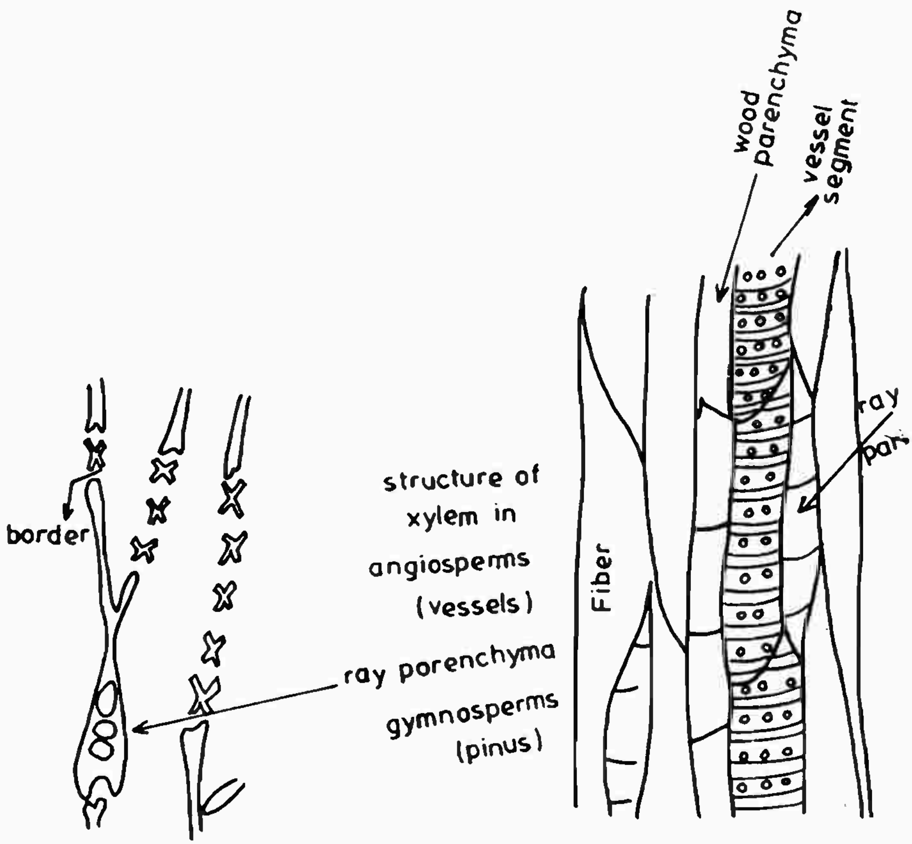


Fig . 28 .

Water is carried upwards in the stem through the nonliving xylem elements , that is through vessels (which only occur in angiosperms) and **tracheids** which occur in the gymnosperins e . g . *Pinus* . Anatomically , these elements appear to be admirably suited for the purpose . The transverse walls of the vessels separating each vessel segment from its neighhours disappear during development leaving only a series of rims to indicate their former location and causing the establishment of continuous tubes from the roots to the leaves . Tracheids offer higer resistance to the flow of water along them than do vessels , and this can be demonstrated readily by comparing the rates of flow of water through lengths of twig of similar diameter under the influence of a pressure gradient . Deciduoue angiosperm tree wood has a specific conductivity which is commonly 3 - 6 times higher that of conifers .

Another indication that xylem is the tissue involved in the movement of water in stems and that there is a close correlation between the amount of xylem associated with individual leaves and the quantity of water they transpire . The number of vessels and tracheids is reduced in subrmerged water plants , but when leaves emerges from water they are well supplied with xylem .

CLASSIFICATION OF PLANTS BASED ON WATER RELATIONSHIPS

Ecologists have long been interested in the classification of plants according to their water relationships . For a time much attentions was directed toward finding a common physiologic or morphologic basis for defining groups , but it gradually become apparent that this objective is not realistic , that alternative adaptations of structural and functonal nature may have equivalent value . Hence , emphasis has shifted to a primarily environmental basis of definition . Accordingly , plants have been grouped according to their degree of adaptation to water availability . Those living in water or very wet conditions are called Hydrophytes , those adapted for life in equal temperate conditions of moderate humidity are called **Mesophytes** , those adapted for life in drought are called **Xerophytes**, and those which can live under salty conditions are called **Halophytes** .

A - The Halophytes

Plants adapted for living in soil conditions of high salinity are often called **halohytes** . These are found commonly in coastal areas where extensive salt marshes often develop , as well as around the wells and springs in the deserts .

Two principal groups of factors seem to control the distribution of halophytes , viz : the degree of aeration of the soil and its salinity .

Soil Aeration

The abb and flow of tide means that soil water saturation is always high though , perhaps surprisingly, even on a rising tide the soil water table never runs tight to the soil surface , unless the area is actually inundated . The depth of this aerated layer is an important factor controlling the distribution of salt marsh plants , as many of them have their roots confined to this layer . Even though this zone is described as aerated , the amount of oxygen present is low and this too may be a factor influencing plant distribution .

Halophytes often possess aerenchyma which may assist root growth under conditions of low oxygen concentration .

Soil Salinity

In the past it was thought that the high concentration of salt and other solutes induced what has been termed **physiological drought .** The implication was that plants were often unable to obtain sufficient water , due to the high osmotic potential of the soil solution . It now seems that this concept must be discarded (refused) . So many salt marsh plants appear to be able to make their use of the soil water though they may have rather high transpiration rats and seem to affect no great degree of water conservation .

The osmotic potential of the cells of many halophytes is extremely high , but it is the salinity of the soil , due to the presence of sodium and chloide ions , that is the important factor influencing plant survival . Germination in particular is affected by salinity , on the whole the higher the salinity the lower the germination rate , Table blow shows this effect in a number of plants .

Salinity	Spartina townsendii	Aster tripolium	Salicornia europaea	Halimione portulacoides
Tapwater	80%	45%	93%	25%
1% Nacl	21%	25%	45%	33
2% Nacl	15%	10%	36%	0%
3% Nacl	3%	0	38%	0
5% Nacl	0	0	36%	0
10 % Nal	0	0	12%	0

Tolerance of *Salicornia europaea* is high and enable it to be the primary coloniser of lower mud flats . Salinity of soil may fall in the spring - time which may provide a more favourable season for other species to germinate and become established .

Salinity also acts as an inhibiting factor on subsequent growth and development . *Salicoria* grows best at a salt concentration between 1.32 and 2.5 % while *Aster* shows its optimum growth around 0.5 - 1 % .

Plants growing in salt concentration beyond their optima are usually stunted . There may be several factors causer for this . The presence of Na ions may break down the colloidal structure of soil . Alternatively , plant cells may be unable to reach the abnormally high osmotic potentials which would be required to obtain water from soil solution . Table below gives data of osmotic potentials of a variety of plants .

Species	Osmotic pot (atm.)	Species	Osmotic potential (atm .)
Gulaux maritima *Spartina patens*	14.6 20.9	*Triglochin maritma* *Salicornia europaea*	24.6 39.7

It must be emphasized that these figures will vary over different parts of the same plant , from plant to plant of the same species, and also at different times of the day and year .

Adaptations that enable halophytes to cope with problems that arise from excessively high osmotic potentials include succulence . This may be an environmentally induced feature as in the *Anagallis arvensis* ssp . *arvensis* which is more common on sand dunes , or it may be genetically controlled as in *Salicornia europaea* . It is probable that these plants compensate fo their salt uptake by a corresponding water intake when the soil conditions are favourable . There seems no reason why this water should not be temporarily stored . Indeed salt marsh plants are known to have high transpiration rates so some store may be essential when soil osmotic potential rises too high . The grandual drying up of the leaves of many succulents towards the end of the year suggests that this storage system may be essential during the hotter parts of the year . *Salicornia perennis* loses all its succulent leaves in autumn .

Many species , e . g . *Limonium* , *Tamarix* , *Glaux* . etc . excrete salt from special glands , though how far this prevents a serious increase in the internal concentration of salt is not known . Finally , in a number of species , the leaves simply die off when the internal salt concentration rises too high ; this happens again usually towards the end of the season .

The net effect of all these adaptation is to enable halophytes to absorb and transpire much the same quantity of water per unit area plant as an ordinary mesophyte .

Halophyts, or plants grow in saline soils which ingured only by high concentration of salts, are distinguished into :

a) Facultative Halophytes : or salt tolerant species, which have an optimum development on non-saline soils. but tolerate a certain amount of salt. We find these plants on salt soils because the competition of the non-halophytes is less .

b) Euhalophytes : or species with an optimum growth on soil with a certain salt countent . They may grow also on normal soils poor in salts, but they will not do so well . On such soils they eagrly take in every trace of salts ever-present in the soil .

Halophytes are plants keeping large quantity of water in their tissues , with high osmotic pressure and reduced rate of transpiration . Their succulence being due to the presence of Cl-ions . They are capable of high degree of chlorophyll assimilation despite the presence of salts in their tissues. As water is transpired and salt remains in the transpiring leaves , accumulation of salts in the leaves should take place in the long run . The halophytes over-come this in different ways :

1- small number of plants are able to excrete salts, i.e *Excretion type* e.g. *Spartina, Aeluropus, Diplachne* (grass-es) *: Glaux, Armeria, Limonium, Limoniastrum, Cressa, Frankenia* (weeds and bushes) ; *Tamarix* , etc. (woody plants) . The salt excretion takes place by certain glandular cells. It is an active process .

2- Regulating type : The extreme halophytes, like *Salicornia, Arthrocnemum, Halocnemun* etc. lack the ability to excrete salts. They are very succulent and hinder the rising of the salt concentration by a permanent increase of their water content . Therefore , they become more and more succulent during their development .

3- Cumulative type : This type lack regulating mechanisms . The salt concentration therefore rises more and more during the growing season, and when a certatin level is reached, part of the plant where salt accumulation occur (or even the whole plant) will die e.g *Juncus* spp .

Generally, as long as salt content of soil does not increase too much, the halophytes store comparatively more salt in the cell sap. When the difference between the osmotic pressure of the cell sap and the osmotic pressure of the soil solution becomes greater, water absorption becomes easier and the development of plant is further . But when the osmotic pressure of the cell sap and that of the soil solution are the same, water absorption is till possible, but it is more difficult and the growth of plant is retarted . When the osmotic pressure of the cell sap is no longer exceeds that of the soil solution water absorption ceases and the plant dies .

B- Hydrophytes .

Hydrophytes include :

a) aquatic plants which normally grow in water and swamp and

b) bog plants which inhabit soils conaining a quantity of water that would prove superoptimal for the average plant . In all these habitats water per se in not detrimental, but the extreme slowness with which oxygen dissolves and diffuses into water or saturated soil produces a critical conditions with which plants can cope only if specialized . Unlike other ecologic groups ; the higher plants that are hydrophytes regularly extend their roots into saturated soil or water . In a number of emergent hydrophytes, with respect to aeration , e.g *Avicennia* mangrove, special root branches grow erect until they project above the poorly aerated rooting medium . These structures called *pneumatophores*, usually have a well developed interellular system of air spaces continuous with the stomata so that they are of unquestioned value in gas exchange .

Many plants that grow best in muddy soils where the 0_2 concentration is extremely low have developed especially low cut 0_2 requirement for germination . For example , the 0_2 requirement for the germination of rice is only one-fifth as great as that of wheat .

Anaerobic respiration is well developed in certain hydrophtes which grow in still water or wet soil . It begins when the oxygen content of the inter-celluler spaces drops to about 3% and it assumes increasingly greater importance as the 0_2 content drops still lower .

One of the most outstanding structural peculiarites shared by most hydrophytes is the spongines of their tissues . Owing to the disintegration of groups of cells , or the separation of cells so as to create enlarged intercellular air spaces , cavities **(Lacunae)** are developed which become filled with gases . Most mesophytes have a continueous system of intercellular air spaces, but hydrophytes have especially large cavities . Parenchym containing cavities called **lacunar tissue** ; periderm containing intercellualr spaces is called **aerenchyma** .

In completely submerged plants (e.g ***Elodae, Anacharis*** etc .) the air cavities can only accumulate air by-products of photosynthesis during the day, and this is used up in respiration at night during which time O_2 accumulates . Thus , the lacunae serve as gas-storage compartment . The cavities in emergent or floating-leaved aquatics *(e.g **Eich-***

hornia) generally form a continuous system of air passage-ways by means of which submerged organs can exchange gases with the air via stomata in the emersed organs .

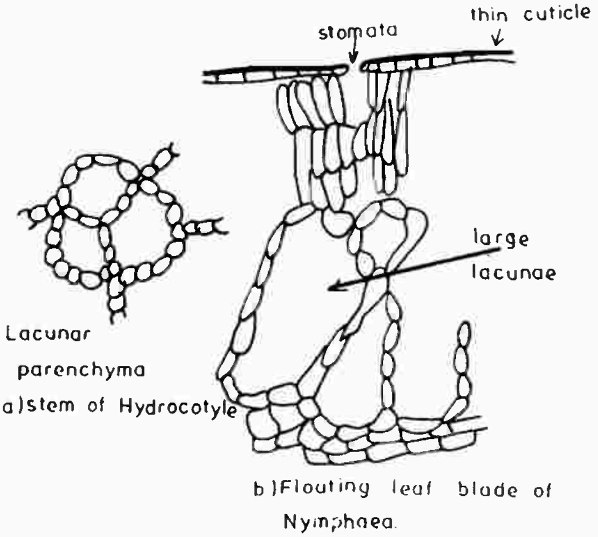


Fig . 29 .

The plant organs of the hydrophytes usually lack a cuticle or periderm and any stomata that form are nonfunctional . As a result of the lack of cutin , submerged organs should be capable of absorbing water and nutrients directly . Transpiration rate operates feebly in most vascular aquatic plants .

The roots of hydrophytes are usually shorter and less branched than those of mesophytes and xerophytes . Furthermore , the rootlets are often devoid of root hais , and rootcaps are typically elongated and sheathlike , and are called **rootpockets .**

Classification of Hydrophytes :

Hydrophytes may subdivided into five morphoecologic groups as follows :

1 - floating hydrophytes : are plants that are in contact with water and air but not with soil . Examples : duckweeds *(Lemna minor, Spirodela)* , water hyacinth *(Eichhornia)* .

2- Suspended Hydrophytes : Plants such as phytoplankton *(Saragassum)* are in contact with water alone . In this and in the preceding group the depth of water beneath the plant is of minor importance and the members commonly travel great distances by water currents .

This group differs from the first in the important respect that the plants are absolutly free from transpiration stress and yet inhabit the best-lighted and best aerated strata of bodies of water . However , gas exchange is always a problem with suspended and submersed plants .

3 - Submerged anchored Hydrophytes :

In this category are those plants that grow entirely under water and are attached to the substratum e.g *Anacharis, Zostera, Ceratophyllum* , *Potamogeton, Chara*, and most macroscopic algae .

4 - Floating-Leaved Anhored Hydrophytes :

These include *Nymphaea* (water lily) as well as other plants with leaves lying on the water surface . *Nymphaea* leaves have a waxy surface causes water drops to roll off quickely . This adaptation is of obvious benefit to plants whose stomata are confined to the upper surface of the blade .

5 - Emergent Achored Hydrophytes :

These, the so-called " amphibious plants " grow in shallow water and extend their shoots well above the surface . Examples : rice *(Oryza sativa)*, bullrush *(Scirpus)*, Cattail *(Typha)* , cordgrass *(Spartina)* , mangroves *(Avicennia and Rhizophora)* . reeds (*Phragmites*) etc.

Phyraeophytes are transitional between this group and mesophtes .

C - Mesophytes :

Mesophytes include plant species which can neither inhabit water or wet soil , nor saline soil but survive on habitats where water is reduced. The plant of this group grow well in a moderate conditions of water . The special structural and physiologic adaptation found in hydrophytes , xerophytes and halophytes are lacking except in certain species of mesophytes derived in evolution from one of the other groups .

D - Xerophytes { Drought = water scarcity }

Xerophytes are plants of relatively dry habitats ; therefore almost all regions contain species that are xerophytes , The term xerophytes (drought resistant plants) includes a wide range of plants some with little obvious adaptation , others are highly modified . The most fascinating xerophytes are those found in or near deserts . No plant is capable of living in indefinite drought , it is only where water is present either deep in soil or occasionally from rain that some form of plant life can exist .

It is possible to classify xerophytes on the basis of their anatomical and physiological characteristics . Accordingly , xerophytes are grouped under : A) drought evaders and B) drought endurars .

A) Drought evaders :

These are the drought escape plants which are killed by drought and survive during dry conditions as seeds or spores . Annuals and ephemerals form much of the vegetation that springs up almost overnight after a heavy desert shower . They germinate , grow , flower and set seeds in only four to six weeks . They are adapted for life in deserts simply by tiding over the drought period in the form of seeds . Examples of these plants are : *Filago spathulata, Ifloga spicata, Papaver rhoes, Plantago* spp., etc .

B) Drought endurers :

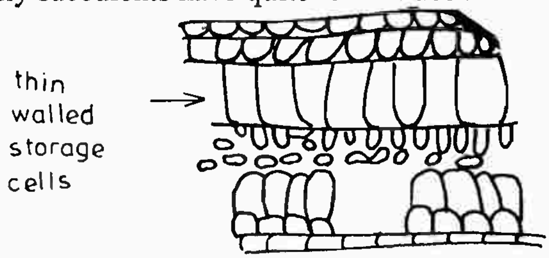
These are the plants adapted to drought survival or the plants that form the permanent vegetation cover of the dry regions i.e. **perennial plants** . These plants are characterized by the following :

1) Maintainance of water uptake :

There are a number of desrt plants with exceedingly deep roots which enable them to tap the water table as and when it is available . Other desert plants , particularly the *Cacti* have shallow spreading root system which enable the plant to obtain maximum water when rainfall occurs . However , a surface root system of this sort is found to become almost completely desiccated in dry weather .

2 - High Osmotic values :

As would be expected, most (or all) xerophytes have high osmotic potentials and so can extract water more readily from drying soils . Shrubby species often have osmotic potentials in excess of 25 atmospheres , but many succulents have quite low values .



3 - Storage of water (succulence)

Many xerophytes have rounded , fleshy leaves and stems in which considerable quantities of water may be stored . These structures are composed mainly of large parenchymatous cells containing mucilage This probably helps the cells to imbibe water . The ice plant (*Mesembryanthemum crystallinum*) possesses large bladder - liker epidermal cells in which water in storeds .

4 - Reduction of water loss

There are many adaptations which help to prevent excessive water loss. One of the most obvious involves a reduction in the surface area of the plant . If this goes along with an increase in volume the plant will also become more succulent . Leaves, stems or both may be modified in this way , in consequence drought endurers have often been classified into stem and leaf succulent plants .

5 - Reduction in surface area

In the leaf succulent plants although the leaves are swollen , there is probably little reduction in transpiring surface .The internodes are short and the leaves are more succulent and tightly packed .

6 - Deciduous leaves

Quite a number of xerophytes shed their leaves in times of drought . Usually the older leaves are shed first and the most vital ones near the apex are the last to go .

7 - Slow rate of transpiration

Apart from reduction in the surface area of the plant , transpiratin can also be lessened by modificaton of the stem and leaf surface . The deposition of cutin , a fatty derivative , gives many plants a shiny surface , this is particularly seen in *Opuntia* and *Agave* . Sometimes the cuticle may have a waxy layer which gives the plant bluish bloom . These substances probably reduce cuticulare transpiration . Many xerophytes , e.g *Stachys* sp . appear white due to the presence of white hairs over the leaf surface . The hairy covering may reduce transpiration by creating air layer around the leaf .

Transpiration is probably more strongly limited by the number , size and arrangment of stomata . Compared with mesophytes (number of stomata = 400 - 1000) xerophytes stomata are usually less than 100/

mm . Quite often the stomata may be sunk in pits as in the pine trees and in *Dasyliron* . In *Dasyliron* there are two cavities outside the guard cells which must effectively reduce the rate at which water molecules diffuse through the stomatal system . In marram grass (*Ammphila*) and *Nerium olerander* there are hairs around the sunken stoma which reduce the water loss . A number of xerophytes , particularly members of Aizoaceae such as *Mesembryanthemum* have an inverted stomatal rythm , the stomata being closed by day and open at night. As most of water loss from plant is through the stomata , this physiological adaptation must be of considerable importance , provided that sufficient CO_2 can be taken up for photosynthesis .

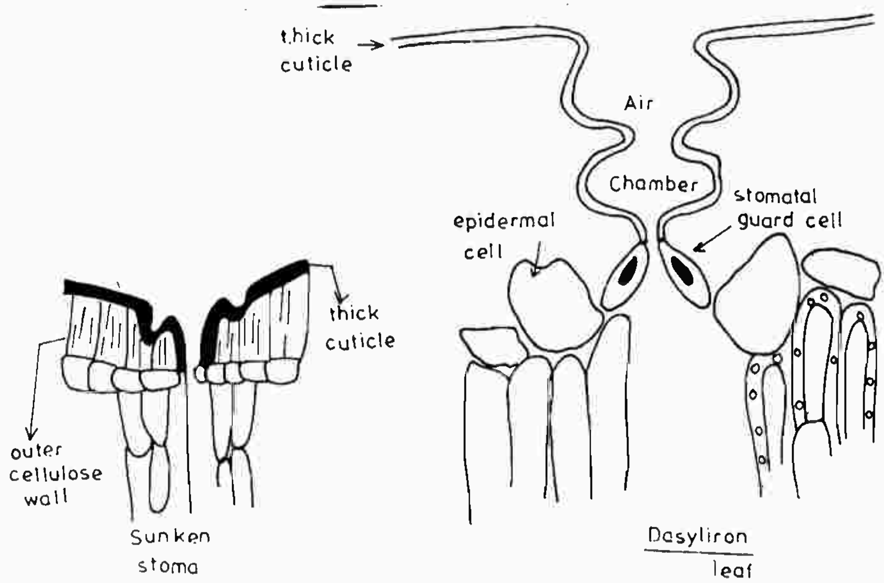


Fig . 31

Another physiological point that is certainly of interst is the fact that many xerophytes are aromatic . Various Labiates e. g *Thymes* , Composites e. g *Artemisia* , *Achillea etc* . each has a characteristic odour . It has been suggested , though not proved , that the production of aromatic volatile oils in some way screens the plant and helps prevent excessive transpiration .

8 - Desiccation

The ability of xerophytes to " come to life " so quickly and to survive in a high state of desiccation is as remarkable as the vitality of dormant seeds . While it is probably true that the protoplasm of many xerophytes can stand varying degrees of desiccation , the ability of some species to recover after severe dehydration is observed among the desert plants . Examples are many . *Myrothammus* which lives in crevices of granite rocks in Rhodesia ,after 4 month of drought the plant was dry and brittle . Their water content being less than 10% of normal . Parts of this plants (twigs) were kept in an air - dry environmert for a further 13 months . They were then put in water and become green and expanded overnight . *Panicum turgidum* grass of the Egyptian desert looks dead during the dry season , but after winter spill of rain the plant recovers its green aspect again . The leaves may be more tolerant to desiccation than other parts of the plant such as root hairs .

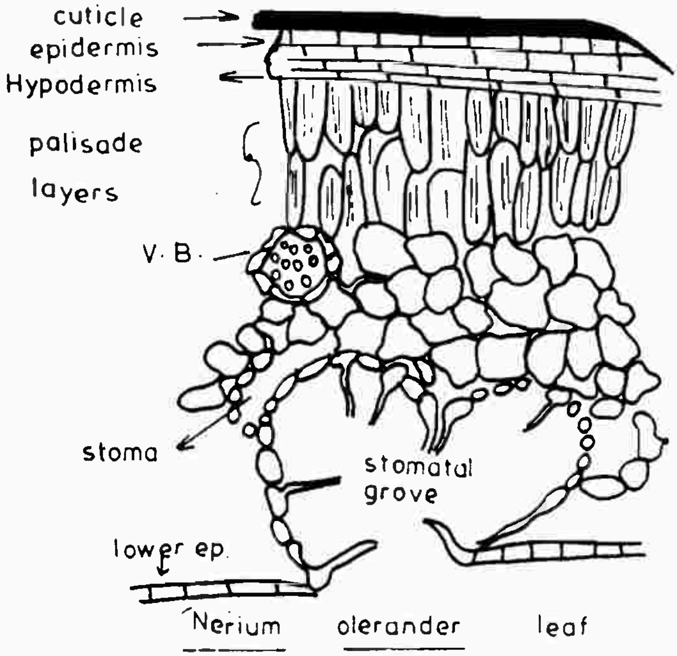


Fig : 32

9 - Modification of the green organs into spines

One of the morphological characteristic of the desert plants (xerophytes) is the modification of its green organs into spines . It was proved that such modification does not only reduce the total amount of transpiration as a rsult of the reduction in the transpiring surface , but also reduce the transpiration rate in a unit area . In *Zilla spinosa* - which is a very commin desert plant - it was observed that the size of its leaves is decreased with the decrease in the humidity of the environment associated with the increase in the number and size of spines . On the other hand , the leaves are larger and spines are lesser in relatively more humid contitions . Examples of this type of modification in the Egyptian desert , are *Fagonia* spp . , *Launaea spinosa* , *Capparis spinosa* etc .

TRANSPIRATION

Except in submerged aquatic plants , the amount of water retained by a plant is only a small fraction of the total absorbed by the roots . By far the greater part is transported to the aerial parts where it evaporates into the surrounding air . The loss of water as vapour from plants is known as transpiration . It was estimated that maize (Zea mays) plants respire over 98% of all the water it absorbs . Most of the rest is retained in the plant and only a minute proportion (O.2%) is used in photosynthesis . The proportions are probably representative for mesophytes growing under moderately dry conditions .

Thranspiration has often been described as a " necessary evil " . Exposure to the atmosphere of a large area of a moist cell surface is necessary to facilitate the absorption of CO 2 and O_2 by leaves , and this inevitably causes loss of water by evaporation . If plants had evolved a cuticle which allowed the free passage of CO_2 and O_2 molecules , but not water , presumably they would not transpire . Some plants show adaptations which cause transpiration to be reduced , but this is only achieved at the expense of reduced CO2 assimilation and slower growth . Closure of stomta at night , as commonly occurs , serve to conserve water a time when photosynthesis is stopped by the absence of light .

It is likely that more plants die from lack of sufficient water to replace that lost in transpiration , than from any other single cause , and even a temporary water deficit can sometimes be fatal . In many parts of the world , the yield of crops can be icresased by artificial irrigation even in periods of normal rainfall . Spraying of crops with synthetic substances (antitranspirants) which reduce the rate of evaporation of water from leaves , is often effective in increasing yields , particularly in dry seasons .

Transpiration may have some beneficial effects on plant growth . It is possible that , in some situations a plant may deplete (exhaust) the inorganic nutrient of soil in the immediate vicinity of its roots . This may occur to such an extent that growth is affected . A rapid rate of movement of water into a plant , as a result of transpiration, helps to prevent this by bringing dissolved substances to the root surface from more distant regions of the soil .

Environmetal Factors Affecting Transpiration

The rate of transpiration characeristically exhibits a diurnal periodicity which is related to various meteorelogical conditions . In general transpiration is low at night , increases rapidly after sunrise to maximum in early afternoon and falls to its low night value . Solar radiation appears to be most closely correlated with transpiration rate . One reason for this is that sunlight provides energy for evaporation . Since light energty must be absorbed before it can be utilized the colour of an evaporating surface has a marked effect on water loss both from an atmometer and a plant , being greater from a dark absorbing surface than that from one with reflectance . Light has a greater effect on transpiration than it has on evaporation and this is attributable to a reduction in the effective evaporation surface of leaves at night by closure of the stomata .

Transpiration occurs more rapidly when the air surrounding a plant is dry , than when it is wet . Air movement over a leaf surface tends to remove water vapour and to increase rate of transpiration . At high wind speeds , however , transpiration rate may fall because stomatal closure is induced by mechanical or by drying of the leaf .

If the availability of water to plant is reduced , absorption decreases because of reduction in the water potential gradient between the soil and root . An increase in the concentration of soil solution has the same effect . Reduced absorption leads to an increase in the tension of water in the xylem , this causes the potential of water in the lesf to decrease and their walls tend to dry out . This incereases the resistance of the pathway for diffusin of water from the cells into the intercelluer spaces of the leaf , which in turn reduces transpiration . When water stress becomes considerable , the stomata close and this causes a further reduction in transpiration .

Effects of plant structure on transpiration

Every plant has a characteristic rate of transpiration under a given set of environmental conditions , and this is governed by the structure of its various parts . Of particular importance in this connection are the surface area , external morphology and internal structure of the leaves .

In general , plants with large area of foliage transpire more rapidly than those with a smaller leaf area , although per unit area of leaf the rate may be lower . Plants growing in dry places often shed some of their leaves when water stresses become severe and in this way loss of water is reduced . Reduction of leaf area is one of the characteristic features of xerophytes .

The leaves of different plant species lose water at very different rates when expressed on a unit area basis . Such diferences are attributable to structural features of the leaf and in particular to the composition of the cuticle ; the number , size , distribution and stucture of stomata , and the arrangment of vascular tissue . Leaves of the same plant growing under dufferent conitions e.g. in light or in shade show differences in structure , e.g. amount of spongy mesophyll , thickness of cuticle , number of stomata which affect water loss etc .

The properties of cuticle profoundly influence transpiration especially at night when the stomata are closed . In shade plants , such as ferns , where the cuticle is thin and as much as 30% of the total water lost is transpired through the cuticle (cuticular transpirution) while as a contrast in desext succlents loss through the the cuticle is negligible .

The presence of haires and scale on the surface of leaves might be expected to increase transpiration because of the increase in surface area .On the other hand , they tend to reduce transpiration by helping to retain moist air at the leaf surface . Another effect of hairs and scales is to make a leaf surface more effective , and this may reduce transpiration because of a reduction in absorption of solar radiation . Dense hairness in often associated withe the xerophytic habit which suggests that the first effect is less important than the others .

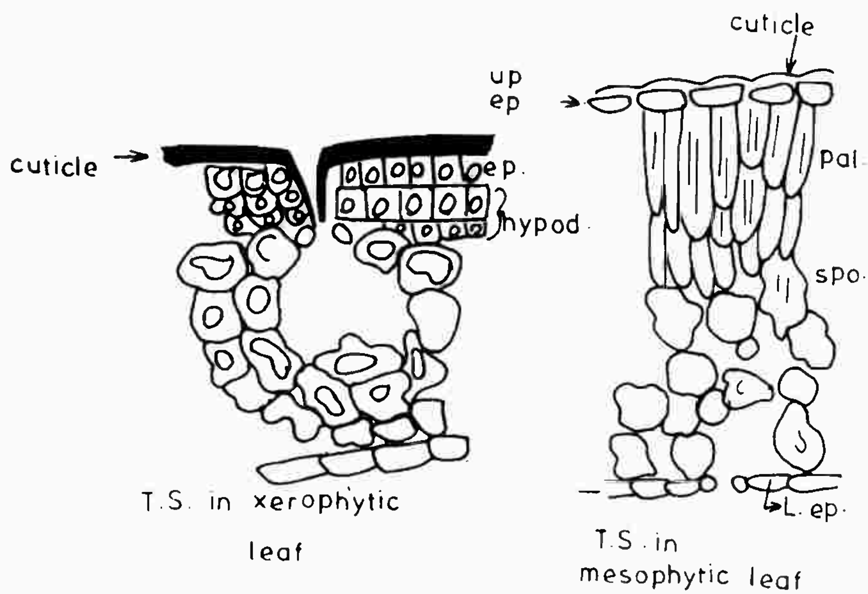


Fig . 33

Plants which transpire rapidly tend to have more water conducting elements in the stem than those which transpire slowly . Transpiration is reduced if water deficits develop in plant , and this happens when transpiration is in excess of absorption .

Adequate absorption , especially under conditions of low water supply is dependent on a well developed root system . Plants growing in dry situations commoly have a better developed root system than those of the same species growing with an abundant water supply , and desert plants in particular are characterized by having very large root area to shoot - area ratios .

Absorption of Atmosphoric Water By Leaves And Shoots

Most investigators have found evidence that there is water absorption by aerial organs of plant either from near saturated vapour or from liquid water , but the amounts have generally been small and subsequent redistribution of water within the plant have been very slow .

Whether or not the main pathway for water entry is via the cuticle or stomata is still in doubt . Since dew (the main source of water absorbed by the aerial parts)is primarly of nocturnal occurrence (i . e at night) , and since the stomata of most species are normally closed for most of the night , it seems probable that water uptake occurs primarily through the cuticle . Even if some uptake occurs via the stomata , its significance will be reduced with relatively high cuticular permeability to liquid flow .

Another possible pathway is via specialized epidermal cells . It was noted that most of the water obsorbed by *Chaetame aristata* leaves occurred through specialized cells in the epidermis . It was also noted that absorption by the upper leaf surface , where most of the cells are located , was much greater than on the under surface where stomatal frequencey could be expected to be highest .

Generally , the initial rate of water uptake by the aerial parts would be inversely related to leaf water content .

Transfer of the absorbed water through the plant can be expected to follow normal pathways and be subject to similar resistance and driving forces as transpiration . Thus , with plants rooted in soil , even when the soil is dry at the permanent wilting percentage , the plants regained turgid and the soil still dry . This may be due to the fact that absorption of water by leaves generally appears to be very slow and the quantity of water absorbed are usually quite small . Also , although transfer of this water to other branches is quite sure , the rate of internal movement appears to be fairly slow. Consequently , the amount of water transpired to other branches and to the roots may in some cases , have been insufficient to enable recover of turgor .

The presence of liquid water on the shoots of plants can influence the water economy of the plant in two ways , directly by actual entry of water into the plant , or indirectly by reducing transpiration . Both these factors tend to reduce the degree to which leaf water deficits develop and to increase turgor and promote plant growth . Under natural conditions such phenomena could possibly occur as a result of wetting of the leaves by rain , dew or sprinkler irrigation

Although dew could never comprise more than a small proportion of the water requirement of a normally transpiring plant , it might possibly represent an important water source to plants under stress (i .e under dry conditions) . In the first place it occurs at night , at such a time water intake could accelerate the restoration of leaf turgor and hence promote growth . Furthermore , dew frequently remains on the leaves for several hours after sunrise , delaying the onset of renewed stress .

In deserts , dew reduces transpiration . Plants exposed to dew develop great length, high number of branchs and leaves , than those not exposed . This provides evidence of the direct effec of dew , either through resaturation of leaf tissues dehydrated during the day , or else by delaying the onset of the total levels of dehydraion .

Effects Of Internal Water Deficits On Plants

Many studies of anatomical , morphological and biochemical changes , and of changes in rates of physiological processes caused by lack of water have been published . A few examples of the effects of the internal water deficits in plants are discussed in the following :

1- Growth

Every - one is familiar with the stunted plants produced under drought conditions . This stunting represents both the direct and the indirect effects of severe and long - continued internal water deficit. Among the important direct effects is reduction in cell division and in cell enlargment .

Elongation of stems and enlargment of leaves of several species of plants were materially reduced by internal water deficits . As the greatest water deficit occurs near midday , and as growth at night is often limited by low temperature , maximum growth commonly occurs in the early morning and again in the evening with a distinct reduction near midday .

The anatomical differences btween sun and shade leaves probably are partly the result of differences in turgidity of cells . The frequent loss of turgidity by leaves that are growing in full sun probably checks cell enlargment and results in reduced leaf area and differences in anatomy as compared with shade leaves , which are seldom wilted .

2- Stomatal Opening

Stomata are very sensetive to a water deficit in the leaves . Stomatal closure is very closely correlated with decreased moisture content of the leaves ; the earlier in the day a moisture deficit develops , the earlier the stomata close . It was observed that the stomata of oak seedlings in dry soil were closed during the day although those on well - watered seedlings were open . The extent of opening of stomata during day may serve as a good idication of the amount of water available to the plants . Stomatal aperture is a reliable indicator of whether or not irrigation of crop plants (e . g citrus) is needed , because as soil dries , the stomata progressively close earlier in the day.

3 - Photosynthesis

A water deficit in the leaves seriously reduces the rate of photosynthesis . Decreasing soil moisture also causes decreased photosynthesis rates in plants and the amount of reduction being greatest when condition are favourable for high transpiration . Photosynthesis incrases rapidly when the soil is wetted but does not return to normal for several days

Reduction in photosynthesis may be in part a direct result of dehydration of the protoplasm of the leaves , and it may in part the result of closure of stomata .

4 - Biochemical Effects

The chemical composition of plants can be materially modified by internal water deficit . One of the most common effects is the conversion of starch to sugar . It was found that there was a low starch content in bean palnts which were subjected to a high soil moisture tension , with no difference in reducing sugar content compared to plants grow in low soil - moisture tensions . This is attributed to the fact that drought decreases the use of carbohydrates more than it decreases photosynthesis .

Wheat plants exposed to drought differ from well - waterd plants by being higher in hemicellulose and sugars, especially sucrose . Under dry conditons (drought) , soybeans produces large amounts of hemicellulose and that starch is present in larger amount than in well - watered plants . Tomato plants subjected to very high humidity for 9 days grew more rapidly and accumulated less carbohydrate than did plants grown with low humidity . High moisture streas caused by low humidity caused an increase in nitrate nitrogen and a smaller increase in soluble organic nitrogen .

Fruit grown under moderate moisture stress often differs somewhat in texture and composition from that grown with an abundance of water . It was found that pears from dry plots were sweeter in taste than those from wet plots .

5 - Permeability of Roots

Plants which have been permanently wilted often recover very slowly after the soil is watered . Although the leaves may regain their turgidity , in a few hours , the rate of transpiration and photosynthesis may not return to normal for several days . Less water will pass through the roots of wilted plants under a given pressure gradient than will pass through the roots of similar plants that have not been wilted . This decrease in water in - take might be the result of decreased permeability or of decreased absorbing surface .

THE WATER SUPPLAY OF DESERT PLANTS

By desesrts we mean arid regions with a very low and unreliable rainfall. It is generally supposed that perennial plants in suçh regions suffer from a lack of water and need special physiological adaptations such as a physiological drought resistance , low transpiration rate , high osmotic pressure .. etc . Often it is difficult to understand how perennial plants can thrive in a desert with perhaps only 25 mm of rainfall per year , e . g . around Cairo . But rainfall as such is nøt the appropriate measure to estimate the water supply of desert plants , which is considerably better than it appears if we consider only the rainfall data . Rainfall in mm means the amount in litres per square meter , therefore it is also necessary to compare it with the transpiring surface of the plants per square meter . To understand properly the water economy of deser-yt plants , we must keep two facts in mind :

1- The density of the vegetation decreases in arid countries with the decreasing ranifall .

2- In extremely dry countries with a very low vegetative cover-density , the amount of run - off increases and the water is unevenly distributed in the soil after a rain . The major portion of the soil remains dry (the water rund off and does not penetrate into the soil) and on a small part of the area (depressions , runnels , wadis) the water accumulates and penterates quite deep into soil .

The decrease in rainfall and consequent reduction in plant cover - density in arid regions creats a greater distance between individual plants and cause the water penetration into the soil to become deep . Therefore,the root systems of plants in arid regions are deepen and some have a greater horizontal growth . The shoot - root growth ratio also decreased with the rainfall . Some physiological experiments allow the supposition that the growth of shoot is more reduced than the growth of roots , as the water supply of the plants becomes more cretical .

Under humid conditions the osmotic pressure is low , therefore we have to expect a vigorous shoot and side root growth , but slow growth of the main root . With increasing aridity the osmotic pressure increases , the growth of the shoot is retarded , also that of side roots , but elongation of main root is increased . This is an accordance with the facts observed in the field : the shoot/root ratio of plants in arid riegions decreaes with the rainfall . *Trifolium* was grown in moist soil (80% of the water capacity) and in dry soil (40% of the water capcity) . During the first week the total increase in dry weight of the plants was the same in both cases (16 gm) , although the ratio of the shoots to the roots decreased apprecially in the dry soil as follows :

Trifolium sp Percentage of total dry weight of plants in moist and dry soil :

Plants in	1 - Shoots	2 - Roots	Ratio 1 : 2
Moist soil Dry soil	66.0 % 41.4 %	34.0 % 58.6	1.94 0.71

In an area where the rainfall becomes less than 100 mm , the second factor , the run - off , is more important . This is primarily due to the low density of the vegetation , and consequently even in nearly flat deserts the run - off is extremely high . The water penetrates into the soil more readily in sandy runnels or depressions moistening the soil to a greater depth . Following the rain the upper layer of the soil dries out , although in the deeper layers the moisture may be conserved for years.

The type of vegetation also changes under these conditions . The **diffuse type** " , that is a vegetation more or less evenly distributed , given way to a " **restricted type** " , a vegetation confined only to rather restricted areas (depressions , runnels , wadis) . In this type of area , the water supply is usually adequate .

The root systems of plants in this type of situation are quite deep and correspond to the deeper water penetration .

The study on the root systems of desert plants around Cario recorded the following root penetration depths :

species	root depth	species (m)	root depth (m)
Pituranthus tortuosus	5.0 m	*Moltkia callosa*	4.00 m
Farsetia aegyptiaca	3.30 m	*Zilla spinosa*	2.80 m
Convolvulus lanatus	2.50 m	*Euphorbia cornuta*	2.30 m
Centaurea aegyptiaca	2.10 m	*Fagonia arabica*	1.20 m

The adeptation of the perennial desert plants seems to be chiefly a morphological one rather than a physiological one . The chief adaptations are the reduction of the transpiring surface , the better development of the main root system , and the ability to reduce water loss during prolonged drought periods to nearly nil .

The succulents prefer an arid climate with two rainy seasons in order to refill their water storage tissues . During the dry seasons the succulents can remain without water uptake . Therefore , their root system is weakly developed and shallow . The water economy of succulent plants is quite different from that of other xerophytes . Succulens are drought resistant rather than drought tolerant .

The annual or ephemeral plants and also the geophytes in arid countries grow during the short periods when water is in abundance . Their water supply is guaranteed and therefore does not present any problems for them .

Evapo - Transpiration

Water losses from soils occur in two ways : (1) by the evaporation of water at the soil surface , and (2) by transpiration from the leaf surfaces of water which has been absorbed by the plants and translocated to the leaves . The combined loss resulting from these two processes , termed evapo - transpiration , is responsible for most of the water removal from soils under normal field conditions . On irrigated soils located in arid regions , for example, it is commonly account the loss of 30 to 40 inches of water during the growing season of a crop such as alfalfa . Obviously , the phenomenon is of special significance to growing plants .

Factors Affecting Evapo - transpiration

These are the following :

1- **Radient Energy :** Much thermal energy is required to evaporate water , whether from soil directly or from leaf surface . The primary source of this energy is the sun . The radient energy absored by soils and plants varies greatly from area to area and from day to day within a given area . Thus , the solar heat is high in regions such as the southwestern part of USA , Egyptian Western and Eastern Deserts , Arabian Desert, ... etc , where there is little cloudiness to reduce the full sunshine . In the humid regions , by contrast , there is less direct sunshine and the annual solar energy is low . In any given area , there are notable day - by day variations in solar heat because of the presence or absence of clouds .

So long as moisture is available for evaporation , one would expect a close relationship between evaporation and the absorption of radient energy .

2 - Atmospheric Vapour Pressure

The vapour pressure of the atmosphere helps to control evapoation from soils and transpiration of plants . If it is low compared to the vapour pressure at the plant and soil surfaces , evaporation takes place rapidly . If it is high , such as the case on " humid " days , evaporation is slow . The atmospheric vapour pressure markedly influences evapo - transpiration as shown by the relatively high vapour losses from irrigated soils in arid climates . In humid rigions with comparable temperatures , evaporation losses are considerably less .

3 - Temperature

Evaporation of water is greatly influenced by temperature . Consequently , during warm and hot days , the vapour pressure at the leaf surfaces or the surface of a moist soil is quite high.Temperature does not have a similar direct effect on the vapour pressure of the atmosphere . As a result , on hot days there is a large difference in vapour pressure between leaf or soil surfaces and the atmosphere - a greater vapour - pressure gradient - and evaporation proceeds rapidly . The fact that on bright , clear days plants and especially soils may by warmer than atmosphere futher emphasizes the importance of temperature in controlling evapo - transpiration .

4 - Wind

A dry wind will continually sweep away moisture vapour from a wet surface . The moist air moved is replaced by air with a lower content of moisture . This tends to maintain the vapour - pressure gradient and evaporation is greatly encouraged . The drying effect of even a gentle wind is noticeable even though the air motion may not be at a particularly low humidity level . Hence , the capacity of a high wind operating under a steep vapour - pressure gradient to enhance eveporation both from soils and plants is tremendous .

5 - Soil Moisture Supply

In discussing the influence of the other factors on evapo - transpiration , the assumption has been made that the soil and plant surfaces are plentifully supplied with moisture . Under these conditions , the climatic factors already considered will largely control vapour losses . At lower moisture content , however , soil moisture tension will limit the rate of supply of water to the soil and plant surfaces and evapo - transpiration losses will decrease accordingly , see Table below .

Moisture Condition of soil	Evapo - transpiration (inches)	
	Corn	alfalfa
High	17.7	24.4
Medium	12.7	20.5

As moisture is depleted from the soil surface and the root zone, evaporation losses decreases. The plant responds to this moisture deficiency by the closing of leaf stomata and ultimately by wilting. In the soil, capillarity will at first partially replenish moisture lost by evaporation at the surface. With time, however, the rate of loss by evaporation and plant uptake will deplete the surface soil. Capillarity to the upper layers will then be too slow to be of such practical importance. Under these conditions, some movement of moisture in the vapour phase from lower horizons will then take place.

Evaporation versus Transpiration

The relative amounts of water removed from soil by evaporation and by transpiration are of interest. In general, considerably more water is lost from an area by transpiration than would be lost by evaporation from the same soil surface having no vegetation. An experiment showed that a tank with bare soil surface lost 18.9 Ib./sq. ft. of surface over a period of 4 years (equicalent to 3 3/8 inch of water). A 4 year - old prune trees growing in a similar tank lost, 1,250 Ib. of water by transpiration in one growing season. Another field experiment showed that about 85% of the water loss from a stand of *Andropogon sp*. was by transpirotion and about 15% by evoporation from soil surface.

Hydrologists are concerned with the amount of water lost by transpiration and evaporation, because it affects the water reserves of an area. Transpiration may even be great enough to cause daily fluctuations in the level of the ground - water table. It was found that the water level in test wells began to fall at 9 to ll a. m. and reached its lowest level at 6 to 7 p. m, then rose during the night. Numerous measurements have been made by hydroligists of what they term **consumptive use of water.** This is the total amount of water lost by evaporation plus that absorded (or intercepted) by the plant cover of an area. These sources of loss are combined because it is difficult (or even impossible) to measure them separately over a large area. Measurements of consumptive use have been by growing crop plants and native vegetation in large containers.

Water consumption is much greater if the water table is near the surface than if it is at a depth of several feet. In general it appears that, on an area basis, considerable more water is lost by transpiration of the supply is always abundant than if it is somewhat limited at times.

This is partly because larger shoots are produced when there is an abundance of water and partly because the rate of transpiration in this case is less often retarded by wilting and stomatal closure .

Lysimetry

Lysimetry in its various forms is the only hydrological method in which the experimenter has complete knowledge of all the terms of the following equation .

$$E = W - (Qr + Q1 + Qi + \Delta Qw + \Delta Qs) / A$$

E = Evaporation W = precipitation Qr = volume of surface and subsurface runoff catchment Q1 = volume of leakage from catchment (not measured in Qr) Qi = volume of intercepted water .

Δ QW = volume change in ground water storage .

Δ QS = " " " water stored above water table .

A = area (catchmant)

Lysimetry is of importance not only for gathering evaporation information but also as an independent check of the suitability of micrometeorological methods and for calibarating emperical formula used for estimating evaporation .

A lysimeter is a device in which a volume of soil , which may be planted by vegetation , is located is a container to isolate it hydrologically from the surrounding soil . Lysimeters are constructed to make Qr = O . Although lysimeters are well defined hydrologically , they must be repesentative samples of the surrounds if they are to provide useful evaporation measurements . Representative of soil (thermal , moisture , and mechanical properties) and of the vegetation (height , density , physiological well - being) is necessary . The intended use of the lysimeter will dictate the design and operation necessary to obtain suitable representiveness . Major factors affecting design include :

(1) whether measurements of potential evaporation or measurements of E under drought are needed ; (2) the sturucture of the vegetation (grass , hay , rowe crops , ect .) and of the roots (deep , shallow , etc .) and (3) the period over which the evaporation is to be measured (hours , days or months) . These factors influence the design of the ly-

simeter with respect to depth and moisture control , area , and the method of measuring water loss from the lysimeter . Design and operation also are affected by other factors .

The evaporation from single plants in pots may be found by weighing the pot , and the evaporation from leaves may be found either with potometers or by weighing out leaves . These standard techniques are simplified lysimeters .