Biogeography

SOILS:

Soils constitute a major element in the natural environment, linking climate and vegetation, and they have a profound effect on man's activities through their relative fertility. The scientific study of soils is known as **pedology**; the process of soil formation is referred to as **pedogenesis (soil genesis)**

Soil is the upper weathered layer of the Earth's crust affected by plants and animals. A vertical section through this zone constitutes a soil profile; in each soil profile there are usually several distinguishable layers or horizons, which enable different types of soil to be recognized.

Soil contains matter in all three states: solid, liquid and gaseous. The solid portion is partly organic and partly inorganic. The inorganic, or mineral, part of the soil is made up of particles derived from the parent material, the rocks which weather to form the soil. The organic portion consists of living and decayed plant and animal materials such as roots and worms. The end-product of decay is humus, black amorphous organic matter. Soil water is a dilute but complex chemical solution derived from direct precipitation and from run-off, seepage, and groundwater. The soil atmosphere fills the pore spaces of the soil when these are not occupied by water.

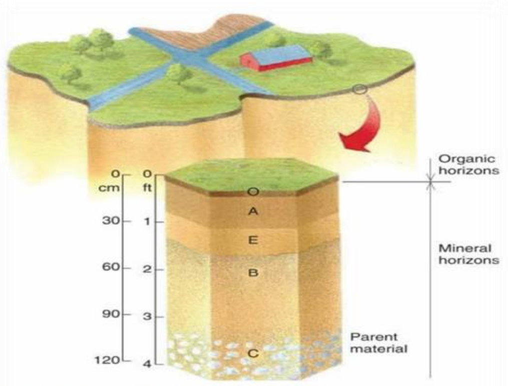
The texture of a soil refers to the sizes of the solid particles composing the soil. The sizes range from gravel to clay. The proportions of the different sizes present vary from soil to soil and from layer to layer. Texture largely determines the water-retention properties of the soil. In a sandy soil, pore spaces are large and water drains rapidly: in a clay soil, the individual pore spaces are too small for adequate drainage. Generally speaking, loam textures are best for plant growth.

Soil acidity is a property related to the proportion of exchangeable hydrogen ion present in the soil in relation to other elements. The degree of acidity is measured on the logarithmic pH scale which ranges from 0 (extreme acidity) to 14 (extreme alkalinity). Few soils reach these limits; a pH value of about 6.5 is normally regarded as the most favorable for the growth of cereal crops.

Colour varies considerably in soils and can tell us much about how a soil is formed and what it is made up of. In recently formed soils, the colour will largely reflect that of the parent material, but in many other cases, the colour is different from the underlying rock. Soils can range from white to black, usually depending on the amount of humus. In cool humid areas, most soils contain relatively high humus content and are generally black or dark brown, whereas in desert or semi-desert areas, little humus is present and soils are light brown or grey. Reddish colors in soils are associated with the presence of ferric compounds, particularly the oxides and hydroxides, and usually indicate that the soil is well drained, although locally the colour may be derived from a red-coloured parent material.

SOIL HORIZONS (SOIL PROFILE)

Most soils have distinctive horizontal layers that differ in physical and chemical composition, organic content, or structure. We call these layers as **soil horizons.**



10.14 Soil horizons
A column of soil will normally show a series of horizons, which are horizontal layers with different properties.

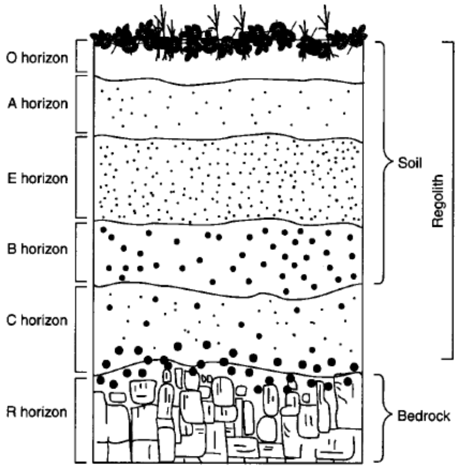
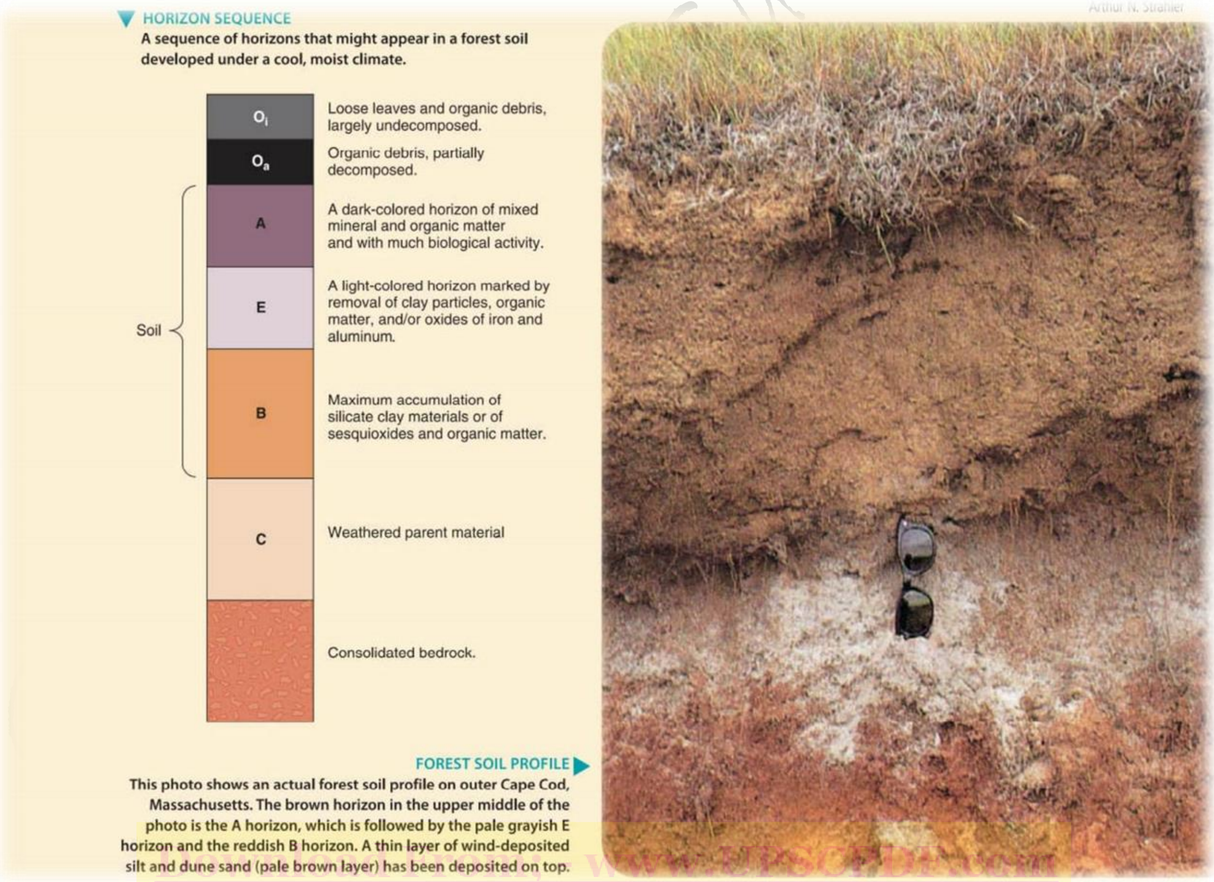


Figure 15.1 A soil profile. The layers (horizons) of a typical soil. Not all soils have all the horizons.



They develop through interactions among climate, living organisms, and the land surface, over time. Horizons usually develop either by selective removal or accumulation of certain ions, colloids, and chemical compounds. This removal or accumulation is normally produced by

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water seeping through the soil profile from the surface to deeper layers. Horizons often have different soil textures and colors .A soil profile, as shown in Figure, displays the horizons on a cross section through the soil.

There are two types of soil horizons: organic and mineral.

Organic horizons, marked with the capital letter **O**, lie over mineral horizons and are formed from plant and animal matter. The upper O_i *horizon* contains decomposing organic matter that you can easily recognize by eye, such as leaves or twigs. The lower O_a *horizon* contains humus, which has broken down beyond recognition.

There are four main mineral horizons. The ***A horizon*** is enriched with organic matter, washed downward from the organic horizons. Next is the ***E horizon***. Clay particles and oxides of aluminum and iron are removed from the ***E horizon*** by downward-percolating water, leaving behind pure grains of sand or coarse silt.

The ***B horizon*** receives the clay particles, aluminum, and iron oxides, as well as organic matter washed down from the A and E horizons. It's dense and tough because its natural spaces are filled with clays and oxides.

Beneath the ***B horizon*** is the ***C horizon***. It consists of the parent mineral matter of the soil. Below this regolith lies bedrock or sediments of much older age than the soil. <u>Soil scientists limit the term *soil* to the A, E, and B horizons, which plant roots can readily reach.</u>

SOIL FORMING PROCESSES

There are four classes of soil-forming processes: ***soil enrichment, removal, translocation, and transformation.***

Soil Enrichment

In ***soil enrichment***, matter—organic or inorganic—is added to the soil. Surface mineral enrichment of silt by river floods or as wind-blown dust is an example. Organic enrichment occurs as water carries humus from the O horizon into the A horizon below.

Removal Process

In ***removal*** processes, material is removed from the soil body. This occurs when erosion carries soil particles into streams and rivers. ***Leaching***, the loss of soil compounds and minerals by solution in water flowing to lower levels is another important removal process.

Cheluviation is downward movement of materials in the soil which is very similar to leaching. However cheluviation occur through the influence of organic agents which are also referred to as chelating agents. The process involves plant acids rather than mere water as the case with leaching.

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Translocation Process

Translocation describes the movement of materials upward or downward within the soil.

Downward Translocation: Fine particles particularly clays and colloids are translocated downward, a process called **eluviation**. This leaves behind grains of sand or coarse silt, forming the ***E horizon***. Material brought downward from the ***E horizon***—clay particles, humus, or sesquioxides of iron and aluminum—accumulates in the ***B horizon***, a process called **illuviation**.

The topmost layer of the soil is a thin deposit of wind-blown silt and dune sand, which has augmented the soil profile. Humus, moving downward from decaying organic matter in the ***O horizon***, has enriched the **A horizon**, giving it a brownish color. Eluviation has removed colloids and sesquioxides from the whitened ***E horizon***, and illuviation has added them to the ***B horizon***, which displays the orange-red colors of iron sesquioxide.

The translocation of calcium carbonate is another important process. In moist climates, a large amount of surplus soil water moves downward to the groundwater zone. This water movement leaches calcium carbonate from the entire soil in a process called ***decalcification***. Soils that have lost most of their calcium are also usually acidic, and so they are low in bases. Adding lime or pulverized limestone will not only correct the acid condition, but will also restore the missing calcium, an important plant nutrient.

In dry climates, annual precipitation is not sufficient to leach the carbonate out of the soil and into the groundwater below. Instead, it is carried down to the ***B horizon***, where it is deposited as white grains, plates, or nodules, in a process called ***calcification***. **Calcification** can produce a cemented layer, known as a *hard pan* that interferes with both eluviation and illuviation. This renders the soil less fertile by preventing the exchange of nutrients.

In colder climates, a pan can also form from the accumulation of oxides of iron and aluminum by illuviation. This type of pan can block drainage and keep the soil saturated for long periods, resulting in chemical reducing conditions.

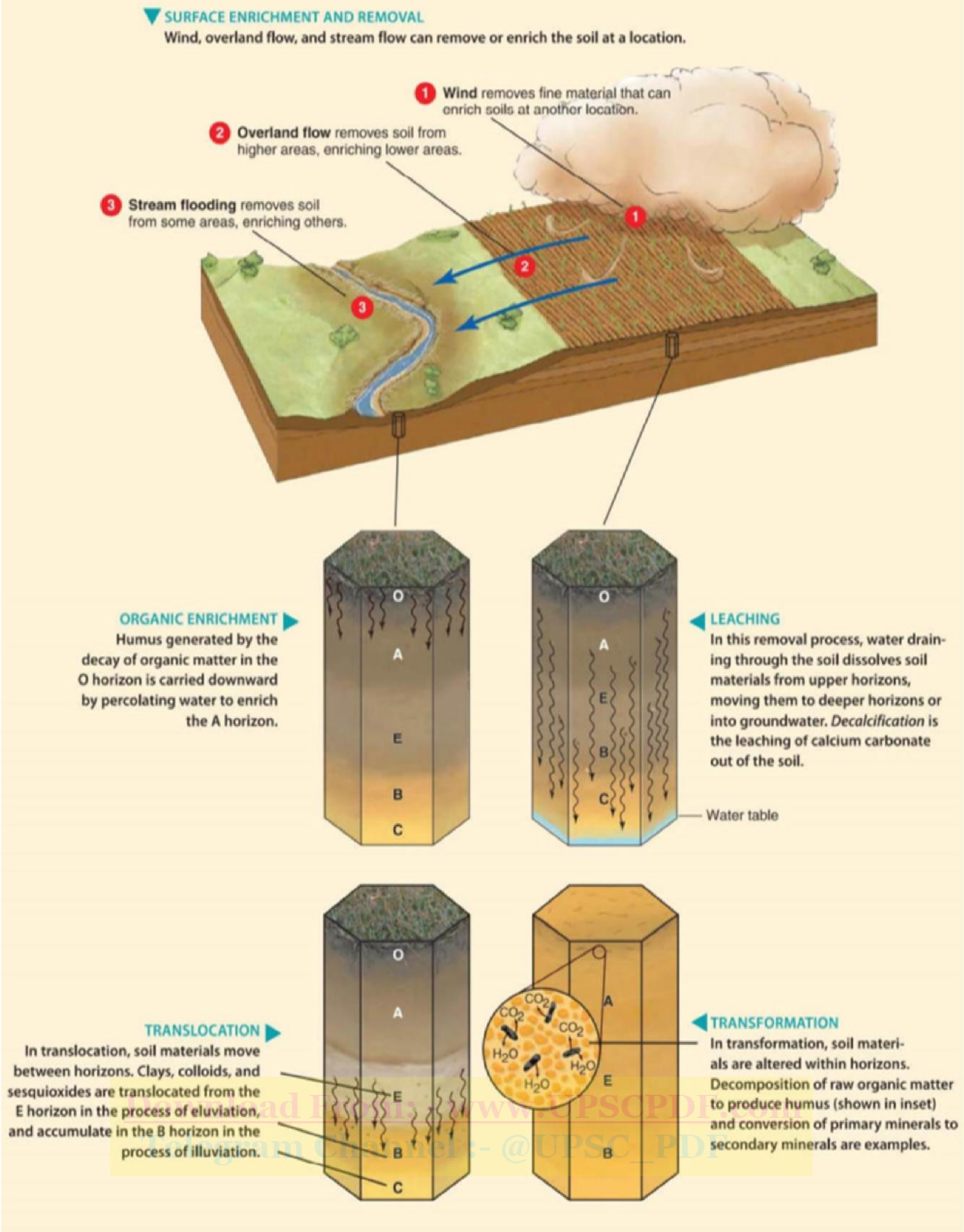
Upward translocation can also occur in desert climates. In some low areas, a layer of groundwater lies close to the surface, producing a flat, poorly drained area. As water at or near the soil surface evaporates, groundwater is drawn upward to replace it by capillary tension, much like a cotton wick draws oil upward in an oil lamp. This groundwater is often rich in dissolved salts. When the salt-rich water evaporates, the salts are deposited and build up. This process is called ***salinization.*** Large amounts of these salts are toxic to many kinds of plants. When salinization occurs in irrigated lands in a desert climate, the soil can be ruined, with little hope of revival.

Transformation Process

The last class of soil-forming processes involves the ***transformation*** of material within the soil body. An example is the conversion of minerals from primary to secondary types, another example is decomposition of organic matter by microorganisms to produce humus, a process termed as ***humifcation***. In warm moist climates, transformation of organic matter to carbon dioxide and water can be nearly complete, leaving virtually no organic matter in the soil.

10.16 Soil formation processes

Enrichment, removal, translocation, and transformation are four important processes of soil formation.



FACTORS CONTROLLING SOIL FORMATION

Climate

Climate, measured by precipitation and temperature, is an important determinant of soil properties. As we have seen, precipitation controls the downward movement of nutrients and other chemical compounds in soils by translocation. If precipitation is high, water will wash nutrients deeper into the soil and out of reach of plant roots. If precipitation is low, salts will build up in the soil and restrict fertility.

Soil temperature affects the chemical development of soils and the formation of horizons. Below 10°C, biological activities are slowed; and at or below the freezing point (0°C; 32°F), biological activity stops and chemical processes affecting minerals are inactive. Thus, decomposition is slow in cold climates, and so organic matter accumulates to form a thick ***O horizon***. This material becomes humus, which is carried downward to enrich the ***A horizon***. In contrast, bacteria rapidly decompose plant material in the warm, moist climates of low latitudes. ***O horizons*** are lacking, and the entire soil profile will contain very little organic matter.

Organisms

Living plants and animals, as well as their nonliving organic products, have an important effect on soil. Plant roots, by their growth, mix and disturb the soil and provide organic material directly to upper soil horizons.

Organisms living in the soil include many species, from bacteria to burrowing mammals. Earthworms continually rework the soil not only by burrowing, but also by passing soil through their intestinal tracts. And moles, gophers, rabbits, badgers, prairie dogs, and other burrowing animals make larger, tube like openings.

Relief

The configuration, or shape, of the ground surface, known as ***relief,*** also influences soil formation. Generally speaking, soil horizons are thick on gentle slopes and thin on steep slopes. This is because the soil is more rapidly removed by erosion on the steeper slopes. In addition, slopes facing away from the Sun are sheltered from direct insolation and so tend to have cooler, moister soils. Slopes facing toward the Sun are exposed to direct solar rays, raising soil temperatures and increasing evapotranspiration.

Parent Material

Soil chemistry is influenced by the original source of parent material. For example, iron-rich bedrock produces soils rich in iron oxides, whereas limestone forms calcium-rich soils. Some types of secondary minerals, weathered from particular primary minerals, can produce soils with unique properties. Also, soil texture is largely determined by the size of mineral grains within the parent material.

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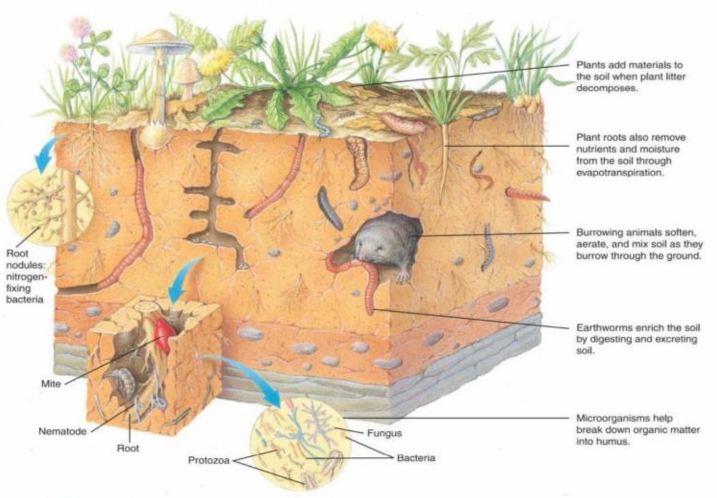
Time

The characteristics and properties of soils require time for development. For example, a fresh deposit of mineral matter, like the clean, sorted sand of a dune, may require hundreds to thousands of years to acquire the structure and properties of a sandy soil. A soil scientist's rule of thumb is that it takes about 500years to form 2.5 cm (1 in.) of topsoil.

Human Activity

Human activity also influences the physical and chemical nature of the soil. Clearing of native vegetation for crops can induce erosion, removing upper layers that are rich in organic matter. Large areas of agricultural soils have been plowed and planted for centuries. As a result, both the structure and composition of these agricultural soils have undergone great changes. These altered soils are often recognized as distinct soil classes that are just as important as natural soils.



10.17 Soil organisms

The diversity of life in fertile soil includes plants, algae, fungi, earthworms, flatworms, roundworms, insects, spiders and mites, bacteria, and burrowing animals such as moles and groundhogs. Soil horizons are not drawn to scale.

THE CLASSIFICATION & DISTRIBUTION OF SOILS:

It is very difficult to achieve a classification of soils that is both meaningful to the geographer and at the same time an accurate reflection of all soil types and gradations**.** Two main types of classification used today may be recognized as those based on the assumed origins of the soil; and those based on the observable properties of the profile. Examples of each are given below.

ZONAL SYSTEM:

One of the most popular classifications of soils has been the zonal system. This was proposed many years ago by Russian pedologists (Dukuchaiev, Glinka) who recognized the strong relationship between climate, vegetation and soil zones throughout the world. Three main classes of soil are recognized.

1. ***Zonal soils*** are those that are well developed and reflect the influence of climate as the major soil-forming factor.
2. ***Intrazonal*** types are well-developed soils formed where some local factor is dominant.
3. ***Azonal*** soils are those that are immature or poorly developed.

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World Pattern of Soil

Zonal Types:

Podzols (ash-soil):

The effect of the cheluviation process is to produce soils with a characteristic bleached E horizon. In some profiles, the humus is washed down the profile and accumulates as a humus-enriched B horizon, forming a **humus podzol**. In others, there is a marked concentration of iron oxide at this level, forming an **iron podzol**. Sometimes this takes the form of an iron-pan, impeding drainage, and resulting in a **gley podzol**. Podzols of these three types are most wide-spread in the cool climates immediately **south of the tundra region**, and are found typically in association with coniferous forest.

Brown Earth:

These soils are found equator ward of the main podzol zone in milder climates supporting a deciduous forest cover. The soils still exhibit leaching, but of a far less intense nature than podzols. Although free calcium is absent from the upper part of the profile, there is no downward movement of sesquioxides, and their dispersed distribution gives rise to the overall brown colour of the soil. In addition, humus is well distributed throughout the profile and is less acidic than in podzols. Brown earths are widespread in **Britain**, except in the highland areas

Tundra Soils:

The great variations that exist in the patterns of ground ice in the tundra cause equally complex variations in soils. Where slope conditions are fairly stable, the slow rate of plant decomposition usually results in the presence of a peaty layer at the soil surface. In areas of active slope movement, soils are inevitably thin. In the most extreme conditions where there is no plant growth, the soils are ahumic. The **brown polar desert soils** of the **Antarctic** are of this nature. By way of contrast, the birch-forested tundra margins in the northern hemisphere possess Arctic brown forest soils, characterised by a thick dark organic *A horizon*.

Sierozems:

Sierozems of desertic and semi-desertic areas can be regarded as extreme forms of chestnut soils in which lime and gypsum come even nearer to the surface because of upward capillary attraction. Since most of the plants are adapted to arid conditions, there is little leaf fall, and organic matter in these soils is low. However, when irrigated, Sierozems can be very fertile, because of their high base status.

Chernozem, Chestnut and Prairie Soils:

The best examples of ***chernozems*** and their variants are found in association with **steppe or prairie vegetation**. The light rainfall of these areas leads to incomplete leaching and the formation of a calcium-rich horizon deep in the profile. Above this is a deep dark layer of soil which can be up to a meter thick. The humus content of this layer is surprisingly often no more than ten per cent, the dark colour being associated with the base(alkaline)-rich mineral matrix. Chernozems have a well-developed crumb structure. The ideal parent material for this soil seems to be loess, which is widespread in the **mid-west of North America, Russia and northern China.**

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Chestnut soils occur on the arid side of the Chernozem belt under a natural vegetation of low grass-steppe. The illuvial carbonate layer is closer to the surface than in chernozems and they have a lower organic content.

Prairie soils occupy the transition zone of increasing wetness between chernozems and forest brown earths

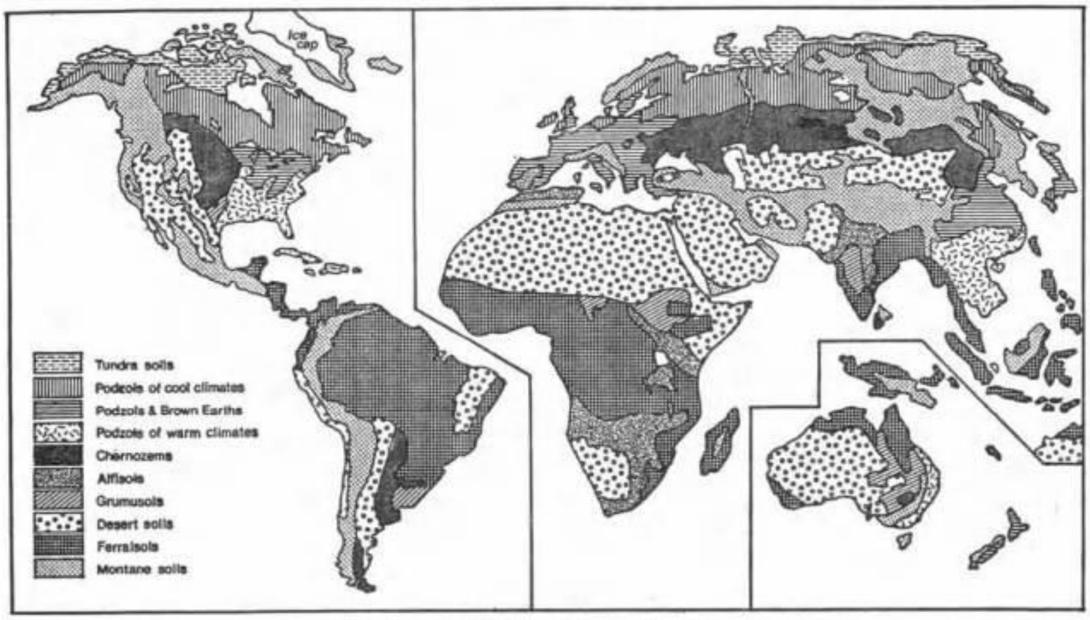

Fig. 18.4. World pattern of soils (zonal types).

Grumusols:

These are dark clayey soils of savanna or grass-covered areas which have a warm climate with wet and dry seasons. There are no eluvial or illuvial horizons, but the whole solum is rich in bases, especially calcium, and hence its dark colour. These soils are characterised by a high degree of dry-season cracking

Ferralsols:

Soils of intertropical areas are often referred to as lateritic, but strictly speaking, laterite is a weathering product and not a soil type. Most tropical soils are, however, rich in ferric oxide and are collectively known as Ferralsols. The abundance of sesquioxides of iron and aluminium accounts for the red, brown or occasionally yellow colour of the soil. The A horizon makes up the first meter of a typical profile, and is usually acidic with a low humus content. The B horizon commonly extends to fifteen meters or more and is predominantly clayey. Ferralsolic soils are low in fertility because of the lack of humus and bases.

Intrazonal Types:

Hydromorphic soils are those which have undergone gleying and are associated with marshes, swamps or poorly drained upland. Two main types can be recognized, according to the position of the water-table in the profile: groundwater gleys, where ground water is below the surface; and surface-water gleys.

Gleying is essentially the process of waterlogging and reduction in soils. In waterlogged soils where water replaces air in pores, oxygen is quickly used up by microbes feeding on soil organic matter.

Calcimorphic soils develop on calcareous parent material. **Rendzinas** are dark, organic rich, and are associated with chalk rock in **Britain**. Another **Calcimorphic** soil is **terra rossa**, which by contrast is a predominantly mineral soil and is found mainly in the **Mediterranean region**. The upper horizons are rich in clay and reddish in colour, sharply contrasting with the parent material.

Halomorphic (saline) soils are mostly found in deserts. There are three common types in this group.

- **Solanchak** (white alkali soils) develop in depressions and exhibit white salt crusts in dry periods.
- **Solonetz** (black alkali soils) are the product of intense alkalinisation and are characterised by the presence of sodium carbonate.
- **Solodic** soils develop when leaching in the presence of excess sodium causes the loss of clays and sesquioxides, forming a bleached, eluviated horizon looking rather like a podzol.

Azonal Soils:

Immature soils may exist because of the characteristics of the parent material or the nature of the terrain, or simply the lack of time for development. Such situations typically occur in areas where fresh parent material is being deposited or exposed.

For example, on active flood-plains, alluvial soils have little or no profile development, because of their frequent burial under new sediments; Regosols are composed of dry and loose dune sands or loess. Lithosols are accumulations of imperfectly weathered rock fragments on steep slopes where erosion rates remove soil almost as fast as it is formed.

A number of **criticisms** have been leveled against the zonal concept.

- One is that the zonal soil type of one climate may well be found in another. For example, podzols, normally recognized as the zonal soil type of cool continental climates, also occur in maritime areas and in the tropics.
- Another difficulty concerns the azonal class: Azonal soils are not necessarily a reflection of the lack of time for development, but may be a result of local factors that have arrested soil development over a long period.
- A third point is that soil profiles do not always reflect the prevailing climate, and may have characteristics inherited from previous climates

USDA SOIL TAXONOMY:

In recent years, the **US Department of Agriculture** has adopted a system of soil classification based on observed soil properties rather than genetic considerations. For this analysis, we will group the soil orders based on four factors that can characterize a particular order: maturity, climate, parent material, and high organic matter.

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Table 10.1 Soil Orders

Soil Order	Distribution	Characteristics
Soils Characterized by Maturity		
Entisols	Recently deposited materials or materials that don't form horizons	▪ No distinct horizons
Inceptisols	Young soils with minerals capable of further weathering and alteration	▪ Weakly developed horizons
Alfisols	Humid and subhumid climates, usually with forest cover	▪ Subsurface accumulation of clay ▪ High base status
Spodosols	Cold, moist climates, often with boreal forest cover	▪ Low in humus ▪ Low base status
Ultisols	Equatorial to subtropical zones, and warm, moist climates with a weak to strong dry season	▪ Subsurface accumulation of clay ▪ Low base status
Oxisols	Moist climates in equatorial to subtropical zones, often with rainforest vegetation	▪ Subsurface accumulation of mineral oxides ▪ Very low base status
Soils Characterized by Climate		
Mollisols	Semiarid to subhumid midlatitude grasslands	▪ Dark, organic-rich, upper horizon ▪ Loose texture ▪ Very high base status
Aridisols	Dry climates of deserts and semideserts	▪ Low content of organic matter ▪ Accumulation of salts
Gelisols	Cold, frozen climates	▪ Underlain by permafrost ▪ Subject to churning by freeze/thaw
Soils Characterized by Parent Material		
Vertisols	Clay parent material in climates with alternating wet and dry seasons	▪ Clay-rich ▪ High base status ▪ Subject to churning and cracking
Andisols	Soils developed on volcanic ash	▪ Dark, fertile soils with high amounts of carbon ▪ Found near active volcanoes
Soils High in Organic Matter		
Histosols	Cool, poorly drained areas	▪ Very high content of organic matter

Table 18.4. Major Orders of the USDA Soil Taxonomy.

Order	*Description*	*Approx. equivalents (Zonal system)*
1. Entisols	Embryonic mineral soils	Azonal
2. Vertisols	Disturbed and inverted clay soils	Grumusols
3. Inceptisols	Young soils with weakly developed horizons	Some brown earths
4. Aridisols	Saline and alkaline soils of deserts	Desert seirozems
5. Mollisols	Soft soils with thick organic-rich surface layer	Chernozems, Chestnut, Prairie
6. Spodosols	Leached acid soils with ashy B horizon	Podzols
7. Alfisols	Leached basic or slightly acidic soils with clay-enriched B horizons	Degraded chernozems
8. Ultisols	Deeply weathered, leached acid soils	
9. Oxisols	Very deeply weathered, highly leached	Ferralsols
10. Histosols	Organic soils	Bog soils

Soils Characterized By Maturity:

Where materials have been recently deposited soils have no horizons or poorly developed horizons and are capable of further mineral alteration.

Entisols and Inceptisols

1. ***Entisols*** are mineral soils without distinct horizons. They are soils in the sense that they support plants, and they may be found in any climate and under any vegetation. Entisols lack horizons, often because they are only recently deposited. They may occur in any climate or region.
2. ***Inceptisols*** are soils with weakly developed horizons, usually because the soil is quite young. Inceptisols have only weakly developed horizons. Inceptisols of river floodplains and deltas are often very productive.

Entisols and Inceptisols can be found anywhere from **equatorial to arctic latitude** zones. Entisols and Inceptisols of floodplains and delta plains in warm and moist climates are **among the most highly productive agricultural soils** in the world because of their favorable texture, ample nutrient content, and large soil-water storage.

Alfisols and Spodosols

1. The ***Alfisols*** are soils characterized by a clay-rich horizon produced by illuviation and a high base status. The world distribution of Alfisols is extremely wide in latitude, ranging from as high as 60° N in North America and Eurasia to the equatorial zone in South America and Africa Because the Alfisols span an enormous range in climate types, four important suborders of Alf sols, each with its own climate affiliation
    - ***Boralfs*** are Alfisols of cold (boreal) forest lands of North America and Eurasia. They have a gray surface horizon and brownish subsoil.
    - ***Udalfs*** are brownish Alfisols of the mid latitude zone.
    - ***Ustalfs*** are brownish to reddish Alfisols of the warmer climates.
    - ***Xeralfs*** are Alfisols of the Mediterranean climate, with its cool moist winter and dry summer. The Xeralfs are typically brownish or reddish in color.

2. ***Spodosols*** have a light-colored albic horizon of eluviation, and a dense spodic horizon of illuviation. They develop under cold needle leaf forests and are quite acidic. Spodosols are closely associated with regions recently covered by the great ice sheets of the Late Cenozoic Ice Age. Spodosols are naturally poor soils in terms of agricultural productivity. Because they are acidic, lime application is essential.

Oxisols and Ultisols

- ***Oxisols*** have developed in the moist climates of the equatorial, tropical, and subtropical zones on land surfaces that have been stable over long periods of time. We find these soils over vast areas of South America and Africa in the wet equatorial climate, where the native vegetation is rainforest.

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- ***Ultisols*** are similar to the Oxisols, but have a subsurface clay horizon. They originate in closely related environments. We find Ultisols throughout Southeast Asia and the East Indies. Other important areas are in eastern Australia, Central America, South America, and the southeastern United States. Ultisols are also vulnerable to devastating soil erosion, particularly on steep hill slopes.

Soils Characterized By Climate

Mollisols:

Mollisols are soils of grasslands in sub humid to semiarid climates. They have a thick, dark brown surface layer, termed a mollic epipedon. Because of their loose texture and high base status, they are highly productive. In North America, Mollisols dominate the Great Plains region, the Columbia Plateau, and the northern Great Basin. In South America, a large area of Mollisols covers the Pampa region of Argentina and Uruguay. In Eurasia, a great belt of Mollisols stretches from Romania eastward across the steppes of Russia, Siberia, and Mongolia.

Aridisols:

Aridisols are desert soils with weakly developed horizons. They often exhibit subsurface layers composed of an accumulation of calcium carbonate or soluble salts. With irrigation and proper management, they are quite fertile. The Aridisols are closely correlated with the arid subtypes of the dry tropical climate, dry subtropical climate, and dry mid-latitude climate.

Gelisols:

Gelisols are soils of permafrost regions that are churned by freeze/thaw ice action. They usually consist of very recent parent material, left behind by glacial activity during the Ice Age, along with organic matter that decays slowly at low temperatures.

Soils Characterized By Parent Materials

Vertisols:

Vertisols develop on certain types of volcanic rock in wet-dry climates under grassland and savanna vegetation. They expand and contract with wetting and drying, creating deep cracks in the soil. They are black in color and have a high content of the clay mineral montmorillonite, which is formed from the weathering of particular volcanic rocks. An important region of Vertisols is the Deccan Plateau of western India, where basalt, a dark variety of igneous rock, supplies the silicate minerals that are altered into the necessary clay minerals.

Andisols:

Andisols are unique soils that form on volcanic ash of relatively recent origin. They are dark in color and typically fertile. In moist climates they support a dense natural vegetation cover; they form over a wide range of latitudes and climates.

Soils High In Organic Matter

Histosols:

Histosols are organic soils, often termed peats or mucks. They are typically formed in cool or cold climates in areas of poor drainage. Throughout the northern regions of Spodosols are countless patches of **Histosols**. This unique soil order has a very high content of organic matter in a thick, dark upper layer.

GENERAL CLASSIFICATION OF SOILS

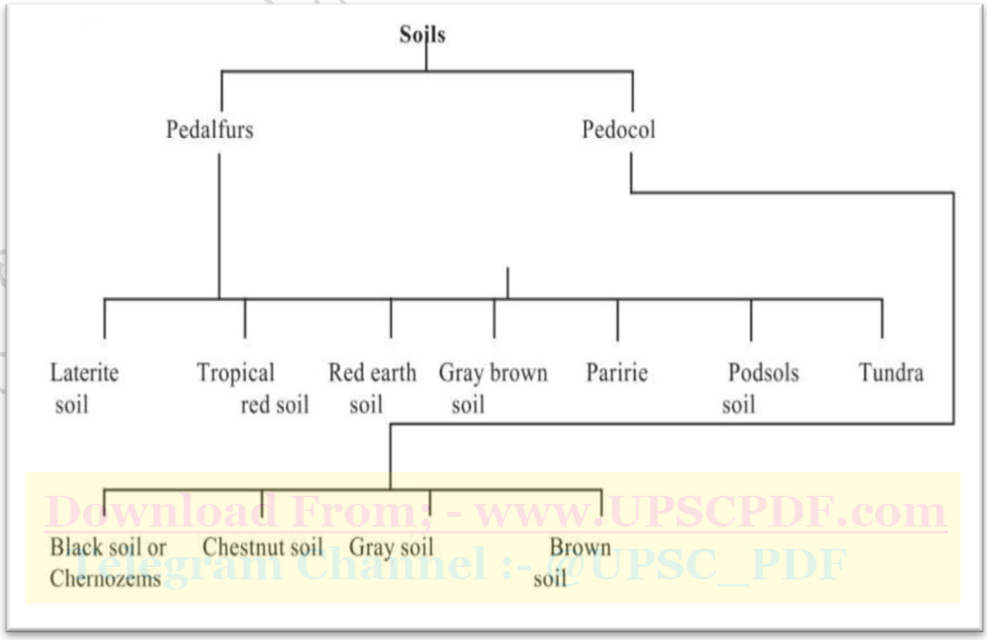
The most comprehensive basis for the classification of soils is the specific climate and vegetation under which the soil has grown and developed. Accordingly, the soils of the world can be broadly classified into two broad classes:-

Pedalfurs

These soils have grown in humid areas under rich vegetation cover. These contain a greater proportion of aluminium and iron. But these lack in such important plant food as potassium, calcium and phosphorus.

Pedocols

These soils which have grown under arid conditions. These retain all the elements which go to make plant foods. These soils are found in regions having less than 25 inches of rainfall per annum. Generally lighter in colour, they do not suffer from leaching and are alkaline. These broad classes of soil contain further sub divisions or sub-varieties on the basis of the type of vegetation cover, temperature conditions and the amount of precipitation. Their sub-varieties will be clear from the chart given below:



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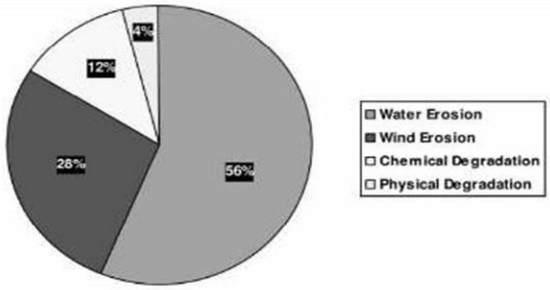
SOIL EROSION, DEGRADATION AND CONSERVATION:

Soil erosion and land degradation together, constitute one of the major problems that disturb the ecological balance of the world. Rapid increase in human population has placed a great strain on the land and soil resources resulting in land degradation and soil erosion. On a worldwide basis more than 4.85 billion acres (1.96 billion hectares) or 17% of the earth under vegetation has been degraded by humans to various extents.



ig. 17.1: A pie-chart showing percentage of world wide soil degradation agents (Modified from 'World map of the Status of Human –induced soil degradation 1990)

SOIL EROSION

Soil erosion is the loosening and displacement of topsoil particles from the land. Soil erosion is a natural process that occurs on all lands. Soil erosion may occur at a slow or fast rate. Soil erosion in nature may be (a) a slow process (or geological erosion) or (b) a fast process promoted by deforestation, floods, tornadoes or other human activities.

TYPES OF SOIL EROSION:

Soil erosion is classified on the basis of the physical agent responsible for erosion. The various types of soil erosion are consequently referred to as: (a) Water erosion (b) Wind erosion.

(a) ***Water erosion***

Running water is one of the main agents, which carries away soil particles. Soil erosion by water occurs by means of raindrops, waves or ice. Soil erosion by water is termed differently according to the intensity and nature of erosion.

(i) **Raindrop erosion:** Raindrops falling on land surface cause detachment of the soil particles. The loose soil particles are washed away by flowing water. Raindrops thus initiate water erosion. Presence of vegetation on land prevents raindrops from falling directly on the soil thus erosion of soil in areas covered by vegetation is prevented.

(ii) **Sheet erosion:** The detachment and transportation of soil particles by flowing rainwater is called sheet or wash off erosion. This is very slow process and often remains not noticed.

(iii) **Rill erosion:** In rill erosion finger like **rills** appear on the cultivated land after it has undergone sheet erosion. These rills are usually smoothened out every year

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while forming. Each year the rills slowly increase in number become wider and deeper. When rills increase in size they are called **gullies**. Ravines are deep gullies.

(iv) **Stream bank erosion:** The erosion of soil from the banks (shores) of the streams or rivers due to the flowing water is called bank erosion. In certain areas where river changes its course, the river banks get eroded at a rapid rate. Stream bank erosion damages the adjoining agricultural lands, highways and bridges.

(v) **Landslide:** Sudden mass movement of soil is called landslide. Landslides occur due to instability or loss of balance of land mass with respect to gravity. Loss in balance occurred mainly due to excessive water or moisture in the earth mass. Gravity acts on such an unstable landmass and causes the large chunks of surface materials such as soil and rocks slide down rapidly.

(vi) **Coastal erosion:** Coastal erosion of soil occurs along sea shores. It is caused by the wave action of the sea and the inward movement of the sea into the land.

*(b) **Wind erosion***

Soil erosion by wind is more common in areas where the natural vegetation has been destroyed. Such conditions occur mainly in arid and dry areas along the sandy shores of oceans, lakes and rivers. The loose soil particles are blown and transported from wind by following three ways:

(i) **Saltation:** blown by wind in a series of short bounces.

(ii) **Suspension:** transported over long distances in the form of suspended particles.

(iii) **Surface creep:** transported at ground level by high velocity winds.

<u>SOIL EROSION CAUSED BY HUMAN ACTIVITIES</u>

Certain human activities accelerate soil erosion. • Deforestation • Farming • Mining • Developmental work, human settlements and transport.

Deforestation:

Deforestation includes cutting and felling of trees, removal of forest litter. Browsing and trampling by livestock, forest fires, also leads to cause deforestation etc. Deforestation leads to erosion. Deforestation further leads to land degradation, nutrient and the disruption of the delicate soil plant relationship.

Farming:

Agriculture is a major human activity that causes soil erosion. Crops are grown, harvested, land re-ploughed, exposed to wind and rain intermittently. All this prevents replenishment of moisture. Agriculture also causes the worst type of soil erosion on farmland in the form of wash-off or sheet erosion. On the arid and semiarid areas, sand blows and sand shifts act in a similar fashion as sheet erosion does, where water is the chief agent. Consequently, a creeping effect of desertification sets in and the fertility of the land is lost progressively.

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The following agricultural practices can lead to accelerated soil erosion:

1. **Tilling or ploughing** increases the chances of erosion because it disturbs the natural soil surface and protective vegetation.

2. **Continuous cropping:** Continuous cropping of the same land and extending of cultivation of marginal and sub-marginal lands encourages soil erosion.

3. **Cultivation on mountain slopes:** Cultivation on mountain slopes without appropriate land treatment measures such as bounding, terracing and trenching cause soil erosion and loss of soil nutrients.

4. **Monoculture:** Monoculture refers to the practice of planting of the same variety of crop in the field. Monoculture practices can lead to soil erosion in three ways.

(i) A monoculture crop is harvested all at one time, which leaves the entire fields bare exposing it to both water and wind.
(ii) Without vegetation natural rainfall is not retained by the soil and flows rapidly over the surface rather than into the ground. It also carries away the top soil which results in soil erosion and degradation.
(iii) In the event any disease or pest invades the field, the entire crop is usually wiped out leaving the bare soil susceptible to water and wind.

5. **Overgrazing:** It means too many animals are allowed to feed on a piece of grassland. Trampling and grazing by cattle destroys the vegetation of the area. In the absence of adequate vegetative cover the land becomes highly susceptible to both wind and water erosion.
6. **Economic activities:** Soil erosion also occurs due to economic activities. The extraction of useful natural resources such as metals, minerals and fossil fuels etc., from the land causes serious disturbance to the land leading to soil erosion and drastic changes in the landscape.

7. **Developmental activities:** Soil erosion may also occur because of various developmental activities such as housing, transport, communication, recreation, etc. Building construction also promotes soil erosion because accelerated soil erosion takes place during construction of houses, roads, rail tracks etc. The construction of such facilities causes massive disturbance to land, resulting in soil erosion and disruption of natural drainage system

<u>Consequences of Soil Erosion:</u>

1. The fine particles of the topsoil which contain the bulk of nutrients and organic matter needed by the plants are lost from soil erosion. Wind erosion removes the finer soil material including organic matter, clay and slit, in a suspension (colloidal) form and leaving behind coarser, less fertile material.
2. Erosion may result in removal of seeds or seedlings so that the soil becomes bare. Bare soil is more vulnerable to erosion both by wind and water. Removal of seeds and seedlings reduces the ability of soil to store water.

3. Sheet, rill, gully and stream bank erosion also cause siltation of rivers, streams and fields. Deposition of silt results in damage of crops and pastures, and sedimentation of water bodies like streams, dams, reservoirs etc. Sedimentation of water bodies deteriorate water quality and damage aquatic habitats and organisms.
4. Gully erosion also results in loss of large volumes of soil. Wider deep gullies sometimes reach 30 m and thus severely limit land use. Large gullies disrupt normal farm operation.
5. Stream bank erosion not only causes loss of land, but also changes the course of a river or stream. Stream banks erosion also damage public roads. Wind erosion also damages roads and fertile agricultural fields by depositing large quantities of air blown soil particles.
6. Mass movement of land or landslides also inhibits farm production and land use. It also causes mortality in animals and humans.
7. Coastal erosion causes the adjourning land to become covered by sand.

Prevention of Soil Erosion

- It is essential to retain vegetation cover that soil is not exposed to rain, vegetation cover is important because roots of plants hold soil particles together. Plants intercept rainfall and protect soil from direct impact of raindrops.
- Cattle grazing should be controlled.
- Crop rotation and keeping the land fallow (not planting anything in the soil for some time) should be adopted
- Vegetation and soil management should be improved in order to increase soil organic matter.
- To prevent stream bank erosion runoff water should be stored in the catchment for as possible by maintaining vegetation cover and as by constructing dams for storing water
- For prevention or reduction of coastal erosion, protective vegetation along the beaches should be re-established. The best method of controlling coastal dune erosion is not to disturb the dunes and the coastal system. Further, construction of buildings and other development should be located behind the dune system.
- The vegetation cover over sandy soils should be kept above 30%.Access of wind to the soil should be controlled by leaving the stubble or mulch on the soil. (Stubble is the remains of crop left after harvesting).
- Wind speed can be broken or controlled by planting trees in form of a shelter belt.

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LAND/SOIL DEGRADATION

Degraded land is classified on the basis of productive capacity of the land. Slight degradation refers to the condition that where crop yield potential is reduced by 10%. Moderate degradation refers to 10-50% reduction in yield potential and in severely degradation means that the land has yield potential is lost more than 50% of its potential yield capacity (productive capacity).

Some causes of land degradation are:

- Use of agrochemical (chemical fertilizers and pesticides)
- Excessive irrigation
- Cultivation of high yielding plant varieties.

Agrochemical and their harmful effects on land:

Agrochemicals are applied to the soil for two main reasons namely to: (i) replenish or replace soil nutrients by using chemical fertilizers. (ii) Destroy plant pests by using toxic chemicals called pesticides.

(i) **The adverse effect of use of chemical fertilizer:-**

Plants take up nutrients from soil. Repeated crop cultivation depletes nutrients in the soil. Therefore, nutrients in soil have to be augmented periodically by applying chemical fertilizers. However, excess use of chemical fertilizers and pesticides leads to the following problems:

- Most of the chemical fertilizers used in modern agriculture contain macronutrients like nitrogen, phosphorus and potassium (NPK). Excessive addition of NPK to the soil however causes the plants to absorb more micronutrients from the soil. As a result soil becomes deficient in micronutrients like zinc, iron, copper etc, and the soil productivity decreases.
- Fertilizer which is not used by plants is washed down with rainwater and carried into water bodies, resulting in eutrophication or algal bloom leading to death of aquatic life.
- About one fourth of the applied fertilizer is not used by the crop plants and is leached down into the soil and underground water aquifer. Excess nitrates in water are harmful especially in bottle-fed infants in who cause the disease, **methaemoglobinaemia.**

(ii) **The adverse effects of the use of plant protection chemicals:-**

Toxic chemical used to kill pests of cultivated crops. These poisonous chemicals are collectively called biocides (agents that kill organism) they are not selective i.e., they not only kill the target pests but may also kill other non/not target and other useful organisms. Moreover, Biocides tend to remain active long after destroying the target organisms i.e. pests, weeds, fungi or rodents. It is persistence that makes these chemicals harmful to us.

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Problems due to excessive irrigation:

Excessive irrigation of soil may leads to water logging and accumulation of salt in the soil. Both these degrade the soil.

(i) **Water logging:** Excessive irrigation of land without proper drainage raises the water table. This causes the soil to become drenched with water or water logged. This waterlogged soil cannot support good plant growth due to lack of air particularly oxygen in the soil, which is essential for respiration of plant roots. Water logged soils lack mechanical strength and cannot support the weight of plants which fell down and gets logged thus become submerged in the mud.

(ii) **Salt affectation:** In areas of high temperature, excessive irrigation of land usually causes the accumulation of salt in the soil. This is because water evaporates fast leaving behind traces of salt in the soil. As cycles of irrigation are repeated the left over salt accumulated and forms a thick layer of grey or white effervescence on the surface. The productivity of salt affected soil is low. Plants in saline soil are unable to absorb nutrients and so face water stress (lack of water) even when moisture is abundant in the soil

Impact of high yielding plant varieties on leads to soil degradation:

High Yielding Varieties (HYV) have helped to increase food production but at the same time they have greatly impacted to the environment are manmade varieties of agricultural plants, fodder plants, forest trees, livestock and fishes. The HYVs require adequate irrigation and extensive use of fertilizers, pesticides to be successful. As we have already seen about land degradation due to agrochemical.

MEASURES FOR PREVENTING SOIL EROSION AND LAND DEGRADATION

Tree planting:

To prevent wind erosion, trees should be planted in such a way so that they break the force of the wind. The trees not only cover soil from the sun, wind and water, they also help to hold the soil particles.

Cultivation and farming techniques

Certain cultivation and farming techniques also reduce soil erosion. These include:

- Cultivation of land at the right angles to the direction of wind helps to reduce soil erosion by wind.
- **Ploughing style**: The ploughing style substantially reduces the amount of erosion. Tilling the field at right angles to the slope called counter ploughing in soil of the land helps prevent or reduce soil erosion. The ridges that are created act like tiny dams and hold the water and help its seepage into the soil instead of let it run down freely the slopes causing soil pollution. Contour ploughing can reduce soil erosion by up to 50%

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- **Strip Farming:** This method is another controlling method of soil erosion. This involves planting the main crops in widely spaced rows and filling in the spaces with another crop to ensure complete ground cover. The ground is completely covered so it retards water flow which thus soaks down into the soil, consequently reducing erosion problems.
- **Terracing**: It is another method of reducing or preventing soil erosion on mountain slopes. In this method, terraces are created on the steep slopes. Terracing is usually done on slopes, by leveling off areas on the slope to prevent the flow of water down it. There are disadvantages to terracing however, in that the terraces themselves can be easily eroded and they generally require a lot of maintenance and repair.
- The time or season at which a field is tilled can also have a major effect on the amount of erosion that takes place during the year. If a field is ploughed in the fall, erosion can take place all winter long, however if the ground cover remains until spring, there is not as much time for the erosion to take place.
- No-till cultivation is also used as a preventive method for soil erosion. Specialized machinery are available that can loosen the soil, plant seeds and take care of weed control all at once with minimum disturbance to the soil. However there is an adverse effect due to this practice as weed and insect populations can increase since they are not continuously being removed and so can compete or destroy crops.
- Polyvarietal cultivation also helps in controlling soil erosion. In this method the field is planted with several varieties of the same crop. As the harvest time varies for different varieties of the crops they are selectively harvested at different time. As the entire field is not harvested at one time and so it is not bare or exposed all at once and the land remains protected from erosion.
- Addition of organic matter to the soil is also an important method for reducing soil erosion. This is achieved by ploughing in crop residues or entire the crop grown specifically for being ploughed into the ground. Microbes in the soil decompose the organic matter and produce polysaccharides which are sticky and act in gluing in the soil particles together and thus help the soil to resist erosion.

Agriculture technologies for preventing soil degradation

i. **Organic farming or green manures:** Instead of applying chemical fertilizer for supplementing the nitrogen content of soil, we can use the natural process that involves the use of nitrogen fixing bacteria in the legume root nodules. In addition to this, the use of organic forms of fertilizers such as cow dung, agricultural wastes also improves the nutrients status of soils. This may also help to reduce the excessive and prolonged use of chemical fertilizers and thus minimize their toxic effects.

ii. **Bio fertilizers: Micro**-organisms are important constituents of fertile soils. They participate in the development of soil structure, add to the available nutritional elements and improve the physical conditions of soil. A large variety of micro-organisms are being used as biofertilisers for improving the nutritional status of crop fields.

iii. **Biological pest control (biological control):** The natural predators and parasites of pests play a significant role in controlling plant pests and pathogens. They are

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nowadays used by farmers to control or eliminate plant pests. The biological control agents of pests do not enter in the food chain or poison animals and so are not likely to harm mankind.

PROBLEMS OF DEFORESTATION AND CONSERVATION MEASURES:

Forests are ecological as well as socio-economic resource. Forests have to be managed judiciously not only because they are source of various products and industrial raw materials but also for environmental protection and various services they provide. Approximately 1/3rd of the earth's total land area is covered by forests .The forests provide habitat for wildlife, resources such as timber, fire wood, drugs etc. and aesthetic environment. Indirectly, the forests benefit people by protecting watersheds from soil erosion, keeping rivers and reservoirs free of silt, and facilitate the recharging of groundwater.

DEFORESTATION:

Deforestation is a very broad term, which consists of cutting of trees including repeated lopping, felling, and removal of forest litter, browsing, grazing and trampling of seedlings. It can also be defined as the removal or damage of vegetation in a forest to the extent that it no longer supports its natural flora and fauna.

CAUSES OF DEFORESTATION

The most common reason for deforestation is cutting of wood for fuel, lumber and paper. Another important cause relates to the clearing of forest land for agriculture, including conversion to crop land and pasture. The main causes of deforestation are:

(1)Agriculture

The expanding agriculture is one of the most important causes of deforestation. As demands for agricultural products rises, more and more land is brought under cultivation and for that more forests are cleared, grasslands and even marshes, and lands under water are reclaimed. Thus there is much more ecological destruction than gain in term of crop yield. The forest soils after clearing are unable to support farming for long periods due to exhaustion of nutrients. Once the soils become unfit for cultivation, the area suffers from to soil erosion and degradation.

(2) Shifting cultivation

Shifting cultivation or Jhoom farming is a 12000-year old practice and a step towards transition from food collection to food production. It is also known as **slash and- burn method** of **farming.** Annually about 5 lakhs hectares of forest is cleared for this type of farming. This method of cultivation causes extreme deforestation, as after 2-3 years of tilling, the land is left to the mercy of nature to recover. Even today, shifting cultivation is practiced in the states of Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Andaman and Nicobar Islands.

(3) Demand for firewood

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Firewood has been used as a source of energy for cooking, heating etc. Almost 44% of the total global wood produced fulfils the fuel requirements of the world. Close look at the pattern of utilization of wood produced will show that the developed countries utilize 16% of their share for fuel requirements. India consumes nearly 135-170 Mt (Million tons) of firewood annually and 10-15 ha of forest cover is being stripped off to meet the minimum fuel needs of urban and rural poor.

(4) Wood for industry and commercial use

Wood, the versatile forest produce, is used for several industrial purposes, such as making crates, packing cases, furniture, match boxes, wooden boxes, paper and pulp, plywood, etc. Unrestricted exploitation of timber as well as other wood products for commercial purposes is the main cause of forest degradation. For example the apple industry in the Himalayan region has led to the destruction of fir and other tree species, for making wooden boxes used for transporting apples. Similarly, plywood crates were used for packing particularly tea and other produce.

(5) Urbanization and developmental projects

Often urbanization and developmental activities lead to deforestation. The process of deforestation begins with building of infrastructure in the form of roads, railway lines, building of dams, townships, electric supply etc. Thermal power plants, mining for coal, metal ores and minerals are also important causes of deforestation.

(6) Overgrazing of forests of moderate cover by animals mainly in the tropical and subtropical and arid and semi-arid areas has resulted into large-scale degradation of natural vegetation if not the complete destruction of forests.

(7) Other causes

Recent developments everywhere in world have caused large scale environmental degradation, especially in tropical forest areas. The large amounts of resources –living and nonliving (minerals, river, land) found in these forests have attracted both industry and other developmental agencies, which have severely depleted forest cover. **Forest fires** whether natural or manmade are effective destroyers of forest covers.

<u>CONSEQUENCES OF DEFORESTATION</u>

Deforestation affects both physical and biological components of the environment.

(1) **Soil erosion and flash flood**

A shrinking forest cover coupled with over exploitation of ground water has accelerated erosion along the slopes of the lower Himalayas and Aravali hills, making them prone to landslides. Destruction of the forests has altered rainfall pattern. Lack of forest cover has resulted in water flowing off the ground, washing away the top soil which is finally deposited as silt in the river beds. Forests check soil-erosion, landslides and reduce intensity of flood and drought.

(2) **Climatic change**

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Forests enhance local precipitation and improve water holding capacity of soil, regulate water cycle, maintain soil fertility by returning the nutrients to the soil through leaf fall and decomposition of litter. Forests check soil-erosion, landslides and reduce intensity of flood and droughts. Forests have profound effect on the climate. Forest absorbed carbon dioxide from the atmosphere and help in balancing carbon dioxide and oxygen in the atmosphere. The forests play a vital role in maintaining oxygen supply in the air, we breathe. They also play a vital role in the regulation of water (water cycle) in the environment and act as environmental buffers regulating climate and atmospheric humidity.

Heat build-up in the atmosphere is one of the important problems of the century known as **greenhouse effect** is the partly caused by the result from deforestation**.** The entire Himalayan ecosystem is threatened and is under severe imbalance as snow –line has thinned and perennial springs have dried up. Annual rainfall has declined by 3 to 4%. Chronic droughts have begun even in areas like Tamilnadu and Himanchal Pradesh where they were not known earlier.

(3)**Loss of wild life**

The destruction and alteration of habitats due to deforestation causes ecological imbalance in the region concerned. The shrinkage of green cover has adverse effects on the stability of the ecosystem.

CONSERVATION MEASURES

The protection and conservation of forest resources are not only desirable but are also necessary for the economic development of a nation and maintenance of environmental and ecological balance from local through regional to global levels. Integrated Conservation Research (ICR), an ecological group of U.S.A., has launched massive programs of forest conservation in collaboration with UNESCO's MAN AND BIOSPHERE (MAB) programme.

The first and foremost task to conserve forests is to protect the existing forests from merciless and reckless cutting of trees by greedy economic man. This task may be achieved through government legislation and by arousing public interest in the importance of the forest resources.

The National Forest Policy of India has also laid down certain basic principles for proper management and conservation of the forest resources of the country such as

- Classification of forests according to functional aspects into protected forests, reserved forests, village forests etc.
- Expansion in the forest cover by planting trees in order to ameliorate the physical and climatic conditions for the welfare of the people,
- Provision for ensuring progressive increasing supplies of fodder for animals and timber for agricultural implements and firewood to local inhabitants nearer to the forests,
- Opposition to reckless extension of agricultural land at the cost of forest land,
- Extension of forested area by massive plan of tree plantation on a large-scale at war-footing so as to bring 33 percent of the country's geographical area under forest etc.

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Important measure of effective conservation of natural forest is to adapt scientific and judicious method of cutting of trees by following selective approach. Only mature and desired trees should be cut and unwanted trees of low economic value should be avoided.

To cover more and more wasteland and already deforested land with forests through vigorous planning of afforestation. Forests should not be replaced by commercially important fruit orchards. For example, cultivation of apples in many parts of the Himalayas in general and Himachal Pradesh (India) in particular has done great damage to the original stands of natural forests. Apple cultivation causes deforestation in two ways viz. (i) Apple cultivation requires clearance of land from vegetal cover and (ii) Huge quantity of wood is required for packing of apples every years.

The Integrated Conservation Research, an U.S. ecological research group, has suggested elaborate programs for the betterment of forests. These programs include (i) agro forestry, (ii) ethno botany and (iii) natural history-oriented tourism.

SOCIAL FORESTRY&AGRO FORESTRY

Social forestry is management and development of forest with afforestation on barren lands to achieve environmental benefit and rural development. The term was first used by National Commission on Agriculture, Government of India, in 1976. It was then that India embarked upon a social forestry project with the aim of taking the pressure off the forests and making use of all unused and fallow land. Government forest areas that are close to human settlement and have been degraded over the years due to human activities needed to be afforested. Trees were to be planted in and around agricultural fields. Plantation of trees along railway lines and roadsides, and river and canal banks were carried out. They were planted in village common land, Government wasteland and Panchayat land.

Government also extended incentives so that the planted sapling would be cared and maintained. Initially government encouraged free distribution of USUFRUCT species. Programme was launched as mass mobilisation programme with the intention of involving the common population.

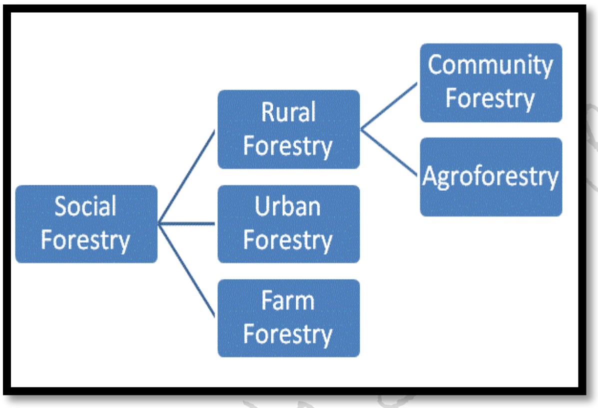
Benefits:

- ✓ Suppose to diversify non-farm options or non-crop income options for poor farmers & landless laborers.
- ✓ It was also designed to ensure better land use where waste land encroached into forestry plantation.
- ✓ The programme was supposed to be one of the initiatives under afforestation scheme with the objective of increasing farming area of India to meet the total target of 33% forest area.
- ✓ This programme became part of wasteland development programme to encourage forestry land use on slope and upstream.
- ✓ With the introduction of this scheme the government formally recognised the local communities' rights to forest resources, and is now encouraging rural participation in the management of natural resources. Through the social forestry scheme, the government has involved community participation, as part of a drive towards afforestation, and rehabilitating the degraded forest and common lands.

Shortcomings:

- ✓ Although social forestry as a concept was revolutionary but in India it was not too much success. Primarily because of wrong implementation under the incentive given to farmers & villagers to encourage Social forestry. Many farmers opted for diverting agricultural land to forestry; this compromises Agricultural prospect & food security.
- ✓ Although Programme suggested USUFRUCT species but because of lack of ecological understanding & lack of specific directive most of the plantation opted for is eucalyptus which is not ecologically suitable in Indian setting.

Types of Social Forestry:



A) Farm forestry:

At present, in almost all the countries where social forestry programmes have been taken up both commercially and non- commercially farm forestry is being promoted in one form or the other. Individual farmers are being encouraged to plant trees on their own farmland to meet the domestic needs of the family. In many areas this tradition of growing trees on the farmland already exists. Non-commercial farm forestry is the main thrust of most of the social forestry projects in the country today. It is not always necessary that the farmer grows trees for fuel wood, but very often they are interested in growing trees without any economic motive. They may want it to provide shade for the agricultural crops; as wind shelters; soil conservation or to use wasteland.

B) Urban Forestry:

It is raising and management of trees on private or publically owned lands in and around urban centres for the purpose of improving urban environment. Urban forestry includes the management of individual as well as groups of trees. Urban forestry is also not restricted to trees that have been planted. Many urban trees may have established naturally, although in an environment in which competition for land is high, they are unlikely to survive long unless actively cultivated and managed. Urban forestry also includes the management of forests at the urban fringe.

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C) Rural Forestry:

I. Community forestry:

It is the raising of trees on community land and not on private land as in farm forestry. All these programmes aim to provide for the entire community and not for any individual. The government has the responsibility of providing seedlings, fertilizers but the community has to take responsibility of protecting the trees. Some communities manage the plantations sensibly and in a sustainable manner so that the village continues to benefit. Some others take advantage and sell the timber for a short-term individual profit. Common land being everyone's land is very easy to exploit. Over the last 20 years, large-scale planting of Eucalyptus, as a fast growing exotic, has occurred in India, making it a part of the drive to reforest the subcontinent, and create an adequate supply of timber for rural communities under the augur of 'social forestry'.

II. Agro forestry:

Agro forestry is defined as a land use system which integrates trees and shrubs on farmlands and rural landscapes to enhance productivity, profitability, diversity and ecosystem sustainability. It is a dynamic, ecologically based natural resource management system that through integration of woody perennials on farms and in the agricultural landscape diversifies and sustains production and builds social institutions. It combines forestry with:

- Production of multiple outputs with protection of the resource base;
- Places emphasis on the use of multiple indigenous trees and shrubs;
- Particularly suitable for low-input conditions and fragile environments;
- It involves the interplay of socio-cultural values more than in most other land-use systems;
- It is structurally and functionally more complex than monoculture.

Agro forestry systems include both traditional and modern land-use systems where trees are managed together with crops and or/ animal production systems in agricultural settings. Agro forestry is practiced in both irrigated and rain fed conditions where it produces food, fuel, fodder, timber, fertilizer and fibre, contributes to food, nutritional and ecological security, sustains livelihoods, alleviates poverty and promotes productive and resilient cropping and farming environments.

Agro forestry also has the potential to enhance ecosystem services through carbon storage, prevention of deforestation, biodiversity conservation, and soil and water conservation. In addition, when strategically applied on a large scale, with appropriate mix of species, agro forestry enables agricultural land to withstand extreme weather events, such as floods and droughts, and climate change.

BENEFITS OF AGROFORESTRY SYSTEM:

a) Environmental benefits :

- Reduction of pressure on natural forests.
- More efficient recycling of nutrients by deep rooted trees on the site.

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- Better protection of ecological systems.
- Reduction of surface run-off, nutrient leaching and soil erosion through impeding effect of tree roots and stems on these processes.
- Improvement of microclimate, such as lowering of soil surface temperature and reduction of evaporation of soil moisture through a combination of mulching and shading.
- Increment in soil nutrients through addition and decomposition of litter fall.
- Improvement of soil structure through the constant addition of organic matter from decomposed litter.
- It is also recognized that Agro forestry is perhaps the only alternative to meeting the target of increasing forest or tree cover to 33 per cent from the present level of less than 25 per cent, as envisaged in the National Forest Policy (1988).
- Agro forestry is known to have the potential to mitigate the climate change effects through microclimate moderation and natural resources conservation in the short run and through carbon sequestration in the long run. Agro forestry species are known to sequester as much carbon in below ground biomass as the primary forests, and far greater than the crop and grass systems.

b) Economic benefits:

- Increment in outputs of food, fuel wood, fodder, fertilizer and timber.
- Reduction in incidence of total crop failure, which is common to single cropping or monoculture systems.
- Increase in levels of farm income due to improved and sustained productivity.
- Agro forestry has significant potential to provide employment to rural and urban population through production, industrial application and value addition ventures. Current estimates show that about 65 % of the country's timber requirement is met from the trees grown on farms. Agro forestry also generates significant employment opportunities.

C) Social benefits:

- Improvement in rural living standards from sustained employment and higher income.
- Improvement in nutrition and health due to increased quality and diversity of food outputs.
- Stabilization and improvement of communities through elimination of the need to shift sites of farm activities.

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Factors Influencing World Distribution of Plants and Animals:

Humans, animals and plants are globally distributed, they are termed cosmopolitan in their distribution some other animals have restricted distribution and they are said to be endemic.

Cosmopolitan - same and similar species widely distributed all over the world.

Endemic - same and similar species occurring in the same geographical location and in no other place. Some animal species are restricted to a particular continent for instance, the giraffe is only found in Africa and in no other part of the world, the marmoset monkeys are found only in South America. However, there are also plants and animals that are restricted to a very small area of the world. For instance, the California red wood trees which are likely restricted to California; they live for over 2000 years and they are the longest trees in the world, they can't be found in anywhere else in the world. These California red woods are example of plants with a very narrow endemic range. There may be some plants such as coconuts (*Cocos nucifera*) which have very wide endemic range which are defined throughout the tropics and they are said to be pan-tropical in their distribution.

In some cases, the pattern of distribution of plants and animals may be discontinuous or disjoint. When it is discontinuous or disjoint, then we agree that that particular animal or plant may be found in two widely separate areas in other word; they may be found let say in Central America and in Indonesia and not in any other area in between them. However, it is always the biogeographers' task to find out how this type of distribution came about in view of the fact that the distance which separates them is so great that makes it seem impossible for the species to have migrated from one area to another. An example of this type of distribution of animal is called Tapir-an animal that is found in South America and Malaysia. Certainly, questions as to how this distribution came about must have given rise to a number of theories, some of these theories include:

i. The theory of continental drift which is also known Wegener's theory or Jigsaw theory
ii. Darwin's theory of evolution
iii. Theory of plate tectonic
iv. The theory of climate

Global distribution of plants and animals depends on abiotic and biotic factors; the abiotic are the non-living factors and also the biotic factors or the living factors.

Abiotic factors affecting distribution of plants and animals

1. **Rocks**- the rocks of the lithosphere have to be weathered and the soil has to be formed before for a plant to grow. The immediate environmental factor affecting plant is therefore the soil and these soils characteristics mostly depend on the parent rock. Rocks favour certain plants; and, in some instances, differences in rocks adapt them to different species of Lichens and Mosses.

2. **Food**- all living species must have food to survive, without the food they die, this is one of the foundations for the differences in limitation of plants, animal in different locations of the world.

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3. **Air**- all living things (plants and animals) need air to breathe and for survival, air is needed for respiration to take place in organism. All living organisms only survive where there is air in abundance, when the air pressure is low, especially in higher altitudes some may find it difficult to breathe because of the insufficient amount of oxygen present at such height. Oxygen and carbon dioxides are very important for both plants and animals, oxygen is essential for respiration and it is utilized during various growth and development process, while carbon dioxide is needed for photosynthesis to take place.

4. **Water**- water enter the ecosystem through snow, drizzle, sleet, rain, hail which are generally termed as precipitation. Precipitation determines, along with mean temperature, the world-wide distribution of Biomes**.** Some animals are aquatic in nature, they must have water to live in, and on the other hand, some animals including desert rats are able to survive in arid areas where they are unlikely ever to drink water. Water is very important for vital functions, however, only animals that can conserve water are found in the deserts. The desert animals like pocket mice and kangaroo rats (and their old world counterparts, gerbils) get most of the moisture they need from the seeds and grains they eat, the reptiles have many adaptations to conserve water such as producing highly concentrated urine and nearly dry faeces that allow them to eliminate body waste without losing precious moisture. This is a similar case with the desert plants. For instance, Xerophytes, such acacia, Camel thorn tree, Saguaro, prickly pear and Joshua trees, have unique features for adaptation and for storing and conserving water. They often have few or no leaves, which reduce transpiration. The plants have fleshly stems and swollen leaves, they absorbs large amounts of water during the infrequent period of rain, thereby swelling up the stems only to contract later as moisture is slowly lost through transpiration. The Phreatophytes- are plants that grow extremely long roots; the roots allow them to acquire moisture at or near the water table

5. **Nutrients**- Nitrogen is needed to make proteins, enzymes, nucleotides and vitamins. Phosphorus is used in the formation of phospholipids and other structures.

6. **Soil-** For plants, soil type is a major factor in deciding the type and variety of species growing in a particular area as the minerals, water contents, microorganisms etc. all differ in different soils. Soil is a combination of various organic and inorganic matters and with varying content, the water retention capacity of the soil, the fertility, and presence of minerals changes. While clay soil can retain more water but less air, black soil is ideal for plant growth with balance of air and water retention capacities. The soil's pH helps the absorption of nutrients by the plant. If the soil is acidic, desertification can take place and ruin the chances for plant habitat.

7. **Temperature-** the ability to survive at extremes temperatures varies widely among plants and animals. Animals respond to variation in temperature both physiologically and behaviourally. For instance, birds and mammals are hot blooded animals (endotherms); they maintain relatively high body temperatures using the heat by their own metabolism. Other animals (such as insects, reptiles, amphibians, fish among others) are termed cold blooded (ectotherms), they regulate their body temperatures using the surrounding temperature or by using the ambient temperature. Ectotherms- use sources of heat such as solar radiation (direct

and indirect) and conduction to help adjust their body temperature, hanging the position of fur or feathers (example of such include the Carolina and Chickadee), these may seen through sweating, shivering panting, burrowing, hibernating and seeking shade in trees or water. Some desert animals may even store water in their body. Consequently, plants like animals are not able to move away in other to escape the high or the low temperatures in their environment; in this case, photosynthesis slows down or stops when temperatures get too high or too low. The leaves of trees can lose some heat by evapotranspiration (the loss of water through small holes in leaves). However, some plants may have hairy stems and leaves which helps to withstand the low temperatures, they may also have more solutes in cytoplasm to reduce freezing point while other have short growth and they grow very close to each other to resist the cold temperatures and wind.

8. **Light**- light is an important climatic factor that is used for the production of chlorophyll and photosynthesis; light has a big influence on a daily and seasonal activity of plants and animals. Light is need for photosynthesis to take place and it is the main source of energy in almost all ecosystems. Energy enters the ecosystem through the source of light- the sun.

Biotic factors affecting distribution of plants and animals

1. **Competition**- Competitive interactions have been seen to be one of the major factors that diminish populations of plants and animals from their main habitats; plants and animal compete for space, space is needed for reproduction, exercise and a feeding. There is also competition for several resources such as food, water, and mates. All of these can affect how a species is distributed; due to limited resources, populations may be evenly distributed to minimize competition, as is found in the forests habitat, where competition for sunlight produces an even distribution of trees.

2. **Predation**- Predation affects the global distribution and abundance of plant and animal species, the strength and direction of energy flow within a system and the diversity and composition of communities. Predators also play an essential role in evolution.

3. **Diseases**- plants diseases can be fungal, bacterial, viral or through animal in origin; they include insects/pest, plant diseases, and invasive weeds. These diseases affect food crops, causing significant losses to farmers and threatening food security. For instance, banana diseases, Locusts, fruit flies, armyworm, cassava mosaic and wheat rusts are very destructive to plant live; their outbreaks and upsurges can cause huge losses to crops and pastures, threatening the livelihoods of vulnerable farmers and the food and nutrition security of millions at a time. However, plant population will obviously reduce in such environment and will thrive well in areas where such diseases are not found. Animals are no left out in such situation, they are also affected by various diseases outbreaks which is brought about by global warming, which severely affect the balance of an ecosystem; this is seen through changes in animal and plant global distribution, as well as their behaviour. If there are more plants than usual in an area, populations of animals that eat that plant may increase. If one animal's population increases, the population of animals that eats that animal might also increase. Other changes in the community will cause a population to decrease. If a population

becomes diseased, the population may decrease and the population of animals that eat the diseased animals will also decrease.

4. **Humans-** Humans can influence animal and plant populations in various ways hence, causing them to migrate away from their natural habitat to a new environment. When humans develop land for houses and buildings, they cut down trees and change animal and plant habitats. Some animals like the skunk and raccoon the can adapt, but other animals can't adapt and their populations are affected. Pollution can also hurt animal and plant populations. Sometimes hunting can affect animal populations. For instance, whale populations have been lowered because of overhunting. Man contributes to the global distribution of plant animals through urbanization and agricultural activity, these developments have displaced both animals and plants from their natural habitats and some plant and animal species are forced to move to a new and strange environment since they can't cope with the harsh condition, while others have gone into extinction.

World Distribution of Animals

The study of distributional patterns of animals at global scale is carried out in different ways e.g.:

a. Collective study of the distributional patterns of all members of particular species. This involves the division of animals in definite distributional areas on the basis of the abundance of animal's species;
b. Animal distribution is also studied at community level which involves the consideration and study of total population of all individuals of all species of a given region.

It may be pointed out that the distributional patterns of animals at global or regional levels are more complex than the distribution of vegetation because animals are very much mobile. Thus no animal species is universally distributed because several factors distort the uniformity of distributional patterns of animals.

Distribution of Land Animals:

The following facts must be taken into account while studying the world distributional patterns of animals:

i. Physical environmental conditions determine the number, abundance and diversity of animals. Maximum diversity is noticed among the vertebrate animals of the land and freshwater habitats of the tropical regions.
ii. There is zonal pattern in the world distribution of animals.

This zonal pattern of the animal distribution is in two forms viz.:

(a) Horizontal zones, and
(b) Vertical zones.

- Latitudes have maximum control on the horizontal zonal patterns of animal distribution because sunlight decreases from the equator towards the poles, which means there is corresponding decrease in vegetation and its diversity towards increasing latitudes and hence species diversity also decreases from the equator towards the poles.
- It may be further pointed out that the origin and evolution of animals first took place in the tropical or the equatorial regions from where animals were dispersed to other areas. Thus the development of animal zones in the higher latitudes took place because of the dispersal and migration of animals from the animal zones of the tropical regions.
- Thus the horizontal animal zones of the higher latitudes are the result of the dispersal and migration of animals and various phases of speculation. For example, the development of temperate animal zone took place due to subtraction of animals during their migration from the tropical zone.

(iii) The animals have radiated in all directions from the centres of their origin. In other words, the animals have dispersed and migrated in all directions through various routes from the centres of their origin. Consequently, the distributional patterns of the world fauna are found in concentric zones.

(iv) The diversity of animals of any region is the result of several phases of their dispersal and colonization.

(v) The concentration of animals could be possible only in the mammals whereas the distribution of other species of animals is more widespread and is not specific.

(vi) The distributional patterns of all the animal species are not uniform because the distribution of same animal species is continuous while that of other species is discontinuous or disjunct. For example, the distribution of moose (a type of deer) is found in continuous zonal pattern in the taiga regions of North America and Eurasia whereas the distribution of Azure – winged maggie, weather fish and bitterling is discontinuous as their two continuous distribution zones in middle and western Europe and in south-east Asia are separated by an extensive zone devoid of these animals.

(vii) Oceanic islands are characterized by special types of animals because there has been minimum migration and dispersal of plants and animals to the islands because of great oceanic barriers. Hawaii island, which was never connected with any landmass in the geological history of the earth, lacks in reptiles, amphibians, freshwater fishes and mammals (except one species of bats).

A.R. Wallace attempted the classification of world animals into faunal regions in 1876. Since then a number of attempts have been made to divide the world animals into faunal regions by several scientists e.g., P.J. Darlington (1957), S.C. Kendleigh (1961), W. George (1962), De Latin (1967), W.T. Neil and M.D.F. Udavardy (1969), De Laubenfels (1970), J. lilies (1974) etc. but still the division of world animals into faunal regions as presented by A.R. Wallace is the most convincing and acceptable among all the subsequent divisions. Normally, the world is divided into the following 6 major faunal regions.

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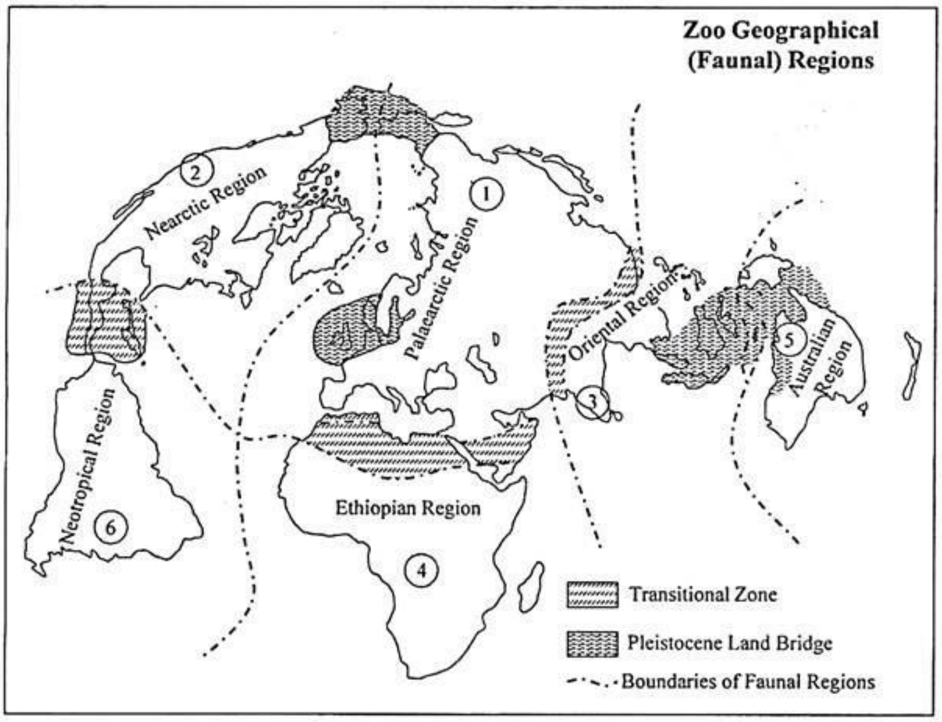

Fig. 44.2 : World distribution of land animals and major faunal regions of the world.

(1) Palaearctic Region:

Palaearctic region includes Europe and middle and north Asia which represent 28 chordate families. The important animals of this great faunal region are Russian desmans, dormice of Eurasia, Mediterranean mole rats, saiga and chiru antelope (a type of deer), acentors, crocodiles, lizards etc. Reptiles are found in lesser number.

This faunal region is further divided into 5 sub-regions on the basis of vegetation e.g.:

(i) Tundra region represents caribou, lemming, muskox, arctic hare, arctic fox, wolf, polar bear etc.

(ii) Temperate coniferous forest region- moose, mule, deer, lynx etc. are the important animals of this region,

(iii) Temperate grassland region represents saiga, wild ass, horse, camel, jerboa, hamster, jackal etc.,

(iv) Deciduous forest region represents racoons, oppossum, red fox, black bear as important animals, and

(v) Desert region – the important animals of this region are lizards, snakes, hamster, hedgehog, rat, jerboa, cottontail etc.

The Palaearctic faunal region includes 136 families of vertebrate animals, 100 genera of mammals and 174 genera of birds. Besides, 3 unique families of vertebrate animals, 35 and 57 unique genera of mammals and birds respectively are also found in the Palaearctic faunal region.

(2) Nearctic Region:

Nearctic region consists of the geographical territories of North America and Greenland. It is significant to point out that there is much similarity between Palaearctic and Nearctic faunal regions. Both the regions were connected through the Bering Land Bridge during Tertiary Epoch and Pleistocene period. This land bridge (fig.44.1) enabled free exchange and migration of animals between these two regions which resulted into much mixture of animal species and therefore increase in species diversity.

For example, American and European bisons reproduce after having sexual intercourses between them. Both the regions have salmons and trouts. On the basis of such biological similarities between Palaearctic and Nearctic regions, some scientists have grouped these two regions into one single region as Holarctic region. It may be pointed out that in the beginning, horses, pigs, goats and sheep were not present in the Nearctic region but later on these animals migrated to North America from N.E. Asia through the land-bridge of Bering Strait.

The Nearctic region is characterized by a few special and typical animals e.g. pocket gophers, pocket mice, prong- horns, wild turkeys etc. Reptiles are found in large numbers. There are 122 families of all vertebrates, 74 genera of mammals, and 169 genera of birds. Besides, 12 unique families of invertebrates, 24 unique genera of mammals and 52 unique genera of birds are also found in this region.

Nearctic faunal region is also divided like Palaearctic region in 5 sub-faunal regions on the basis of vegetation:

(i) Tundra region is characterized by the dominance of caribou, musk ox, lemming, arctic wolf, arctic fox, polar bear etc. It may be pointed out that the genera of the animals of Palaearctic and Nearctic faunal regions are the same but their species vary.

(ii) Temperate coniferous forest region includes moose, mule, deer, wolverine, lynx etc.

(iii) Temperate grassland region is characterized by bison, pronghorn, jack rabbit, prairie dog, gopher, fox, coynote etc.

(iv) Deciduous forest region includes racoons, oppossum, red fox, black bear etc. The genera of animals of deciduous forest regions of the Palaearctic and Nearctic faunal regions are almost the same but their species vary.

(v) Desert region is characterized by lizards, snakes, kangaroo, jerboa, hamster, hedgehog, cottontail etc.

(3) Oriental Region:

Oriental region includes the geographical areas of mainly south and south-east Asia. The Himalayas, Tibetan plateau and Chinese mountainous region form transitional zones between Palaearctic and oriental faunal regions. Similarly, East Indies form transitional zone between Oriental and Australian faunal regions. The whole of this faunal region falls under tropical regions and hence this faunal region is associated with the Ethiopian faunal region.

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This faunal region represents 164 families of all vertebrates, 118 genera of mammals and 340 genera of birds out of which there are 12 unique families of vertebrates, 55 unique genera of mammals and 165 unique genera of birds. This faunal region is characterized by the dominance of Indian elephants, rhinos, several species of deers, antelopes, pheasants, tigers, lizards, snakes, gibbons, monkeys, sun bear, porcupine etc. Tree shrews, gibbons, orangutans and tapirs are the typical animals of the Oriental faunal region.

(4) Ethiopian Region:

Ethiopian region incorporates substantial areas of the whole of Africa south of Sahara and far off south western Arabia which is separated from the African region by Red Sea. This faunal region also falls under tropical climatic regions. Unlike other faunal regions, this region is characterized by minimum diversity of animals though there is complete absence of moles, beavers, bears and camels in this region. This region represents 174 families (22 are unique) of vertebrate animals, 140 genera (90 are unique) of mammals and 294 genera (179 are unique) of birds.

This faunal region is further divided into 3 sub-regions:

(i) Desert region is characterized by the dominance of springbok, porcupine, jerboa, rock hyrax etc.
(ii) Savanna region represents zebra, eland, gemsbok, hartebeest, gnu, giraffe, elephant, ostrich, lion, cheetah etc.
(iii) Tropical forest region includes important animals like okapi, gorilla, chimpanzee, monkey, forest elephant etc.

There is similarity in a few animals of the Oriental and Ethiopian faunal regions like elephants, lions, cheetah etc. Hippopotamus, aardvark, ostrich and rodents and a few species of insectivorous animals are exclusively found in the Ethiopian faunal region.

(5) Australian Region:

Australian region includes Australia, New Zealand and islands between S.E. Asia and Australia (such as New Guinea, Soloman, Samoa etc.). Some scientists do not include New Zealand in the Australian faunal region. There is difference of opinions among the scientists about the linkage of this region with the oriental faunal region. This region is dominated by placental animals. Marsupials (characterized by pouch attached to the outer part of their abdomen) are the typical animals of the Australian faunal region.

These animals carry their off-springs in their pouch which has feeding mechanisms. There are 141 families (22 are unique) of vertebrate animals, 72 genera (44 are unique) of animals and 298 genera (1989 are unique) of birds.

This faunal region is further divided into 3 sub–regions:

(i) Desert region is characterized by marsupial, mole, jerboa, parakeet, lizard etc.
(ii) Savanna region is represented by emu, red kangaroo, bandicoot, wombat, cockatoo, parrot etc.

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(iii) Tropical forest region is dominated by tree and musk kangaroos, wallaby, koala, oppossum, cassowary, etc.

(6) Neotropical Region:

Neotropical region includes the whole of South America which is characterized by tropical environments. This region represents the largest number of exclusive mammals (which are not found elsewhere). About 32 families of marsupials (which are quite different from the Australian marsupials), and several typical and special families and genera of monkeys, birds and rodents are exclusively found only in this faunal region. There are 168 families (44 are unique) of vertebrate animals, 130 genera (103 are unique) of mammals and 683 genera (576 are unique) of birds in this faunal region.

This faunal region is further divided into 3 sub-regions:

(i) Temperate grassland region is dominated by guanaco, rhea, viscacha, cavy, fox, shunt etc.
(ii) Desert region is characterized by guanaco, rehea, armadilo, vulture etc.
(iii) Tropical forest region is represented by monkey, kinkajou, pygmy ant eater, sloth, tree snakes, parrot, humming birds etc

Some scientists have assigned the status of minor faunal region to those islands which have been connected with the mainland (though this concept of isolation of some islands from the mainland throughout the geological history of the earth is still debatable). Such islands include Hawaii Island, Greater Antilles, Madagascar and New Zealand. The solenodons and hutia family of rodents in Greater Antilles; tenrecs, lemurs, aye-aye, Malagasy mongooses and fossa, Malagasy rats and vanga shrikes in Madagascar and Kiwis, tustara, New Zealand frogs etc. in New Zealand are some of the important animals of such so called isolated islands.

World Distribution of Plants

There is a wide range of variations in the distribution of vegetation on the globe. There is a zonal pattern of vegetation from equator towards the poles and from seal level to vegetation level on the high mountains.

The distribution of plants is affected and controlled by a variety of factors e.g.:

(a) Climatic factors (sunlight, temperature, moisture and humidity, precipitation, soil-moisture etc.);
(b) Edaphic factors (soil nutrients, soil texture, soil structure, acidity and alkalinity, nature and properties of soil profiles etc.);
(c) Biotic factors (effects of living organisms mainly animals and man of a particular habitat on plants, interactions between different plant species and between plants and animals like natural selection, competition, mutualism, parasitism etc.);
(d) Physical factors (reliefs and topography, slope angle, gradient and slope aspect, etc.);
(e) Tectonic factors (continental displacement and drift, plate movements, endogenetic forces and movements, vulcanicity and seismic events etc.);

(f) Fire factor (forest fire-natural forest fire through lightning, man-induced forest fire-both intentional and accidental;
(g) Dispersion of plants, and
(h) Human interferences.

Distribution of plants may be attempted in a variety of ways viz.:

(i) On the basis of habitats as the distribution of terrestrial and aquatic plants,
(ii) On the basis of floral divisions,
(iii)On the basis of latitudinal and altitudinal extents, and
(iv)On the basis of characteristic features of plant communities etc.

The land plant species of the world are grouped into 6 major floristic kingdoms on the basis of their worldwide distribution as given below:

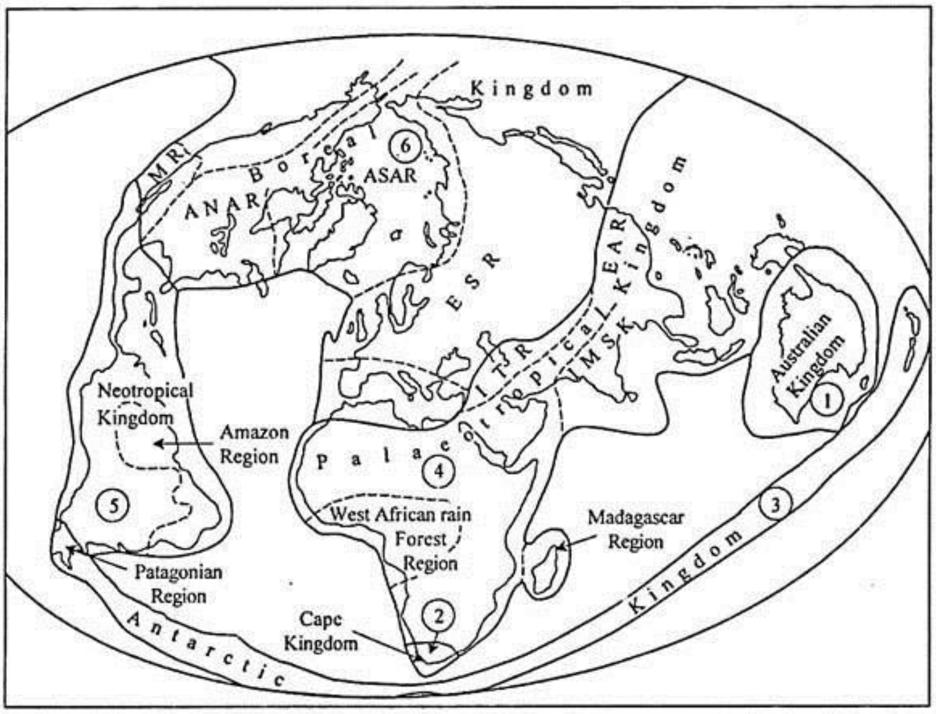

Fig. 43.2 : The present-day distribution of land plants. The major floral kingdoms and floral regions have been demarcated on the basis of dominant flowering trees and their species, IMSK - Indo - Malayan subkingdom; EAR - East Asian Region; ESR - Euro- Siberian Region, ITR - Iran - Turanian Region; MR - Mediterranean Region; ANAR - Atlantic -North American Region, ASAR - Arctic and Sub- Arctic Region. The solid lines denote boundaries of major floral kingdoms whereas dashed lines indicate the limits of floral regions.

(1) Australian Kingdom:

This floristic kingdom includes the plants of whole Australia which is characterized by typical plant species e.g., eucalyptus. The different species of this unique genus of eucalyptus are so dominant in Australia that they represent 75 percent of all Australian plants. There are over 600 species of eucalyptus which greatly vary as regards their general characteristics as they range from tall, giant and shady eucalyptus trees to dwarf and stunted desert eucalyptus trees. Eucalyptus is said to be related to mimosa which is still found in South America (only a few species).

Eucalyptus has been dispersed and distributed by man (deliberately) from Australia to almost every continent. One can see extensive plantation of eucalyptus in India particularly along the rail and road sides and it is being expanded rapidly by deliberate actions of man in all parts of the country irrespective of environmental requirements and suitability of this unique exotic plant. The typical endemic floras of Australia having unique characteristics have developed due to its isolation from other continents of the southern hemisphere because of continental drift.

(2) Cape Kingdom:

The floral kingdom has developed in the southern tip of Africa wherein the plants having bulbs and tubers have developed and these represent the typical plant species of this floral kingdom. The plants of this kingdom belong to the category of cryptophytes which bear buds in the form of bulbs and tubers which are buried in the soils. These bulbs and tubers give birth to other plants as new shoots come out from these bulbs and tubers and are developed as plants.

These plants represent most plants of the gradient such as garden flowering plants (e.g., Loplia, Kniphogia, Erica Freesia etc.). The dispersal of these garden plants became possible when South Africa was colonized by Europeans who distributed these garden flowering plants from South Africa to the gardens of other parts of the world.

There is gradual decrease in the number and area of these garden flowering plants in their own native areas (southern part of South Africa) because their areas are continuously being replaced by agricultural lands. The untouched areas still have sclerophyllous shrubs which attain the height of a few meters. There is undergrowth of herbaceous shrubs in the sclerophyllous shrubs. It may be remembered that the native vegetation of this region before the European colonization consisted of temperate evergreen forests which were extensively cleared off by the Europeans for agricultural proposes and thus the sclerophyllous shrubs developed in this region at later date as secondary succession of vegetation.

(3) Antarctic Kingdom:

This kingdom includes a narrow strip in the north of Antarctica which runs from Patagonia and southern Chile of South America to New Zealand. The most important representative plant of this zone is Nothofagus which is also known as Southern Beech. About 100 million years ago temperate grasses developed as the native vegetation of this region (New Zealand).

The most outstanding and typical species of the grasses were Tussock Grasses though a few species of Sedges (plants which grow in water) and dicotyledon shrubs were also developed but these original native vegetation have undergone massive modification and transformation since the colonization of New Zealand by the Europeans.

Thus, the present-day vegetation of New Zealand is of modified type which is still characterized by two types of tussock grasses viz.:

(i) Short Tussock Grasslands have two main species e.g., festuca and poa. The average height of these grasses is upto 0.5 m and the colour is yellow-grey,
(ii) Tall Tussock Grasslands have the main species of Chiomechloa.

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Warm temperate areas of New Zealand are characterized by the dominance of the forest of gymnosperms and angiosperms trees. The main species of the coniferous family of gymnosperms are Podcarpaceae, Cupressaceae and Araucariaceae whereas flowering plants are included in Angiosperms of which Nothofagus is the most important plant.

The sub-tropical forests of New Zealand are of evergreen type which is characterized by dense cover of tall trees having different vertical strata of other plants. The original vegetation of New Zealand has been greatly modified and destroyed by human activities and the mammals (mainly grazing red deers and rabbits) brought by them from Europe. This has led to the destabilization of vegetation community at large scale.

(4) Palaeotropical Kingdom:

This kingdom includes most of Africa, South West Asia, South Asia, South East Asia and southern and middle portions of China. **This floral kingdom is further divided into 3 sub-kingdoms e.g.:**

(i) African sub-kingdom,
(ii) Indo-Malaysian sub-kingdom, and
(iii)Polynesian sub-kingdom.

This floral kingdom is also divided into several floral provinces or regions (fig.) e.g., West African rainforest region, Madagascar region, Iran-Turanian region, East Asian region, etc. There is great variation in plant species from one region to another region but few plants are common to all sub- kingdoms and regions.

(5) Neotropical Kingdom:

This region includes the whole of South America except southern Chile and Patagonia. A few genera are common to this kingdom and palaeotropical kingdom mainly Africa because the original flowering plants were developed in South America and Africa during Cretaceous period when all members of Gondwanaland were united together. Later on the spreading of Atlantic sea-floor, disruption of Gondwanaland and westward drift of South America from Africa became responsible for the origin and development of new species at regional level and therefore variations in the plant species of South America and Africa were introduced.

(6) Boreal Kingdom:

This floral kingdom includes the whole of North America except Middle America, Greenland, entire Europe, northern Asia and Arctic region. This is the most extensive kingdom of all the floral kingdoms. This is again divided into several sub-kingdoms and regions or provinces e.g. Rocky Mountainous Region (RMR); Atlantic – North American Region (ANAR, fig.); Arctic and Sub-Arctic Region (ASAR); Europe-Siberian Region (ESR); Mediterranean Region (MR) etc.

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Wild Life

Wildlife traditionally refers to undomesticated animal species, but has come to include all plants, fungi, and other organisms that grow or live wild in an area without being introduced by humans. Wildlife can be found in all ecosystems. Deserts, forests, rain forests, plains, grasslands and other areas including the most developed urban areas, all have distinct forms of wildlife. While the term in popular culture usually refers to animals that are untouched by human factors, most scientists agree that much wildlife is affected by human activities.

Biologists estimate there are between 5 and 15 million species of plants, animals, and micro-organisms existing on Earth today, of which only about 1.5 million have been described and named. The estimated total includes around 300,000 plant species, between 4 and 8 million insects, and about 50,000 vertebrate species (of which about 10,000 are birds and 4,000 are mammals).

Problems of Wild Life

Today, about 23% (1,130 species) of mammals and 12% (1,194 species) of birds are considered as threatened by IUCN.

According to various surveys and reports, our planet has lost more than 58% of its wildlife since 1970 and is experiencing the sixth mass extinction. The 2016 Living Planet Report reveals the troubling extent of this and other environmental crises around the world, but it also sheds light on the ways we can still protect and rehabilitate what's left. An index compiled with data from the Zoological Society of London to measure the abundance of biodiversity was down 58 per cent from 1970 to 2012 and would fall 67 per cent by 2020 on current trends, the **WWF** said in a report.

In 1972, The Wildlife Conservation Act was passed by the Government of India. In 1980, The World Conservation Strategy was developed by the “International Union for Conservation of Nature and Natural Resources” (IUCN) with assistance from The United Nations Environment Program and the World Wildlife Fund and in collaboration with the Food and Agriculture Organization of UN and the United Nations Educational, Scientific and Cultural Organization (UNESCO).

Global biodiversity is being lost much faster than natural extinction due to changes in land use, unsustainable use of natural resources, invasive alien species, climate change and pollution among others. Land conversion by humans, resulting in natural habitat loss, is most evident in tropical forests and is less intensive in temperate, boreal and arctic regions. Pollution from atmospheric nitrogen deposition is most severe in northern temperate areas close to urban centres; and the introduction of damaging alien species is usually brought about through patterns of human activity.

Species loss is also compounded by:

- the ongoing growth of human populations and unsustainable consumer lifestyles
- increasing production of waste and pollutants
- urban development
- International conflict.

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Fewer natural wildlife habitat areas remain each year. Moreover, the habitat that remains has often been degraded to bear little resemblance to the wild areas which existed in the past. Habitat loss due to destruction, fragmentation and degradation of habitat is the primary threat to the survival of wildlife.

- **Climate Change**: Global warming is making hot days hotter, rainfall and flooding heavier, hurricanes stronger and droughts more severe. This intensification of weather and climate extremes will be the most visible impact of global warming in our everyday lives. It is also causing dangerous changes to the landscape of our world, adding stress to wildlife species and their habitat. Since many types of plants and animals have specific habitat requirements, climate change could cause disastrous loss of wildlife species. A slight drop or rise in average rainfall will translate into large seasonal changes. Hibernating mammals, reptiles, amphibians and insects are harmed and disturbed. Plants and wildlife are sensitive to moisture change so, they will be harmed by any change in moisture level. Natural phenomena like floods, earthquakes, volcanoes, lightning and forest fires also affect wildlife.

- **Unregulated Hunting and poaching**: Unregulated hunting and poaching causes a major threat to wildlife. Along with this, mismanagement of forest department and forest guards triggers this problem.

- **Pollution**: Pollutants released into the environment are ingested by a wide variety of organisms. Pesticides and toxic chemical being widely used, making the environment toxic to certain plants, insects, and rodents.

- **Over exploitation**: Over exploitation is the over use of wildlife and plant species by people for food, clothing, pets, medicine, sport and many other purposes. People have always depended on wildlife and plants for food, clothing, medicine, shelter and many other needs. More resources are being consumed than the natural world can supply. The danger is that if too many individuals of a species are taken from their natural environment, the species may no longer be able to survive. The loss of one species can affect many other species in an ecosystem. The hunting, trapping, collecting and fishing of wildlife at unsustainable levels is not something new. The passenger pigeon was hunted to extinction, early in the last century, and over-hunting nearly caused the extinction of the American bison and several species of whales.

- **Deforestation**: Humans are continually expanding and developing, leading to an invasion of wildlife habitats. As humans continue to grow, they clear forested land to create more space. This stresses wildlife populations as there are fewer homes and food sources for wildlife to survive.

- **Population**: The increasing population of human beings is the major threat to wildlife. More people on the globe means more consumption of food, water and fuel, therefore more waste is generated. Major threats to wildlife are directly related to increasing population of human beings. Low population of humans results in less disturbance to wildlife.

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Wild Life Conservation

Wildlife conservation is the practice of protecting wild plant and animal species and their habitat. Wildlife plays an important role in balancing the ecosystem and provides stability to different natural processes of nature. The goal of wildlife conservation is to ensure that nature will be around for future generations to enjoy and also to recognize the importance of wildlife and wilderness for humans and other species alike. Many nations have government agencies and NGO's dedicated to wildlife conservation, which help to implement policies designed to protect wildlife. Numerous independent non-profit organizations also promote various wildlife conservation causes.

Wildlife conservation has become an increasingly important practice due to the negative effects of human activity on wildlife. An endangered species is defined as a population of a living species that is in the danger of becoming extinct because the species has a very low or falling population, or because they are threatened by the varying environmental or prepositional parameters.

In 1972, the Government of India enacted a law called the Wild Life (Protection) Act. In America, the Endangered Species Act of 1973 protects some U.S. species that were in danger from over exploitation, and the Convention on International Trade in Endangered Species of Fauna and Flora (CITES) works to prevent the global trade of wildlife, but there are many species that are not protected from being illegally traded or being over-harvested.

The World Conservation Strategy was developed in 1980 by the International Union for Conservation of Nature and Natural Resources (IUCN) with advice, cooperation and financial assistance of the United Nations Environment Programme (UNEP) and the World Wildlife Fund and in collaboration with the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Educational, Scientific and Cultural Organization (UNESCO)" The strategy aims to "provide an intellectual framework and practical guidance for conservation actions." This thorough guidebook covers everything from the intended "users" of the strategy to its very priorities. It even includes a map section containing areas that have large seafood consumption and are therefore endangered by over fishing.

Why do we need to protect wildlife?

The theme of 2016 World Environment Day was zero tolerance to poaching of wildlife. For many people, showing concern for wildlife is redundant in view of the large number of people living below the poverty line in India.

In a deeper analysis, it will appear that protecting wildlife is vital for the present as well as future generations. Life in the wild promotes biological diversity, which in turn, provides materials for food, clothing, medicines, papers, beverages and spices for daily use.

From the days of the hunter-gatherer—when hunting animals and gathering fruits, tubers and herbs sustained humans—till the present time, human society, without even being aware of it, always depended on nature.

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Science helped us to understand the extent of diversity in the wild, study life cycles, domesticate wild species and breed, cultivate and trade them. Technology helped us add value and extract maximum profit from the use of natural resources.

Recognising biodiversity

Biodiversity was finally recognised as the sovereign right of every country in June 1992 at the United Nations Conference on Environment and Development, Earth Summit, in Rio de Janeiro, Brazil. Till then it was an open-access free resource, largely taken from technologically-poor south to the tech-savvy northern countries.

India had a gross domestic product of 25 even in the 16th century only through trading products of living natural resources such as silk, cotton, spices, indigo and so on. The Convention on Biological Diversity signed by more than 190 countries till date for the first time not only announced the sovereign right of each country on biodiversity, but also made it clear that the provider country must get for giving access to the resources from the receiver country.

In 1972, India enacted the Wildlife (Protection) Act, but it only provides different levels of legal protection to scheduled species—at different levels from schedule 1 to 5. While Schedule 6 enlisted very few plant species or group of plants like Orchidaceae, it failed miserably to protect other endangered plant species. The Botanical Survey of India has published four volumes of Red Data Book on Indian plants, but the Act failed to take advantage of that.

Trading in wildlife

Because of its value, wildlife is poached illegally and some the species have been brought under the network of the Act. Ivory, tiger skin and bones, leopard skin, rhino, otter skin and products made out of hair from wild animals (such as paint brush from mongoose hair) are the most illegally traded wildlife.

TRAFFIC India, the wildlife trade monitoring network and the WWF are helping track down illegal wildlife trade. The customs department is responsible for intercepting any consignment containing illegal wildlife trade products.

India's porous border with Nepal, Myanmar and Bangladesh is often used to transport such products. India has more than 600 Protected Areas (PA) to conserve wildlife. Most of the poaching occurs within the PAs—at one point the Panna Tiger Reserve had no tiger, all being poached.

The highest numbers of rhinos are poached within the sanctuaries. The major reason is inadequate infrastructure, lack of noctavision binoculars, lack of sniffer dogs and lack of modern firearms and vehicles to apprehend the poachers. Poachers are often better equipped and alert.

India has set up 47 tiger reserves. A study for six tiger reserves to provide qualitative and quantitative estimates for as many as 25 ecosystem services were made by the Centre for Ecological Services Management and the Indian Institute of Forest Management, Bhopal. The study indicates monetary value of benefits from selected services range from Rs 8.3 to Rs 17.6 billion rupees annually.

"In terms of unit area this translates into Rs 50,000 to Rs 1, 90,000 per hectare per year. In addition, selected tiger reserves protect and conserve stock valued in the range of Rs 22 to Rs 650 billion." (Verma, 2015) The data from the Sundarbans Tiger Reserve in West Bengal is worth quoting.

"Sundarbans forms the largest contiguous track of mangrove forest found anywhere in the world and is the only mangrove forest inhabited by tigers. It is estimated that the Sundarbans Tiger Reserve provides flow benefits worth Rs 12.8 billion (Rs 0.50 lakh/hectare) annually. Important ecosystem services originating from STR include nursery function (Rs 5.17 billion year-1), genepool protection (Rs 2.87 billion year-1), provisioning of fish (Rs 1.6 billion year-1) and waste assimilation services (Rs 1.5 billion year-1). Other important services emanating from Sundarbans include generation of employment for local communities (Rs 36 million year-1), moderation of cyclonic storms (Rs 275 million year-1), provision of habitat and refugia for wildlife (Rs 360 million year-1) and sequestration of carbon (Rs 462 million year-1)."

So, from one unique conservation area more than Rs. 60,000 crore worth of benefit is derived. Ultimately, it is the human society that benefits from wildlife.

Article source: https://www.downtoearth.org.in/blog/wildlife-biodiversity/why-there-is-a-need-to-protect-wildlife--54326

Major Gene Pool Centers

A large gene pool indicates extensive genetic diversity, which is associated with robust populations that can survive bouts of intense selection. Meanwhile, low genetic diversity can cause reduced biological fitness and an increased chance of extinction.

The centre of origin is a geographical area where a group of organisms, either domesticated or wild, first developed its distinctive properties. Many authorities believe centre of origin are also centres of diversity. But at the same time many scientists argue that it is almost impossible to assemble meaningful information on the origin and evolution of certain crops as the evidence dims and fades away with each passing year. The first person to pose the question of the geographic origin of cultivated plants was Alphonse de Candolle. Based on the evolutionary concepts of Darwin and taking the findings of Candolle as points of departure, the Russian scientist ***Nicolay Ivanovich Vavilov*** developed his hypotheses on the centres of origin of cultivated plants in the early 1920s.

Vavilov Gene Pool Centres

Vavilov assumed that most of the main agricultural species could be traced back to one particular region, which would be its **centre of origin**. Furthermore, he assumed that these centres would be common for a range of crops, and that such regions could be universal centres of origin and of type formation, i.e. genetic diversification.

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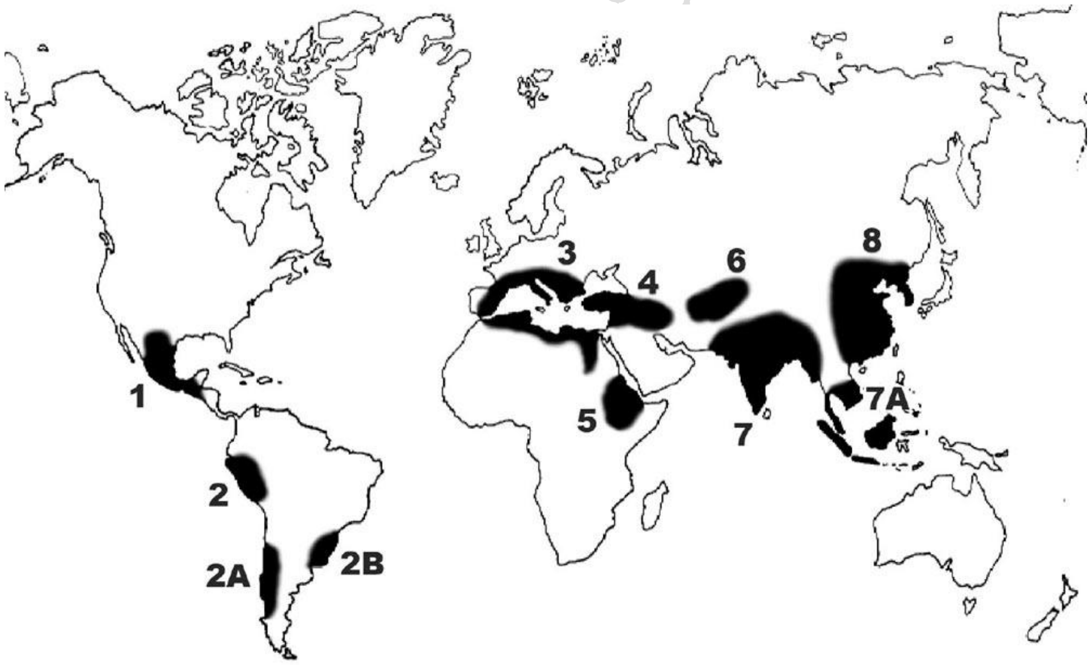
One of Vavilov's first findings was that it was possible to distinguish between primary and secondary groups of cultivated plants. The primary crops were the basic ancient cultivated plants that were known to humanity only in their cultivated state (e.g. wheat, barley, rice, soybeans, flax and cotton). The secondary crops comprised all the plants that were derived from weeds that infested the primary crop fields, and were found to be useful on their own (e.g. rye, oats, and false flax).

The region of maximum variation, usually including endemic types and characteristics, could also be the centre of origin. The centres of origin would, as a rule, be characterised by many endemic variable traits and could comprise characteristics of entire genera. Within the centres of origin, Vavilov determined so-called foci of type formation of the most important cultivated plants i.e. hearts of the centres with regard to genetic diversification and type formation.

Whereas Vavilov's principles were strengthened throughout the period of empirical investigations, the numbers and borders of the centres of origin of cultivated plants changed continuously. In the end, he suggested the following centres of origin of cultivated plants.

For crop plants, Nikolai Vavilov identified differing numbers of centers: three in 1924, five in 1926, six in 1929, seven in 1931, eight in 1935 and reduced to seven again in 1940.



Vavilov centers of origin: (1) Mexico-Guatemala, (2) Peru-Ecuador-Bolivia, (2A) Southern Chile, (2B) Paraguay-Southern Brazil, (3) Mediterranean, (4) Middle East, (5) Ethiopia, (6) Central Asia, (7) Indo-Burma, (7A) Siam-Malaya-Java, (8) China and Korea

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World centers of origin of cultivated plants

Center	Plants
1) South Mexican and Central American Center	Includes southern sections of Mexico, Guatemala, Honduras and Costa Rica. • **Grains and Legumes:** maize, common bean, lima bean, tepary bean, jack bean, grain amaranth • **Melon Plants:** malabar gourd, winter pumpkin, chayote • **Fiber Plants:** upland cotton, bourbon cotton, henequen (sisal) • **Miscellaneous:** sweetpotato, arrowroot, pepper, papaya, guava, cashew, wild black cherry, chochenial, cherry tomato, cacao.
2) South American Center	62 plants listed; three subcenters ***2) Peruvian, Ecuadorean, Bolivian Center:*** • **Root Tubers:** Andean potato, other endemic cultivated potato species. Fourteen or more species with chromosome numbers varying from 24 to 60, Edible nasturtium • **Grains and Legumes:** starchy maize, lima bean, common bean • **Root Tubers:** edible canna, potato • **Vegetable Crops:** pepino, tomato, ground cherry, pumpkin, pepper • **Fiber Plants:** Egyptian cotton • **Fruit and Miscellaneous:** cocoa, passion flower, guava, heilborn, quinine tree, tobacco, cherimoya, coca ***2A) Chiloe Center*** (Island near the coast of southern Chile) • Common potato (48 chromosomes), Chilean strawberry ***2B) Brazilian-Paraguayan Center*** • manioc, peanut, rubber tree, pineapple, Brazil nut, cashew, Ervamate, purple granadilla.
3) Mediterranean Center	Includes the borders of the Mediterranean Sea. 84 listed plants • **Cereals and Legumes:** durum wheat, emmer, Polish wheat, spelt, Mediterranean oats, sand oats, canarygrass, grass pea, pea, lupine • **Forage Plants:** Egyptian clover, white clover, crimson clover, serradella • **Oil and Fiber Plants:** flax, rape, black mustard, olive • **Vegetables:** gardenbeet, cabbage, turnip, lettuce, asparagus, celery, chicory, pa rsnip, rhubarb, • **EtherealOil and Spice Plants:** caraway, anise, thyme, peppermint, sage, hop.
4) Middle East	Includes interior of Asia Minor, all of Transcaucasia, Iran, and the highlands of Turkmenistan. 83 species • **Grains and Legumes:** einkorn wheat, durum wheat, poulard wheat, common wheat, oriental wheat, Persian wheat, two-row barley, rye, Mediterranean oats, common oats, lentil, lupine • **Forage Plants:** alfalfa, Persian clover, fenugreek, vetch, hairy vetch • **Fruits:** fig, pomegranate, apple, pear, quince, cherry, hawthorn.
5) Ethiopia	Includes Abyssinia, Eritrea, and part of Somaliland. 38 species listed; rich in wheat and barley. • **Grains and Legumes:** Abyssinian hard wheat, poulard wheat, emmer, Polish wheat, barley, grain sorghum, pearl millet, African millet, cowpea, flax, teff • **Miscellaneous:** sesame, castor bean, garden cress, coffee, okra, myrrh, indigo.
6) Central Asiatic Center	Includes Northwest India (Punjab, Northwest Frontier Provinces and Kashmir), Afghanistan, Tajikistan, Uzbekistan, and western Tian-Shan. 43 plants • **Grains and Legumes:** common wheat, club wheat, shot

	wheat, peas, lentil, horse bean, chickpea, mung bean, mustard, flax, sesame • **Fiber Plants:** hemp, cotton • **Vegetables:** onion, garlic, spinach, carrot • **Fruits:** pistacio, pear, almond, grape, apple.
7) Indian Center	Two subcenters ***7) Indo-Burma:*** Main Center (India): Includes Assam, Bangladesh and Burma, but not Northwest India, Punjab, nor Northwest Frontier Provinces, 117 plants • Cereals and Legumes: chickpea, pigeon pea, urd bean, mung bean, rice bean, cowpea, • Vegetables and Tubers: eggplant, cucumber, radish, taro, yam • Fruits: mango, orange, tangerine, citron, tamarind • Sugar, Oil, and Fiber Plants: sugar cane, coconut palm, sesame, safflower, tree cotton, oriental cotton, jute, crotalaria, kenaf • Spices, Stimulants, Dyes, and Miscellaneous: hemp, black pepper, gum arabic, sandalwood, indigo, cinnamon tree, croton, bamboo. ***7A) Siam-Malaya-Java:*** Indo-Malayan Center: Includes Indo-China and the Malay Archipelago, 55 plants • Cereals and Legumes: Job's tears, velvet bean • Fruits: pummelo, banana, breadfruit, mangosteen • Oil, Sugar, Spice, and Fiber Plants: candlenut, coconut palm, sugarcane, clove, nutmeg, black pepper, manila hemp.
8) Chinese Center	A total of 136 endemic plants are listed in the largest independent center • **Cereals and Legumes:** e.g. rice[9] broomcorn millet, Italian millet, Japanese barnyard millet, sorghum, buckwheat, hull-less barley, soybean, Adzuki bean, velvet bean • **Roots, Tubers, and Vegetables:** e.g. Chinese yam, radish, Chinese cabbage, onion, cucumber • **Fruits and Nuts:** e.g. pear, Chinese apple, peach, apricot, cherry, walnut, litchi • **Sugar, Drug, and Fiber Plants:** e.g. Sugar, opium poppy, ginseng camphor, hemp.