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**Introduction**

**Biogeography** is the study of the distribution of plants and animals and related eco-system, the geographical relationship with related environments over time. Biogeography is an integrative field of inquiry that unites concepts and information from ecology, evolutionary biology, geology, and physical geography. Some fundamental concepts in biogeography include

- ✓ **Biospheres:** global sum of all ecosystems.
- ✓ **Evolution:** Change in genetic composition of a population
- ✓ **Extinction:** Disappearance of a species
- ✓ **Dispersal:** Movement of populations away from their point of origin, related to migration
- ✓ **Geodispersal:** The erosion of barriers to biotic dispersal and gene flow, that permit range expansion and the merging of previously isolated biotas
- ✓ **Vicariance :** The formation of barriers to biotic dispersal and gene flow, that tend to subdivide species and biotas, leading to speciation and extinction

**What is a Biosphere?**

Biosphere is the **global sum of all ecosystems.**

- ✎ Biosphere is the **zone of life** on earth and is a **closed** (apart from solar and cosmic radiation) and **self-regulating** system.

-: About this document:-

So, Biosphere is the global ecological system integrating all living beings and their relationships, including their interaction with the elements of the lithosphere, hydrosphere and atmosphere. **The origin of Biosphere was through Biogenesis or Biopoesis.** Biopoesis started 3.5 billion years ago.

Since, Humans have not been able to discover life beyond earth as of now, Earth's life system is the only biosphere currently known. This has been fashionably named as **Biosphere-1**. Biospheres contain the smaller units known as Ecosystems. The ecosystems may be natural or artificial.

### Biosphere-2 and BIO-3

There is a man made Biosphere developed for research purposes in Arizona of United States. This manmade Biosphere is known as **Biosphere-2**. Biosphere-2, which is enclosed by Glass structures, is the **largest closed system ever created**. It studies the possibility of creating artificial Biospheres in space.

Apart from this Biosphere-2, we have one BIOS-3 developed by Russia. It has been constructed by Institute of Biophysics in Krasnoyarsk, Russia. The work on BIOS-3 started in 1965 and finished in 1972. BIOS-3 consists of a 315-cubic-metre habitat suitable for up to three persons, and was initially used for developing closed ecosystems capable of supporting humans. The **Chlorella algae** were used to recycle air breathed by humans, absorbing carbon dioxide and replenishing it with oxygen through photosynthesis. The BIOS-3 was used for conducting 10 manned closure experiments with a one to three man crew.

### Elements of Biosphere

Elements of the biosphere are divided in four categories on functional basis:

1. **Abiotic or Physical Elements:** These include basic elements of the habitats and dead organic compounds.
2. **Producers:** These are primarily autotrophic green plants and are intermediaries between abiotic and biotic components of the biosphere because they manufacture their food through photosynthesis and derive nutrients from the soils through root osmosis. Herbivores and carnivores (consumers) depend for their food on producers.
3. **Consumers:** Consumers are heterotrophic organisms which include animals and man and are further divided into primary consumers (herbivores), secondary consumers (carnivores) and omnivores.
4. **Decomposers:** Decomposers are microorganisms which decompose dead plants and animals.

### Ecosystem

✎ An ecosystem is a biological environment consisting of all the organisms (biota) living in **a particular area**, as well as all the nonliving (abiotic), physical components of the environment with which the organisms interact, such as air, soil, water and sunlight.

Organisms (plants and animals) or biotic communities interact among themselves as well as with their physical environment like soil, air and water. The living organisms interact with one another through their food chains in which one organism consumes another organism. The living organisms like plants interact with soil to get essential nutrients; with air to get carbon dioxide and also with water bodies, for carrying out the process of photosynthesis.

We can say that the Biotic Communities like plants and animals along with soil, air and water of that region form a self-sustaining or functional unit of the living world. This 'functional unit' or 'system' made up of **living + non-living components** which is **capable of independent existence** is called an **Ecosystem**.

- ✎ In an Ecosystem, the Biotic and Non-Biotic components are linked to each other via nutrient cycle and energy flow.
- ✎ An ecosystem can be natural or manmade. The Natural ecosystems are Terrestrial ecosystem, Aquatic ecosystem, **Lentic Ecosystem**-the ecosystem of a lake, pond or swamp or **Lotic Ecosystem**-the ecosystem of a river, stream or spring. The Artificial Ecosystems are manmade. Best example is an aquarium.

Services **derived from ecosystems** are referred to as **Ecosystem Services**. They may include

- ✓ Facilitating the **enjoyment** of nature, which may generate many forms of income and employment in the **tourism** sector, often referred to as eco-tourisms,
- ✓ **Water retention**, thus facilitating a more evenly distributed release of water,
- ✓ **Soil protection**, open-air laboratory for scientific research, etc.

When new elements are introduced in an ecosystem, whether biotic or abiotic, they tend to have a disruptive effect. In some cases, this can lead to ecological collapse or "**trophic cascading**" and the death of many species within the ecosystem.

## Biomes

**Biomes are groups of ecosystems that share similar conditions in an environment. Before we move ahead, let's face this question:**

**Question:** What is the difference between an Ecosystem and a Biome?

1. An ecosystem comprises biotic as well as abiotic components, while a biome has only biotic components
2. An ecosystem is generally larger part of Biosphere, while a Biome is a smaller part.

Which among the above statements is/ are correct?

The above simple looking question would confuse many of you. I have framed both the statements as wrong statements.

The first thing we have to note that a Biome is a larger part that may comprise many ecosystems. Technically, Biomes are groups of ecosystems that share similar conditions in an environment. A biome is a large area with similar flora, fauna, and microorganisms. Most of us are familiar with the tropical rainforests, tundra in the arctic regions, and the evergreen trees in the coniferous forests. Each of these large communities contain species that are adapted to its varying conditions of water, heat, and soil. For instance, polar bears thrive in the arctic while cactus plants have a thick skin to help preserve water in the hot desert.

So, the typical characteristics of the Biomes are that they have:

- Similar **climatic** conditions
- Same kind of abiotic and biotic factors spread over a large area creating a typical ecosystem over that area.

However, please note that a Biome as well as an ecosystem may have many species. In fact, the biomes are divided on the basis of factors such as plant structures (such as trees, shrubs, and grasses), leaf types (such as broadleaf and needleleaf), plant spacing (forest, woodland, savanna), and climate.

Please note that Earth is often divided into generally **six terrestrial biomes and two aquatic biomes**, each of which contains a number of distinct ecosystems. Terrestrial biomes are those that occur on the land and include **deserts, grasslands, tropical forests, temperate forests, taiga, and tundra**.

The Aquatic Biomes occur in water and are often divided into the **marine and freshwater biomes**, depending on the salinity of the water.

Each biome may contain several different ecosystems such as coral reefs, seagrass beds, kelp forests, and salt marshes.

**Ecozones**

We need to tackle another multiple choice question before we understand this concept.

**Question:** What is the difference between an Ecozone and a Biome?

1. An Ecozone comprises only land parts of Earth surface, while the Biomes comprise both aquatic and land parts
2. Each Ecozone has some finite number of species , while each biome has infinite number of species
3. Ecozone is a larger ecosystem. A biome is a group of ecosystems.

Which among the above statements is/ are correct?

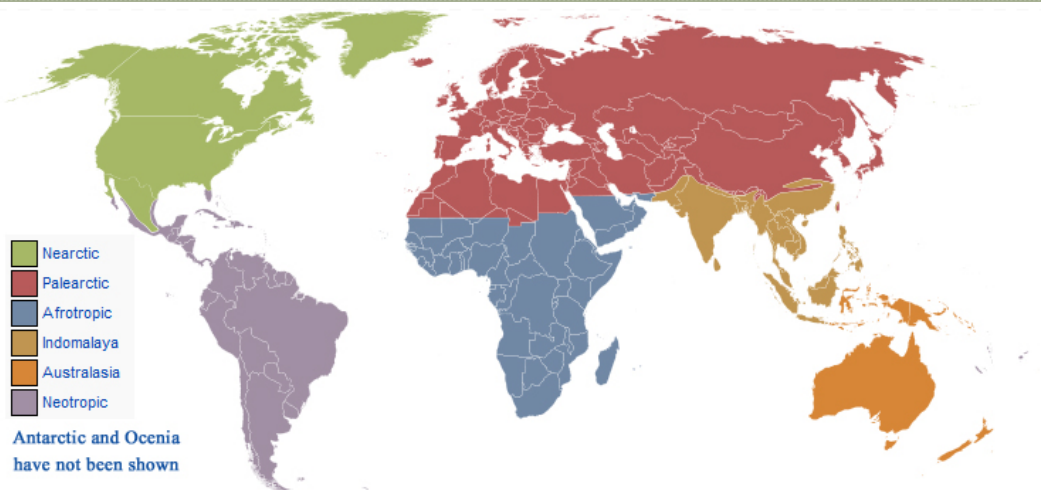
The above question will confuse you if you don't pay attention to fundamentals. The first thing you have to note about the Ecozones is that they are the biogeographic division of the Earth's land surface, based on distributional patterns of terrestrial organisms. This means that they include terrestrial part of the Biosphere and that is why they are alternatively called "**Terrestrial Ecozones**". The second thing you must note is that Ecozones are defined by **genetic, taxonomic, or Geological similarities**, rather than the Morphology, plant structures, leaf types, plant spacing or climates. In the above question, the first statement is **correct**. The second statement is **incorrect** as you may notice. The third statement is also **incorrect** because **an Ecozone can include a number of different biomes**. They both are groups of ecosystems. This means that only first statement I have framed as a correct statement.

**Types of Ecozones**

There are 8 Ecozones on earth as shown in the following table:

Ecozone	Area Km <sup>2</sup>	Included regions
Palaearctic	54.1	Includes the bulk of Eurasia and North Africa, <b>This is largest</b>
Nearctic	22.9	Includes most of North America
Afrotropic	22.1	Includes Sub-Saharan Africa
Neotropic	19.0	Includes South America and the Caribbean
Australasia	7.6	Includes Australia, New Guinea, and neighbouring islands. The northern boundary of this zone is known as the Wallace line.
Indo-Malaya	7.5	Includes the Indian subcontinent and Southeast Asia
Oceania	1.0	Includes Polynesia, Melanesia, Micronesia, New Zealand and some parts of Australia
Antarctic	0.3	Includes Antarctica.





Each Ecozone has been further subdivided into the bioregions. The WWF defines the bioregions as “geographic clusters of ecoregions that may span several habitat types, but have **strong biogeographic affinities, particularly at taxonomic levels higher than the species level (genus, family)**”

☞ For example, **Indomalaya Ecozone** has three bioregions viz. Indian subcontinent, Indochina and Sunda Shelf and Philippines

**Major Biomes and Ecozones of the World**

The following table mentions the major Biomes and Ecozones of the world.

Major Biomes and Ecozones	
Terrestrial biomes	Polar/montane <ol style="list-style-type: none"> <li>1. Tundra</li> <li>2. Taiga, Boreal forests</li> <li>3. Montane grasslands and shrublands</li> </ol>
	Temperate <ol style="list-style-type: none"> <li>1. Coniferous forests</li> <li>2. Broadleaf and mixed forests</li> <li>3. Grasslands, savannas, and shrublands</li> </ol>
	(Sub)tropical <ol style="list-style-type: none"> <li>1. Coniferous forests</li> <li>2. Moist broadleaf forests</li> <li>3. Dry broadleaf forests</li> <li>4. Grasslands, savannas, and shrublands</li> </ol>
	Dry <ol style="list-style-type: none"> <li>1. Mediterranean forests, woodlands, and scrub</li> <li>2. Deserts and xeric shrublands</li> </ol>
	Wet <ol style="list-style-type: none"> <li>1. Flooded grasslands and savannas</li> <li>2. Riparian</li> <li>3. Wetland</li> </ol>
Aquatic biomes	<ol style="list-style-type: none"> <li>1. Pond</li> <li>2. Littoral</li> <li>3. Intertidal zone</li> <li>4. Mangrove forest</li> <li>5. Kelp forest</li> <li>6. Coral reef</li> <li>7. Neritic zone</li> <li>8. Continental shelf</li> <li>9. Pelagic zone</li> <li>10. Benthic zone</li> <li>11. Hydrothermal vents</li> <li>12. Cold seeps</li> </ol>
Other biomes	<ol style="list-style-type: none"> <li>1. Endolithic zone</li> </ol>
Ecozones	<ol style="list-style-type: none"> <li>1. Afrotropic</li> <li>2. Antarctic</li> <li>3. Australasia</li> <li>4. Indomalaya</li> <li>5. Nearctic</li> <li>6. Neotropic</li> <li>7. Oceania</li> <li>8. Palearctic</li> </ol>

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The word **Montane** is derived of *Mountain*. The Montane biome lies between 1800-2000 metres above mean sea level and has cooler temperatures and often have high rainfalls in comparison to the adjacent lowland areas.

### Arctic Tundra

The word Tundra is derived of a Finnish word "*tunturi*" which means **treeless mountain tract**. In Tundra Biome, the **tree growth is hindered by low temperatures and short growing seasons**. The vegetation in Tundra is composed of Dwarf Shrubs, mosses, lichens etc. Some scattered trees are also found. The ecological boundary (**ecotone**) between the tundra and taiga forests is called **tree line or timberline**.

There are three types of Tundra Regions in the world viz. **Arctic Tundra, Alpine Tundra and Antarctic Tundra**. In Northern hemisphere, the Tundra occurs north of the Taiga belt.

- ✎ The **most important characteristic of Tundra is the Permafrost**. Permafrost is the permanently frozen soil. Permafrost is consisting mostly of gravel and finer material. The soil is frozen from 25-90 cms down and no plants can grow in it, so the permafrost is plain without many trees. Some parts of the permafrost are bare and support growth of some lichens.
- ✎ There are **ONLY two seasons in Polar Tundra regions viz. summer and winter**. During winter, it is very cold and dark, while during summer, the temperature rises a bit and the permafrost melts at some points, making the ground soggy.
- ✎ The Arctic Tundra is known for its cold, desert-like conditions. In winter the temperature of Arctic Tundra regions may drop as down as  $-50^{\circ}\text{C}$ . The average winter temperature is  $-34^{\circ}\text{C}$  ( $-30^{\circ}\text{F}$ ), but the average summer temperature is  $3-12^{\circ}\text{C}$  ( $37-54^{\circ}\text{F}$ ) which enables this biome to sustain life. Rainfall may vary in different regions of the arctic. Annual precipitation, including melting snow, is 15 to 25 cm.
- ✎ In summer, the upper layer of Permafrost gets melted and when water saturates the upper surface, bogs and ponds may form, providing moisture for plants. There are **no deep root systems** in the vegetation of the arctic tundra; however, there are still a wide variety of plants that are able to resist the cold climate. There are about 1,700 kinds of plants in the arctic and subarctic, and these include low shrubs, sedges, reindeer mosses, liverworts, and grasses, more than 400 varieties of flowers and crustose and foliose lichen.
- ✎ The plants of the Arctic Tundra region are adapted to sweeping winds and disturbances of the soil. Plants are short and group together to resist the cold temperatures and are protected by the snow during the winter. **They can carry out photosynthesis at low temperatures and low light intensities**. The growing seasons are short and most plants reproduce by **budding** and **division** rather than sexually by flowering.
- ✎ The fauna in the arctic is also diverse. They include herbivorous mammals such as lemmings, voles, caribou, arctic hares and squirrels, Carnivorous mammals such as arctic **foxes, wolves, and polar bears**, Migratory birds such as ravens, snow buntings, falcons, loons, sandpipers, terns, snow birds,



and various species of gulls, Insects such as mosquitoes, flies, moths, grasshoppers, black flies and arctic bumble bees and Fishes such as cod, flatfish, salmon, and trout.

- ✍ The animals of the Arctic Tundra are adapted to handle long, cold winters and to breed and raise young quickly in the summer. Animals such as mammals and birds also have additional insulation from fat. Many animals hibernate during the winter because food is not abundant. Another alternative is to migrate south in the winter, like birds do. Reptiles and amphibians are few or absent because of the extremely cold temperatures. Because of constant immigration and emigration, the population continually oscillates.

### Current Issues with Arctic Tundra

#### Fragile Ecosystem:

From the above description, it is quite evident that the ecosystem of Arctic Tundra is extremely fragile because of the lack of abundant plant life so if the primary consumers can't find enough food, the predators can't eat.

In the Arctic Ecosystem, the primary producers, or the plants are on the bottom of the pyramid. These are very limited resources, which are thrown off by the slightest lack of sunlight and water available to them. The permafrost in the ground also throws off the drainage of the water leaving the plants there hard to digest. In the middle are the primary consumers such as lemmings, musk oxen and insects who feed on the limited plant life available. On top are the small predators such as the snowy owl and arctic fox and polar bears.

- ✍ Due the scarcity of the primary producers, the fragile ecosystem and food chain causes the population continually oscillates.
- ✍ This means that extinction of just one species has the capability to destroy the entire ecosystem in Tundra regions.

#### Problem of Global Warming

Then, due to global warming, the future of the tundra becomes more uncertain. The global warming has caused spread of more woody plants by the increasing temperatures, and it has been feared that it may endanger moss and lichen species in two fifths of the biome in the years to come.

#### Problem of Oil Drilling

Oil Drilling is popular in the tundra because it is rich in mineral resources. The pollution caused by Oil drilling would kill the habitats of fish, and animals. The major problem of oil drilling is the risk of oil spills. When a large spill occurs, it can kill many tiny organisms when it comes in contact with it. As a result, plants will die and will not be able to produce oxygen that we need to live. Also, the herbivores in the ecosystem will die because they will have no food to eat. This can cause major damage to the food chain.

### Alpine Tundra

Consider the following statements about the Alpine Tundra:

1. The Alpine Tundra is located on latitudes which are south of Arctic Tundra and North of Antarctic Tundra.
2. The soil of Alpine Tundra is frozen in winters known as Permafrost
3. The plants and animals of Alpine Tundra are almost similar to that of Arctic Tundra

Which among the above statements is/ are correct?

In the above question, all statements are incorrect. Please note the following points.

- ✗ While the Arctic Tundra is located in Polar regions, the Alpine tundra is **located on mountains throughout the world at high altitude where trees cannot grow**. Alps and Pyrenees of Europe, the Rift Mountains of Africa (such as Mount Kilimanjaro), and a **large portion of the Tibetan Plateau** are best examples of Alpine Tundra.
- ✗ **The growing season is approximately 180 days**. The nighttime temperature is usually below freezing.
- ✗ **The major difference between the arctic Tundra and Alpine Tundra is that unlike the arctic tundra, the soil in the alpine is well drained. The Alpine Tundra does not have permafrost.**
- ✗ **The plants of Alpine Tundra are very similar to those of the arctic ones, however there is a major difference in the fauna of Arctic Tundra** and Alpine Tundra. Kea parrot, marmot, mountain goats, chinchilla, woodland caribou, and pika are some of the best known species of Alpine Tundra.

### Antarctic Tundra

- ✓ Antarctic Tundra occurs on Antarctica and on several Antarctic and subantarctic islands. Most of it is too **cold and dry to support vegetation**. In some portions of Antarctica, there are **areas of rocky soil** that support plant life.
- ✓ The flora presently consists of around 300–400 lichens, 100 mosses, 25 liverworts, and around 700 terrestrial and aquatic algae species, which live on the areas of exposed rock and soil around the shore of the continent.
- ✓ Antarctica's two flowering plant species, the Antarctic **hair grass** (*Deschampsia antarctica*) and Antarctic **pearlwort** (*Colobanthus quitensis*), are found on the **northern and western** parts of the Antarctic Peninsula.
- ✗ **The major difference between Arctic Tundra and Antarctic Tundra is that Antarctic Tundra lacks a large mammal fauna**, while in Arctic Tundra we find an array of mammals as mentioned above. The reason is that **Antarctica is physically isolated from other continents**. However, the shores are inhabited by Sea mammals and sea birds, including seals and penguins. Further, some small mammals, like rabbits and cats, have been introduced by humans to some of the subantarctic islands.



## Taiga Biome

Taiga is also known as **Boreal Forest**. Taiga is **earth's largest terrestrial biome, covering 29% of World's Forest cover** and is characterized by coniferous forests. It covers in North America most of inland Canada and Alaska as well as parts of the extreme northern continental United States; and in most of Sweden, Finland, inland and northern Norway, much of Russia (Siberia), northern Kazakhstan, northern Mongolia, and northern Japan (Hokkaidō Island).

- ✍ As mentioned above, Taiga is the **world's largest land biome**, and makes up 29% of the world's forest cover.
- ✍ Largest areas under Taiga are located in **Russia and Canada**. Please note that there is no Taiga on Southern hemisphere.
- ✍ It accounts for lowest annual average temperatures after the tundra and permanent ice caps.
- ✍ Please note that the **extreme minimums temperatures of Taiga are typically lower than those of the tundra**. In Tundra it is around  $-50^{\circ}\text{C}$ , in Taiga it has been recorded  $-68^{\circ}\text{C}$  at Verkhoyanks in Siberia.

### Question:

Despite being located at southern latitudes than Tundra, why the extreme minimum temperatures have been recorded lowest in Taiga?

- A. Because winters of Taiga get colder due to Polar winds
- B. Because Tundra is near to Arctic Ocean
- C. Because Taiga has clearer skies in comparison to Tundra
- D. All of above reasons.

- ✍ In the above question, the correct answer is B. In winter, there are long periods of frozen Ice on Polar Tundra, yet the **Arctic Ocean contains enough heat to tweak the temperature a little bit**. This is the reason that lowest reliably recorded temperatures in the Northern Hemisphere were recorded in the taiga of northeastern Russia.
- ✍ The soil in Taiga is young with little development and profile. This is mainly because of the fact that cold hinders the development of soil. The taiga **soil is also poor in nutrients**.

### Why the Taiga Soil is poor in nutrients?

- ✍ The Taiga soil is poor in nutrients in comparison to the temperate deciduous forests. This is because the fallen leaves and moss can remain on the forest floor for a **long time** in the cool, moist climate. This would result in poor organic contribution to the soil.
- ✍ Further, the **Taiga soil is acidic due to the falling pine needles**. Since the soil is acidic, the acidity aids in the **decomposition of the mineral components** and the minerals are washed away in the lower horizons. This becomes accessible to the tree roots. This causes infertility of the soil.
- ✍ The leaching of the nutrients, along with the permeability of the soil gives it a light colored eluvial soil horizon leached of most base forming cations such as Calcium. **Since the soil is acidic due to the falling pine needles, the forest floor has only lichens and some moss growing on it.**

- ✎ However, please note that diversity of soil organisms in the boreal forest (southern Taiga) is high, comparable to the tropical rainforest.
- ✎ The Taiga soils are dominated by the microscopic fungi. These microscopic fungi play an important role in the decomposition of the dead phytomass. So, the above mentioned infertility is compensated by the activity of the microorganisms in the upper soil horizons.
- ✎ **In summary the soil of the Taiga Biome and Boreal forests is**
  - ✓ Young with little development
  - ✓ Poor in Nutrients
  - ✓ Rich with Soil organisms
  - ✓ Acidic due to fallen leaves

### Taiga Flora

The first thing we note about Taiga is that - it is spread over both Asia and North America. Both of them were connected by the 1600 kilometers wide **Bering land bridge** at various times during the Pleistocene ice ages in the Geological history. (It connected Alaska to Siberia).

So, due to this reason, a number of animal and plant species were able to colonize both continents and are distributed throughout the taiga biome that spreads in both of them like Tundra.

The forests of the taiga are **largely coniferous**, dominated by larch, spruce, fir, and pine. There are also some small-leaved deciduous trees like birch, alder, willow, and poplar; mostly in areas escaping the most extreme winter cold. Southernmost parts of the taiga has trees such as oak, maple, elm, and tilia scattered among the conifers, and there is usually a gradual transition into a temperate mixed forest.

- ✓ The Southern Taiga is a closed canopy forest consisting closely spaced trees with mossy ground cover. It also has shrubs and wildflowers such as the fireweed.
- ✓ Wherever the trees are located at a father space, land is covered by lichens and mosses. These lichens and mosses are more common in the northernmost taiga.
- ✓ In northernmost taiga the forest cover is not only more sparse, but often stunted in growth

The trees are coniferous which an adaptation to cold harsh climate is. **Most of the species of Taiga such as spruce, fir, and pine are Evergreen.** This is because the sun is low in the horizon for most of the year; it is difficult for plants to generate energy from photosynthesis. The trees do not lose their leaves seasonally and are able to photosynthesize with their older leaves in late winter and spring when light is good but temperatures are still too low for new growth to commence. The leaves are **needle shaped to curb loss of water and with dark green color to increase absorption of sunlight.**

However, Larch, which seems to be most cold-tolerant, is deciduous. The **roots of Taiga Trees are shallow**, which is basically to take advantage of the young thin soils. The conical shape and downward-drooping limbs help them shed snow. Further, there are also some broadleaf plants found in Taiga. Examples are birch, aspen, willow, and rowan.

### Why Taiga is prone to Wildfires?

One of the most important environmental factors that affect the Taiga Forests is **Wildfires**. Wildfires have been an integral part of the Taiga environment for several thousand years. The main natural reason of the wildfires in Taiga is lightning strikes. However, the spread of the fire is dependent on weather, soil conditions, topography and the amount of dry organic matter (fuel) on the soil surface. The combination of these factors forms the fire regime, which is characterized by the intensity, pattern of distribution and type of fire (i.e. ground or crown fire).

By knowing a specific site's *forest type, habitat and local climate*, it is possible to determine the natural frequency of fire, which can vary from just a few years to hundreds of years. For example, wildfires develop more often in forests under a more continental climate (e.g. in Eastern Siberia) and in drier habitats with sandy soils (e.g. on the fluvial-glacial plains of Western Siberia).

### Plant Adaptations to Wildfires

Where fires occur more frequently, plant communities often have special ecological mechanisms to make them more resistant or even adapted to fire. For example the older trees of the Taiga Zones have thicker bark. There are some plants in which the seed cones open just after a wildfire (e.g. Jack Pine), an excellent adaptation to pioneer the development of new trees.

### Advantage Wildfires

Due to heavy and thick bark, and due to the canopy made by the trees, usually, the wildfire would burn away the upper canopy of the trees and let sunlight reach the ground. New plants will grow and provide food for animals that once could not live there because there were only evergreen trees. This is how even wildfires add in development of new forests in Taiga environment. Many smaller herbaceous plants that grow closer to the ground may survive in the Crown wildfires that eliminate only the canopies. The periodic wildfires clear out the tree canopies, allowing sunlight to invigorate new growth on the forest floor. That is why the wildfires have become a necessary part of the life cycle in the taiga.

### Current Issues with Taiga Environment

The Taiga is being destroyed everyday by both humans and nature. Nature causes forest fires with lightning, diseased by parasites or herbicides, and spruce trees that grow on top thick moss are frequently blown over by strong winds. Large-scale clear cutting, plantation forestry, introduction of exotic tree species, soil scarification, ditching, and use of pesticides or herbicides have led to habitat loss. Large-scale industrial forestry, or logging, is the greatest important threat affecting the boreal forest. Other threats to the Taiga are oil and gas exploration, road building, mining, human triggered forest fire, and climate change. Animals of the Taiga are being hunted and trapped for their fur which decreases their population greatly. Hydroelectric power has ruined the water system. Many fish have mercury poisoning. The Taiga is being destroyed equal to that of the rainforest.

### Montane grasslands and shrublands

Please note that this biome is defined in the WWF Classification. It includes all the high altitude (montane, subalpine, and alpine) grasslands and shrublands around the world. They are located in plenty of

subtropical and tropical regions. In India, the elevations of **Western Ghats** are included in **Montane grasslands and shrublands**. Plants of these habitats display adaptations such as rosette structures, waxy surfaces, and hairy leaves.

### Tropical Broadleaf Evergreen Forest: The Rainforest

The tropical rainforest is **earth's most complex biome** in terms of both structure and species diversity. It occurs under optimal growing conditions: abundant precipitation and year round warmth.

The World Wildlife Fund's **biome classification** puts the tropical rainforests under **Tropical Moist Broadleaf Forest**.

The Tropical rain forests is roughly located within **28° north or south** of the equator, spread in Asia, Australia, Africa, South America, Central America, Mexico and on many of the Pacific Islands.

- ✓ The largest rainforests are in Brazil (South America), Democratic Republic of Congo (Africa), and Indonesia.
- ✓ Other tropical rainforests lie in Southeast Asia, Hawaii, and the Caribbean Islands.
- ✓ The Amazon rainforest in South America is the world's largest, covering an area about two-thirds the size of the continental United States.

### Why they are called Rainforests?

- ✓ Because they are wet due to round the year rains. Tropical rainforests are defined by their wet and dry seasons.
- ✓ Tropical rainforests receive **175 to 300 inches precipitation** annually.
- ✓ Tropical rain forests are found in regions where **temperatures and precipitation are high year-round**.
- ✓ Mean monthly temperatures **exceed 18 °C** during all months of the year, due to location near to equator. Please note that there is **no annual rhythm** to the forest; rather **each species has evolved its own flowering and fruiting seasons**. Sunlight is a major limiting factor.

### Layers of Trees:

- ✓ A tropical rainforest consists of four layers: the **emergent trees, canopy, the understory, and the forest floor**.
- ✓ The emergent and canopy layers make up the very top of the rainforest, where a few trees, called emergent, poke out above the green growth to reach the sun. **Most of the plant growth in rainforests is here, close to the sun.**
- ✓ Most rainforest animals, including monkeys, birds, and tree frogs, live in the canopy.
- ✓ Below the canopy are the young trees and shrubs that make up the understory. The plants in this layer **cannot grow to large sizes** because the canopy blocks most of the sunlight.
- ✓ The **forest floor is almost bare** because very little sunlight can get through the canopy and understory to reach the ground. This is where fallen leaves and branches rot quickly to release nutrients for other plants to grow.
- ✓ Large mammals such as South American tapirs and Asian elephants who are too heavy to climb up into the canopy layer live in the dim light of the understory and forest floor.

**Complex Ecosystem:**

- ✓ In Rainforests, the plants and animals depend on each other for survival. For example, some insects can only survive in one type of tree, while some birds only eat one type of insect. If this tree is destroyed, the insects will have no home. If the insects die, the birds who rely on them for food will starve to death. Because of this **interdependence**, if one type of plant or animal becomes extinct, several others could be in danger of extinction as well.

**Rainforest Soils:**

- ✓ It would appear to us that tropical soils are very fertile in order to support this high productivity. **But, it is incorrect to say so.**
- ✓ If we closely look at the system, we find that **soils of Tropical Rain Forests are very thin** and the rock below them highly weathered.
- ✓ An analysis of soils of tropical regions shows them to be virtually **devoid of soluble minerals**.
- ✓ Rocks weather rapidly due to high temperatures and abundant moisture, and millennia of rapid weathering and torrential rains to **wash away nutrients** from the soils have left the soils very low in nutrient stocks.
- ✓ It has also been supported by the analysis of stream water draining tropical regions, which likewise reveals a scarcity of dissolved nutrients.
- ✓ Most tropical soils are clays with **little soluble mineral** content, and moderate to strong acidity which interferes with the ability of roots to take up nutrients. Only about **20% of the humid tropics** has soils that **can support agriculture**, and most of this area is already in use.
- ✓ In soils of the Tropical Rain Forests, the nutrients are found mainly in living plant biomass and in the layer of decomposing litter; **there is little nutrient content of the deeper soil, as there is in temperate-zone ecosystems**. This suggests that plants are intercepting and **taking up nutrients the moment** they are released by decomposition. Many organisms play role in decomposition process: termites, bacteria, fungi, various invertebrates.

**Recycling of Nutrients**

- ✓ Due to the above mentioned reasons, the rainforest reuses almost everything that falls to the ground and decays.
- ✓ When leaves fall from the trees, when flowers wilt and die, and when any animal dies on the forest floor, it decays and all of the nutrients in the decayed species are recycled back into the roots of the trees and plants.
- ✓ Only the **top few inches** of rainforest soil have any **nutrients**. Most of the nutrients are in the biomass, the bulk of animal and plant life above the ground.
- ✓ **The roots of rainforest trees are not very deep**; that way they can collect all of the nutrients in the top few inches of the soil. **Rainforests even recycle their own rain.**
- ✓ As water evaporates in the forest it forms clouds above the canopy that later fall as rain.

**Why a Tropical Rain Forest cannot be replaced very quickly?**

- ✓ A rainforest cannot be replaced. Once it is destroyed it is gone forever (almost thousands of years).
- ✓ We have read above that only the top few inches of rainforest soil have any nutrients. Below that it is **deficient in nutrients**. There is a high temperature and this high temperature leads to decomposition of the organic material as well as the inorganic parent material of the soil. There are frequent rains and these rains leach the decomposing material off the soil, out of the root zone quickly. So, the result is that the Tropical rain Forests have adapted themselves and quickly take up the nutrients and most nutrients in the tropical rain forests is stored in the vegetation.
- ✓ When the forest is harvested for timber or other plant products, or the forest is **burned**, nutrients will be lost from the ecosystem, but the outputs cannot exceed inputs for very long because the stock of nutrient capital in the system will be depleted. When forests are burned, or the cut timber is removed as in logging, the nutrients that were in the tree biomass are either washed out in the case of burning or simply removed from the system.
- ✓ Because there was only a small stock of nutrients in the soil and most of the nutrients were in the biomass, there is little nutrient stock remaining to support regrowth.
- ✓ Thus, we can't simply "regrow" tropical forests once they are burned -- once they are lost they are gone forever (or at least for 1000s of years, and even then the species that regrow will be different from the original forest species).

**Biodiversity:**

- ✓ Rainforests are home to half of all the living animal and plant species on the planet. High biodiversity appears related to high ecological specialization of species.
- ✓ The rainforests are home to more worldwide species than all other biomes added together.
- ✓ About 80 percent of the world's known biodiversity could be found in forests.

**Tropical Monsoon Forests**

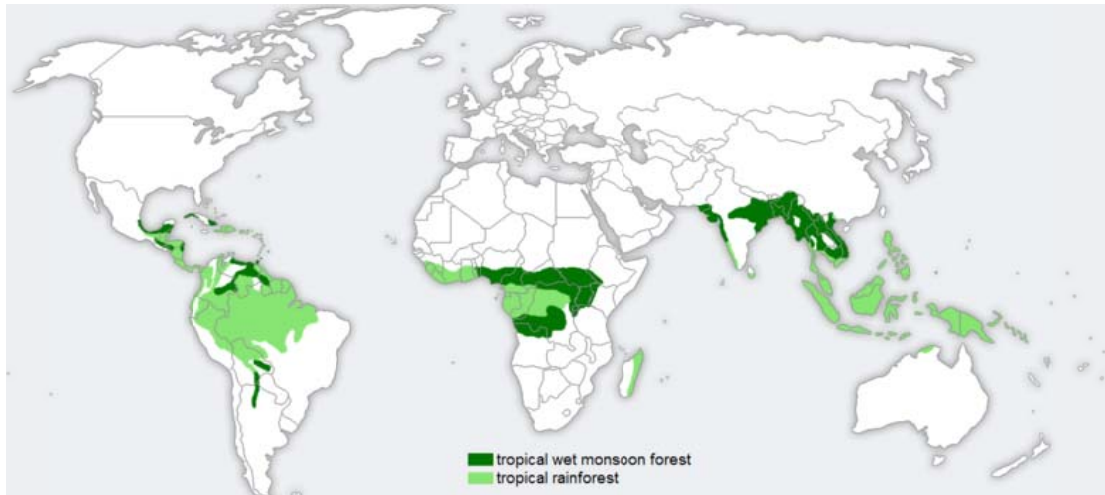
Throughout the world, the tropical monsoon climate experiences abundant rainfall like that of the tropical rain forest climate, but it is concentrated in the high-sun season. Such forests are called Tropical Monsoon Forests. They are located in the monsoon climate beyond the equatorial region between 10° and 25 ° and North and South of the equator. The countries are along the coastal regions of southwest India, Sri Lanka, Bangladesh, Myanmar, South western Africa, French Guiana, and northeast and southeastern Brazil.

Please note that the major controlling factor over the monsoon climate is its relationship to the monsoon circulation. Monsoon circulation of Asia exhibits an onshore flow of air (air moving from ocean towards land) during the summer or high-sun season, and offshore air flow (air moving from land toward water) during the winter or low-sun season. The change in direction is due to the difference in the way water and land heat. In India, the west coastal lowlands, the Western Ghats, and southern parts of Assam have this climate type. It is characterized by high temperatures throughout the year, even in the hills. The rainfall here is seasonal, but heavy and is above 78 cm in a year. Most of the rain is received in the period from May to November, and is adequate for the growth of vegetation during the entire year. December to March are the



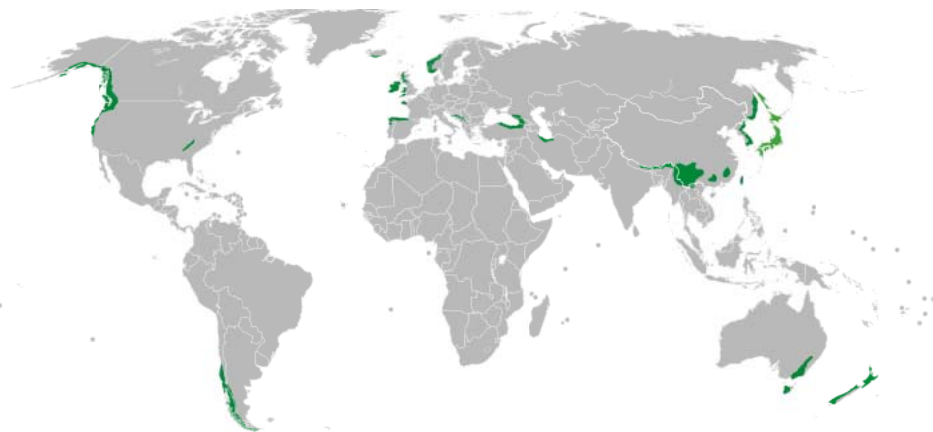
dry months with very little rainfall. The heavy rain is responsible for the tropical wet forests in these regions, which consists of a large number of species of animals. Evergreen forests are the typical feature of the region.

The following graphics shows the location of Tropical Rain Forests and Tropical Monsoon Rainforests throughout the world.



**Temperate rainforests**

Temperate rainforests are dense rainforests that occur in the regions of high rainfall in the temperate zone. We know that the north temperate zone extends from the Tropic of Cancer (at about 23.5 degrees north latitude) to the Arctic Circle (at approximately 66.5 degrees north latitude). The South Temperate Zone extends from the Tropic of Capricorn (at approximately 23.5 degrees south latitude) to the Antarctic Circle (at approximately 66.5 degrees south latitude). The regions in these latitudes, with annual precipitation over 1400 mm and mean annual temperature between 4 and 12 °C. (39 and 54 °F) are called Temperate Rain Forests. The following Graphics shows the distribution of the Temperate Rainforests throughout the world.



**Tropical & Temperate Deciduous Forests**

The deciduous biomes lie on the margin of equatorial and tropical rain forest. The deciduous trees lose their leaves during the dry season just a few months before the advent of summer rains. The monsoon forest average 15m high with no continuous canopy of leaves.

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Caatinga of Brazil is a suitable example. The others are Chaco in Paraguay and northern Argentina, the brigalow scrub of Australia, and the dorveld of South Africa.

- The tropical deciduous forest are also found in Angola, India, Indonesia, Malaysia, Myanmar, North-Eastern Thailand, Zambia, And Zimbabwe. The wood of the trees, especially teak wood is valuable for fine cabinetry. In addition, some of the trees with dry season adaption produce usable waxes and gums, such as carnauba and palm-hard waxes.
- Trees include Maple, many Oaks, Elm, Aspen, and Birch, among others, as well as a number of coniferous genera, such as Larch and Metasequoia.
- Deciduous shrubs include honeysuckle, viburnum, and many others.

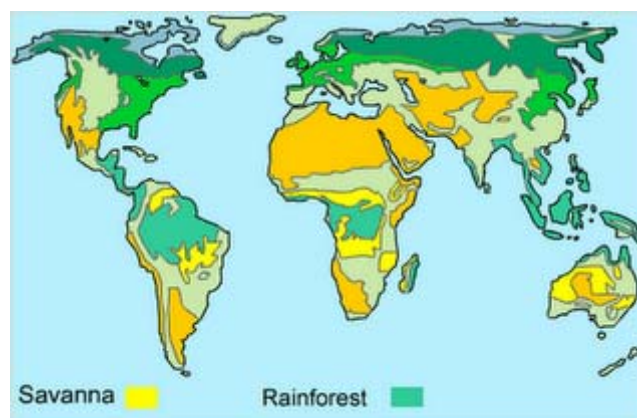
Most temperate woody vines are also deciduous, including grapes, poison ivy, virginia creeper, wisteria, etc. The characteristic is useful in plant identification; for instance in parts of Southern California and the American Southeast, deciduous and evergreen oak species may grow side by side.

Temperate deciduous forest has a temperate of 4 seasons. Temperate deciduous forests get about 950 to 1500 millimeters of rain annually, which is the second most of all the biomes. They have summer highs of about 27 to 32° Celsius with winter high temperatures of around -1 to -15° Celsius.

### Savannahs

A savannah is a grassland ecosystem. In Savannah, the trees are sufficiently small or widely spaced so that the canopy does not close. The open canopy allows sufficient light to reach the ground to support an unbroken herbaceous layer consisting grasses. Please note that some classifications put only those lands in Savannahs which don't have trees. However, most classifications characterize Savannah which is grassy woodland with a significant woody plant component.

The water availability in Savannahs is season and majority of the rainfall is confined to one season. Savanna covers approximately 20% of the Earth's land area. The largest area of savanna is in Africa. The following graphics shows Savannah as well as Rainforests so you are able to distinct the two regions.



The above discussions make it clear that **Savannahs are the grasslands with trees**. But this is not a strict definition and savanna biome also includes **treeless tracts of grasslands**.

- ✓ Please note that forest fires are common in Savannahs but that is mainly because of human interference and not because of the natural reasons as the lightning in case of Taiga Biome. In Taiga,

usually the forest fires are crown fires which destroy the canopy, but in Savannahs, these fires are usually confined to the herbaceous layer and do little long term damage to mature trees. These fires either kill or suppress tree seedlings, thus preventing the establishment of a continuous tree canopy which would prevent further grass growth.

Large areas of savanna have been cleared of trees, and this clearing is continuing today. For example until recently 480,000 ha of savanna were cleared annually in Australia alone primarily to improve pasture production. There are several types of Savannahs as following:

- ✓ **Tropical and subtropical savannas:** Tropical and subtropical grasslands and shrublands as the tropical and subtropical grasslands, savannas, and shrublands biome. The savannas of Africa, including the Serengeti, famous for its wildlife, are typical of this type.
- ✓ **Temperate savannas:** Mid-latitude savannas with wetter summers and drier winters. Examples are Great Plains of the United States.
- ✓ **Mediterranean savannas:** Mid-latitude savannas in Mediterranean climate regions, with mild, rainy winters and hot, dry summers, part of the Mediterranean forests, woodlands, and scrub biome. The oak tree savannas of California, part of the California chaparral and woodlands ecoregion are examples.
- ✓ **Flooded savannas:** That are flooded seasonally or year-round.
- ✓ **Montane savannas:** High-altitude savannas, Example is highland savannas of the Angolan Scarp savanna and woodlands ecoregion.

Please note that Savannah covered more than 40 per cent of the earth's surface before human intervention but were especially modified by human-caused fire. Fire occurs annually throughout the biome. The timing of these fires is important. Early in the dry season, they are beneficial and increase tree cover; if late in the season, they are very hot and kill trees and seeds.

#### Adaptations:

Savanna shrubs and trees are xerophytes or drought resistant, with various adaptations like small thick leaves, rough bark, or waxy leaf surface to protect them from the dryness.

Africa has the largest region of this biome, including the famous Serengeti plains and the Sahel region. Some of the local names of these grasslands include the

- ✓ Llanos in Venezuela,
- ✓ Campo cerrado in Brazil, and
- ✓ Pantanal of southern Brazil. They are also found in Australia, India, Ethiopia, Kenya, and Somalia.

#### Soil of Savannahs:

Savannah grasslands are much richer in humus than the equatorial forests are the main agricultural crops of the savanna lands. The C4 grasses are found in majority in Savannah.

#### Animals:

Savanna are the home of large mammals that graze on savanna grasses or the savanna grasses or feed upon the grazers themselves ; these are lions, cheetah, zebra, giraffe, buffalo, gazelle, wild beast, antelope,

rhinoceros, and elephant. Some of the animal species like the black and white rhino have become extinct during recent time.

### Temperate grasslands

Temperate grasslands are found in the regions with **temperate and semi-arid to semi-humid climates**. The most important characteristic of the Temperate Grasslands is that they have almost no trees and large shrubs and have grasses as the dominant vegetation. Please note that the amount of rainfall is less in temperate grasslands than in savannas.

- ✓ The **Veldts of South Africa**, the **Puszta of Hungary**, the **Pampas of Argentina and Uruguay**, the **Steppes of the former Soviet Union**, and the plains and **Prairies of Central North America** are Temperate Grasslands.

### Climate

- ✓ Temperate grasslands have **hot summers and cold winters**. Rainfall is **moderate**. The amount of annual rainfall influences the height of grassland vegetation, with **taller grasses in wetter regions**.
- ✓ Akin to Savannah, seasonal drought and occasional fires are very important to biodiversity. However, their effects aren't as dramatic in temperate grasslands as they are in savannas.
- ✓ Few natural prairie regions remain because most have been turned into **farms or grazing land**. This is because they are flat, treeless, covered with grass, and have **rich soil**. **Prairies** are grasslands with **tall grasses** while **steppes** are grasslands with **short** grasses.

### Soils of Temperate Grasslands:

- ✓ The soil of the temperate grasslands is deep and dark, with fertile upper layers. It is **nutrient-rich** from the growth and decay of deep, many-branched grass roots. The rotted roots hold the soil together and provide a food source for living plants.
- ✓ Each different species of grass grows best in a particular grassland environment (determined by temperature, rainfall, and soil conditions). The seasonal drought, occasional fires, and grazing by large mammals all prevent woody shrubs and trees from invading and becoming established.
- ✓ However, a few trees, such as cottonwoods, oaks, and willows grow in river valleys, and some nonwoody plants, specifically a few hundred species of flowers, grow among the grasses. The various species of grasses include purple Needlegrass, Blue Grama, Buffalo Grass, and Galleta. Flowers include asters, blazing stars, coneflowers, goldenrods, sunflowers, clovers, psoraleas, and wild indigos.

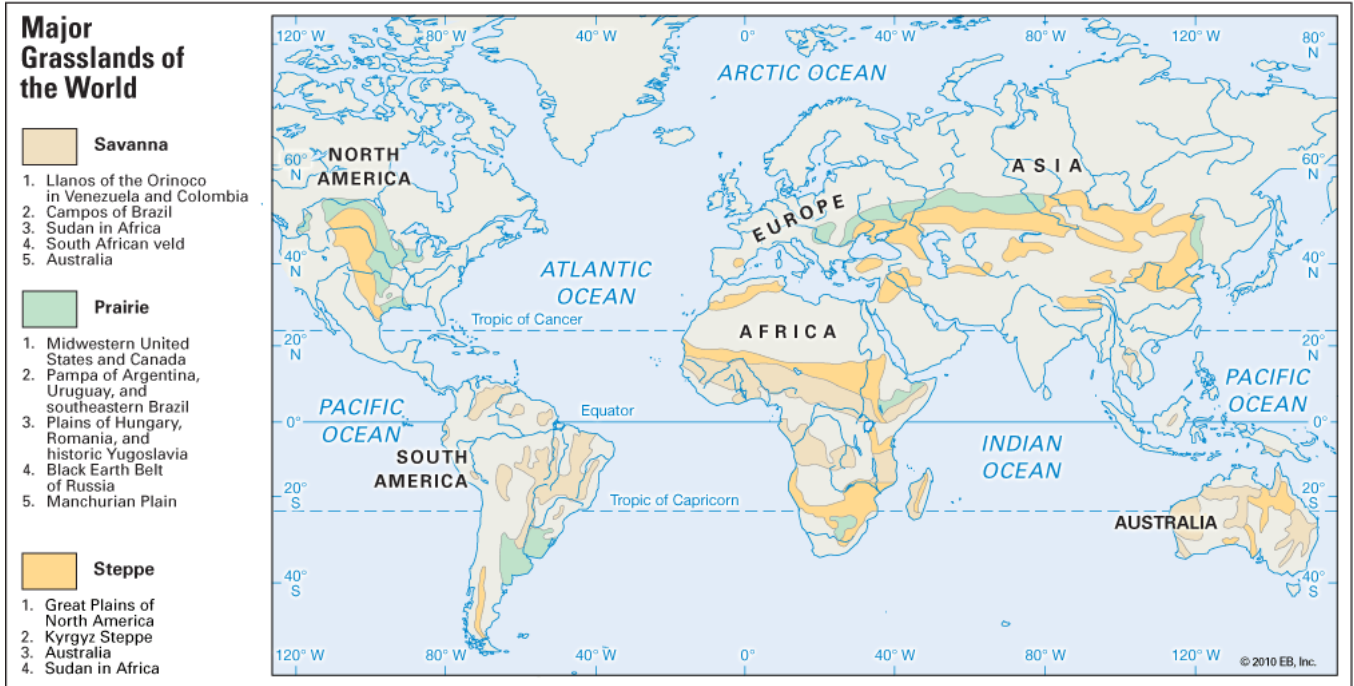
### Rainfall:

- ✓ Precipitation in the temperate grasslands usually occurs in the late spring and early summer. The annual average is about 50.8 to 88.9 cm.
- ✓ The temperature range is very large over the course of the year. Summer temperatures can be well over 38° C (100 degrees Fahrenheit), while winter temperatures can be as low as -40° C (-40 degrees Fahrenheit).

**Fauna:**

- ✓ Animals include gazelles, zebras, rhinoceroses, wild horses, lions, wolves, prairie dogs, jack rabbits, deer, mice, coyotes, foxes, skunks, badgers, blackbirds, grouses, meadowlarks, quails, sparrows, hawks, owls, snakes, grasshoppers, leafhoppers, and spiders.

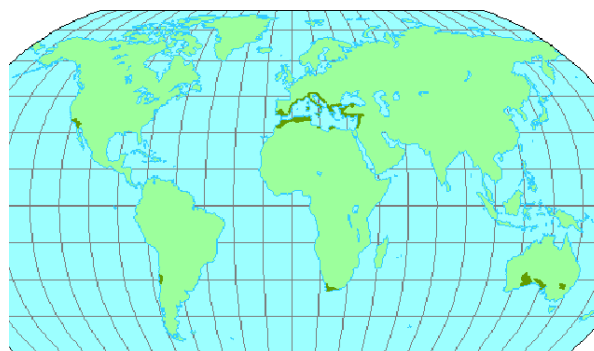
The following graphics sources from Britannica online shows grasslands of the World.



Grasslands of the World © 2010 EB Inc.

**Mediterranean Shrublands**

This biome is found along the coasts of the Mediterranean Sea, California, Central Chile, south-western part of South Africa and southwestern parts of Australia. They have been shown in the following graphics:



Mediterranean Shrublands

The Mediterranean climate has hot and dry summers and mild-wet winters. The natural vegetation of this biome adapted according to the dry and hot summer conditions. Plant ecologists are of the opinion that this biome is well adapted to frequent fires, for many of its characteristically deep-rooted plants have the ability to re-sprout from their roots after a fire.



The dominant shrubs that occupy these regions are stunted and tough in their ability to with-stand hot-summer drought. The **vegetation is called sclerophyllous**. It averages as metre or two in height and has deep, well developed roots, leathery and uneven low branches.

#### Location:

- ✓ Mediterranean-type climate regions occur roughly between **30° and 40°** latitude on the **west coasts of continents**, where offshore there are **cold ocean currents**.
- ✓ Each region in which the Mediterranean shrublands and woodlands occur is island-like in character and thus there is frequently a **high degree of endemism**.

#### Climate:

- ✓ In Mediterranean regions, wet season coincides with the low sun or winter period. Summers are dry. Total annual precipitation ranges between **40 and 90** cms per year.
- ✓ **Temperatures** are those of the **subtropics moderated by maritime influence** and fogs associated with the cold ocean currents.
- ✓ The result is a very limited, but predictable, growing season when there is both sufficient soil moisture and adequately warm temperatures. Many plants are adapted to withstand drought.

#### Flora:

- ✓ Throughout the world, the **Mediterranean biome is characterized by shrubs**. In most regions these shrubs are evergreen and have small, leathery (sclerophyllous) leaves with thick cuticles. Sometimes the leaves are so reduced as to appear needle-like. Many typical members of the shrub flora are aromatic (for example, sage, rosemary, thyme, and oregano) and contain highly flammable oils.

Mediterranean regions have long been impacted by humans especially through the use of fire and the grazing of livestock.

#### Regional Names:

- ✓ In the Mediterranean proper--Europe, North Africa, and Asia Minor, they are known as **Maquis**.
- ✓ In California they are called **Chaparral**
- ✓ In Chile, they are known as **Matorral**
- ✓ In Australia, they are expressed by the **Mallee** scrub vegetation of subtropical Australia.

The Mediterranean region of Europe and Asia has a significant concentration of cork-oak, olive, fig, and citrus fruits. In Australia the bulk of the eucalyptus species is sclerophyllous in form and structure.

#### Desert biome

Deserts and xeric shrublands are characterized by small amount of moisture. They receive an annual average rainfall of ten inches (25 cms) or less, and have an arid or hyperarid climate, characterized by a strong moisture deficit, where annual potential loss of moisture from evapotranspiration well exceeds the moisture received as rainfall.

- ✓ The desert biome of the earth covers about **35 per cent of the total land area** of the world.



- ✓ Deserts are very dry, receiving less than 25cm. In the desert of **Atacama** of northern Chile, only a negligible amount of rain has ever been recorded—a 30-year annual average of only 0.005cm, making it **driest** part of Earth.

The area of the desert biome is **increasing** as there is increasing desertification because of human over interaction. **Deserts and xeric shrublands occur in all tropical, subtropical, and temperate climate regions.** Desert soils tend to be sandy or rocky, and low in organic materials. **Soil is generally saline or alkaline.**

#### Adaptations:

- ✓ Plants and animals in deserts and xeric shrublands are adapted to low moisture conditions. Hyperarid regions are mostly devoid of vegetation and animal life, and include rocky deserts and sand dunes.
- ✓ Vegetation in arid climate regions can include sparse grasslands, shrublands, and woodlands.
- ✓ Deserts are inhabited by the Xerophytes which include succulent plants, geophytes, sclerophyll, and annual plants. Animals, including insects, reptiles, arachnids, birds and mammals, are frequently nocturnal to avoid moisture loss.
- ✓ In the southern Arizona, the unique Saguaro cactus grows to many metres in height and can survive up to 200 years of age if left undisturbed. First blooms do not appear until it is 50 to 75 years old.

#### Cold Deserts:

- ✓ Cold desert occur where seasonal shifting of the subtropical high is of some influence less than six months of the year. Specifically interior locations are dry because of their distance from moisture sources or their location in **rain shadow areas** on the leeward side of mountain ranges such as **Himalayas** and **Andes**.
- ✓ Winter snows occur in the cold deserts but are generally light. Summers are hot—with highs varying between 30° and 40°C.
- ✓ Night time lows—even in the summer, can cool 10° to 20°C from the daytime high.

## SOIL BASICS

### Origin and types of soils

- ✍ The loose material or the upper layer of the mantle rock, made up of loose, heterogeneous material covering solid rock is known as **Regolith**.

Regolith includes dust, soil, broken rock, and other related materials and is present on Earth, the Moon, some asteroids, and other terrestrial planets and moons. The fine particles of the solid rocks along with the organic / inorganic matter are called soil.

The naturally occurring soil is influenced by parent material, climate, relief and the physical, chemical and biological agents such as microorganisms living in it. The naturally occurring soil is influenced by

- ✓ Parent rocks
- ✓ Climate
- ✓ Organic content
- ✓ Topography
- ✓ Land use practices/ Human interference

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✓ Time

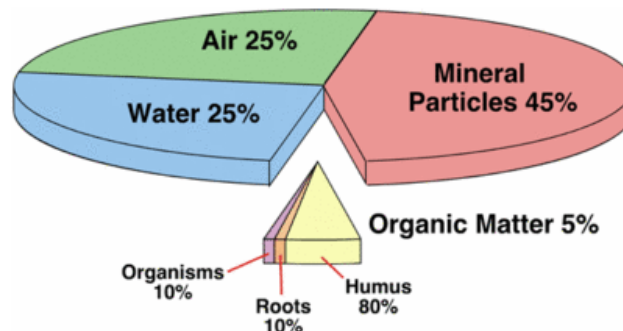
Soil contains mineral particles, decayed organic material, soil water, soil atmosphere, and living organisms, which exist in a complicated and dynamic relationship with one another.

Soil is a dynamic natural body made up of the materials covering the earth's surface in which plants grow. It is composed of both mineral and organic matter.

**Complex Nature of Soil**

- ✓ The above mentioned factors do not work on soil independently or in isolation, but in close association with each other, leading to a whole network of inter-relationships of quite a complex nature.
- ✓ The material of the soil or the parent material is derived from the rocks exposed on the surface. The relief and slope along with the work of various materials.
- ✓ Soils weathering determine conditions for the disintegration of the rock materials. Soils may be transported by the running water, wind or other agents of the rock materials. Soils remain in the original position.
- ✓ When the soil remains in its original position, it is said to be in situ, and in that state it is further modified by the climate, particularly moisture supply, plant growth, and bacterial activity dependent on these factors. A brief supply, plant growth, and bacterial activity dependent on these factors.

A soil is made up of four elements: **inorganic or mineral fraction** (derived from the parent material), **organic material, air and water**. The abundance of each component and its importance in the functioning of the soil system vary from horizon to horizon and from one soil to another.



Soil Components. Source Physicalgeography.net

**Humus:**

- ✓ The end-product of the breakdown of dead organic material is known as Humus.
- ✓ Humus is a structure-less, dark-brown or black jelly found beneath the soil surface. In uncultivated land, the humus is derived from the natural decay of previous generations of plants, while in the ploughed and cultivated land it is supplied as some kind of manure.
- ✓ The humus of ordinary soil is black, and is thus responsible for making the soil darker than the subsoil. It plays an important but very complicated part in maintaining the fertility of soil.

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- ✓ The amount of humus in different soils varies considerably; some, like the peat soil, consist largely of slightly decomposed organic matter which has not yet become humus.

### Soil Texture

- ✓ A soil is generally characterized by the size of its particles. A clayey soil may thus be described as fine, a sandy soil as coarse, while a silty soil is intermediate.
- ✓ If one handles a moist soil sample of each of these he feels gritty, sticky and silky, respectively.
- ✓ The standard unit for the measurement of soil particles is the millimeter, but a smaller unit is the micron (1 micron= 0.001 mm), which is applicable, for instance, to the measurement of soil colloids.

### Sandy Soil

- ✓ Sandy soil is a light soil that consists mainly of sand, i.e., **grains of quartz** with considerable air spaces between them.
- ✓ The sand may either be 'coarse' where the particles are between 0.2 and 2 mm in diameter, or 'fine' where the grains between 0.05 and 0.2 mm are just visible to the naked eye.
- ✓ These light soils allow water to drain through rapidly, taking soluble plant foods with it.
- ✓ Sandy Soils are known as **'hungry' soils**, which not only **need constant manuring** but **may dry out completely during a period of drought** so that shallow-rooted crops fail and pastures 'burn'.
- ✓ They are **good for horticulture** (vegetables and fruits), **legumes** (such as moth and pulses), ground nut and bajra.

### Clayey Soil

- ✓ Clayey soil is an exceptionally fine grained soil, very retentive of moisture.
- ✓ It often becomes plastic when mixed with water. The individual grains of clayey soil are 0.002 mm in diameter.
- ✓ These particles consist mainly of **hydrated aluminum silicates**.
- ✓ Clay **contains little air and can hold more water, so forming a sticky mass**, but when it dries out completely, it forms a hard, concrete like surface, seamed with numerous cracks.
- ✓ Sometimes, a compacted solid layer of clay in the subsoil is formed, which is known as **claypan**, and is often hard and difficult to dig or plough.
- ✓ Clayey soils are often **rich in plant food** and give much **better yields** than that of sandy soils.
- ✓ They are devoted to rice, perennial grasses other crops such as clover. Efficient **drainage** methods, **modern machinery** and careful **liming** enable clayey soils to grow roots, green crops and cereals.

### Silty Soil

- ✓ Silty soil is finer than sand but coarser than clay.
- ✓ Its particles are assumed to have a diameter between 0.02 and 0.002 mm.
- ✓ These soils are **rich in humus** contents and are devoted to numerous cereal and non-cereal crops.

### Loamy Soil

- ✓ It is highly fertile soil consisting mainly of a **mixture of sand and clay**, together with **silt and humus**. It has the good qualities of both sand and clay, but not their bad qualities.

- ✓ It comprises an almost equal mix of sand and silt with less than 30 per cent clay.
- ✓ It can retain some moisture and plant food even under the adverse weather and climatic conditions. It is well-aerated and drained, and can be readily worked.
- ✓ It is generally devoted to wheat, barley, legumes, sugarcane, sugar beet, maize, millets, rice, grasses, vegetables and orchards.

### Understanding Soil pH

Soil pH is a measure of the acidity or basicity in soils. As we know, the pH below 7 is acidic and above 7 is basic. Soil pH is considered a master variable in soils as it controls many chemical processes that take place. It specifically affects plant nutrient availability by controlling the chemical forms of the nutrient. The **optimum pH range for most plants is between 6 and 7.5**, however many plants have adapted to thrive at pH values outside this range.

*The first thing we should note that in cool and moist areas, percolating groundwater leaches out the soluble bases (such as calcium). As a result, the soils gradually become lime-deficient which increases the acidity of the soil.*

Both the highly acidic and alkaline soils are injurious to crops. If the soil becomes unduly acidic, the farmers **apply lime** in various forms to meet the requirements of the soil. **In practice, a pH value between 6 and 6.5, i.e., very slightly acidic, is desired.** Lime not only helps to neutralize the excess acids and so 'sweeten' the soil, but it also **encourages bacteria** and helps to improve the physical, texture of heavy soils. **High soil acidity is typical of cold, humid climates. In arid climates, soils are typically alkaline.**

#### How to Increase soil pH?

Acidity can be corrected by the application of lime, a compound of calcium, carbon and oxygen (CaCO<sub>3</sub>), which removes acid ions and replaces them with the base calcium.

#### How to Decrease soil pH?

- ✓ To decrease the pH of the soil, the **Iron sulphates or aluminum sulphate** as well as elemental sulfur (S) are used through the formation of sulfuric acid.
- ✓ Further, **Urea**, urea phosphate, **ammonium nitrate**, **ammonium phosphates**, ammonium sulphate and monopotassium phosphate fertilizers have an organic matter in the form of plant litter, compost, and manure will **decrease soil pH** through the **decomposition process**.
- ✓ Certain acid organic matter such as pine needles, pine sawdust and acid peat are effective at reducing pH.

#### The problem of Alkaline Soils

- ✓ Alkali or alkaline soils are the soils with **high pH (> 9)**. The first visible impact of Alkaline soil is that it has a **poor soil structure and a low infiltration capacity**.
- ✓ The Alkali soil is generally having a **hard calcareous layer at 0.5 to 1 metre depth**.
- ✓ Alkali soils have dominated presence of minerals such as Sodium Carbonate which causes the soil to **swell**.

- ✓ Please note that **all alkaline soils are basic, but NOT all basic soils are alkaline.** This is because even presence of basic salts, the soil may not become alkaline due to other chemical reactions. For example, pH of a solution can be lowered by the addition of CO<sub>2</sub>. This will reduce the basicity; however, the alkalinity will remain unchanged.
- ✓ The reason is that net reaction produces the same number of equivalents of positively contributing species (H<sup>+</sup>) as negative contributing species (HCO<sub>3</sub><sup>3-</sup> and/or CO<sub>3</sub><sup>2-</sup>).

**How Gypsum helps in Treatment of Alkali soils?**

Gypsum (calcium sulfate, CaSO<sub>4</sub>. 2H<sub>2</sub>O) can be applied as a source of Ca<sup>++</sup> ions to replace the sodium at the exchange complex in the soil. However, there must be enough natural drainage to the underground, or else an artificial subsurface drainage system must be present, to permit leaching of the excess sodium by percolation of rain and/or irrigation water through the soil profile, while using Gypsum.

**Soil Air**

- ✓ Soil air is vital both to soil itself and to organic life within it. A certain amount of air is contained between the individual particles except for the waterlogged soils. The air in the soil helps in the process of oxidation which converts part of the organic material into nitrogen in a form readily available to the plants.
- ✓ On the other hand, too high degree of oxidation may consume so much organic material that the soil becomes increasingly sterile.

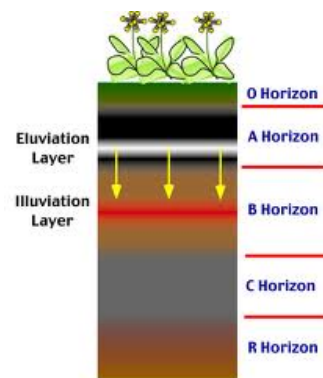
**Soil fertility**

Soil fertility is the ability of soil to sustain plants. Soil has fertility when it contains organic substances and clay minerals that absorb water and certain elements needed by plants. The boundary between horizons is usually visible in the field, using the properties of colour, texture consistency, porosity, the presence or absence of certain minerals, moisture, and chemical processes.

**Soil horizons**

Soil horizons are the building blocks of soil classification. The various layers exposed in a pedon; roughly parallel to the surface and identified as O,A,E,B, and C are known as soil horizon. The O horizon is the topmost layer of most soils. It is composed mainly of plant litter at various levels of decomposition and humus.

- ✓ The **O horizon** is the topmost layer of most soils. It is composed mainly of plant litter at various levels of decomposition and humus.
- ✓ **A horizon** is found below the O layer. This layer is composed primarily of mineral particles and has two characteristics: it is the layer in which humus and other organic materials are mixed with mineral particles, and it is a zone of translocation from which eluviation has removed finer particles and soluble substances, both of which may be deposited at a lower layer. Thus the A horizon is dark in color and usually light in texture and porous. The A horizon is commonly differentiated into a



darker upper horizon or organic accumulation, and a lower horizon showing loss of material by eluviation.

- ✓ The **B horizon** is a mineral soil layer which is strongly influenced by illuviation. Consequently, this layer receives material eluviated from the A horizon. The B horizon also has a higher bulk density than the A horizon due to its enrichment of clay particles. The B horizon may be colored by oxides of iron and aluminum or by calcium carbonate illuviated from the A horizon.
- ✓ The **C horizon** is composed of weathered parent material. The texture of this material can be quite variable with particles ranging in size from clay to boulders. The C horizon has also not been significantly influenced by the pedogenic processes, translocation, and/or organic modification.
- ✓ The final layer in a typical soil profile is called the **R horizon**. This soil layer simply consists of unweathered bedrock.

### Soil Taxonomy

Soil classification based on observable soil properties actually seen in the field is known as soil taxonomy. There are a number of soil classifications presented by the experts of soil science. The major types of the soils have been discussed here:

#### Oxisols

- ✓ These soils develop in the **hot and humid** climates of the **equatorial region**.
- ✓ Called oxisols because they have distinctive horizon with **a mixture of iron and aluminum oxides**.
- ✓ Related vegetation is the luxuriant and diverse tropical and equatorial rain forest. Typical are reddish and yellowish from the iron and aluminum oxides left behind, with a weathered clay-like texture.
- ✓ In fact, these are the lateritic soils in which the leaching process is very strong.
- ✓ The Laterite can be quarried in blocks and used as building material. They are traditionally being used for shifting cultivation. When oxisols are disturbed, soil loss can exceed a thousand tones per sq km per year.
- ✓ The regions dominated by oxisols by oxisols and rain forests are attracting the much worldwide environmental attention.

#### Aridisols (desert soils)

- ✓ The largest single soil order occurs in dry regions of the world. These soils occupy nearly 19 per cent of the earth's land surface.
- ✓ Pale and light near the surface, deficit in moisture.
- ✓ Lack in organic matter. Salinisation is the main problem of these soils. Salinisation complicates farming in Aridisols.

#### Mollisos (grassland soils)

- ✓ They are most productive soils of the earth. They are rich in humus content. They have dark-colored surface.
- ✓ Mollisols are soft, even when dry, with granular pads, loosely arranged when dry.



- ✓ These humus rich organic soils are high in basic cations and have high fertility.
- ✓ **Soils of the steppes and prairies of the world belong to this group.**
- ✓ These soils are being utilized for large-scale commercial grain farming and grazing.
- ✓ The process of calcification is very strong in these soils. When cemented or hardened, these deposits are called *calche or kankar*.

#### **Alfisols (moderately weathered forest soils)**

- ✓ These are the most widespread of the soils orders, extending from near the equator to high latitudes.
- ✓ Pale, grayish brown to reddish in colour and are considered moist versions of Mollisols soil group.
- ✓ Alfisols have moderate-to-high reserves of basic cations and are fertile. However, their productivity depends on moisture and temperature. They are supplemented by the moderate application of lime and other chemical fertilizers.
- ✓ Some of the best agricultural farms of USA have this type of soil

#### **Ultisols**

- ✓ These highly weathered forest soil are found in the temperate climates. These soils tend to be reddish in colour because of residual iron and aluminum oxides in the A horizon.
- ✓ The increased precipitation in ultisol regions means greater mineral alteration, more leaching, and therefore, a lower level of fertility.
- ✓ Fertility is further reduced by certain agricultural practices and the effect of soil damaging crops such as cotton and tobacco. These soils need substantial management.

#### **Spodosols (coniferous forest soils)**

- ✓ Found in the humid continental mild summer climates. Their distribution is found in North America and Eurasia.
- ✓ They are not found in the southern hemisphere.
- ✓ Spodosols lack in humus and clay in the A horizons.
- ✓ The leaves of the conifers add acidity in soil.
- ✓ Their colour is ash gray and they are also known as podzol soils. These are not very fertile soils. To enhance the fertility, the application of lime required.

#### **Entisols (recent, underdeveloped soils)**

- ✓ Usually young or underdeveloped.
- ✓ Lack vertical development of horizons. These are less fertile soils.
- ✓ The sand dunes, ergs, outwash glacial plains, and the poorly drained tundra, tidal mud flats, etc. are the examples of Entisols.

#### **Inceptisols (weakly developed soils)**

- ✓ These soils are **inherently infertile**.
- ✓ They are usually the weakly developed young soil though they are more developed than entisols.
- ✓ They include the soils of most of the arctic tundra and outwash moraines.

**Andisols ( volcanic parent materials)**

- ✓ The term andisols has been derived from **volcanic ash and glass**.
- ✓ Highly fertile and have a high water holding capacity.
- ✓ These soils occupy relatively smaller area, especially around the volcanic ring of fire in the pacific rim. Examples are the fertile soils of Hawaii that produce sugarcane and pineapple as important cash crops.

**Vertisols (expandable clay soils)**

- ✓ Composed of more than 30 per cent clays.
- ✓ Vertisol clays are black when wet and become iron hard when dry.
- ✓ When drying, Vertisols crack and the cracks widen and deepen as the soil dries ; this produces cracks 2-3 cm wide. These are productive soils .
- ✓ The **regur** soils of India are an example of vertisols.

**Histosols (organic soils)**

- ✓ Formed from accumulation of thick organic matter.
- ✓ Bog marsh are the examples of Histosols.
- ✓ Dried Histosols are used as low-grade fuel.