General Knowledge Today

Environment -1: Ecology & Biomes

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Key Ecology Concepts

The study of the interactions between living things and their environments is known as ecology. In ecology, *everything is connected to everything else* and there is a constant interaction between organisms and their environment.

Autecology and Synecology

Autecology & Synecology are two main branches of ecology. Autecology is the study of *individual organism or individual species.* It is also known as population ecology. Synecology is the study of *group of organisms of different species which are associated together as a unit in form of a community*. Also known as *community ecology*.

Autecology helps us to understand the relationships between individual plants and environment. Synecology helps us to understand the relationships between communities and environment.

Various Ecological Units

There are several types of inter-related ecological units such as species, population, community, ecosystem, biome, ecosphere, biosphere etc. Many of these concepts suffer from inconsistencies and confusions over terminology.

Organisms and Populations

Theoretically, an organism should be smallest ecological unit. However, since all organisms have finite life spans, reproducing *population* is considered to be the *smallest ecological unit*; because it is persistent in time. Population refers to a group of individuals that belong to the same species and that are interbreeding.

Why population and not species is smallest ecological unit?

Species refers to a group of organisms in which two individuals are capable to interbreed and ordinarily don't breed with other groups. If a species interbreeds freely with other species, it would no longer be a distinctive organism. But biology is a science of exceptions. There are numerous examples where organisms of a species interbreed with individuals of another species. Such interbreeding between species is more common in plants in comparison to animals. Due to these exceptions, what exactly is a species – is very difficult to define.

Since ecology and environment has more to do with interaction among organisms and with their environment; population and not species is considered the smallest ecological unit. Species is in fact the smallest unit of taxonomic classification rather.

Community

A community refers to *all the populations in a specific area at certain time*. There are two essential things which make a group of populations eligible to be called community. These are interaction and *inter-dependence* for nutrition, food or other resources. Such interactions may involve life-death

struggle among various organisms, as well as nutrient cycles manifested through various kinds of food webs and food chains.

How diversity of populations affects stability in community?

A complex community (i.e. that has a high diversity of populations) is more stable in comparison to community having low diversity. This is because food webs of communities of high diversity are more interconnected, and the greater inter-connectivity makes it more resilient to disturbance. If one species is removed, the other species which depend on it for food have other options to switch.

Producers, consumers and Decomposers

In terms of nutrition, that all organisms within a community are either producers, or consumers or decomposers. The producers or *autotrophs* are the plants which make their own food from inorganic raw material. This work is accomplished via photosynthesis or chemosynthesis. Consumers or *heterotrophs* get their nutrition / energy from the things they consume. They cannot produce their own food and have to look outside world for those things to consume. All organisms finally yield to *decomposers*, which break down organic matter into simple products. Fungi and bacteria are the common decomposers. They serve as the "garbage collectors" or "recyclers" in our environment.

Ecosystem

An ecosystem is *community plus its physical environment*. Thus, ecosystem is a complex community of living plants, animals, and microorganisms (called biotic components of ecosystem) linked by energy and nutrient flows that interact together and their physical environment (called abiotic component of ecosystem) such as soil, air, water, sunlight etc. Kindly note that an ecosystem is the *smallest functional ecological unit.*

An ecosystem may be natural or manmade (such as aquarium), terrestrial or aquatic, and lentic (stagnant water such as pond) and lotic (running water such as river) in case of aquatic systems.

Ecosystem Services

Services derived from ecosystems are referred to as *Ecosystem Services*. There are four categories of Ecosystem Services as follows:

Supporting services

- Nutrient dispersal and cycling
- Seed dispersal
- Primary production

Provisioning services

- Food (including seafood and game), crops, wild foods, and spices
- Water
- Minerals (including diatomite)
- Pharmaceuticals, biochemical, and industrial products

- Energy (hydropower, biomass fuels)

Regulating services

- Carbon sequestration and climate regulation
- Waste decomposition and detoxification
- Purification of water and air
- Crop pollination
- Pest and disease control

Cultural services

- Cultural, intellectual and spiritual inspiration
- Recreational experiences (including ecotourism)
- Scientific discovery

Ecosystem services 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.

Biomes

Biomes are *groups of ecosystems* that *share similar climatic conditions* and *same kind of abiotic and biotic factors* spread over a *large area*. The biomes are either terrestrial or aquatic. There are several systems of classification of biomes. The main types of biomes include Deserts (Hot, Cold, Semi Arid and Coastal), Aquatic Biomes (marine or freshwater), Forest (Tropical, Temperate, Taiga , Montane etc.), Grassland (Savannah etc.) and Tundra (Arctic Tundra, Alpine Tundra).

Importance of Biomes

Biomes play a crucial role in sustaining life on earth. For example, the Aquatic biome is home to millions of fish species and the source of the water cycle. It also plays a very important role in climate formation. The terrestrial biomes provide foods, enrich the air with oxygen and absorb carbon dioxide and other bad gases from the air. They also help regulate climate and so on.

Biosphere and Ecosphere

All the biomes together make up the biosphere. Biosphere is the entire part of the earth where living things exist. This includes soil, water, light, and air. The word Biosphere includes sum total of life and life-support systems viz. atmosphere, hydrosphere, lithosphere, and pedosphere.

What is difference between Biosphere and Ecosphere?

Ecosphere is the global ecosystem i.e. the sum total of life on earth together with the global environment and the earth's total resources containing five essential elements: energy, air, water, sand, and living things. The term ecosphere was coined to denote sum total of life or living things along with organic and inorganic environment supporting it. In summary, *there is no material*

difference between Biosphere and Ecosphere.

Which is suitable term for largest ecological unit – Biosphere or Ecosphere?

The largest ecological unit depends on how we define it. As per the WWF classification, the *largest ecological unit is Biosphere.* In other classifications, the term *Ecosphere is used as largest ecological unit.*

Ecozones

Ecozones are the Biogeographic division of the Earth's land surface, based on distributional patterns of terrestrial organisms. Since they include only terrestrial part of biosphere, they are called Terrestrial Ecozones also.

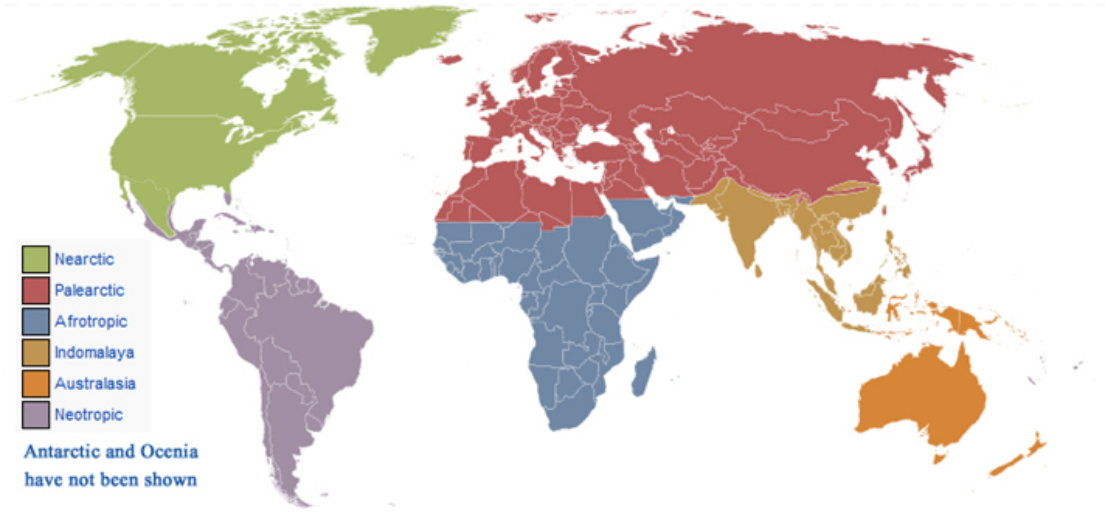
Similarities / Differences between Biomes and Ecozones

Both biomes and Ecozones are groups of ecosystems, however, an Ecozone comprises *only land parts* of Earth surface, while the biomes comprise both aquatic and land parts.

Major Ecozones

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

Ecozone	Area Km²	Included regions
Palearctic	54.1	Includes the bulk of Eurasia and North Africa, This is largest
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.



Ecological Niche

Ecological niche of an organism is the physical space occupied by it, its functional role in the community i.e. tropic position, its position in environment and the conditions of existence.

Difference between Niche and Habitat

A niche describes how an organism *makes its living* and *responds to the distribution of resources* and competitors. The ecological niche involves both the place where an organism lives as well as the roles that an organism does in its habitat. For example, various *habitats* of *house sparrow* include woodlands, grasslands, and deserts; houses, factories, warehouses, zoos etc. However, when we talk about its *niche*, it would include – eating insects, grains, seeds etc.; making nests in houses, trees and shrubs etc. Thus, niche is a broader concept than habitat and its focus is on *functional role* played by the species rather than only the place it needs to live. For any organism, the niche includes both the physical habitat and how it has adapted to life in that habitat.

In summary, *Habitat is "address" while Niche is "profession"*.

Ecological Equivalents

Organisms that occupy the same or similar ecological niches in different geographical regions are known as *Ecological Equivalents*. For examples, owls and cats, both feed on mice; but owls are found in deserts or forests while cats are around human habitations. In this context, owls and cats are ecological equivalents in terms of their feeding role. Similarly, Kangaroos of Australia perform the same functions (herbivores) as antelopes or Bison of North America. Both live in similar habitats of different regions but have similar profession of herbivores.

Can two species share the same niche?

Each species has one Niche; no two species can share the same niche for long because then the competition for resources will drive the inferior species out. This is called *character displacement* or *niche shift* or *niche displacement*. Further, please note that *competition for food, light and space is most severe between two closely related species occupying same niche.*

Narrow Niche and Broad Niche

When an organism is adapted various kinds of environmental conditions for its survival, it has a generalized or broad niche. Such organisms are called *generalists.* On the other hand, if the organism needs specific set of conditions for its survival, it has a specialized niche or narrow niche. Such organisms are called *specialists.*

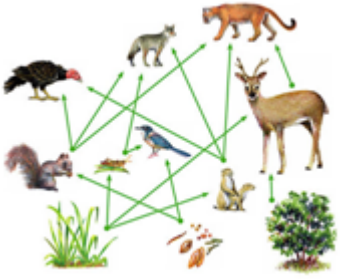
There are many species of plants and animals which can survive only a narrow range of climatic or environmental conditions. For example, Giant Panda has a very specialized niche because 99% of its food is bamboo plants. The destruction of bamboo in China has led the Giant Panda to reach stage of near extinction. Thus, *narrow niche is one of the reasons behind the extinction of species.*

- Examples of Narrow Niche: Giraffes, Lemurs, Ganges River Dolphin etc.
- Example of Broad Niche: Humans, Rodents, House Sparrows etc.

Food Chain and Food Webs

Food chain refers to a linked feeding series in an ecosystem. A food chain illustrates the order in which a *chain of organisms feed upon each other* and the sequence of organisms through which energy and materials are transferred, in the form of food, from one tropic level to another. The following graphics shows a simple food chain.

The food chains are not isolated and are inter-linked to each other. For example, a Hawk can eat snakes as well as other smaller birds. A mouse can eat grass, bread or even grasshoppers. A Lizard can eat insects of different types. Thus, various food chains are intertwined in each other making a food web. A Foodweb is thus a system of interlocking and interdependent food chains. A typical Foodweb is shown in the below graphics.



Trophic Levels

There are basically four levels to the food chain viz. producers, primary consumers, secondary consumers, and tertiary consumers.

First Trophic Level (Plants)

Producers or Autotrophs produce all of the available food. They make up the first trophic (feeding) level. *They possess the highest biomass (the total weight of all the organisms in an area) and the greatest numbers.* This is evident from the fact that the plants make around 99 percent of the earth's total biomass.

Second Trophic Level (Herbivores or Primary Consumers)

Primary consumers (Herbivores) are organisms that directly feed on producers. A good example is a cow. They make up the second trophic level.

Third Trophic Level (Carnivores or Secondary Consumers)

The next level consists of organisms that feed on primary consumers. They are the secondary consumers, and they make up the third trophic level. They are called carnivores and omnivores

Fourth Trophic Level (Apex Predators or Tertiary Consumers)

Apex predator species occupy the highest trophic level(s) and have a crucial role in maintaining the health of their ecosystems. Apex predators affect prey species' population dynamics. Where two competing species are in an ecologically unstable relationship, apex predators tend to create stability if they prey upon both. Inter-predator relationships are also affected by apex status.

Ecological Pyramids

An ecological pyramid shows the relationship of biomass, productivity or energy at different trophic levels. The primary producers are generally shown at the bottom and apex predators at the top. The pyramids are different for different ecosystems. There are three types of Ecological Pyramids as follows:

- Pyramid of numbers: This shows the number of individual organisms at successive trophic levels. *It can be upright or inverted.*
- Pyramid of Biomass: This shows the biomass at successive trophic levels. It can be *upright or inverted.*
- Pyramid of energy: It shows the rate of energy flow and/or productivity at successive trophic levels. *It is always upright.*

Pyramid of Numbers

This Pyramid shows the numbers of the producers, herbivores and the carnivores at their successive trophic levels. This pyramid can be either upright, or inverted or partially upright.

Pyramid of numbers in grassland Ecosystem

In a grassland ecosystem, the number of producers (mainly grasses) is always maximum, followed by decreasing numbers at second trophic level (herbivores), third trophic level (carnivores) and least number of apex predators. *Thus, a pyramid of numbers in grassland is upright.*

Pyramid of Numbers in Pond Ecosystem

In a pond ecosystem, the producers are phyto-planktons such as algae, bacteria etc. They are maximum in number. The small herbivorous fishes, rotifers etc. are smaller in number than producers , while the small carnivorous fishes are even less in number. Finally, the apex consumers or biggest carnivorous fishes are least in number. Thus, the *Pyramid of numbers in a Pond Ecosystem is also upright.*

Pyramid of Numbers in Forest Ecosystem

In a forest ecosystem, the producers are large size trees which make the base of Pyramid. The herbivores such as fruit eating birds, deer, elephants etc. make the primary consumers and are less than primary producers. After that, the number goes down at each successive level. *Thus, a Pyramid of numbers in a Forest Ecosystem is partially upright or spindle shaped.*

Pyramid of Biomass : Terrestrial system

Pyramid of Numbers in Parasitic Food Chain

A single plant or animal in a parasitic food chain may support numerous parasites, which might be further supporting a larger number of hyperparasites. *Thus, the pyramid of numbers in a parasitic food chain is inverted.*

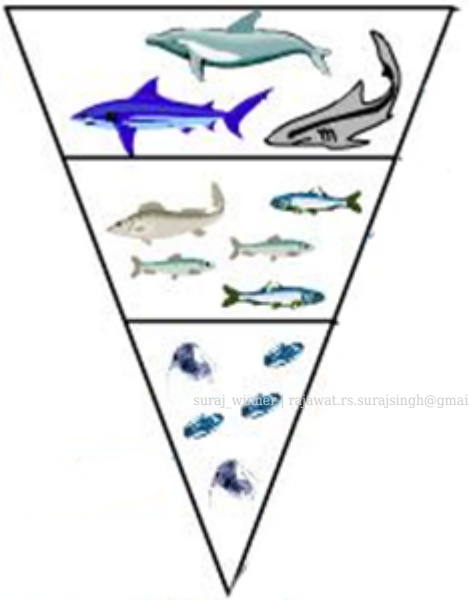
Pyramid of Biomass

Pyramid of Biomass in Forests and Grasslands

Pyramid of biomass for terrestrial ecosystems (grasslands, forests) the biomass generally decreases at

each higher trophic level from plants via herbivores to carnivores. This is evident from the fact that the terrestrial producers' viz. grasses, trees and shrubs have a much higher biomass than the animals that consume them, such as deer, zebras and insects. The level with the least biomass is the highest predators in the food chain, such as foxes and eagles. Thus, in terrestrial ecosystems, the Pyramid of Biomass is upright.

Pyramid of Biomass in Aquatic Ecosystems

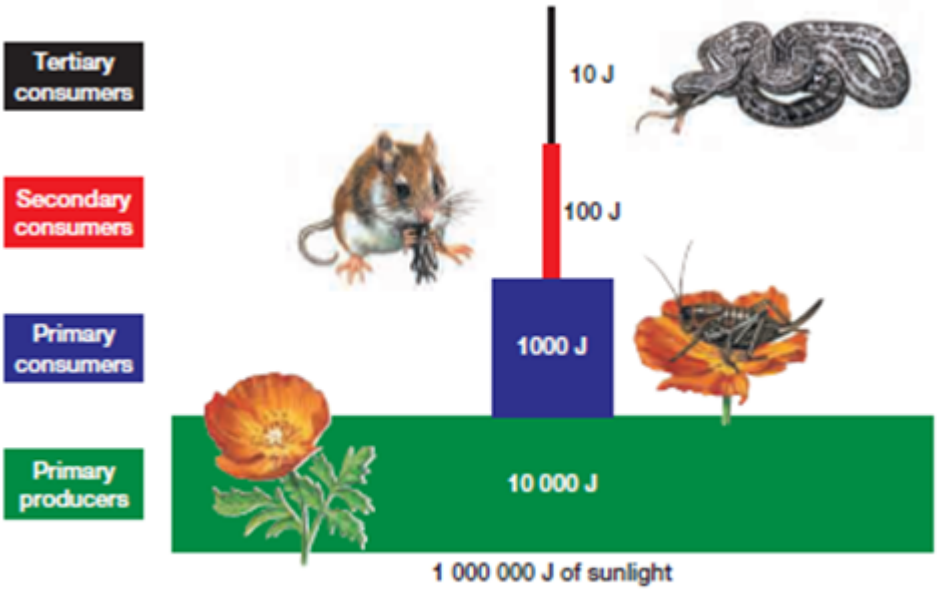


Pyramid of Biomass : Ocean Ecosystem

In the aquatic system, the biomass can increase at higher trophic levels. For example, in Oceans, the food chain typically starts with phytoplankton and ends at predatory fish, which has largest biomass. Thus, the pyramid of biomass is inverted in the aquatic systems including marine, ponds etc.

Pyramid of Energy

Energy cannot be recycled and during the flow of energy from one trophic level to other, there is a considerable loss in the form of heat, respiration, mechanical energy etc. Thus, highest energy is available to primary producers and lowest to tertiary consumers. Thus, the pyramid of energy is always upright and vertical. In this pyramid, the energy is minimum as the highest trophic level and is maximum at the lowest trophic level.



Pyramid of Energy

Since there is a successive reduction in energy flow at successive trophic levels, shorter the food chain, greater would be the available food energy. The reason is
with an increase in the length of food chain, there is a corresponding more loss of energy.

Biomass Productivity

The *rate of generation of biomass in an ecosystem is called Productivity*, which is expressed in units of energy (example: joules per meter² per day) or in units of dry organic matter (example: kg per meter² per year).

Primary Productivity

Primary production is the synthesis of new organic material from inorganic molecules such as water and CO_2 via photosynthesis or chemosynthesis. The rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producers is called primary productivity.

Further, the total energy fixed by plants via photosynthesis is called *Gross Primary Productivity*. A small fraction of this energy fixed is used in the respiration of plants, which gives them necessary energy for various physiological and morphological functions. When this respiratory utilization is reduced from Gross Primary Productivity, what we get is *Net Primary Productivity*. Net Primary Productivity is the actual rate of biomass productivity, which refers to the balance between gross photosynthesis and respiration and other plant losses. The primary productivity is also known as *energy storage at producer level.*

Highest Net Primary Productivity of Various Ecosystems

Kindly note that *highest primary productivity is found in Tropical Forests, Estuaries and Swamps/ Marshes.* Each of them produces around 9000 Kcal per meter² per year.

- Tropical Rainforests have high primary productivity because of availability of plenty of solar light and water.
- A typical estuary has high primary productivity because it is shallow (gets plenty of sunlight) and has turbulent water (which brings the nutrient rich material from sea bed).
- Swamps and Marshes have high primary productivity because they have lots of nutrients and sunlight.

After Tropical Rainforests, Estuaries and Swamps / Marshes, the highest primary productivity is found in coral reefs, algal beds and temperate forests. *Least primary productivity is found in cold and hot deserts including tundra.*

Secondary Productivity

Productivity of heterotrophs such as animals is called *secondary productivity*. It is also known as *energy storage at consumer level*. Secondary productivity is done by consumers via assimilation of the food they take. Since not all the primary biomass is consumed; and since not all the consumed is digested; secondary production is only a fraction of primary production.

Key Features of Biomes

Tundra Biome

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.

Distribution of Tundra Biome

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.

Salient Features of Tundra Biome

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 *very few 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°C. The average winter temperature is -34° C (-30° F), but the average summer temperature is 3-12° C (37-54° 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.

Fragile Ecosystem of the Arctic Tundra

From the above description, it is quite clear 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 oscillate. This means that extinction of just one species has the capability to destroy the entire ecosystem in Tundra regions.

Global Warming & Tundra Climate

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.

Oil Drilling in Tundra

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

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 night-time temperature is usually below freezing.

Difference between Arctic Tundra and Alpine Tundra

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

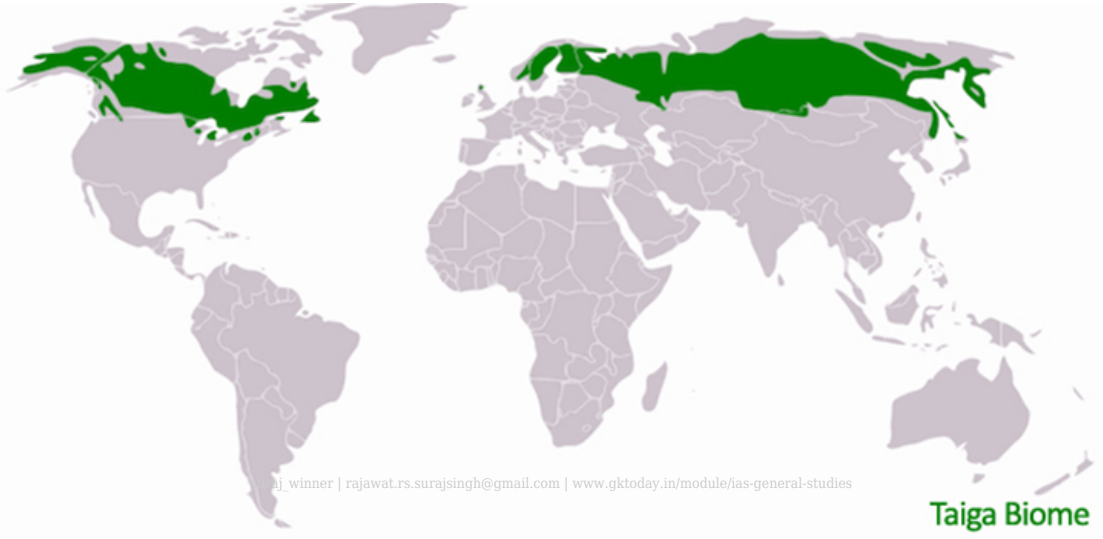
Antarctic Tundra occurs on Antarctica and on several Antarctic and sub-antarctic islands. Most of it is too cold and dry to support vegetation. In some portions of Antarctica, there are areas of rocky soil that support plant life. The flora presently consists of around 300–400 lichens, 100 mosses, 25 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.

Extent of Taiga Biome

Taiga Biome 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).



Largest areas under Taiga are located in Russia and Canada. Please note that there is no Taiga on Southern hemisphere.

Key Features of Taiga Biome

Taiga accounts for *lowest annual average temperatures after the tundra and permanent ice caps*. Here we note that the *extreme minimums temperatures of Taiga are typically lower than those of the tundra.* In Tundra it is around -50°C, in Taiga it has been recorded -68°C at Verkhoyanks in Siberia.

In winter, there are long periods of frozen Ice on Polar Tundra, yet the nearby *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 north-eastern 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***.

Soil Features in Taiga Biome

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, *without decomposing* 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 leaching of

the minerals makes them inaccessible to the tree roots. This causes infertility of the soil.

The leaching of the nutrients, along with the permeability of the soil gives Taiga 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, *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 in comparison to Tropical Forests
- Acidic due to fallen leaves

Flora of Taiga Biome

Taiga is spread over both Asia and North America. Both of them were connected by the 1600 kilometres 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.

Taiga Environment Challenges

The Taiga is being destroyed everyday by both humans and nature. Nature causes forest fires with lighting, 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 effecting 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.

Wildfires in Taiga Biome

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 lightening 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 (.g. Jack Pine, an excellent adoption 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.

Montane grasslands and shrublands

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 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.*

Distribution of Tropical Rainforests

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. They roughly cover 6-7% of earth's area and are home to half of its biodiversity. 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.

Etymology: Rainforests

Rainforests are called so because they are wet due to round the year rains. *There are apparently no seasons in Tropical rain forests near the equator, yet the tropical rainforests which are away from equator have only 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 in Rainforests

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 of Rainforests

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.

Biodiversity in Rainforests

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.

Why a Tropical Rain Forest cannot be replaced very quickly?

A rainforest cannot be replaced as 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.

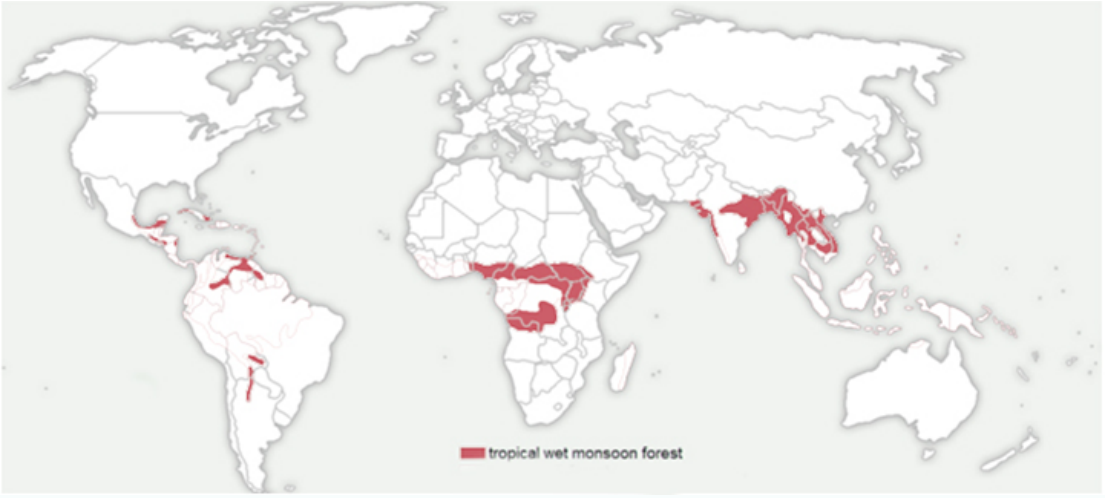
Thus, we can't simply "regrow" tropical forests once they are burned — once they are lost they are gone forever (or at least for 1000s of years, and even then the species that regrow will be different from the original forest species).

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.

Distribution of 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 south-eastern Brazil.



Salient Features of Tropical Monsoon Rainforests

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 adjacent 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.

Distribution of Temperate Rainforests

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 adjacent 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. 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 highs temperatures of around -1 to -15° Celsius.

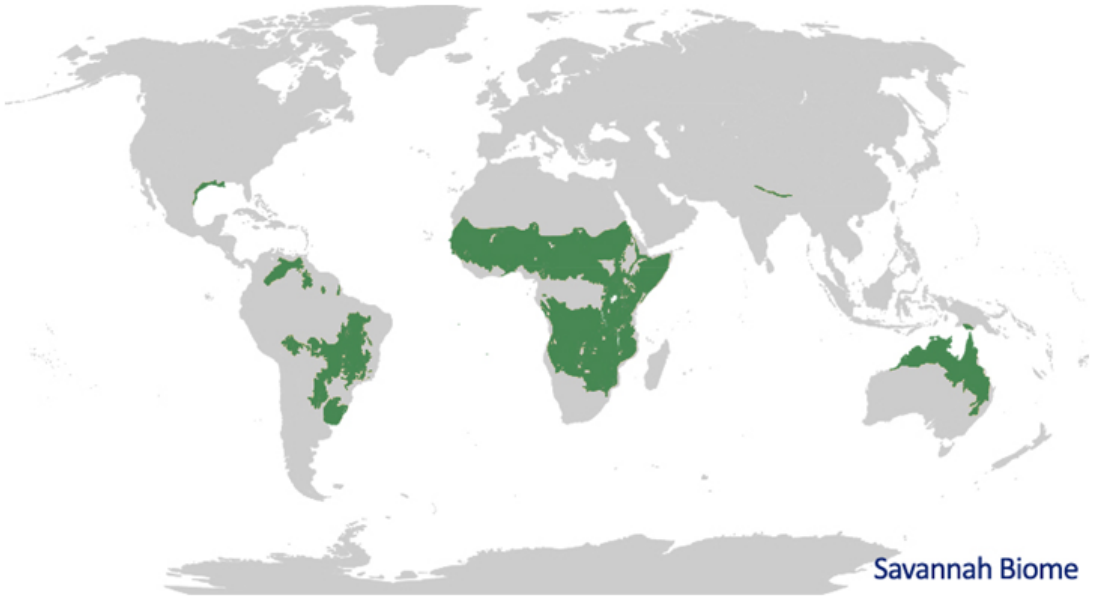
Savannah Biome

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.

Distribution of Savannahs

Savannah covers approximately 20% of the Earth's land area. *The largest area of Savannah is in Africa.*

The following graphics shows Savannah as well as Rainforests so you are able to distinct the two regions.



Salient Features of Savannah

Savannahs are the grasslands with trees. But this is not a strict definition and Savannah biome also includes *treeless tracts of grasslands*. The water availability in Savannahs is seasonal and majority of the rainfall is confined to one season.

Forest Fire as a feature of Savannah

Like Taiga, *the forest fires are common in Savannahs also* 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 Savannah have been cleared of trees, and this clearing is continuing today. For example until recently 480,000 ha of Savannah were cleared annually in Australia alone primarily to improve pasture production.

Types of Savannahs

There are several types of Savannahs as following:

Tropical and subtropical Savannahs

Tropical and subtropical grasslands and shrublands as the tropical and subtropical grasslands, Savannahs, and shrublands biome. The Savannahs of Africa, including the Serengeti, famous for its wildlife, are typical of this type.

Temperate Savannahs

Mid-latitude Savannahs with wetter summers and drier winters. Examples are Great Plains of the United States.

Mediterranean Savannahs

Mid-latitude Savannahs in Mediterranean climate regions, with mild, rainy winters and hot, dry summers, part of the Mediterranean forests, woodlands, and scrub biome. The oak tree Savannahs of California, part of the California chaparral and woodlands eco-region are examples.

Flooded Savannahs

That are flooded seasonally or year-round.

Montane Savannahs

These are high-altitude Savannahs; example is highland Savannahs of the Angolan Scarp Savannah and woodlands ecoregions.

Threats to Savannahs

Savannah covered more than 40 per cent of the earth's surface once upon a time, before the human caused fire started damaging them. 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 in Savannahs

Savannah 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*. The C4 grasses are found in majority in Savannah.

Animals in Savannahs

Savannah are the home of large mammals that graze on Savannah grasses or the Savannah 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 Savannahs. 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 in Temperate Grasslands

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 Savannahs. 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

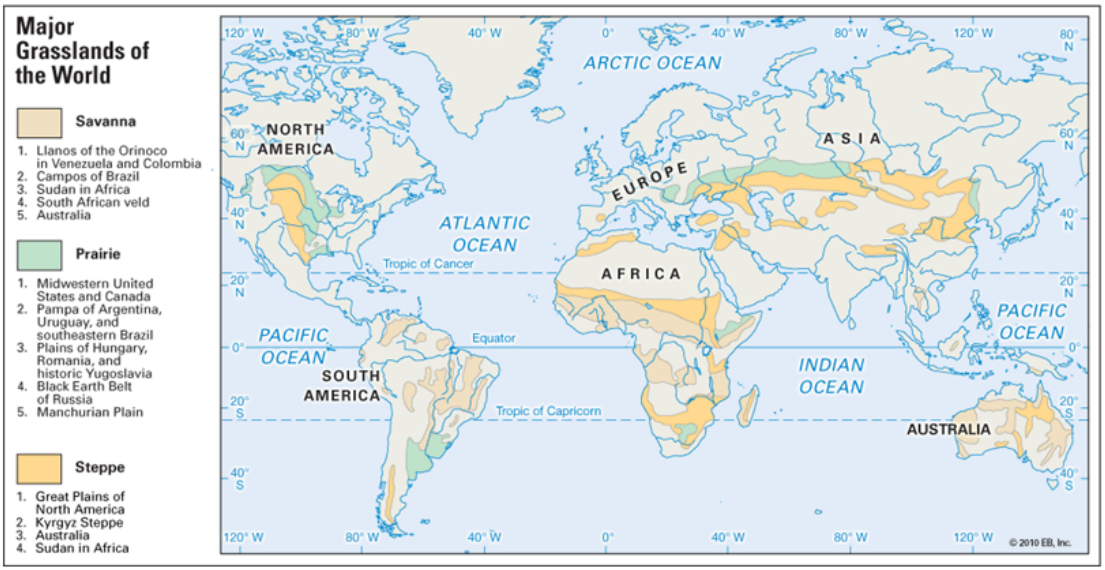
The soil of the temperate grasslands is deep and dark, with fertile upper layers. It is nutrient-rich from the growth and decay of deep, many-branched grass roots. The rotted roots hold the soil together and provide a food source for living plants. Each different species of grass grows best in a particular 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 in the Temperate Grasslands

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 in the Temperate Grasslands

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 sourced from Britannica online shows grasslands of the World.



Mediterranean Shrublands (Chaparral Biome)

Mediterranean Shrublands or Chaparral biome is found along the coasts of the Mediterranean Sea, California, Central Chile, south-western part of South Africa and south-western parts of Australia.

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.

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* and due to this, the *chaparral vegetation is also known as sclerophyllous.* It averages as metre or two in height and has deep, well developed roots, leathery and uneven low branches.

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.

Other Regional Names

- In the Mediterranean proper–Europe, North Africa, and Asia Minor, they are known as *Maquis*.
- 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 hyper arid 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. Desert 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 in Desert Biome

- Plants and animals in deserts and xeric shrublands are adapted to low moisture conditions. Hyper-arid 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.