

Chapter 6

Terrestrial Biomes and Aquatic Systems

- **What is a biome?**
- A biome is a major region with distinct plant and animal communities well adapted to the region's physical environment.
- Contain many communities of a similar nature, whose distribution is largely controlled by *climate*
- A biome is *the largest terrestrial community or the largest ecological unit*.
- It is a collection of many ecosystems in a region that have similar structure and function.
- The collection of different biomes of the earth comprise the **biosphere**.

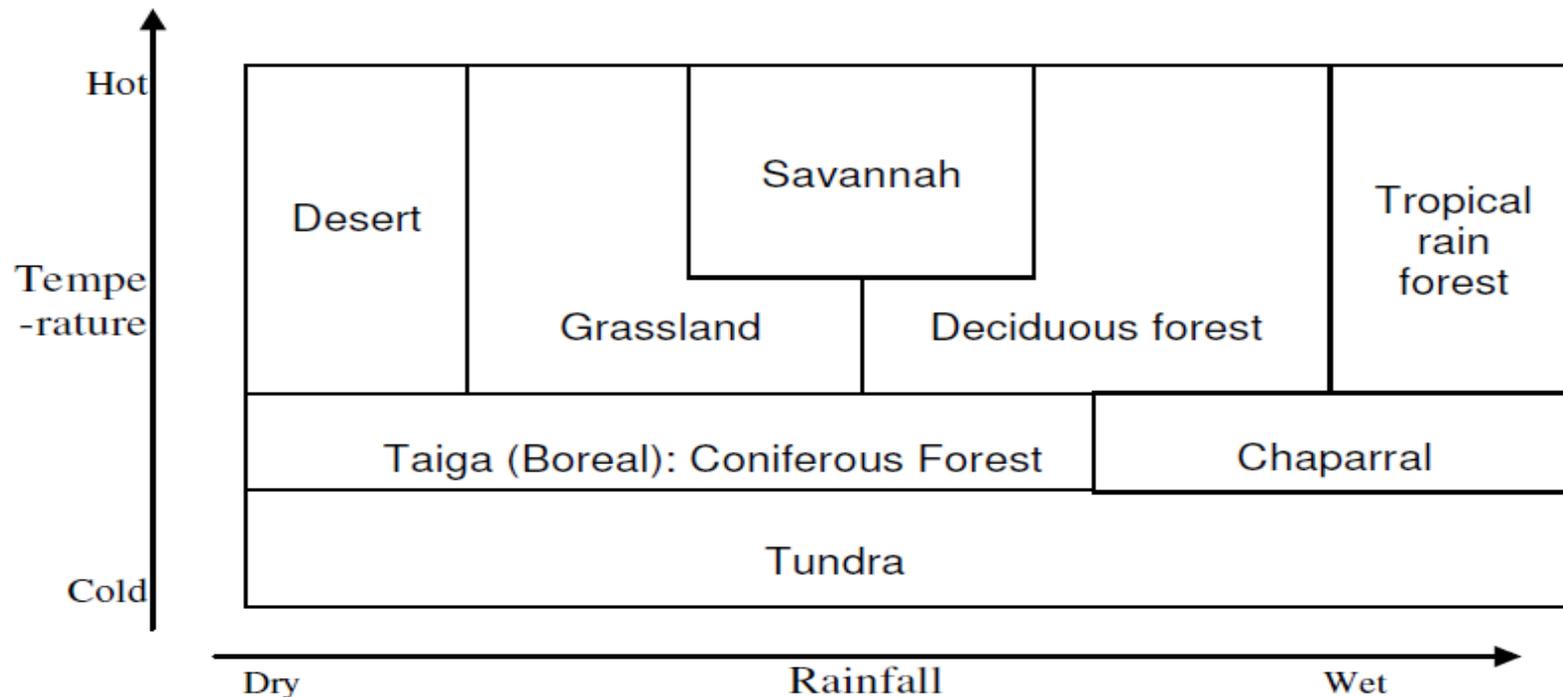
- Biomes are defined by the global pattern of species.
- This pattern is influenced by regional climate, soil characteristics, substrate condition (due to periodic flooding for example), and other environmental factors.
- In turn, the nature of its climate and soil partly depends on latitude, altitude and slope.
- As a result, plants and animals of a biome are restricted by the nature of the environment at a particular climatic zone.
- A biome is composed of the climax vegetation and all associated sub-climax (flora, fauna) and soils.
- However, it can often be identified and named by:
 - a) The dominant climax flora (vegetation) type,**
 - b) The vertical stratification or vegetation adaptation.**

- Plants tend to reflect the general climatic features of an area more accurately than animals.
- Therefore, a biome is often defined by the uniqueness of its plant and animal species within a geographical area that has a distinct climatic condition.
- ***Adjacent biome does not have a sharp demarcation and boundary.*** However, biomes in extremely remote areas are distinguishable by the uniqueness of their plant and animal species.
- A biome ***could be continuous, exclusively localized to one geographic location on earth, or non continuous, scattered in different geographic areas.*** →if ecosystem have similar structure and function, they are grouped under the same biome.

- In general, to understand the nature of the earth's major biomes, one needs to learn the following:
 - The dominant, characteristic, and unique growth forms (plants); vertical stratification; leaf shape, size, and habit; and special adaptations of the vegetation (such as reproductive strategies, dispersal mechanisms and root structure)
 - The types of animals (especially vertebrates), characteristic of the biome and their typical morphological, physiological, and/or behavioral adaptations to the environment.
 - The general characteristics of the regional climate and the limitations or requirements imposed upon life by specific temperature and/or precipitation patterns.
 - The soil order(s) that characterize the biome and those processes involved in soil development.
 - The global distribution pattern where each biome is found and how each varies geographically.

The geographical distribution and productivity of the various biomes is controlled primarily by the **climatic variables, i.e. precipitation and temperature.**

In a broader sense **biomes** of the world could be classified into **terrestrial (also called continental) biomes, and Aquatic biomes (Systems),**



The effect of temperature and rainfall on the formation of biomes

Classification of Major Terrestrial Biomes

- Different authors classify terrestrial biomes differently.
- The wellknown and widely used system of classification, however, is done using latitude (temperature zonation) and altitudinal variation

| Latitudinal/ temperate Zonation | Altitudinal zonation | | | |
|----------------------------------|----------------------|---------------|---------------|---------------|
| | 0-100m | 1000-2000m | 2000-4000m | 4000-6000m |
| Tropical (0° - 20°) | Tropical | Subtropical | Temperate | Arctic-alpine |
| Subtropical (40° - 40°) | Subtropical | Temperate | Arctic-alpine | - |
| Temperate (40° - 60°) | Temperate | Arctic-alpine | - | - |
| Arctic and Antarctic (60° - 80°) | Arctic-alpine | - | - | - |

Comparison of Temperature and altitude zonations for classification of biomes

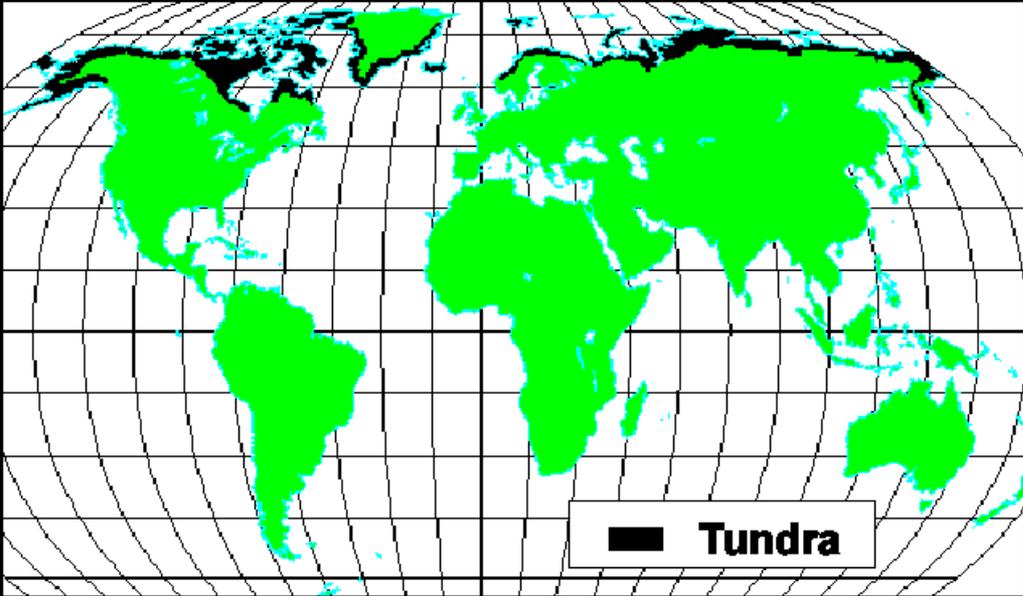
- The whole terrestrial ecosystems of the world are classified into eight major biomes based on their uniqueness.
- Table 6.2 describes the geographic location and the climate pattern of each major terrestrial biome.

| No | Name of the biome | Geographic location | Climate |
|----|-------------------------------------|-------------------------------------|------------|
| 1 | <i>Tundra</i> | Arctic or Sub-arctic area | humid type |
| 2 | <i>Taiga or boreal forest</i> | Sub-arctic and Boreal area | humid type |
| 3 | <i>Temperate coniferous forests</i> | Temperate cold area | humid type |
| 4 | <i>Grasslands</i> | Temperate warm or sub-tropical area | semi-arid |
| 5 | <i>Chaparral</i> | Temperate warm or sub-tropical area | semi-arid |
| 6 | <i>Tropical rain forest</i> | Tropical area | humid area |
| 7 | <i>Tropical savanna</i> | Tropical area | Semi-arid |
| 8 | <i>Deserts</i> | Tropical area | Arid |

1. Arctic and Alpine Tundra

- Tundra means marshy plain.
- The geographical distribution of the tundra biome is largely pole ward of **60° North** latitude across Asia, Europe and North America
- The tundra biome is characterized by an **absence of trees, the presence of dwarf plants, and a wet, spongy, and hilly ground surface**
- Soils of this biome are usually permanently frozen (**permafrost**)
- Temperature, precipitation, and evaporation are low
- Rainfall not higher than 25 millimeters
- Temperature is 10°C in average.
- The light is extremely low, and the length of growing season is only 60 days a year.
- The species diversity of tundra vegetation is relatively low.

- Plant communities are usually composed of a few species of dwarf shrubs, a few grass species, sedges, and mosses.
- The most characteristic arctic tundra plants are lichens and Reindeer Moss (*Cladonia spp.*).
- The principal herbivores in this biome include caribou, musk ox, arctic hare, voles, and lemmings.
- Most of the bird species have the ability to migrate and live in warmer locations during the cold winter months.
- The few carnivore species include the arctic fox, snow owl, polar bear, and wolves.
- Reptiles and amphibians are few or completely absent because of the extremely cold temperatures.



2. Taiga (coniferous forest)

- This moist-cool, transcontinental coniferous forest, or taiga lies largely between the 45⁰ and 57⁰ North latitudes across east-west of north America, Europe and Asia
- The climate of this biome is cool to cold with more precipitation than tundra, (10-35cm) occurring mainly in the summer.
- The average temperature ranges from 6⁰C to 20⁰C in summer, and experiences sever winter condition.
- The length of growing season is 150 days a year.

- The vegetation of boreal biome is dominated by *evergreen variety of tree species with needle leaves*.
- The understory is relatively void of vegetation as a result of the low light penetration even during the spring and fall months.
- Mammals common to the boreal forest include moose, bear, deer, wolf, snowshoe hare, vole, chipmunks, shrews, and bats.
- Reptiles are rare, once again, because of cold temperature.
- The soils of Boreal forests are characterized by a deep litter layer and slow decomposition.
- Soils of this biome are also *acidic and mineral deficient* because of the large movement of water vertically through the profile and subsequent leaching

3. Temperate Deciduous Forest

- As its name indicates, this biome is characterized by a moderate climate and deciduous trees.
- It occupied much of the eastern half of the US, central Europe, Korea, and China.
- The annual rainfall ranges between 50 and 75 cm.
- This biome has been very extensively affected by human activity, and *much of it has been converted into agricultural fields or urban developments.*
- Dominant plants include **broad-leaved hard wood trees** which shed their leaves at the onset of autumn.
- The understory of shrubs and herbs in a mature deciduous forest is typically well developed and richly diversified.

Many different types of herbivores and carnivores, and some reptiles and amphibians exist here.

Brown forest soils characterize temperate deciduous forest ecosystems.

The surface litter layer in these soils is thin due to rapid decomposition.



4. Grassland

- This biome is found across most continents, and is locally named differently:
 - In Europe and Asia it is called Steppes.
 - In South America - Pampas.
 - In Southern part of Africa - Veldts, and
 - In Central North America - Prairie.
- Annual rainfall ranges between 25-75 cm, and experiences severe winter followed by drought and fire in summer.
- The tall grass prairie is dominated by species of Bluestem (*Andropogon* spp.). This particular species dominated much areas of this biome forming dense covers up to 3m tall.
- In the western end of the prairie, where precipitation is less, Buffalo Grass (*Buchloe dactyloides*) and other grasses only a few inches above the soil surface are common.
- Flowering herbs, including many kinds of composites and legumes, are common but much less important than grass species.

- Trees are limited to low lying areas and the narrow zone immediately adjacent to streams.
- In the tall grass prairie organic rich and black chernozemic soils are common.
- Chernozems are among the richest in nutrients and consequently the most fertile soil in the world.
- As a result of their fertility, most grassland ecosystems have been *modified by humans to agricultural land*.
- Grassland mammals are dominated by smaller burrowing herbivores (prairie dogs, jack rabbits, ground squirrels, and gophers) and larger running herbivores such as bison, pronghorn antelope, larks and elk.
- Carnivores include badger, coyote, ferret, wolf, and cougar.
- The population size of many of these species has been drastically reduced because of habitat destruction. Some of these species are on the edge of extinction.

5. Desert

- In general, the major desert biomes of the Earth are geographically found scattered all over the continents between **25° to 40° North and South latitude**
- The desert consists of shrub-covered land where the plants are spatially quite dispersed.
- Many desert areas have less than 250 millimeters of precipitation annually.
- The temperature is highly fluctuating with extremely hot days and extremely cold nights
- Short-lived annual plants, Cacti are a common type of drought resistant plants
- Desert can be devoid of vegetation if precipitation is very low.

- Most desert mammals tend to be nocturnal (to avoid high T°)
- Desert habitats have a rich lizard and snake fauna because high temperatures promote the success of cold blooded life forms.
- Swarms of ants, locusts, wasps, scorpions, spiders, insectivore birds, desert rats, rabbits, foxes and various cats are also common to this biome.
- Because productivity is low, the litter layer is comparably limited and organic content of surface soil layers is very low.
- Also, evaporation tends to concentrate salts at the soil surface

6. Chaparral (Mediterranean Scrub)

- Chaparral has a very specific spatial distribution.
- It is found in a narrow zone between 32^o and 40^o latitude North and South on the west coasts of the continents along **Mediterranean sea**, Pacific coast of South America, Southern Africa and Southern Australia
- This area has a dry climate because of the dominance of the subtropical high pressure zone during the fall, summer, and spring months.
- Precipitation falls mainly in the winter months because of the seasonal movement of the polar front and its associated mid-latitude cyclone storms.

- Annual rainfall averages between 300 and 750 millimeters, and most of this rain falls in a period between 2 to 4 months long.
- As a result of the climate, the vegetation that inhabits this biome exhibits a number of adaptations to withstand drought and fire.
- Trees and shrubs living in this zone tend to be **small with hard evergreen leaves.**

- Plants in the chaparral do not drop their leaves during the dry season because of the expense of replacement.
- The dry climate slows the rate of leaf decomposition in the soil.
- No nutrients available for uptake to produce new leaves when the wet season begins.
- Instead, the plants of the chaparral develop leaves that can withstand arid conditions.
- Many of the plant species have thorns to protect them from herbivore damage.
- This biome is sometimes also called Mediterranean Scrubland or sclerophyll forest.

7. Tropical Savanna

- The savanna biome constitutes extensive areas in eastern Africa, South America, and Australia
- The biome is dominated by grassland vegetation with scattered drought-resistant trees that generally do not exceed 10 m in height.
- Tree and shrub species in the savanna usually shed their leaves during the dry season.
- This adaptation reduces water loss from the plants.
- New leaves appear several weeks before the start of the rain season.
- Scientists believe that savanna plant species may have developed this strategy to take advantage of the season variance of the start of the rains.

- Climatically, these biomes are characterized by distinct wet season with prolonged dry seasons.
- Temperatures are hot all year long, and the annual rainfall is 100-150cm.
- Dominant trees include Acacia, Palm and a number of legumes tree species.
- Savannas also support the richest diversity of grazing mammals in the world.
- The grazing animals provide food for a great variety of predators.
- Grazing animals include giraffes, zebra, elephant, buffalo, kangaroos and a number of other antelopes.
- Predators include lions, cheetah, hyena, and a number of cats.
- The soils are more nutrient rich than tropical forest soils.
- Some soils become extremely dry because of high evaporation

8. Tropical Rainforest

- Tropical rainforests occur in a broad zone largely in the tropics mainly in central America along Amazon and Orinoco rivers; south America, Congo river basin in Africa; and in southern Africa around Madagascar.
- Annual rainfall, which exceeds 2000 to 2250 mm is generally evenly distributed throughout the year.
- Temperature and humidity are relatively high throughout the year.
- Tropical rain forest covers $1/12^{\text{th}}$ of the earth's surface, and supporting about half of the earth's flora and fauna (about 5 million Species).
- The Flora is highly diverse. For example, a square kilometer may contain as many as 100 different tree species as compared to 3 or 4 in the temperate zone.

- The various trees of the tropical rain forests are closely spaced together and form a thick continuous canopy some 25 to 35 meters tall.
- Every so often this canopy is interrupted by the presence of very tall trees (up to 40 meters) that have wide buttressed bases
- Epiphytic orchids and vines (lianas) are common characteristic of the tropical rainforest biome.
- Some other common plants include ferns and palms.
- Most plants are evergreen with large, dark green, leathery leaves.
- Tropical trees often have buttress bases to help support their heavy aboveground biomass.

- The tropical rainforest is also home to a great variety of animals. Some scientists believe that 30 to 50 % of all of the Earth's animal species may be found in this biome.
- Animals include apes (like chimpanzees, gorillas and orangutans), old and new world monkeys, different amphibians, reptiles, anteaters, birds, bats, carnivores, invertebrates and 70-80% of all the known insects.
- Decomposition is rapid in the tropics because of high temperatures and an abundance of moisture.
- Because of the frequent and heavy rains, tropical soils are subject to extreme chemical weathering and leaching
- These environmental conditions also make tropical soils acidic and nutrient poor.

Aquatic Systems

Major Physical Factors affecting the distribution of aquatic organisms

- 3/4th of the earth is covered by water.
- Water bodies like that of terrestrial ecosystems support a wide variety of organisms.
- The distribution of organisms in aquatic systems is largely affected by different biological and physical factors.
- The major physical factors include: *salinity, turbidity, light intensity, water movement, dissolved gas concentration, water temperature and pressure, among many others.*
- *The effect of these factors is highly influenced by water depth, as altitude* does in the terrestrial habitats.

A. Temperature:

- Because of high specific heat of water, there is very little daily temperature fluctuation in aquatic system unlike that of the terrestrial ecosystems.
- During summer season, where there is little water movement, a **clear stratification in temperature** is observed in relatively non-moving waters such as lakes.

Three layers are observed:

- a) **Epilimnion**: This is the upper layer of the water that is warmer and freely circulating, (means “upper lake” in Greek).*
- b) **Metalimnion**: This is the middle layer of the water system. In this layer there is a decline in temperature by 0.6°C in every 1 m of water depth. This gradual change (gradient) in temperature is termed as **THERMOCLINE**.*
- c) **Hypolimnion**: The lower deep cold zone of the lake (means “lower lake” in Greek).*

B. Light:

- Light intensity is one of the important physical factors in aquatic systems that affect the distribution of organisms.
 - Light intensity declines with increasing water depth.
 - With increasing water depth, **three major light zones are recognized** (see figure below)
- a) *Littoral zone: This is the shallow zone of the lake where light penetrates to the depth of the water floor. It is closer to the land hence, is rich in nutrients. This zone is inhabited by various rooted aquatic plants such as water lilies, rushes and sedges.*
- b) *Limnetic zone: It is the open upper zone of the water system dominated by planktons, nektons and pelagic organisms. This zone is largely occupied by photosynthetic organisms hence the rate of photosynthesis is higher than that of respiration.*
- The zone is productive hence, also called ***EUPHOTIC zone***.

c) Benthic zone: *It is the bottom part of the water system where sediments and dead materials rest. The region is largely inhabited by benthoses, which are bottom dweller communities that decompose dead organic matters into inorganic nutrients. In this zone there is high oxygen utilization, because the rate of respiration (consumption) is higher than the rate of photosynthesis. A variety of flatworms, Protists, crustaceans and insect larvae are inhabitants of this zone.*

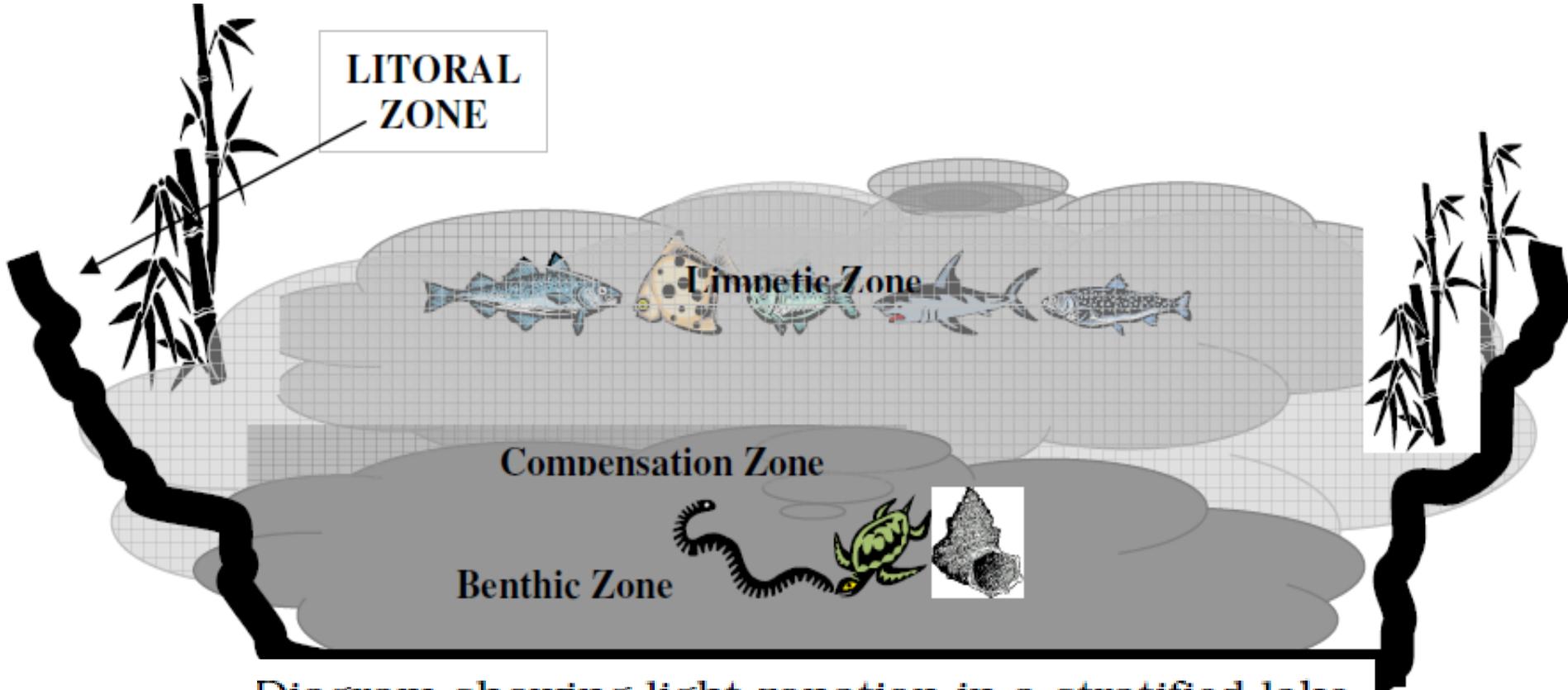


Diagram showing light zonation in a stratified lake

C. Nutrient:

- The nutrient level in water systems is affected by:
 - The amount of primary production in the ecosystem and
 - The amount of organic nutrients transported from the surrounding land ecosystems.
- As the amount of nutrient load increases, the Biological Oxygen Demand (BOD) of the water system increases.
- This means, *more oxygen is demanded by decomposer organisms to break larger organic molecules, and generate energy for their consumption.*
- The scarcity of dissolved oxygen in the water, among many other effects of enrichment of organic nutrients, may cause undesired impact on the community structure.
- Water systems could be classified into different types based on their productivity and the availability of dissolved nutrients:

- a) ***Oligotrophic lakes:*** These are poor or non-productive water systems due to poor nutrient level. This poor productivity could be either because of poor nutrient level in the lake or the physico-chemical nature of the water (E.g., turbidity, pH, temperature).
- b) ***Mesotrophic lakes:*** These are moderately productive water systems that have moderate amount of nutrient.
- c) ***Eutrophic lakes:*** These are highly productive lakes due to accumulation of organic nutrient in the lake.
- d) ***Hypertrophic lakes:*** These aquatic ecosystems have excessive nutrient due to transportation of wastes from agriculture, rivers and burning fossils. As the result, the productivity is extremely high hence, could cause extreme ***eutrofication of the water system.***

Classification of Aquatic biomes

- Global aquatic systems fall into two broad classes defined by the level of salinity
- a) Salt waters:* This includes those aquatic systems with high salt concentration usually exceeding 30 parts per thousand (PPT).
- It includes oceans, seas, and estuarine habitats and inland brackish waters.
- Saline waters cover large proportion of the earth, accounting for more than **97%** of the whole water systems.
- These waters support a wide variety of organisms from microscopic to largest mammals.

b) Fresh waters: This includes those aquatic systems with low salt concentration.

- It includes rivers, streams, ponds, inland marshlands and swamps.
- Freshwaters are conventionally classified into two categories.
 - a) ***Lotic waters:*** include all running waters such as rivers and streams.
 - b) ***Lentic waters:*** include all standing (*stagnant*) fresh waters like ponds and lakes.
- *The study of the biological and physical characteristics of freshwaters is called **LIMNOLOGY***
- Based on the nature of the environment and the **unique group of plants and animals they support**, the water systems of the world are classified into different biomes (systems).
- The following is brief description of major aquatic systems

Freshwater Biomes

Lakes and Ponds – Are inland bodies of standing water, typically freshwater. Lakes are usually larger than ponds.

Rivers and Streams – Are natural bodies of moving waters that drain into an ocean, lake, or other body of water and are usually fed by converging tributaries along their length.

- Rivers are typically larger than streams.

Wetlands – Are lowland areas permanently or temporarily saturated with water. They are characterized by low soil oxygen. The soil is hydric, adapted to alternation of aerobic and anaerobic conditions due to the flux of the water level.

- *Marsh* - Marshes are wetland areas often dominated by grasses and reeds.
- *Swamp* - A wetland area that may be permanently or intermittently covered with water, often dominated by woody vegetation.
- *Bog* - A wetland area rich in accumulated plant material and with acidic soils surrounding a body of open water. Bogs have a flora dominated by sedges, heaths, and sphagnum.

Marine Biomes:

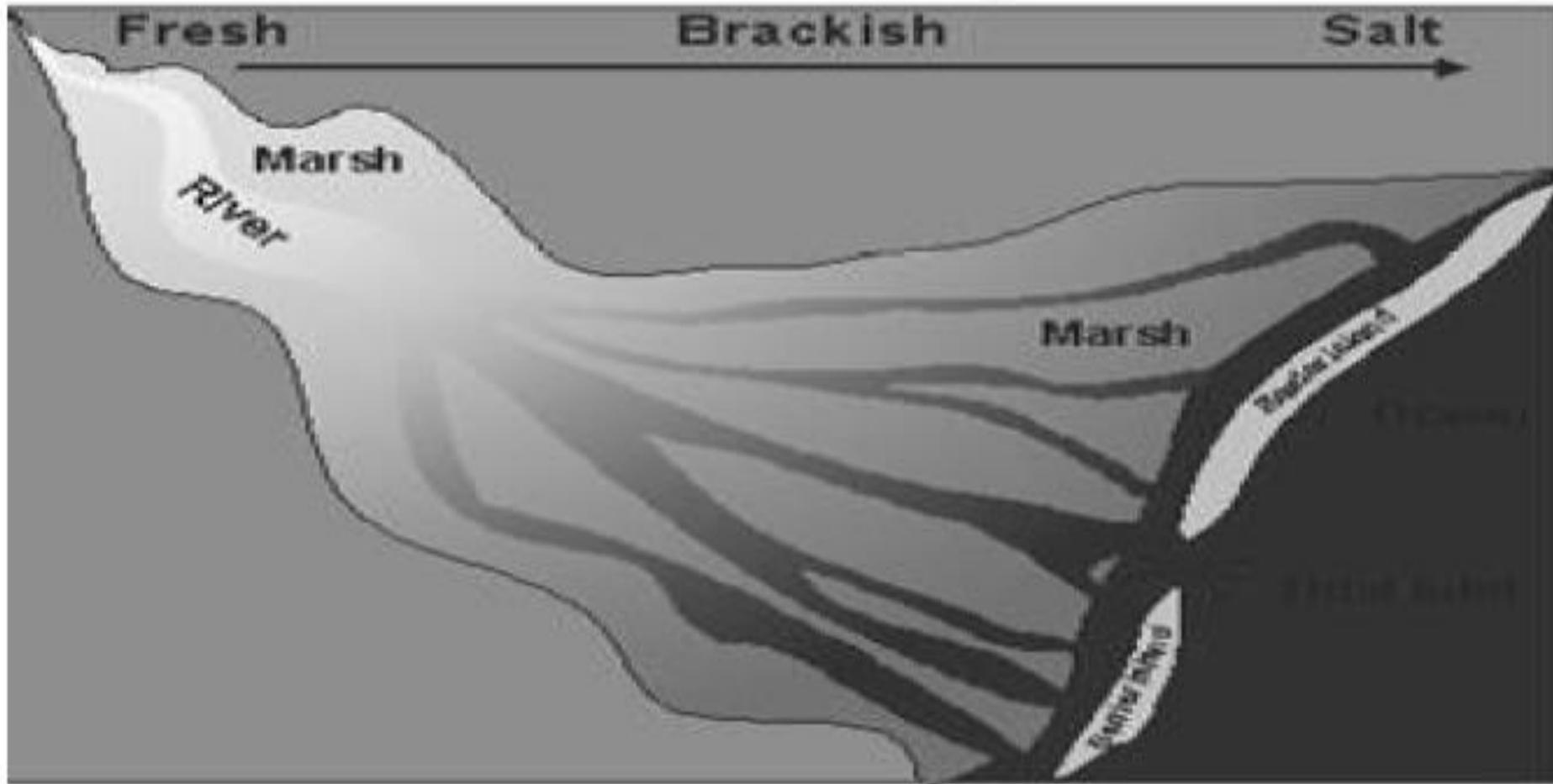
- **Pelagic** - An aquatic biome consisting of the open ocean, far from land. It does not include sea bottom (benthic zone).
- **Coastal** – It includes the land near to the coast or shoreline.
 - **Temperate coastal** - An aquatic biome including the ocean bottom in coastal areas of temperate regions, to about 1000 m depth.
 - **Tropical coastal** - An aquatic biome including the ocean bottom in coastal areas of tropical regions, to about 1000 m depth.

- **Benthic** – It is an aquatic biome consisting of the ocean bottom below the pelagic and coastal zones.
- Bottom habitats in the very deepest oceans (below 9000 m) are sometimes referred to as the abyssal zone.
- **Abyssal** – It is a biome on or near the ocean floor in the deep ocean.
- It is characterized by complete lack of light, extremely high water pressure, low nutrient availability, and continuous cold, usually less than 3°C.
- **Oceanic vent** – Are areas of the deep sea floor where continental plates are being pushed apart.
- Oceanic vents are places where hot sulfur-rich water is released from the ocean floor.

- **Reef** – It is a biome found in warm, shallow oceans, mostly in the tropics and subtropics, with low nutrient availability.
- The reefs form the basis for rich communities of other invertebrates, plants, fish, and protists.
- The polyps live only on the reef surface.
- Because they depend on symbiotic photosynthetic algae, zooxanthellae, they live on shallow waters where light penetrates.
- The reef is made from the calcium carbonate skeletons of coral polyps.

- **Brackish water** – Are systems with salty water, usually in coastal marshes and estuaries.
- Estuaries are ecosystems where fresh waters (such as rivers) join salty waters (such as oceans).
- They have diluted water, and because of their uniqueness, they are breeding sites for many aquatic animals.
- They have exceptionally high species diversity.

Brackish water



The end of chapter 6

“Closing of one door signify the opening of the next one” (unknown).