Chapter Five

Biogeography

Chapter Concepts

- Biosphere
- Ecosystems of the Earth
- Soil System

The biosphere can be defined as the part of Earth where life exits. It includes the forests, grasslands, and familiar animals of land together with the numerous creatures that inhibit the sea and atmosphere. Biosphere consists of 1.5 million described species and perhaps as many as 3 million not yet described. Each species lives within its own limited environmental setting.

Biosphere (Ecosphere)

The intricate, interconnected web that links all organisms with their physical environment is the biosphere. Sometimes called *Ecosphere*, the biosphere is the area in which physical and chemical factors form the context of life. The biosphere exists in the overlap among abiotic sphere, extending from the seafloor to about 8 km (5 miles) into the atmosphere. Life is sustainable within these natural limits. In turn, life processes have powerfully shaped the other three spheres through various interactive processes. The biosphere has evolved, reorganised itself at times, faced extinction, gained new vitality, and managed to flourish overall. Earth's biosphere is the only one known in the solar system in which life exists.

Components of Biosphere

The abiotic or inorganic component of the biosphere represents physical environment of the whole biosphere or part thereof. For example, light, temperature, water, air, climate, rocks, etc are the abiotic components of the biosphere. The abiotic of the biosphere includes the lithosphere, the atmosphere and the hydrosphere.

The biotic or organic components of the biosphere consist of three subsystems, e.g. (i) plants, (ii) animals including man, and (iii) the micro-organism.

Ecosystem

Ecosystem is a self-regulating association of living plants, animals, and their non-living physical and chemical environment. The concept of ecosystem was developed by Tansley.

Ecological Succession

The process whereby different and usually more complex assemblages of plants and animals replace older and usually simpler communities is known as ecological succession.

Ecotone

A boundary transition zone between adjoining ecosystems that may vary in width and represent areas of tension as similar species of plants and animals compete for the resources.

Producer

Organism that are capable of using carbon dioxide as their sole source of carbon, which they chemically fix through photosynthesis to provide their own nourishment. Such organism is also called *autotroph*.

From these producers, which manufacture their own food, energy flows through the system along a circuit called the *food chain*, reaching consumers and eventually decomposers. Ecosystems are generally structured in a food-web, a complex network of interconnected food chains. In a food-web, consumers participate in several different food-chains. Organism that share the same basic foods are said to be at the same trophic (feeding, nutrition) level.

Consumer

Organism in an ecosystem that depends on producers (autotrophs), organism capable of using carbon dioxide as their sole source of carbon for their source of nutrients.

Herbivore

The primary consumer in a food chain, which eats plant material formed by a producer that has synthesized organic molecule.

Carnivores

A carnivore is a secondary consumer eats primary and secondary consumers and is referred to as the '*top carnivore*' in the food chain.

Omnivore

A consumer that feeds on both producers (plants) and consumers (meat) – a role occupied by humans, among other animals.

Decomposer

Microorganism that digest and recycle organic debris and waste in their environment: includes bacteria, fungi, insects, and worms.

Food Chain

The circuit along which energy flows from producers, who manufacture their own food, to consumers; a non-directional flow of chemical energy, ending with decomposer. Basically all animals depend on plants for their food. Foxes may eat rabbits, but rabbits feed on grass. A hawk eats a lizard, the lizard has just eaten a grasshopper, and the grasshopper was feeding on grass blade. Similarly the caterpillar eats the leaf; the blue-tit eats the caterpillar, but may fall prey to the kestrel **(Fig .5.1)**.

Food-web

A complex network of interconnected food chain.

Niche

(French nicher, to nest) refers to the function, or occupation, of a life form within a given community. It is the way an organism obtains and sustain the physical, chemical and biological factors it needs to survive. It is the basic function, or occupation, of a life-form within a given community, the way an organism obtains its food, air and water. In other words, it is the description of an organism's functional role in habitat – its '*job*.' Among the functions, a niche includes (i) a habitat niche, (ii) a trophic (food) niche, and (iii) a reproductive niche.

Ecological Relationship

A study of food-chains and webs is a study of who eats what, and where they do the eating **Fig. 5.2.** Demonstrates the summer time distribution of population in two ecosystems, grassland and temperate forest. The stepped population pyramid is characteristic of summer conditions in such ecosystems. It may be observed from the Fig. 5.2 that there is a decreasing number of organism at each successive higher trophic level. The base of the temperate forest pyramid is narrow, however, because most of the producers are large, highly productive trees and shrubs, which are

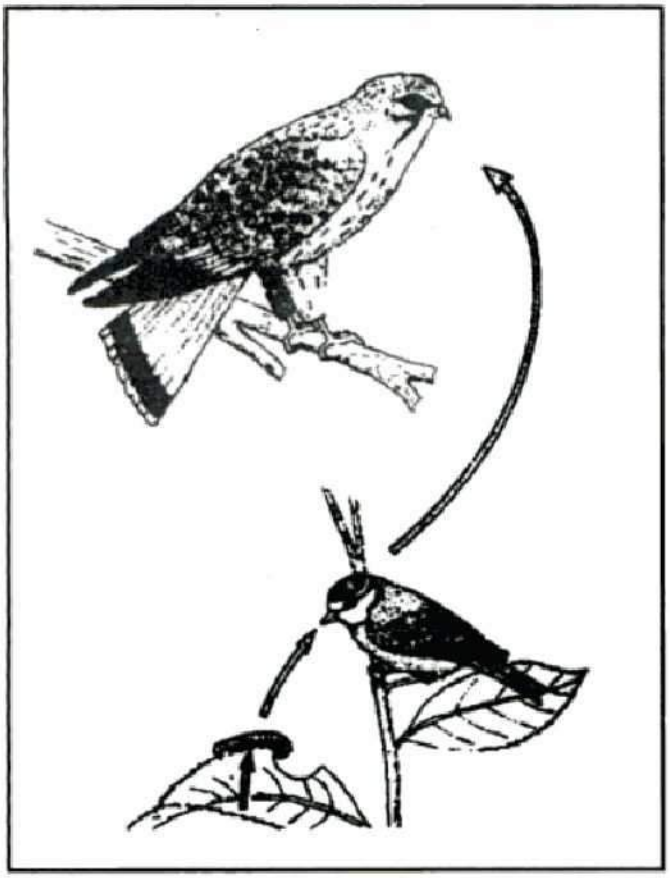

Fig.5.1 – A Food Chain: The caterpillar eats the leaf; the blue-tit eats the caterpillar but may fall prey to the kestrel

outnumbered by the consumers they can support in the chain.

Eutrophication

A natural process in which lakes receive nutrients and sediment and become enriched; the gradual filling and natural aging of water bodies.

Life Zone

An altitudinal zonation of plants and animals that form distinctive communities. Each life zone possesses its own temperature and precipitation relationships.

Biomass

Biomass is the net dry weight of organic material; it is biomass that feeds the food chain.

Ecosystems of the Earth

The major ecosystems of the Earth are generally divided into: (i) aquatic, and (ii) terrestrial.

(i) Aquatic Ecosystem : An association of plants and animals and their non-living environment in water-setting is known as aquatic ecosystem. The oceans, lakes, estuaries, deltas and freshwater bodies are the examples of aquatic ecosystem.

(ii) Terrestrial Ecosystem : A self-regulating association characterised by specific plant formations; usually named for the predominant vegetation and known as biome when large and stable.

The Major Terrestrial Biomes

Biome is a large terrestrial ecosystem characterised by specific plant communities and formations; usually named after the predominant vegetation in the region. Following are the major terrestrial biomes:

1. Equatorial and Tropical Rain Forest (ETR): This biome is found on both sides of the equator. It is characterised with hot and humid climate. The climate of the equatorial biome is characterised by day-length (12hours), high insolation, and the average annual temperature around 25°C, and the average annual rainfall is about 200 cm.

The Amazon region is the largest tract of equatorial and tropical rain forest, also called the *selva*. Rain forests are also found in the Congo Basin, Madagascar (Africa), South East Asia (Indonesia, Malaysia, Thailand, etc.), Colombia, Ecuador and western Venezuela. Rain forests represent approximately one-half of Earth's remaining forests, occupying about 7% of the total land area worldwide **(Fig. 5.3)**.

The equatorial rain forests are characterised with Lianas (vines) stretch from tree to tree, entwining them with cords that can reach 20 cm in diameter. Epiphytes flourish there too; such plants as orchids, bromeliads, and ferns that live entirely above the ground, supported physically but not nutritionally by the structure of other plants.

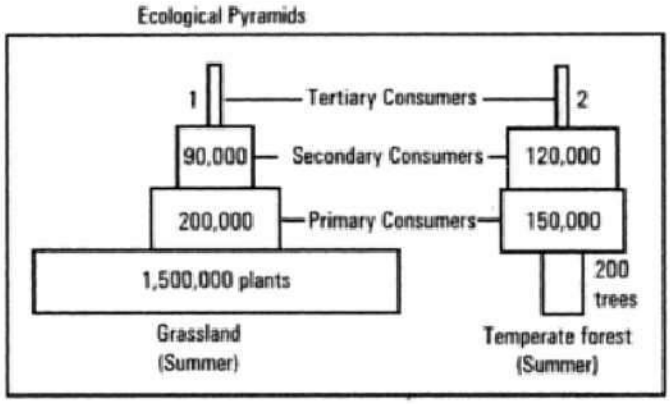

Fig.5.2 – Ecological pyramids for 0.1 hectare (0.25 acres) of grassland and forest in the summers are shown

Source: Fundamentals of Ecology by E. P. Odum, 1971

The rain forest canopy form three levels. The upper level is not continuous, but features tall trees whose high crowns rise above the middle canopy. The middle canopy is the most continuous, with its broad leaves blocking much of the light and creating darkened forest floor. The lower level is composed of seedlings, ferns, bamboo, etc.

The trees have smooth, slender trunks, covered with thin bark and buttressed by large wall-like flanks that grow out from the trees to brace the trunk. There are usually no branches for at least the lower two-thirds of the tree trunks.

The wood of many rain forest trees is extremely hard, heavy, and dense – in fact, some species will not even float. Exceptions are *balsa* and a few others, which are very light. The main varieties include mahogany, ebony, and rosewood. Logging is difficult because individual species are widely scattered; a species may occur only once or twice per square kilometre.

The insect and animal life of the rain forest is diverse, ranging from small decomposers (bacteria) to many animals living exclusively in the upper stories of the trees. These tree dwellers are known as arboreal. They include monkeys, lemurs, sloths, parrots, and snakes. Beautiful birds of many colours, tree frogs, lizards, bats, and rich insect life that include over 500 species of butterflies are found in rain forests.

More than one-half of Earth's original rain forest is gone, cleared for timber, fuel, pastures and farming. Unfortunately, the dominant trees require from 100 to 250 years to establish themselves after major disturbance.

2.Tropical Seasonal Forest and Scurb (TrSF): This biome occupies the regions of low and erratic rainfall. The trees of this region are deciduous and semi-deciduous. The semi-deciduous trees lose their leaves during the dry season. The rainfall in this biome is confined to about 90 days. In fact, it is the biome found in the monsoon climate. The monsoonal forest average 15 m high with no continuous canopy of leaves. This biome stretches into North-East India, Indonesia, Malaysia, Myanmar, Philippines, Thailand, Brazil, Zambia, and Tanzania **(Fig. 5.3).** The main trees are *sal, sagon* (teak), *shisum*, gum-trees like carnauba and palm-hard waxes.

Local names are given to these communities: the *caatinga* of Bahia State of North-East Brazil, the *chaco* area of Paraguay and North Argentina, the *brigalow scrub* of Australia, and *dornveld* of South Africa.

3.Tropical Savanna: The savanna biome consists of a combination of trees and grassland in various proportions. This is a transitional biome between the tropical forests and semi-arid tropical steppes, and deserts. The savanna biome also includes treeless tracts of grasslands. The trees of savanna woodlands are characteristically flat topped. Savannas covered more than 40% of the Earth's land surface before human intervention but were especially modified by human-caused fire. Fires occur annually throughout the biome. Elephant grasses averaging 5 m high are found in this biome. This biome is much richer in humus than the wetter tropics and are better drained, thereby providing a better base for agriculture. Sorghums (millets), wheat, and

groundnut (peanuts) are common crops grown in this biome.

Savanna shrubs and trees are frequently *xerophytic*, or drought resistant, with various adaptations to protect them from the dryness. They are characterised by small thick leaves, rough bark, or waxy leaf surfaces.

Africa has the largest region of this biome, including the famous Serengeti Plains and the Sahel region. It is also found in parts of Australia, India, and South America **(Fig. 5.3)**. Some of the local names for these lands include the *Llanos* in Venezuela, *Campo Cerrado* in Brazil and Guiana, and the *Pantanal* of south western Brazil. The main animals of the savanna grassland are lions, cheetah (tigers), zebra, giraffe, buffalo, gazelle, wildebeast, antelope, rhinoceros, and elephant.

4.Hot Deserts and Semi-deserts: The desert biome includes several formation classes that are transitional from savanna biomes into vegetation of the arid desert. It consist of the semi-desert and hot desert regions.

The semi-desert is a transitional biome found in a wide latitude range from the tropical zone to the mid-latitude zone. Semi-desert consists of sparse xerophytic shrubs. One example is the sage brush vegetation of the Colorado Plateau (USA) and Cactus plants **(Fig. 5.3)**.

The dry deserts stretch mainly in the hot deserts of the world. The main vegetation consist of small, hard-leaved, or spiny shrubs, succulent plants (such as cactus), or hard grasses. The typical desert vegetation include saguaro cactus, the prickly pear cactus, the ocotillo, creosote bush, and smoke tree.

5. Cold Deserts and Semi-deserts: The cold deserts and semi-desert biomes are found in the higher latitudes. This biome stretches over Sierra Nevada (USA), Ladakh (India), and Andes (Argentina). Winter snow occurs in the cold deserts, but are generally light. Summers are hot. The dryness, clear skies, and sparse vegetation lead to high radiative heat loss and cool evenings. Many areas of these deserts are

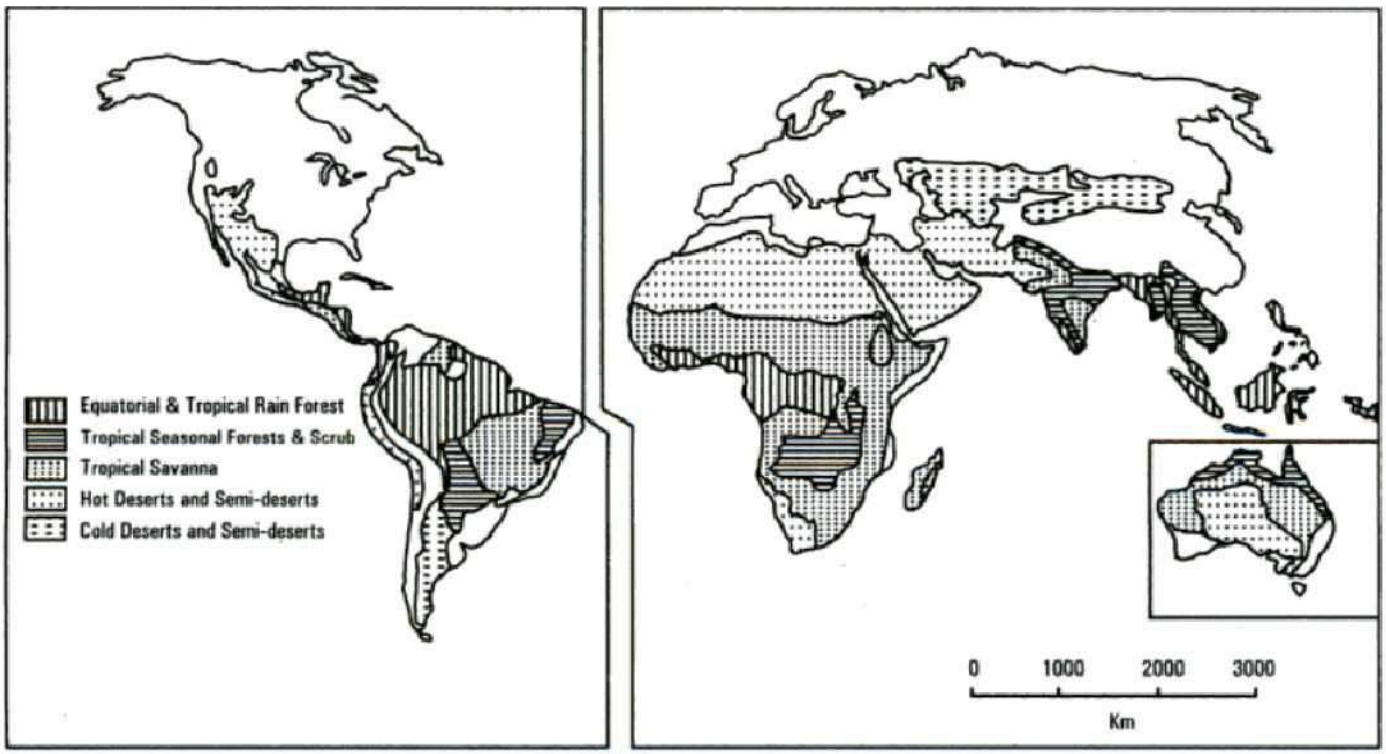

Fig. 5.3 – The major terrestrial biomes of the world (after Christopherson R.W. Geosystems, 1999, Printice-Hall)

covered with sage-brush and scrub vegetation **(Fig.5.3)**.

6. Temperate Rain Forest: The temperate rain forest biome is recognised by its lush green forests at the middle and high latitudes. This biome is mainly confined along narrow margins of the Pacific Northwest in North America **(Fig. 5.4)**. *The tallest trees in the world,* namely, redwood (*sequoia sempervirens*), douglas fir, spruce, cedar, and hemlock occur in this biome. These trees can exceed 1500 years of age and typically range in height from 60 to 90 m with some exceeding 100 m. This biome includes several distinct communities in North America, Europe, and Asia. Some of the other important trees of this biome are deciduous oak, beech, hickory, maple, elm, chestnut, pines, etc **(Fig. 5.4)**.

7. Mid-latitude Broad-leaf Mixed Forests: This biome is found in the moist continental climates of North America, Europe, and Asia **(Fig. 5.4)**. The main trees of this biome are pines, hemlock, with deciduous varieties of oak, beech, hickory, maple, elm, chestnut, etc.

8. Mediterranean Shrubland (MSh): The Mediterranean biome has hot rainless summer and cool-moist winters. The dominant species of trees of this biome are stunted and tough in their ability to withstand hot summer drought. The vegetation is called *sclerophyllous* (from *sclera* or 'hard' and *phyllos* for 'leaf'); it averages a metre or two in height and has deep, well developed roots, leathery leaves, and uneven low branches. In California this vegetation is known as *chaparral*. In the European Mediterranean region it is known as *maquis*. In Chile, such a region is called *mattoral;* in south Australia *mallee* scrub. The cork-oak is also a vegetation of this biome **(Fig. 5.4)**.

9. Mid-latitude Grasslands: This biome includes the *steppes* (Eurasia), *prairie* (USA, Canada), *pampas* (Argentina), *velds* (South Africa), and *downs* in (Australia). This biome is known for nutritious grasses. The grasses flower in spring and early summer **(Fig. 5.4)**.

10. Needleleaf Biome or Boreal Forest: The needleleaf forest biome is also called the boreal forest **(Fig. 5.4)**. A more open form of boreal forest in the arctic and sub-arctic regions is known as *taiga*. In the Southern Hemisphere, this biome is found in the montane regions. The main trees of this biome are pine, spruce, and fir. The Sierra Nevada, Rocky Mountains, Alps, and Himalayas have similar forest communities **(Fig. 5.4)**.

11. Tundra Biome: The tundra region remains snow covered over the greater parts of the year.

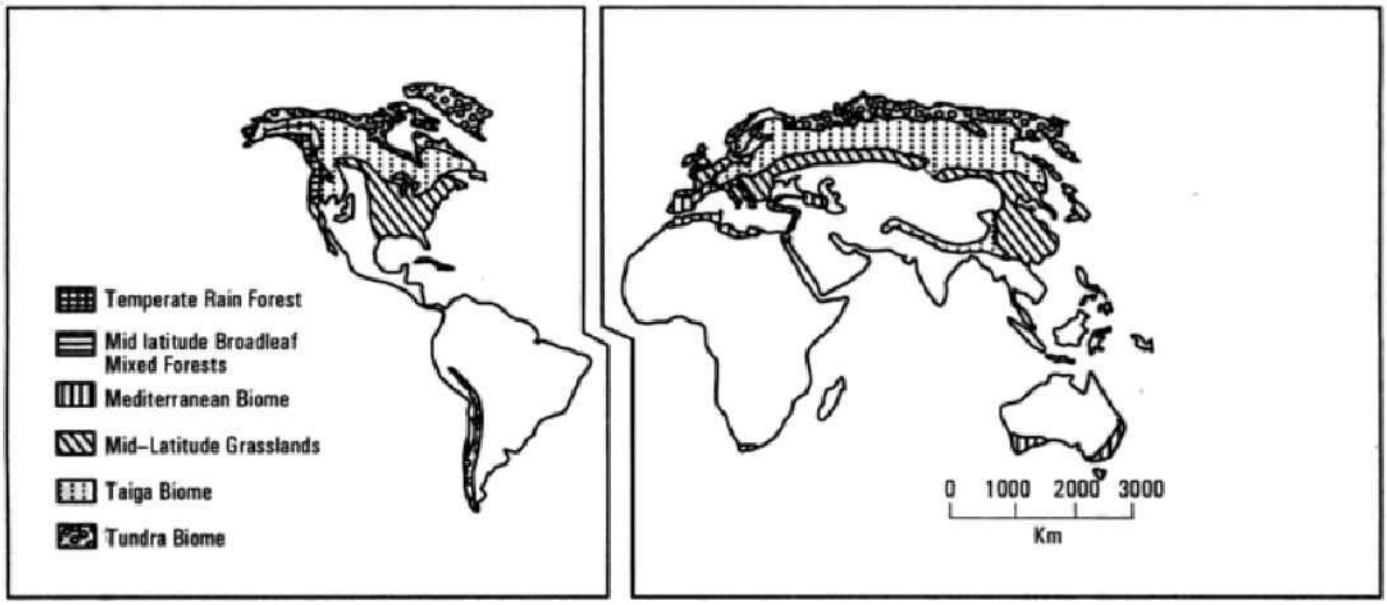

Fig. 5.4 – The major terrestrial biomes of the world (After Christopherson, R.W., Geosystems, 1999, Printice-Hall)

In this climate plants grow only during the brief summer of long days and short nights. Plants of the tundra biome are mostly low herbs, sedges, cotton grasses, grasses, mosses, and lichen **(Fig. 5.4)**.

Mangrove (Rhizophora) Forests

Low, muddy coasts in tropical and some sub-tropical areas are often home to tangled masses of trees known as mangroves. These large flowering plants are never completely submerged, but because of their intimate association with the ocean they are considered marine plants. They thrive in the sediment rich lagoons, bays, deltas and estuaries of the rivers of South Asia, South-East Asia, tropical Africa, Cameroon, and the tropical Americas. In addition to mangrove, there are salt marshes in the Northern Hemisphere around 30th parallel. In these marshy lands grow the salt tolerant plants known as *halophytic*. The wetland ecosystems are quite fragile and are threatened by human development. In some countries, the salty areas and mangroves have been reclaimed because the conceived fear of disease or pestilence in the swamplands.

Biodiversity

Today, over six hundred billion humans, approximately one million animal species and 355,000 known plant species depend on the air, water and land of the Earth. The location of areas of exceptionally high biological richness–biodiversity hotspots have been shown in **Fig. 5.5**.

It may be observed from **Fig. 5.5** that the Islands of Antilles, Meso-American forests, tropical Andes, Cerrado (Brazil) and the Atlantic forest region have special bio-diversity. The Guinea forests of West Africa, Madagascar, Cape and Western Cape (South Africa), Western Ghats (India), South-East Asia, especially Indonesia, Malyasia, Philippines, etc. have exceptionally high biological diversity.

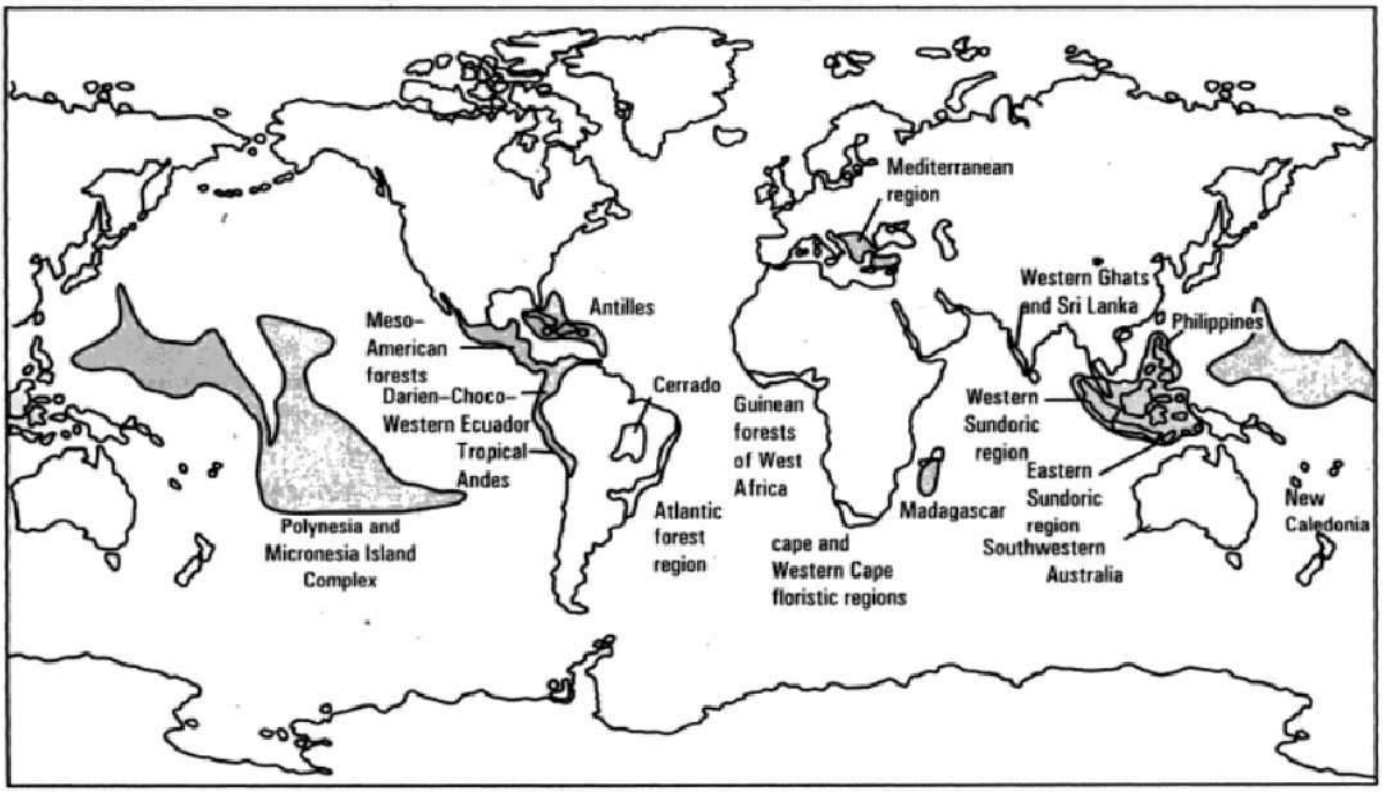

Fig. 5.5. – The location of areas of exceptionally high biological richness–biodiversity hot spots, as determined by Conservation International

Source: C. Barry Cox et. al. 2004, *An Ecological and Evolulionary Approach, 6th ed. London Blackwell Science. p. 25*

Soil System

A dynamic natural body made up of fine materials covering Earth's surface in which plants grow; composed of both mineral and organic matter (Christopherson).

Components of Soil

A soil is made up of four elements: (i) parent material – inorganic or mineral fraction (derived from the parent material), (ii) organic material (humus), (iii) air, and (iv) water.

Parent Material

The parent material includes both hard, resistant rocks such as granite and slate, and also the less resistant rocks such as recent volcanic lavas and ashes, and most of the sedimentary rocks like limestone and sandstone.

Humus

Humus is the end-product of the breakdown of dead organic material. It is structureless, dark-brown or black jelly found beneath the soil surface. The humus of ordinary soil is black, and is thus responsible for making the soil darker than the subsoil. It plays an important role in maintaining the fertility of the soil.

Soil Horizon

The various layers exposed in a *pedon*; roughly parallel to the surface and identified as O, A, E, B, and C.

Soil Profile or Pedon

A vertical section of soil in which all the soil horizons are shown, is known as soil profile. Most of the soil profiles include three master horizons. Soil profile extends from the surface to the deepest extent of plant roots, or to where regolith or bed-rock is encountered **(Fig. 5.6)**.

Soil Texture

A soil is generally characterised 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 **(Fig. 5.7).** If one handles a moist soil sample of each of these he feels gritty, sticky, and silky. The standard unit for the measurement of soil particles is the millimetres, but a smaller unit is the micron (1micron=0.001 mm), which is applicable, for instance, to the measurement of soil colloids.

Soil Structure

Soil structure refers to the arrangement of soil particles. The way in which sand, silt, clay and humus bond together to form *peds* is known as soil structure. Structure can partially modify the effects of soil texture. The term *ped* describes an individual unit of soil particles; it is tiny natural lump or cluster of particles held together.

Soil Taxonomy

A soil classification system based on observed properties actually seen in the field; published in 1975 by the U.S. Soil Conservation Service.

Soil Fertility

The ability of soil to support plant productivity when it contains organic substance and clay minerals that absorb water and certain elemental ions needed by plants.

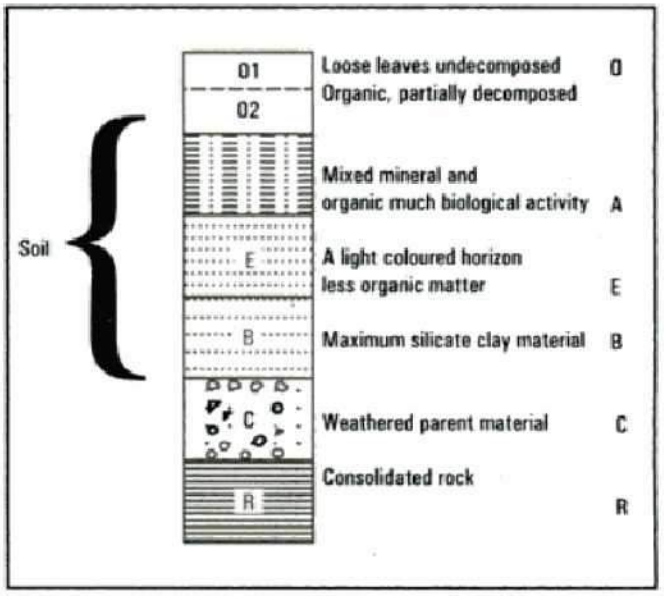

Fig. 5.6 – Soil profile and soil horizons

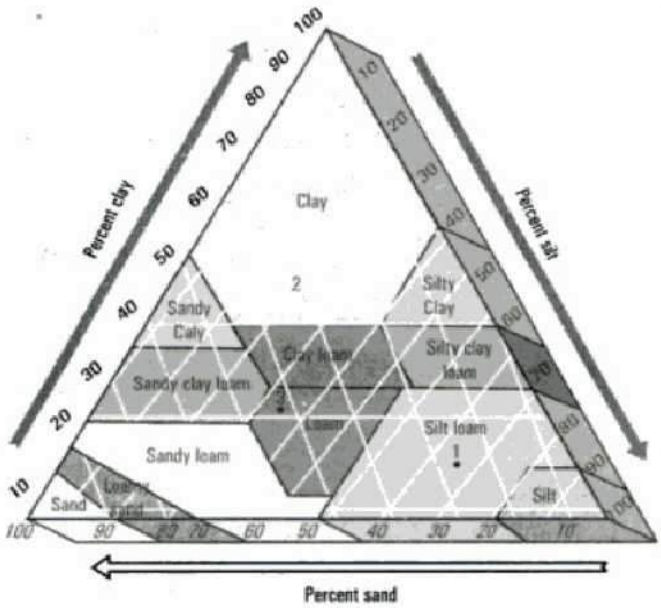

Fig. 5.7 – soil texture triangle. As an example, points 1, 2, and 3 designate samples taken at three different horizons in the Miami silt loam in Indiana. A sample taken near the surface in the A horizon is recorded at point 1; in the B horizon at point 2; and in the C horizon at point 3. Note that silt dominates the surface, clay the B horizon, and sand the C horizon [After USDA Soil Conservation Service, soil Taxonomy, Agricultural Handbook No. 436, Washington, DC: U.S. Government Printing Office 1975]

Major Soil Types

Soils may be divided into (i) zonal, (ii) intrazonal, and (iii) azonal categories.

(i)Zonal Soil: The soil whose characteristics are dominated by the influence of climate and vegetation is known as zonal soil. These soils occur on gently undulating land where drainage is free and where the parent material is of neither extreme texture nor chemical composition.

(ii) Intrazonal: The soil which has been influenced in its development less by climate and vegetation than by other local factors, such as effective drainage, excessive evaporation or parent material (such as limestone), terrain or age is known as intrazonal soil.

(iii) Azonal: The soil which has not been sufficiently subjected to soil-forming processes for the development of a mature profile and so is little changed from the parent rock material is known as azonal soil. Azonal soils do not have B horizon because it is too immature. Thus, A horizon lies immediately above C horizon. Examples are soil forming on sand-dunes, recently deposited alluvium, scree, glacial moraines, marine mud-flats, and volcanic soils.

Soil Taxonomy – Eleven Soil Orders

***Table 5.1:** Soil Taxonomy Soil Orders*

Order	*Marbut Equivalent*	*General Location and Climate*	*World Land Area*	*Description*
Oxisol (ox)	Latosois lateritic soil	Tropical soils, hot humid areas	9.2	Maximum weathering and eluviations, oxic horizon, continuous plinthite layer
Aridisol (arid)	Reddish desert gray desert, sierozem	Desert soils, hot dry areas	19.2	Limited alteration of parent material low climate activity, light colour.
Mollisols (modify)	Chestnut, chernozem	Grassland soils subhumid,	9.0	Noticeably dark with organic material,

		semi-arid lands		base saturation high, surface with well structured horizons
Alfisols (alfafa)	Gray brown podzolic, degraded chernozem	Moderately weathered forest soils, humid temperate forests	14.7	B horizon high in clays, moderate to high degree of base saturation
Ultisols (ultimate)	Red yellow pozolic, reddish yellow lateritic	Highly weathered forest soils, subtropical forests	8.5	Similar to Alfisols B horizon high in clays, generally low amount of base saturation
Spodosols (odd)	Podzols brown podzolic	Northern conifer forest soils, cool humid forests	5.4	Strongly acidic, coarse texture
Entisols (recent)	Azonal soils, tundra	Recent soil profile, undeveloped, all climates	12.5	Limited development young soils lacking horizons
Inceptisols (inception)	Sub-arctic brown forest lithisols	Weakly developed soils, humid regions	15.8	Intermediate development
Vertisols) (invert	Tropical black clays	Subtropics, sufficient dry period	2.1	Forms large cracks on drying, self mixing action
Histosols (histology)	Peat, bog, muck	Organic soils, wet places	0.8	Peat or bog, organic matter over 20% with clay, no horizon
Andisols (andesite)	-	Areas affected by frequent volcanic activity	Less than 1%	Volcanic parent material

***Source**: Christopherson, R.W., 1995,* **Geosystems**, *New Jersey, Prentice Hall, p.464.*

Soil Erosion

Soil is the most valuable asset to humanity. Its use and misuse resulted into serious problems of soil erosion. At present, soil erosion is a worldwide phenomenon.

Approximately 1.2 billion hectares of the Earth's soil suffer some degree of degradation through erosion caused by human misuse and abuse. The areas of serious concern lie in Asia, Africa, Europe, Australia, North America and South Americas **(Fig. 5.8)**. According to one estimate, 75,000 million tones of productive soil is eroded annually. In India, the problem of soil erosion is quite serious as annually about 6000 million tonnes of soil is being eroded.

Soil erosion not only affects the areas from which soil is removed, but also affects the environment where it is deposited. Such deposits, if takes place in lakes and ponds, destroy the aquatic ecosystems by adding more nutrients, notably nitrogen and phosphorous. It is therefore, imperative to adopt remedial measures to combat soil erosion and to protect the neighbouring ecosystems.

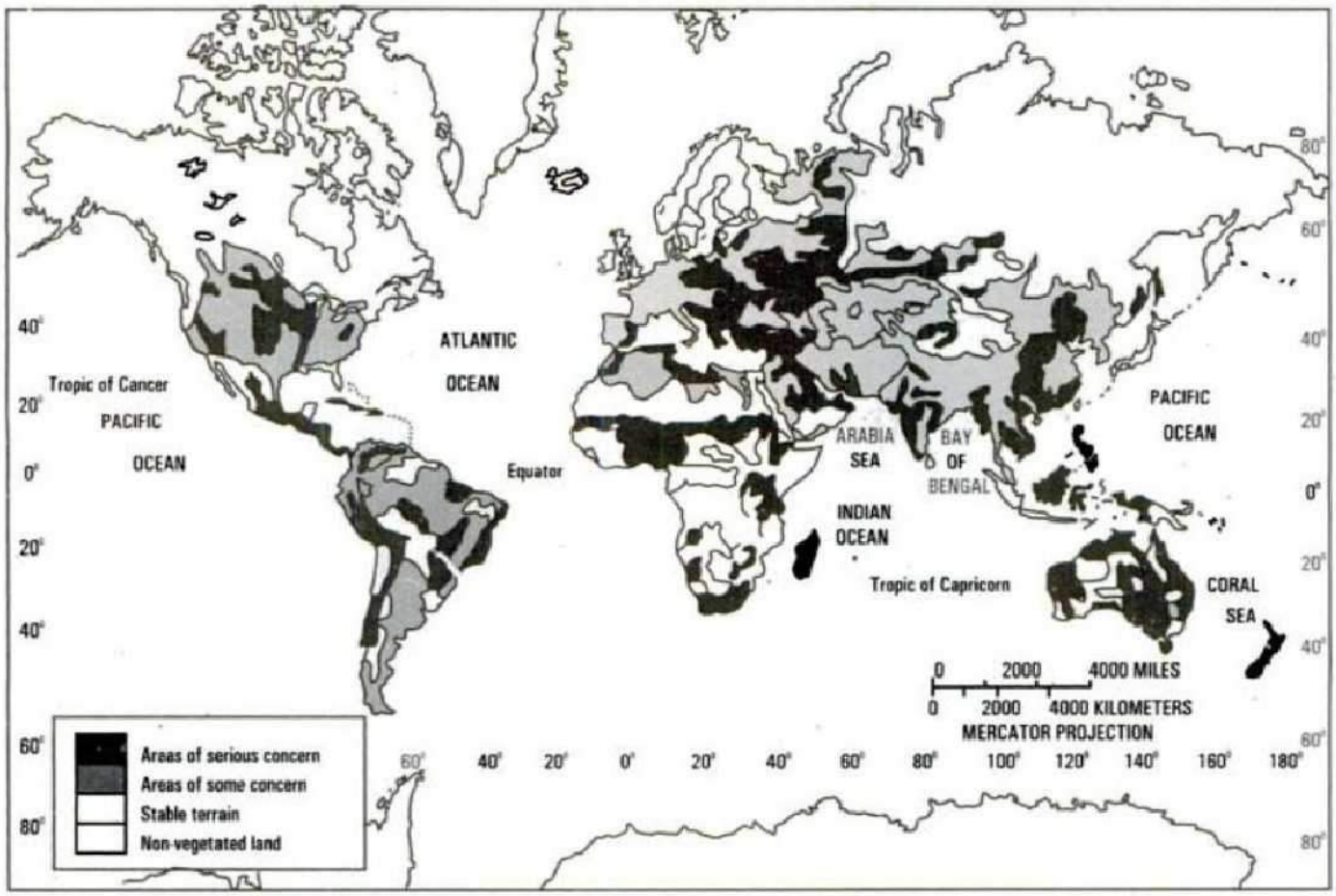

Fig. 5.8 – Approximately 1.2 billion hectares (3.0 billion acres) of Earth's soils suffer some degree of degradation through erosion caused by human misuse and abuse. [A Global Assessment of Soil Degradation, adapted from United Nations Environment Programme, International Soil Reference and Information Centre, "Map of Status of Human-induced Soil Degradation," Sheet 2, Nairobi, Kenya, 1990.]

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