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**ECOLOGY OF HOT DESERT**

**(BOT 442)**

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**2018**

**COURSE OBJECTIVES**

* Basic information on climatological factors on the desert.
* Definition of desertification and classification of desert.
* Desertification and the relationship between the rainfall and water contents of the soil.
* Development the drought forms, drought country and desert in the world.
* Ecology of desert ecosystem

**RECOMMENDED BOOKS AND RESEARCH PAPERS**

* Walter Whitford and Elizabeth Ludwig Wade (2002) Ecology of Desert Systems. Academic Press, USA (ISBN: 978-0-12-747261-4)
* Edgell, H. Stewart (2006) Arabian Deserts Nature, Origin and Evolution. Springer (ISBN 9781402039690)
* Peter Vincent (2008) Saudi Arabia: An Environmental Overview. Taylor & Francis, The Netherlands. (ISBN ISBN 9780415413879)
* Abdulatif H. Al-Nafie (2008) Phytogeography of Saudi Arabia. Saudi Journal of Biological Sciences 15 (1) 159-176 June, ISSN 1319-562 X
* **WHAT IS ECOLOGY?**
* Ecology is the study of interactions among organisms and between the organism and its physical (abiotic) environment.
* Physical conditions experienced by an organism is called as Abiotic components or abiotic factor.
* The biological or living components that make up an organism’s surroundings is called as Biotic components or biotic factor
* Ecology can also be defined as the study of living organisms in relation to their habits and habitats.
* In context of biology, Ecology is the scientific study of the relationships between organisms and their environment.
* The term Ecology is taken from the Greek words that is oikos= means“house” and logy = means “the study of”.
* Ecology is concerned with four levels of biological organization that is organisms, populations, communities and biomes.
* **WHAT IS HABIT AND HABITAT?**
* Habitat: The zone in which the organism (plants and animals) lives and where it can find food, shelter, protection and mates for reproduction.
* Habit: Aspects of behavior or structure.
* **ENVIRONMENT**
* Environment is the interactions among the abiotic (physical and chemical) and biological component.
* Environmental science is an interdisciplinary academic field that integrates physical, biological and information sciences (including ecology, biology, physics, chemistry, zoology, mineralogy, oceanology, soil science, geology, atmospheric science) to the study of the environment, and the solution of environmental problems.
* **ORGANISM AND ITS ENVIRONMENT**
* Ecology at the organism level (physiological ecology) explains how different organisms are adapted to their environments in terms of survival and reproduction.
* The rotation of earth and the tilt of its axis cause annual variations in temperature and seasons. Major biomes (desert, rain forest, tundra etc.) are formed due to these variations and precipitation (rain & snow).
* Regional and local variations within each biome lead to the formation of different habitats.
* On Earth, life exists even in extreme and harsh habitats.
* The physico-chemical (abiotic) components (water, light, temperature, soil etc.) and biotic components (pathogens, parasites, predators, competitors etc.) lead to variation of different habitats.
* **ECOSYSTEM**
* An ecosystem is a functional unit of nature, where living organisms interact among themselves and also with the surrounding physical environment.
* Ecosystem is a biological community of interacting organisms and their physical environment.
* All organisms along with physical environment in a single location.
* Various ecosystems make up the largest life unit called biosphere.

**Types of ecosystems**

* Terrestrial ecosystem: Forest, grassland, desert etc.
* Aquatic ecosystem: Pond, lake, wetland, river & estuary.
* Man-made ecosystem: Crop fields and aquarium

The entire biosphere can be regarded as a global ecosystem.

* **STRUCTURE OF ECOSYSTEM**
* In an ecosystem, interaction of biotic and abiotic components occurs. These components function as a unit.
* **Abiotic components:** Abiotic components of ecosystem are energy, Physical factor and chemicals.
* Energy: energy in an ecosystem comes from sun in the form of solar energy.
* Physical factors – Physical factors in an ecosystem are temperature, light, wind, etc.
* Chemicals- Chemicals in an ecosystem are inorganic substances (like oxygen, carbon, etc.) and organic substances (like carbohydrates, proteins, etc.).
* **Biotic components**
* Producers - green plants (autotrophs)

-Herbivores (primary consumers)

* Consumers - animals (heterotrophs)

-Carnivores- (primary, secondary, tertiary, etc. consumers)

-Omnivores- can feed on both plants and animals

-Scavengers (top carnivores)- utilize the dead remains of animals

* **Decomposers** (like Bacteria and Fungi)
* **FUNCTION OF ECOSYSTEM**
* There are four basic components of functioning of an ecosystem:

1. PRODUCTIVITY
2. DECOMPOSITION
3. ENERGY FLOW
4. NUTRIENT CYCLING

* **PRODUCTIVITY**
* A constant input of solar energy is the basic requirement for any ecosystem to function and sustain.
* The amount of biomass or organic matter produced per unit area over a time period by plants during photosynthesis is called primary production / productivity.
* **BIOSPHERE (SPHERE OF LIFE)**

Total portion of lithosphere, hydrosphere and atmosphere that supports the life of organisms.

* Zonobiomes (Biomes)
* Equatorial diurnal climate
* Tropical
* Subtropical (Desert)
* Mediterranean
* Warm temperate
* Temperate
* Arid temperate (Continental)
* Cold temperate
* Arctic (Tundra)
* **Hierarchical Structure of Ecological Systems**
* **Organism**: The fundamental unit of ecology.
* **Population**: A group of individuals of a single species inhabiting a specific area.
* **Community**: An association of interacting species living in a particular area.
* **Ecosystem**: A biological community plus all of the abiotic factors influencing that community.
* **Biome**: A large naturally occurring community of flora and fauna occupying a major habitat.
* **Biosphere**: The aggregation of all ecosystems (the sum of all of the organisms of the earth and their environment). The living zone of the planet.
* **MAJOR BRANCHES OF ECOLOGY**
* **Taxonomic Ecology**: Plant ecology, animal ecology, microbial ecology, avian (birds) ecology
* **Time/ Place Ecology**: marine ecology, tropical ecology. Freshwater ecology, paleoecology (paleo= fossils)
* **Processes Ecology**: behavioral ecology, physiological ecology, evolutionary ecology
* **WHY STUDY ECOLOGY?**
* Ecological knowledge is essential to know how the natural systems work.
* The study of Ecology helps in managing resources and economy.
* Humans harvest biotic resources from environment that have market value.
* Humans receive many "services" from nature (i.e., water purification)
* Humans have damaging effects on resources and services
* **ECOSYSTEM SERVICES**

The products of ecosystem processes are called ecosystem services. For example- healthy forest ecosystems purify air and water, mitigate droughts and floods, cycle nutrients, generate fertile soils, provide wildlife habitat, maintain biodiversity, pollinate crops, provide storage site for carbon and provide cultural values.

* **TYPES OF DESERT**
* Cold desert
* Hot desert: The main form of precipitation in a hot desert is rain. But that's only ten inches or less of rain per year.
* **DIFFERENT DEFINITIONS OF DESERT**
* A temperate region that receives an average annual rainfall of less than 250 mm a year, generally infrequent, where evaporation exceeds precipitation.
* Desolate or barren region, waterless and treeless, but with scanty herbage.
* An uninhabited and uncultivated tract of country.
* A dry region lacking moisture to support vegetation.
* Deserted region, a barren tract incapable of supporting population, as the vast sand plains of Asia and Africa, which are devoid of moisture and vegetation.
* An ecosystem with less than 100 mm of precipitation per year.
* Botanists consider that deserts are areas of sparse and specialized vegetation and refer to them as desert biomes. Areas, in which deficient and uncertain rainfall has made a strong impression on structure, functions and behavior of living things.
* **HISTORIANS AND EXPLORERS OF ARABIAN DESERTS**
* Ibn Battuta (1304–1368)
* Al-Idrisi (1099–1168)
* Yaqut (1179–1229)
* Niebuhr (1762)
* Burckhardt (1829)
* Burton (1855–1866)
* Doughty (1877–1878)
* Palgrave (1865)
* Blunt (1881)
* Lawrence (1926)
* Thomas (1929–1932)
* Philby (1933)
* Thesiger (1948–49)
* **Deserts based on average annual rainfall**
* **Hyper-arid**: where rainfall <25 mm
* **Arid**: where rainfall is 25–200 mm
* **Semi-arid**: where rainfall is 200–500 mm
* **HOT DESERTS OF THE WORLD**

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| **Name** | **Location** | **Size** | **Physical  Features** |
| Arabian | Arabian Peninsula | 2,300,000 km2 | Covered almost entirely by sand; has some of the most extensive stretches of sand dunes in the world. |
| Australian | Great Sandy, Victoria, Simpson, Gibson, and Sturt) Australia | 2,300,000 km2  (1/3 of Australia) | Great Sandy, Victoria, and Simpson are sandy; Gibson and Sturt are stony. |
| Chihuahuan | North Central Mexico and Southwestern United States (Arizona, New Mexico, Texas) | 455,000 km2 | High plateau covered by stony areas and sandy soil. Many mountains. |
| Kalahari | Southwestern Africa | 520,000 km2 | Covered by sand dunes. |
| Mojave | Southwestern United States (Arizona, California, Nevada) | 65,000 km2 | Covered by sandy soil |
| Monte | Argentina | 325,000 km2 | Covered by sand and soil |
| Sahara | Northern Africa | 9,100,000 km2 | Covered by mountains, rocky areas, huge areas of dunes. Areas in the central sometimes get no rain for years at a time. |
| Sonoran | Southwestern United States (Arizona, California) and parts of Mexico (Baja Peninsula, Sonora) | 312,000 km2 | Covered by sand, soil. Gets more rain than any other North American desert. |
| Thar | India and Pakistan | 200,000 km2 | Majority of desert covered by sand dunes |

* **FLORA AND FAUNA OF THE HOT DESERTS OF THE WORLD**

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| **Name** | **Flora** | **Fauna** |
| Arabian | Acacia, Oleander, Saltbush | Desert locust, Dromedary camel, Gazelle, Lizard, Jackal, Oryx |
| Australian | Acacia, Casuarina tree, Eucalyptus, Saltbush, Spinifex grass | Blue-tongued lizard, Dingo, Fat-tailed mouse, Kangaroo, Marsupial mole, Rabbit-eared Bandicoot, Sand goanna, Spinifex hopping mouse, Throny devil |
| Chihuahuan | Cacti, Chihuahuan flax, Creosote bush, Lechuguilla, Mesquite, Mexican gold poppy | Coyote, Diamondback Rattlesnake, Javelina, Kangaroo rat, Roadrunner |
| Kalahari | Acacia, Aloe | Gazelle, Gerbil, Ground squirrel, Hyena, Jackel, Sandgrouse, Springbok |
| Mojave | Creosote bush, Desert sand verbena, Joshua tree, Mesquite | Bighorn sheep, Chuckwalla, Coyote, Jackrabbit, Sidewinder, Zebra-tailed lizard |
| Monte | Cardon cactus, Creosote bush, Paloverde | Armadillo, Cavy, Jaguarundi, Puma, Tinamou, Tuco-Tuco |
| Sahara | Acacia, Grasses, Tamarisks | Addax antelope, Dorcas gazelle, Fennec fox, Horned Viper, Jackal, Jerboa, Sandgrouse, Spiny-yailed lizard |
| Sonoran | Agave, Coulter's globemallow, Creosote bush, Desert mariposa lily, Mesquite, Ocotillo, Paloverde, Saguaro | Coati, Elf owl, Gila monster, Kangaroo Rat, Pack rat, Roadrunner, Sidewinder, Tarantula |
| Thar | Acacia, Euphorbias, Grasses, Shrubs | Black buck, Dromedary camel, Great Indian bustard, Indian spiny-tailed lizard, Jackel, Sandgrouse |

**CHARACTERISTICS OF PLANTS OF HOT AND DRY DESERT (XEROPHYTIC /SPECIAL ADAPTATION)**

* Canopy in most deserts is very rare.
* Plants are mainly ground-hugging shrubs and short woody tree.
* Leaves are fully supported with nutrients and with water-conserving characteristics.
* Leaves are “replete” (fully supported with nutrients) with water-conserving characteristics. They tend to be small, thick and covered with a thick cuticle (outer layer).
* In the cacti, the leaves are much-reduced (to spines) and photosynthetic activity is restricted to the stems.
* Some plants open their stomata (microscopic openings in the epidermis of leaves that allow for gas exchange) only at night when evaporation rates are lowest. These plants include: yuccas, prickly pears, ephedras, agaves etc.
* **SIGNIFICANCE OF REMOTE SENSING IN ECOLOGY**
* Remote sensing is the acquisition of information about an object without making physical contact with the object and thus in contrast to on-site observation.
* Remote sensing is used in numerous fields, including geography, land surveying and most Earth Science disciplines (for example, Hydrology, Ecology)
* **DESERTIFICATION**
* Desertification is a type of land degradation in which a relatively dry area of land becomes increasingly arid, typically losing its bodies of water as well as vegetation and wildlife.
* Desertification is caused by a variety of factors, such as through climate change (particularly the current global warming) and through the overexploitation of soil through human activity.
* **CHARACTERISTICS OF HOT AND DRY DESERT**
* The seasons are generally warm throughout the year and very hot in the summer.
* The winters usually bring little rainfall.
* Mean annual temperatures range from 20-25° C.
* The extreme maximum ranges from 43-49° C.
* Minimum temperatures sometimes drop to -18° C.
* Rainfall is usually very low. Sometimes rain starts falling and evaporates before reaching the ground.
* Soils are rocky and have no subsurface water.
* The finer dust and sand particles are blown elsewhere, leaving heavier pieces behind.
* **Linkages among Global Climate Change, Rain fall, Biodiversity Loss and Desertification**
* A perusal of global vegetation map reveals that deserts area are on or near to Equator or just above to equator.
* Recent heavy pollutions resulted in to global climate change. The global climate change affects the rainfall. The rainfall is more than normal at particular place or the rainfall is less than normal at particular place. Especially if there is less rainfall at particular place, it lead to loss of vegetation / biodiversity, and in such a way global climate change lead to the process of desertification.
* The interior of the Arabian Peninsula which is dry today, it was once green
* **PENINSULAS**

A Peninsula is a piece of land surrounded by water on the majority of its border, while being connected to a mainland from which it extends.

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| **Rank** | **Peninsula; Surrounding Waters** | **Area (Sq Miles)** |
| 1 | Arabian Peninsula; Arabian Sea, Persian Gulf, Gulf of Aden, Gulf of Oman, and Red Sea | 1,250,006 |
| 2 | Deccan Peninsula; Arabian Sea, Bay of Bengal, and Indian Ocean | 800,004 |
| 3 | Indochina; Bay of Bengal, China Sea, Indian Ocean, and Strait of Malacca | 748,553 |
| 4 | Horn of Africa; Arabian Sea and Gulf of Aden | 726,975 |
| 5 | Alaskan Peninsula; Bering Sea and Pacific Ocean | 579,153 |
| 6 | Labrador Peninsula; Atlantic Ocean, Gulf of St. Lawrence, Hudson Bay, and Labrador Sea | 540,543 |
| 7 | Scandinavia; Baltic Sea, North Sea, and Norwegian Sea | 289,577 |
| 8 | The Balkans; Adriatic Sea, Aegean Sea, Black Sea, Ionian Sea, and Mediterranean Sea | 257,414 |
| 9 | Iberian Peninsula; Atlantic Ocean and Mediterranean Sea | 224,711 |
| 10 | Korean Peninsula; East China Sea, Korean Strait, and Yellow Sea | 85,270 |
| 11 | Florida; Atlantic Ocean, Florida Strait, and Gulf of Mexico | 65,755 |
| 12 | Baja California; Gulf of California and Pacific Ocean | 55,363 |
| 13 | Italian Peninsula; Adriatic Sea, Ionian Sea, Mediterranean Sea, and Tyrrhenian Sea | 50,709 |
| 14 | Kola; Barents Sea and White Sea | 38,610 |
| 15 | Sinai; Gulf of Aqaba, Mediterranean Sea, Red Sea, and Suez Canal | 23,166 |

* **GEOMORPHOLOGICAL PROVINCES OF ARABIAN PENINSULA**

(1) Crystalline Uplands of the Arabian Shield

(2) Crystalline Uplands of southern Sinai

(3) Al Kawr Mountains Crystalline Uplands of south Yemen

(4) Solat Crystalline Plain of south-eastern Dhofar

(5) Hugf Depression of north-eastern Oman

(6) Scarp Mountains of Midyan, Ash Shifa’ and Asir

(7) Greater Tabuk Basin

(8) Rutbah-Sakakah-Jawf Palaeozoic–Mesozoic Arch

(9) South Jordan Sandstone Plateau of Tubayq, Hishmah and Ram

(10) Central Arabian Escarpments or Interior Homocline

(11) Central Sinai El Tih and ‘Igma Plateaux

(12) Oman Mountains (Al Hajar) and Ru’us al Jibal-Musandam Peninsula

(13) Mediterranean Coast Ranges of Syria, Lebanon and Palestine

(14) Wadi Araba-Dead Sea-Beka’a-Ghab Rift

(15) Anti-Lebanon-Jabal ash Shaykh (Sheikh) Mountains

(16) West Jordanian Highlands

(17) Eastern Jordanian Plateau

(18) Central Syrian-North-eastern Jordanian Limestone Plateau

(19) Wadi as Sirhan Depression

(20) Palmyrides (Palmyrene Ranges)

(21) Plateau Plains of Homs-Hama and Halab (Aleppo)

(22) Zagros Fold Ranges of north-eastern Iraq

(23) Block Fold Mountains of Jabal ‘Abd Al-’Aziz and Jabal Sinjar

(24) Hadramawt-Mahrah-Dhofar Plateau

(25) Najd Low Plateau of Interior Yemen, Dhofar, and Jiddat al Harasis

(26) Interior Oman Bajada

(27) As Summan Plateau

(28) Widyan Plateau

(29) North Yemen Volcanic Plateau

(30) Ma’rib-Al Jawf Plateau

(31) Qatar Arch Paleogene Peninsula

(32) North-eastern Gulf Plain of Kuwait and Saudi Arabia

(33) United Arab Emirates Coastal Plain

(34) Al Batinah Coastal Plain

(35) Tihamah Coastal Plain

(36) Jiddah-Yanbu al Bahr-Al Wajh Coastal plains

(37) Harrat of Western Arabia

(38) Al Jazirah Alluvial Plain and Terraces

(39) Mesopotamian Alluvial Plain

(40) Shatt al Arab Delta

(41) Baiji Desert

(42) Southern Iraq Alluvial Plains Desert

(43) Ash Shamiyah Desert

(44) Sinai-Negev Desert

(45) An Nafud Desert

(46) Nafud al Mazhur

(47) Nafud areas within Central Escarpments

(48) Ad Dahna Desert

(49) Al Jafurah Desert

(50) Ar Rub‘ al Khali Desert

(51) Ramlat al Wahı-bah (Wahiba Sands)

(52) Ramlat as Sab’atayn

(53) Mahrah Coastal Plain

(54) Jabal ad Druze-Hauran-Ash Shaba-Harrat ash Shamah Volcanic Plateau

(55) Interior Plateau of E. Syria and NW Iraq

(56) Dibdibba Delta, or Alluvial Fan

(57) Northern Syrian Platform

(58) Alluvial Terraces of NW Rub‘ al Khali

(59) Harrat ‘Uwayrid

(60) Ma’rib-Jawf coastal and interior depression

(61) Wajid Sandstone Plateau

* **GENERAL TOPOGRAPHY OF THE ARABIAN PENINSULA**
* Saudi Arabia is a quadrilateral land mass, occupying a major part of the Arabian Peninsula. It covers an area of about 2,250,000 sq. km.
* Climate- Arid (In summer the Peninsula the temperatures can reach into the 50 °C)
* Rain-Few places in Saudi Arabia receive more than 200 mm of rain a year and in the interior several years may pass without any rainfall at all.
* Altitude of the plains in the Central Region is about 500-800 m and the relative height of the mountains and escarpments (Jabal Shammar, Jabal Tuwayq) varies from 300-600 m.
* The Eastern Region is broadly divided into (1) an open plain adjacent to the Dahna sands, (2) the Northern plains which is bordering with Kuwait, (3) the coastal lowlands and (4) the Rub' al-Khali, the largest, continuous sand body in the world.
* Landscape is composed of a variety of habitats such as mountains, Valleys (Wadis), sandy and rocky deserts, meadows (Raudhahs), salt pans
* Geographical sense, Saudi Arabia can be divided into two distinct zones:
  + The rain fed highlands of the western and southwestern regions (Sarawat Mountains)
  + The vast arid and extra arid lands of the interior (Najd).
* In general, the Central Region is characterized by patchy desert.
* The mountains of southwestern region form a continuous chain of escarpments, extending from Taif to Yemen border. The peaks reach elevations of over 2000 m in the vicinity of Taif and extreme south and over 3000 m in the Abha area.
* Mountains on the western side, especially the Asir Mountains are characterized by cool climate, high precipitation and high humidity.
* The mountains of Jizan Region, especially the Fayfa Mountains reach a height of about 2000 m.
* Tihama lies between the Red Sea and the Escarpments. It is narrow in the northwestern side and wider in the southwestern side.
* Approximately 30% of the land of Saudi Arabia is covered by three major sand bodies. The Great Nafud, situated in the northern part of the country is a 60,000 sq km wide. The Rub al-Khali or the Empty Quarter, with its extreme climate, occupies in 500,000 sq km area and is located in the southern and southeastern part of the country
* **MAIN PHYSIOGRAPHIC REGIONS OF THE ARABIAN PENINSULA**
* **The Coastal Lowlands**
* The Red Sea coastal lowlands – Tihamah
* The Gulf Coast plain
* The Red Sea coastal lowlands – Tihamah
* **Harraat**
* Young and old lavas on Harrat Khaybar north-east of Madinah)
* **Sand Seas**
* Al Jafurah
* An Nafud – Ad Dahna
* Ar Rub’ al Khali
* **Mountains**
* Red Sea Escarpment mountains
* Tuwaiq – Al Aramah Escarpments
* Hijaz-Asir Highlands
* **Plateaus and Plains**
* Hisma Plateau
* Tabuk Plain
* Nadj Uplands
* As Summan
* Al Widyan Plain
* **Geographical map of Arabian Peninsula**

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| **Era** | **Time frame (in Ma = million years ago)** |
| Cenozoic | 66 |
| Mesozoic | 251.902 to 66 |
| Paleozoic | 541 to 251.902 |
| Neoproterozoic | 1,000 to 541 |
| Mesoproterozoic | 1,600 to 1,000 |
| Paleoproterozoic | 2,500 to 1,600 |
| Neoarchean | 2,800 to 2,500 |
| Mesoarchean | 3,200 to 2,800 |
| Paleoarchean | 3,600 to 3,200 |
| Eoarchean | 4,000 to 3,600 |

* **CLIMATE OF SAUDI ARABIA**
* There are three climatic zones in the Kingdom of Saudi Arabia
  + - Desert (almost everywhere)
    - Steppe along the western highlands, forming a strip less than 100 miles (160 km) wide in the north but becoming almost 300 miles (480 km) wide at the latitude of Mecca.
    - A small area of humid and mild temperature conditions, with long summers, in the highlands just north of Yemen.
* In March and April, some precipitation, falls in Mecca and Asir.
* Winters, from December to February, are cool, and frost and snow occur in the southern highlands.
* Average temperatures for the coolest months, December through February are 74 °F (23 °C) at Jeddah, 58 °F (14 °C) at Riyadh, and 63 °F (17 °C) at Al-Dammām.
* In March and April, some precipitation, falls in Mecca and Asir.
* Winters, from December to February, are cool, and frost and snow occur in the southern highlands.
* Average temperatures for the coolest months, December through February are 74 °F (23 °C) at Jeddah, 58 °F (14 °C) at Riyadh, and 63 °F (17 °C) at Al-Dammām.
* Summers, from June to August remain hot, with daytime temperatures in the shade exceeding 100 °F (38 °C) in almost all parts of the country. Temperatures in the desert frequently rise as high as 130 °F (55 °C) in the summer.
* Humidity is low, except along the coasts
* The level of precipitation is also low throughout the country, amounting to about 2.5 inches (65 mm) at Jeddah, a little more than 3 inches (75 mm) at Riyadh, and 3 inches at Al-Dammām.
* In the highlands of Asir, precipitation more than 19 inches (480 mm) in a year, falling mostly between May and October when the summer monsoon winds prevail.
* In the Rubʿ al-Khali, a decade may pass with no precipitation at all.
* **WETLANDS OF SAUDI ARABIA**

Despite the extremely arid climate, the Kingdom of Saudi Arabia harbors a broad spectrum of wetland types, which have been classified into eight distinct wetland systems.

1. Coastal systems, including freshwater marshes, mangroves, coral islands, and mudflats.
2. Dunefield systems, including minor aquifer seeps.
3. Sebkha systems, including continental lagoons or salt lakes.
4. Karst systems, which are aquifer-fed karst crater lakelets.
5. Mountain systems, including various seeps and marshes in volcanic areas.
6. Geothermal systems, including springs confined to southern Tihamah.
7. Wadi systems, including intermittent streams and perennial rivers.
8. Man-made systems, including dams and reservoirs as well as outflows from sewage treatment plants.

* **AGRICULTURE IN DESERT OF SAUDI ARABIA**
* Recently converted large areas of desert into agricultural fields.
* By implementing major irrigation projects and adopting large-scale mechanization, this has progressed in developing agriculture in the country, adding previously barren areas to the stock of cultivatable land
* **ECOLOGICAL REGIONS OF ARABIA**
* Arabian desert and East Sahero-Arabian deserts and xeric shrublands
* Red Sea Nubo-Sindian tropical desert and semi-desert
* South-western Arabian foothills savannah
* **Arabian Peninsula fog desert**
* **Socotra Island xeric shrublands**
* **Red Sea coastal desert**
* South-western Arabian montane woodlands
* Al Hajar montane woodlands
* Gulf of Oman desert and semi-desert
* Persian Gulf-Nubo-Sindian tropical desert and semi-desert
* Tigris–Euphrates–Karun alluvial salt marsh
* Mesopotamian shrub desert
* Middle East steppe
* **DESERT PLANT COMMUNITIES**

**COMMUNITY**: An association of interacting species living in a particular area.

1. *Calligonum comosum* community
2. *Haloxylon persicum* community
3. *Artemesia monosperma* community
4. *Scrophularia hypericifolia* community
5. *Stipagrostis drarii* community
6. *Cornulacea arabica* community
7. *Calligonum crinitum and Dipterygium glaucum* community
8. *Haloxylon salicornicum* community
9. *Rhanterium epapposum* community
10. *Seidlitzia rosmarinus* community

* **THE INFLUENCE OF HUMAN OCCUPATION ON ARABIAN DESERTS**
* Effects of overgrazing
* Vehicular use and recreation
* Cultivation
* Woodcutting
* Construction
* **Significance of Taxonomic and Biodiversity study in Ecological studies**
* **TAXONOMY IS THE GATEWAY OF ECOLOGY**

**Herbarium: Plant collecting, Preservation and Documentation**

* A herbarium is a collection of dried plants systematically named and arranged for ready reference and study.
* To make a herbarium specimen, the plant is collected, and notes are made about it. The plant is then pressed until dry between blotters that absorb moisture and mounted onto a herbarium sheet with a suitable label, and stored in steel cabinet arranged into some system of classification.
* Herbarium techniques involve: (i) Collection, (ii) Drying, (iii) Poisoning, (iv) Mounting, (v) Stitching, (vi) Labelling, and (vii) Deposition in the herbarium.
* The FLORA is the main Resources of Taxonomic Information.
* **Flora**: It is the documentation of plants occurring in a particular region.
* **Identifying Plant Families**
* **Caryophyllaceae**
* Herbs
* Leaves in opposite pairs, unlobed, untoothed
* Flowers usually have 5 petals
* Flowers usually have 5 sepals
* Flowers in cymes (group of flowers, terminal flower opens first)
* Single capsule fruit
* **Brassicaceae**
* Herbs
* Alternate leaves
* No stipules
* Flowers have 4 petals in a cross
* Flowers have 4 sepals
* Many cultivated vegetables
* **Apiaceae**
* Herbs
* Leaves usually alternate with sheathing, inflated leaf-stalk bases
* Flowers have 5 separate petals
* Flowers small
* Umbels type of inflorescence
* **Lamiaceae / Labiatae**
* Herbs
* Square stems
* Leaves opposite
* Leaves often toothed
* No stipules
* Tubular flowers
* Flowers usually have hood and prominent lower lip
* **Asteraceae / Compositae**
* Largest family of flowering plants worldwide
* Herbs
* Leaves without stipules
* Flowers small in dense heads
* Petals always joined into a corolla-tube (petals fused together below forming a tube)
* **Cucurbitaceae**
* Herbaceous vines
* Tendrils present
* Plants usually monecious
* Flowers 5-merous
* Ovary inferior
* Fruit usually a pepo
* **Asclepiadaceae**

* Perennial herbs, vines, and shrubs with milky sap, some cactus-like
* Leaves opposite or whorled, simple, entire
* Flowers bisexual, actinomorphic, with elaborate corona containing hoods and horns
* Highly specialized pollination mechanism
* Pollen contained in waxy pollinia connected in pairs to glands
* Stamens and carpels united into gynostegium
* Fruit a follicle
* seeds with tuft of silky hairs
* **Euphorbiaceae**
* Habit: herbs, shrubs, stem succulents, trees; often with milky sap
* Leaves: alternate, opposite, whorled; simple (rarely palmately compound); stipulate
* Plants: monoecious or dioecious
* Inflorescence: cymose, racemes, cyathium
* Perianth: 0 (4-6); distinct or basally connate, free or adnate at base to stamens
* Stamens: 1-many, distinct or variously connate
* Ovary: 3 carpels; connate; superior; 3 (1-4) locules with 1 or 2 apical-axile ovules per locule; styles 3 (1-4), often forked
* Fruit: schizocarpic capsule (drupe, berry, pod, samara)
* **Poaceae**
* Habit: Mainly herbs (annuals or perennials) or shrubs. Some are trees like
* Root: Adventitious, fibrous, branched or stilt (as in maize).
* Stem: Underground rhizome in all perennial grasses, cylindrical, distinct nodes and internodes, herbaceous or woody.
* Leaves: Alternate, simple, extipulate, sessile, leaf base forming tubular sheath, sheath open, surrounding the internodes completely, hairy or rough, linear, parallel venation.
* Inflorescence: Compound spike, sessile or stalked. Each unit is called spikelet, may be a spike of spikelets (Triticum) or panicle of spikelets (Avena).
* Perianth: Represented by membranous scales called lodicules, many (Ochlandra) or three or two or absent.
* Androecium: Stamens usually three, some times six (Bambusa) rarely one (species of Fistuca). Filaments long, anthers dithecous, versatile and linear.
* Gynoecium: Monocarpellary (presumed to be three of which two are aborted), unilocular, single ovule on basal placentation, style short or absent, stigma bifid, ovary superior.
* Fruit: A caryopsis with pericarp completely united with the seed coat, rarely a nut (Dendrocalamus) or a berry (Bambusa).
* Seed: Endospermic, with a single cotyledon called scutellum, pressed against the endosperm
* **Fabaceae / Leguminosae**
* Five-petalled flowers
* Leaves usually trifoliate or pinnate
* Wide standard petal at top
* 5 sepals forming calyx-tube (lower parts of sepals fused)
* Fruit an elongated pod
* **Malvaceae:**
* Presence of epicalyx
* Petals with twisted aestivation
* Stamens indefinite and monoadelphous
* Anthers reniform and monothecous
* Ovary two- many carpels with axile placentation.

**Taxonomic Key**

An identification device, consisting of contrasting statements used to narrow down the identity of a taxon

* **Example of important Succulent species of Saudi Arabia**
* *Zygophyllum*
* *Huernia*
* *Adenium*
* *Euphorbia*

**Example of Poisonous Plants of Saudi Arabia**

* *Calotropis procera*
* **Example of Weeds of Saudi Arabia**
* *Cenchrus ciliaris*
* **Example of Aquatic species of Saudi Arabia**
* The aquatic flora in Saudi Arabia contains more than 40 aquatic or semi aquatic species. Example *Lemna* sp, *Ceratophyllum demersum* etc.
* **Example of Parasitic plants of Saudi Arabia**
* There are about 32 species parasitic, Like Cuscuta species.
* **Example of Cultivated plants of Saudi Arabia**
* Example: Dates (*phoenix dactylifera*)
* **Example of Underground plant of Saudi Arabia**
* *Example: Allium asirense*

**Aromatic and Medicinal Plants of Saudi Arabia**

* ***Artemisia sieberi* (Family Compositae):**
* Leaves are used as an anthelmintic.
* Anthelmintic is an antiparasitic drugs that expel parasitic worms
* ***Ruta chalepensis* (Family Rutaceae)**
* Leaves are used to cure rheumatism
* Rheumatism is the disease marked by inflammation and pain in the joints, muscles, or fibrous tissue
* ***Withania somnifera (Family Solanaceae)***
* Leaves and roots are used as a poultice
* Poultice is the term used for “applied to the body to relieve soreness and inflammation”
* ***Citrullus colocynthis* (Family Cucurbitaceae)**
* Leaves, seeds and roots are used in insect bits
* **HISTORY OF BOTANICAL STUDIES IN SAUDI ARABIA**
* Kitab al Nabat by A.H. Dinawari (895 A.D.): A comprehensive knowledge of the agriculture and medicinal practices of the Bedouins.
* Discussion about Arabian plants is available in the manuscript Istakhri (915-919 A.D.), Idrisi (11153 A.D.), A.Al-Fida (1331 A.D.).
* Peher Forsskal (1736-1763): Stay in the southern parts of the Arabian Peninsula, and collected a significant number of plants from Yemen and Jizan Region. Some of these plants were described as new in the posthumous publication "Flora Aegyptiaca-Arabica" by Niebuhr (1775).
* Ehrenberg (1825) visited some of the Red Sea Islands, and Studied mainly microorganisms.
* There were some further visitors too in the Arabian Peninsula region but their collection are not available in any Herbarium), like Ehrenberg (1820-26), Aucher-Eloy (1830), Kotschy and Schimper (1836), Anderson (1859), Pelley (1865), Balfour (1880), Schweinfurth (1888), Deflers (1893).
* J.R. Wellsted (1833) traveled along the southern coast of Arabia and collected some plants.
* E. Combes and M.O. Tamisier in the middle of the 19th century accompanied an Egyptian expedition team to the mountains of Asir. Their records were published in the "Voyage en Abssinie et 1` Arabie" in 1851.
* Musil (1909) and Philby (1917) were studied plants of arbian peninsula region during early 19th century.
* E. Blatter (1919-1936) compiled most of the major and minor collections of the previous visitors and published a detailed checklist of the wild plants of Arabia (Flora Arabica).
* The collections of DeMarco (DeMarco & Dinelli, 1974), as part of the work of Italconsult Company for the survey of Agriculture Development, and Mandaville (Saudi Aramco during 1960's) were also remarkable. These collections were deposited in the British Herbaria.
* A.M. Migahid, A.El-Sheikh, U. Bairele, P. Kong, H.M. Hassan, H.A. Abulfatih were also collected plant from different region of Saudi Arabia . The collections are deposited in the Herbarium (KSU) of Botany & Microbiology, King Saud University. The flora of Saudi Arabia appeared in 1974, 1978 and 1988-1990.
* S. Collenette (1972-1999) : Collections are deposited in the Royal Botanic Gardens (E), Edinburgh and RBG, Kew (K), a set of which is also deposited at the National Herbarium (RIY) of the Ministry of Agriculture.
* The floristic wealth of Saudi Arabia was enumerated approximately 15 years ago in the three volumes of ‘Flora of Saudi Arabia’ (by S. Chaudhary).
* **PLANT BIODIVERSITY OF SAUDI ARABIA**
* The flora of Saudi Arabia is somewhat a complex one, having affinities with the floras of East Africa, North Africa, the Mediterranean countries and the Irano-Turanian countries.
* Plants are xerophytes (require little water) and are mostly small herbs and shrubs that are useful as forage.
* Few small areas of grass and trees in southern Asir.
* The regions along the northwestern and southwestern regions, however, are densely vegetated and contain the highest number of species. Approximately 70% of the country's floristic elements are reported from these areas.
* Total number of species recorded: about 2300 species
* Gymnosperms: 9 species (*Juniperus phoenicea)*
* Pteridophytes : 27 species (Example: *Marsilea aegyptiaca)*
* Total number of families: 131
* Families represented by single species : 33
* 418 species belonging to 27 families are monocots
* Saudi Arabia contains 97 (4.25%) trees, 564 (24.73%) shrubs and about 1620 (71.02%) herbs.
* 67 species are endangered (*Huernia saudi-Arabica)*
* 56 are endemic to the region (Example: *Aloe sheilae* Lavr.).
* Gramineae with 261 species is the largest monocot family in Saudi Arabia, followed by Cyperaceae with 40 species. Among the genera, *Cyperus*is the largest with 21 species.
* **TYPES OF HABITATS AND THEIR VEGETATION IN SAUDI ARABIA**

1. **Marine Habitat**

* Saudi Arabia has 2500 kilometers of coastlines along the Red Sea and the Arabian Gulf.
* Marine life is concerned with the plants, animals and other organisms that live in the ocean and seas. Given that in biology; many phyla, families and genera have some species that live in the sea and others that live on land.
* A mangrove is a shrub or small tree that grows in coastal region.
* A halophyte is a plant that grows in waters of high salinity, coming into contact with saline water through its roots, such as in saline semi-deserts, mangrove swamps, marshes and sloughs and seashores.
* 7 genus of the plants have been reported from red sea.
* *Avicenia marina* and *Rhizophora mucronata* found in gulf water only.

**2. Terrestrial habitats**

Terrestrial habitats are ones that are found on land, like forests, grasslands, deserts, shorelines, and wetlands

**(A) Islands**

**(B) Wet land**

**(C) Vally (Wadies)**

**(D) Mountains**

**(E) Forest mountain regions**

**(F) Al Harat**

**(G) Sandy Deserts**

**TYPES OF HABITATS AND THEIR VEGETATION IN SAUDI ARABIA**

**2. Terrestrial habitats**

1. **Islands**

* Teran and Snafer islands in Akaba gulf
* Farasan islands in red sea.
* Farasan archipelago, lies in the southern part of Red Sea (160 20` -170 20` N, 410 24`-420 26` E), is about 40 km. away from the Jizan coast and attains a width of approximately 120 km. in SE to NW direction.
* The flora comprises about 200 species of flowering plants in 49 families.

**TYPES OF HABITATS AND THEIR VEGETATION IN SAUDI ARABIA**

**2. Terrestrial habitats**

1. **Wet land**

* Natural freshwater wetlands are the key biological sites in arid landscapes.
* It includes ponds, streams and springs, as well as artificial wetlands such as reservoirs.
* They attract and support a diverse assemblage of plants and animals. Example *Phragmites* sp. and *Typha* sp

**TYPES OF HABITATS AND THEIR VEGETATION IN SAUDI ARABIA**

**2. Terrestrial habitats**

**(C) Vally (Wadies)**

An elongate depression of the earth's surface usually between ranges of hills or mountains. An area drained by a river and its tributaries.

**TYPES OF HABITATS AND THEIR VEGETATION IN SAUDI ARABIA**

**2. Terrestrial habitats**

**(D) Mountains**

* More then 55 mountain which are above then 2000 meter in height.
* The mountains of southwestern region form a continuous chain of escarpments, extending from Taif to Yemen border.
* The peaks reach elevations of over 2000 m in the vicinity of Taif and extreme south and over 3000 m in the Abha area.
* On the western side of the highlands, the mountains fall in a series of dramatic escarpments and finally merge with the Tihama coastal plain while the eastern sides slop more or less gradually towards the interior parts of the country.
* Mountains on the northwestern sides are generally discontinuous, less rugged and much drier. The east facing slopes decent gradually and end in a high plateau.
* The mountains on the western side, especially the Asir Mountains are characterized by cool climate, high precipitation and high humidity.
* Affinity with the plants of East African countries
* 537 species of vascular plants have been recorded from the Fayfa area

**TYPES OF HABITATS AND THEIR VEGETATION IN SAUDI ARABIA**

**2. Terrestrial habitats**

**(F) Al Harat**

* Lava fields (called harrah in Arabic) are widespread in the western part of Saudi Arabia.
* There are about fifteen lava fields, ranging in size from small to huge
* Poorly vegetated

**TYPES OF HABITATS AND THEIR VEGETATION IN SAUDI ARABIA**

**2. Terrestrial habitats**

**(G) Sandy desert**

* 30% of the land in Saudi Arabia is covered by sandy-deserts.
* More then 125 species in Great Nafud, Dahna, Rub Al-Khali, Jafurah
* Rub-al-Khali or the 'Empty Quarter' is believed to be the largest continuous sand body in the world and supports the life of at least a few endemic plants such as *Calligonum crinitum* spp. *arabicum*, *Tribulus macropterus* var. *arabicus*(*Tribulus arabicus*), *Cornulaca arabica*, etc.
* **PLANT COMMUNITIES AND PLANT ASSOCIATIONS IN SAUDI ARABIA**

Vegetation of Saudi Arabia is generally divided into five broad categories.

1. **Vegetation of the coastal plains and Sabkhas**

* Coastal zones and sabkha vegetation and very open drought-deciduous thorn woodlands of the coastal plains and lower foothills.
* Mangrove stands, represented by *Avicennia marina* and *Rhizophora mucronata*,
* Major populations recorded from Tihama

1. **Deserts and scarcely vegetated areas**

* Xeromorphic dwarf-shrublands of rock and gravel deserts (Dominant species:  *Acacia tortilis*, *Haloxylon salicornicum, Astragalus spinosus)*
* Deep sands (Dominant species:  *Calligonum comosum, Haloxylon persicum, Calligonum crinitum)*
* Scarcely vegetated sand dunes and sand covered gavel plains (Dominant species: *Acacia* spp. and *Calligonum comosum*)

1. **Dwarf shrublands**

Xeromorphic dwarf shrublands (Dominant species:  *Calligonum comosum, Haloxylon salicornicum, Rhanterium epapposum, Acacia gerrardii, Acacia ehrenbergiana, Ziziphus nummularia, Lycium shawii)*

1. **Woodlands and xeromorphic shrublands of high altitude areas**

* Drought deciduous thorn woodlands and shrublands of Hijaz Mountains
* Semi evergreen woodlands
* Evergreen Needle-leaved Woodlands (Vegetation of highest part of the northern and southern Hijaz Mountains)
* Mixed formations of drought deciduous shrublands, xeromorphic succulent shrublands and open xeromorphic grasslands and very open xeromorphic semi-desert shrublands (Dominanat species: *Acacia*-*Commiphora* , *Delonix elata, Euphorbia cuneata, Olea europaea,*  *Juniperus phoenicea, Lavandula dentata, Euphorbia* spp.*,*)

1. **Wadi Communities**

* Main wadis in Saudi Arabia are Wadi Rimah, Wadi Fatima, Wadi Hanifa, Wadi Dawasir, Wadi As Sabha, Wadi Nissah and Wadi Al-Batin
* Dominant species of the Central region: *Acacia, Rhazya stricta, Lycium shawii, Pennisetum divisum*, *Ochradenus baccatus*, etc.
* Dominant species of Tihama region: *Acacia, Ziziphus spina-christi, Salvadora persica, Leptadenia pyrotechnica, Tamarix nilotica, Hyphaene thebaica,*
* **PLANT DIVERSITY HOT-SPOTS OF SAUDI ARABIA**
* The most important topographic and floristic diversity of Saudi Arabia can be seen in the mountainous North and South Hijaz regions.
* Mountains in the Fayfa region, close to Yemen borders, and other isolated mountains like Jabal Abu-Hassan also harbor a diverse flora, which is more or less similar to that of East African vegetation.
* Vegetation in the semi-arid mountains of Jabal Shamanseel (1600 m), Jabal Radhwa (2000 m), Jabal Sha'ar (2350 m) are dominated by *Juniperus phoenicea, Delonix elata, Ferula ovina, Pistacia khinjuk, Launaea acanthodes, Commiphora* spp.
* Jabal Lawz (2800 m), the highest mountain in the northern Hijaz also possesses varied vegetation with a strong Mediterrannean influence. Therea re some rare species in theis area are: *Prunus korshinskyi,* such as *Androssace maxima, Plantago maris-mourtii, Tanacetum santolinoides, Scandix pecten-veneris* etc.
* Jabal Dabbagh (2400 m), a granite mountain in the north west of Saudi Arabia, is remarkable amongst the mountains of northern and southern Hijaz range in terms of endemism. Five endemic taxa occur in this mountain including *Delphinium sheilae, Nepeta sheilae* and the only monotypic, endemic genus *Dolichorynchus arabicus*.
* Endemic species are defined as species only found in one specific geographical area.
* Isolated geographical areas, such as island, Lakes or mountain ranges, often have many endemic species.
* Saudi Arabia hosts nearly 200 regional endemics, only about 2.5% of the total flora is strictly endemic to Saudi Arabia.
* **ECOLOGY, PLANT BIODIVERSITY AND CONSERVATION**
* The study of ecology and conservation addresses significant contemporary questions including climate change, the impact of a growing human population and the threat to biodiversity.
* **Biodiversity** is the biological diversity which includes the variety of the whole species present on earth. It includes different animals, plants, micro-organisms)
* **Biodiversity conservation:**
* Plant diversity is disappearing at an unprecedented rate as a direct impact of the way humankind uses the world's natural resources.
* Our flora is fundamentally important to human life as a source of food, shelter and medicine amongst many other things.
* The threats to plant diversity vary worldwide. These include habitat loss and degradation, invasive aliens, over-exploitation of resources, and even climate change.
* Species extinctions are on the rise.
* More than 80,000 seed-bearing plant species (20% of the total) are currently under threat.
* The biodiversity must should be conserve because of its benefit for example services and biological resources (medicine, food, wood products, fibers etc.) which are essential to live our life on earth.
* **Definition of terms used for Conservation status**
* Extinct (EX) – No known individuals remaining.
* Extinct in the wild (EW) – Known only to survive in captivity, or as a naturalized population outside its historic range.
* Critically endangered (CR) – Extremely high risk of extinction in the wild.
* Endangered (EN) – High risk of extinction in the wild.
* Vulnerable (VU) – High risk of endangerment in the wild.
* Near threatened (NT) – Likely to become endangered in the near future.
* Least concern (LC) – Lowest risk; does not qualify for a higher risk category. Widespread and abundant taxa are included in this category.

**In-situ conservation**:

*In-situ* conservation means the conservation of species within their natural habitats. By *In-situ* biodiversity conservation method the biodiversity area may be covered in the form of natural park/ sanctuary/biosphere reserve etc.

Ex-Situ conservation:

* Ex-situ conservation involves the conservation of biological diversity outside of their natural habitats.
* Ex-situ Biodiversity conservation can be done by forming Gene banks, seed banks, botanical garden, collections of In vitro plant tissue culture.
* Ex-situ biodiversity conservation strategy plays an important role in recovery programmes for endangered species.
* Saudi Arabia's biodiversity is under threat from multiple stresses. Climate change is one of the several pressures.
* Saudi Arabia, being located in the arid part of the world is expected to experience faster warming due to climate change than countries located in the tropical or temperate regions.

* **Factors responsible for extinction:**
* Habitat loss and Habitat fragmentation
* Overexploitation
* Introduced species
* Disruption of ecological interactions
* Pollution
* Plant diseases
* Over grazing

* **Example of some endangered plants endemic to Saudi Arabia**
* *Allium asirense* (Alliaceae)
* *Aloe armatissima* (Aloeaceae)
* *Ceropegia tihamana* (Asclepiadaceae)
* *Silene asirensis* (Caryophyllaceae)
* *Cornulaca arabica*  (Chenopodiaceae)
* *Centaurothamnus maximus* (Compositae)
* *Ajuga arabica* (Labiatae)
* *Astragalus collenettiae* (Leguminosae)
* *Reseda pentagyna* (Resedaceae)

* **Preservation approaches:**
* Habitat restoration
* Removal of introduced species
* Cleanup and rehabilitation

* **Strategic goals for conservation and sustainable use of biodiversity**
* Establishment of national parks –protected area
* Establishment of gene banks
* Collection and preservation of germplasm
* Legisation for conservation
* Control an over exploitation

* **Protected area in Saudi Arabia**

At present, Saudi Arabia has 15 protected areas which cover approximately 5% of the land area and conserve about 43% of the country's flora.

* **ENERGY FLOW**
* Sun is the only source of energy for all ecosystem.
* Plants and photosynthetic and chemosynthetic bacteria (autotrophs), fix solar radiant energy to make food.
* The solar energy captured by plants flows through different organisms of an ecosystem.
* **Producers:** All organisms are dependent for their food on producers (green plants), either directly or indirectly. In a terrestrial ecosystem, major producers are herbaceous and woody plants.
* Primary producers in an aquatic ecosystem are phytoplankton, algae and higher plants.
* The energy trapped by the producer is either passed on to a consumer or the organism dies.
* **Consumers (heterotrophs):** These are all animals that depend on plants (directly or indirectly) for their food. They include:
* **Primary consumers (herbivores-** feed on plants). e.g. insects, birds and mammals in terrestrial ecosystem and molluscs in aquatic ecosystem.
* **Secondary consumers (primary carnivores**- feed on herbivores). e.g. frog, fox, man etc.
* **Tertiary consumers (secondary carnivores**- feed on primary carnivores).

**Trophic level**:

* Organisms occupy a place in the natural surroundings or in a community according to their feeding relationship.
* A specific place of organisms in the food chain is known as their trophic level.
* Producers belong to the first trophic level, herbivores to the second and carnivores to the third.

**Flow of Energy in a Ecosystem, Food Chain, Food Web, Model of Desert Ecosystem**

* The natural interconnection of food chains is called as food web
* A given organism may obtain nourishment from many different trophic levels and thus gives rise to a complex and interconnected series of energy transfers.

**ECOLOGICAL PYRAMIDS**

* The representation of a food chain in the form of a pyramid is called ecological pyramid.
* The base of each pyramid represents the producers (first trophic level) while the apex represents tertiary or top level consumer.

Ecological pyramids are 3 types:

* Pyramid of number
* Pyramid of biomass
* Pyramid of energy

**-------THE END-----**