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General Studies

Volume 5

Environment and biodiversity

SIERRA INNOVATIONS

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G.S. PAPER

ENVIRONMENT AND BIODIVERSITY

1 CHAPTER Biodiversity

- **Measure of the biological variety of life on earth.**
- Includes **diversity at genetic, species and ecosystem levels.**
- Comprises the **sum of all the different species of plants, animals, fungi and microbial organisms** that live on Earth, including the ecosystems in which they live.

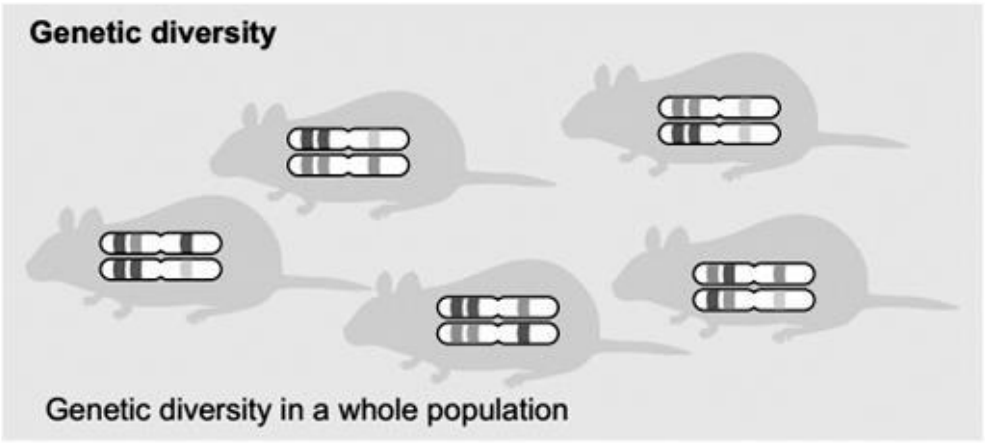
"Biological diversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems." --- **UN Convention of Biological Diversity (UNCBD)**

- **Maximum at the equator** in terrestrial ecosystems due to higher productivity.
- Keeps on **decreasing towards poles.**
- **India** (only 2.4 % of the world' landmass) supports nearly **8.1% of the recorded species.**
- India also **supports 17.7 % of the world's human population and 18% of the world's cattle population.**

Levels of Biodiversity

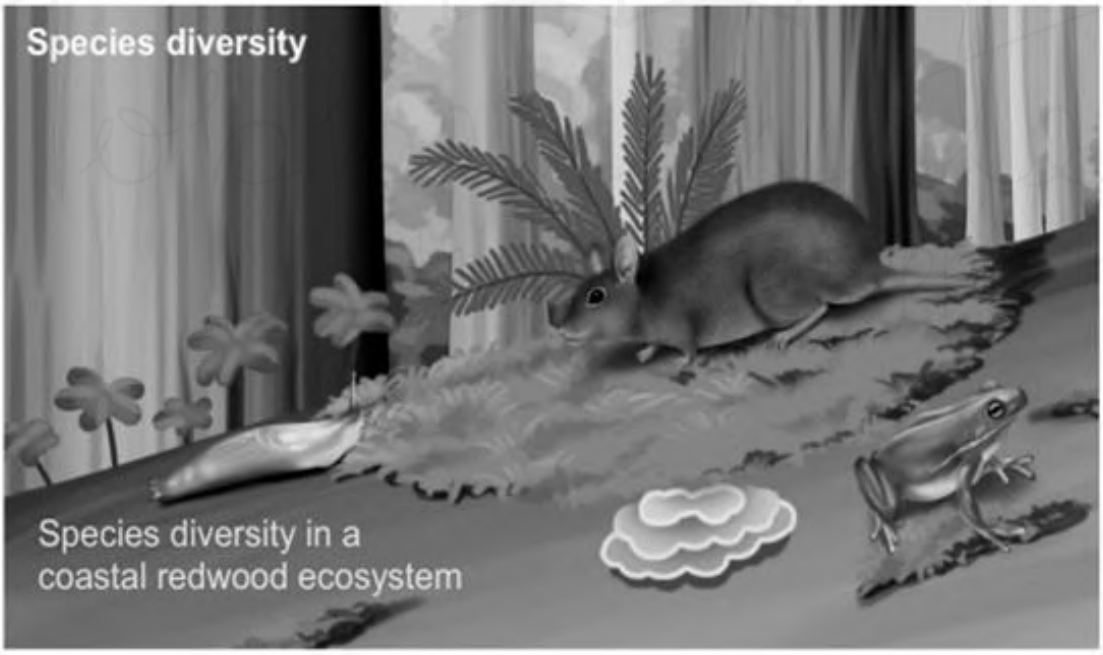
Genetic Diversity

- **Total number of genetic characteristics in the genetic makeup of a species.**
- **Single species can show high genetic diversity** (E.g. Humans: Chinese, Indian American, African etc.).
- **Allows** species **to adapt to changing environments.**
- **Ensures carry on desirable genes** to survive drastic conditions
- Species that **genetically differ from each other do not interbreed** in nature.
- **Closely related species** - **common hereditary characteristics.** Eg. Genes of **humans and chimpanzees** are approximately the same (~ 98.4 %).



Species Diversity

- A **measure of the diversity within an ecological community.**
- **Ratio of one species population over total number of organisms** across all species in the given biome.
    - **Zero species diversity-** means **infinite diversity**
    - **One species diversity-** means only **one species present.**
- **Decreases from equator towards poles.**
- **Tropics harbour more species** than temperate or polar areas.
- **Types:**
    - **Species Richness**
        - Measure of the total number of **species in a community.**
        - **<u>Alpha diversity</u>**-
            - **Diversity within a particular area,** community or ecosystem,
            - Measured by **counting the number of species**(or taxa) within the ecosystem.
        - **<u>Beta diversity-</u>**
            - **Diversity between ecosystems;**
            - Involves **comparing the number of species unique to each of the ecosystems.**
            - Measured as **change in the species between ecosystems.**



Beta Diversity (β)

$\beta = (S_1 - c) + (S_2 - c)$

where,

S_1 - total number of species recorded in the first community,

S_2 - total number of species recorded in the second community

c - number of species common to both communities.

- **<u>Gamma diversity</u>**
    - **diversity of different ecosystems** within a region.
    - **Eg**. the diversity within the Andaman & Nicobar Islands.

Gamma Diversity (γ)

$\gamma = \alpha + \beta$

where,

α - Alpha diversity

β - Beta diversity

- **Evenness of species**
  - Shows the **proportion of species at a given site.**
  - **Shows relative abundance of species in a region** i.e. if there is low evenness it means few species dominate the site.
  - **Measured with the help of the Diversity Index.**

Diversity Index

- A **quantitative measure highlighting diversity** in a community that can simultaneously take into account the phylogenetic relations

$$D_s = 1 - \sum\left(\frac{n}{N}\right)^2$$

D_s = Diversity Index

n = Number of individuals for each species

N = Total number of all individuals

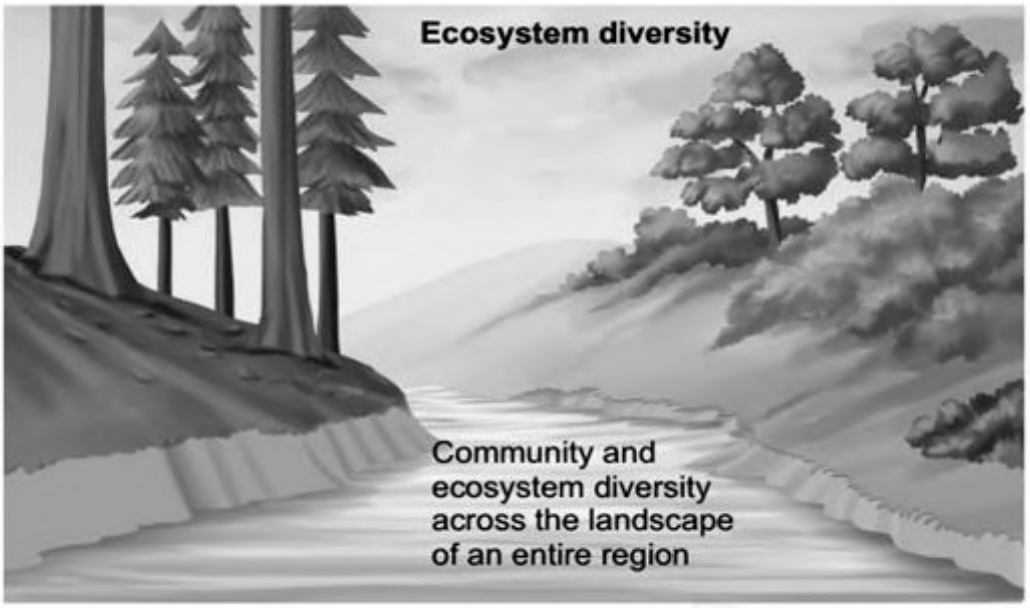
- **Species abundance**
  - **Relative numbers** among species.
  - **Eg.** number of species of plants, animals and microorganisms may be more in an area than that recorded in another area.
- **Taxonomic Diversity**
  - **Average taxonomic path between randomly chosen individuals.**
  - Considers taxonomic differences and heterogeneity (species richness and evenness).

Bioprospecting:

- **Countries having rich biodiversity explore** molecular, genetic and species-level **diversity to derive products of economic importance.**

Ecosystem Diversity

- Refers to the **number of ecosystems in a certain area.**
- Means **variations in the plant and animal species** living together and **connected by food chains and food webs.**
- Greater the variety of ecosystem types, the greater the number of species.



Importance of Biodiversity

Ecological Importance :

- **Controlling Soil Erosion:** by improving the entry and storage of water, which holds soil and roots.
- **Soil Quality improvement:** Healthy biodiversity increases soil resilience to environmental challenges.
- **Healthy Ecosystem formation:** that supplies oxygen, clean air and water, pollination of plants, pest control, wastewater treatment and many ecosystem services.
- **Species protection and conservation**: By maintaining a healthy ecological balance.
- **Management of pollution:** trees and other vegetation improve and maintain air quality by absorbing pollutants such as excessive N_2O, ozone, and particulate matter
- **Nutrient Recycling:** Plants take nutrients from the soil and air, and these nutrients can then form the basis of food chains, which is used by a wide range of other life forms.
- **Source of Knowledge:** Ecologists and scientists do their research about ecosystems based on the structure of biodiversity.
- **Natural Disaster Risk Reduction:** By preventing deforestation and controlling soil erosion, can reduce the risks from natural disasters and climate shocks.

Economic Importance:

- **Food :** Biodiversity is important to provide food to all living organisms in this ecosystem.
- **Fuel:** Provides fossil fuel, petrol, natural gas & also helps in the sustainable growth of wood.
- **Medicinal utility:** Plant & animal biodiversity aids in providing natural ingredients that are crucial for medicine.
- **Poverty alleviation and economic upliftment:** A **chief source of raw materials** for the industries, **provides economic support to farmers, fishers, and poor** population in rural areas by creating job opportunities that reduce poverty.
- **Tourism:** Biodiversity creates a natural tourism attraction – such as wildlife watching, scuba diving, trekking, hiking, bird watching, and camping.

Social Importance

- Provides social benefits like improved employment and the social services provided for vulnerable rural people for their development.

Ethical Importance

- Ensuring the "Right to exist on earth" for all living beings.

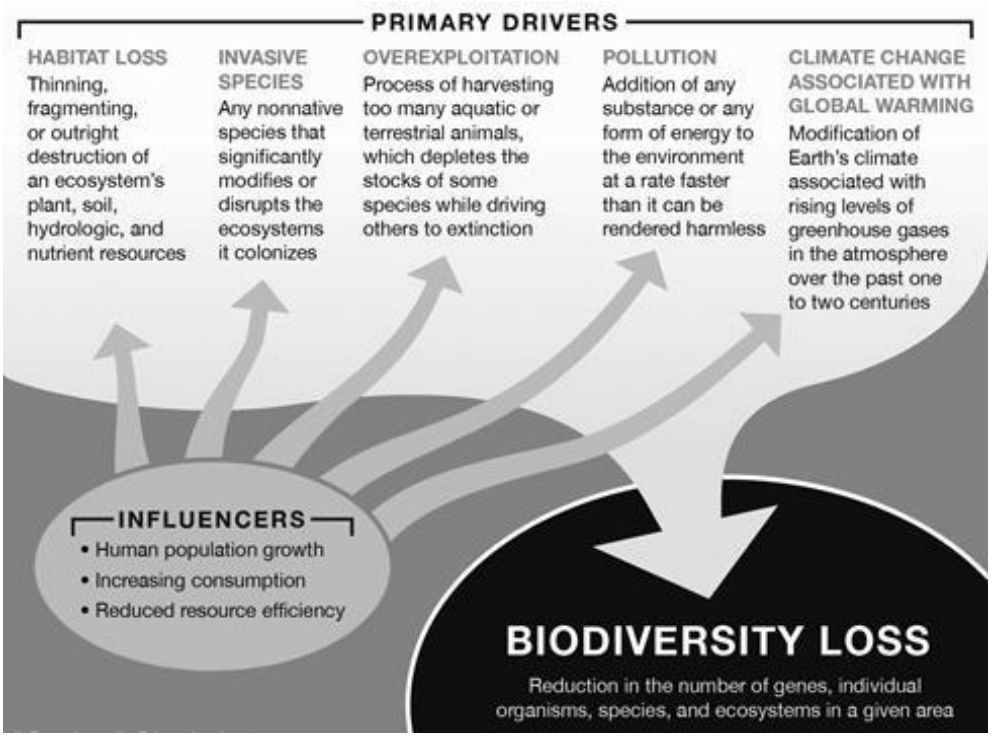
Scientific Importance of Biodiversity

- Performing experiments and research on plants and genes of organisms to make new crops and medicines.

Ecosystem Services

- **Provisioning Services**
  - Providing **raw materials or energy outputs like food, water, medicines** and other resources like **wood, biofuels** etc from ecosystems.
  - Providing conditions for these resources to grow.
- **Regulating Services**
  - Including services that regulate ecological balance.
  - **Birds, rats, frogs, act as natural controllers** and thus help in **pest and disease control.**
- **Supporting services**
  - Providing **habitat for different life forms, retaining biodiversity, nutrient cycling,** and other services for supporting life on the earth.
  - Contribute about 50% to ecosystem services.
- **Cultural services**
  - Includes **tourism; provides recreational, aesthetic, cultural and spiritual services, etc.**

Biodiversity Loss



- Refers to the **decline or disappearance of biological diversity.**
- As per the United Nations (UN) & IPBES out of a total of eight million, one million species are in danger of extinction.
- Can be **regarded as the sixth mass extinction** in the history of the planet.

Reasons

1. Anthropogenic causes

a. Direct causes-

- **Over-exploitation** of Bioresources
- **Hunting & Poaching** of wild animals
- **Deforestation**
- **Agricultural & Industrial expansion**: Eg - Oil palm plantation rise in Indo china has led to a loss of important biodiversity.
- **Indiscriminate use of toxic chemicals** and pesticides

b. Indirect Causes-

- **Habitat degradation** for developmental activities like housing, agriculture, construction of dams, reservoirs, roads, railway tracks, etc.
- Invasion of **Alien or Exotic Species**
- **Pollution** & poisoning of ecosystem
- **Global warming**, GreenHouse effect and **climate change**
- **Co-extinction- Loss or decline of a host species** resulting in the **loss of another species that depend on it**, potentially leading to cascading effects across trophic levels. **Eg** - when **fish become extinct**, **many other predators** that **depend on fish** would also become **extinct**.

2. Natural causes

- **Natural hazard/disasters** - flood, tsunami, volcanoes, landslides
- **Lack of pollination**
- **Disease and Pandemics**
- **Forest Fires**
- **Natural competition** between species
- **Ecological substitutions**, biological factors and manmade pathological causes.

3. Other causes:

- **Man-Animal Conflict**
  - **Occurs when wildlife needs overlap with those of human populations**, costing residents and wild animals.
- **Secondary extinctions**
  - **When one species goes extinct,** there will likely be **other extinctions or even an avalanche of them.**
  - **Eg.** For every **bird or mammal that goes extinct**, one or several species of **parasite also will likely disappear.**

Consequences of Biodiversity Loss

- **Ecological effects**
  - **Natural systems** → Loss of one species result into collapse of entire food chain
  - **Predator species lose their prey** → danger of **extinction if unable to substitute** their prey species **with another.**
  - **Extinct species** which may have consumed **plants** → **no longer able** to do so → **plants will grow excessively** → may **dominate other plants** → **eventual displacement.**
- **Spread of diseases**
  - Eg. **lion kills an antelope** → will **eat** part of it.
  - **Remaining part** → by **other animals.**
  - If these **other animals get extinct** → **no longer able to consume the rest of the antelope** → **wasting** process → several kinds of **diseases.**
  - **If other animals are contaminated** → **can also spread to humans** due to meat consumption.
- **Loss of livelihood for locals**
  - Due to **reduced crop yields** → **Locals raise cattle** in order to survive.
  - But l**oss in biodiversity**→ **decrease in biomass** of feed → **farmers will no longer be able to raise enough cattle d**ue to the feed shortage.
- **Loss of our recreational space**
  - A **forest or a lake** surrounded by plants may be an **optimal area for recreation.**
- **Society effects**
  - **loss of connection to nature** can lead people to become too **stressed and mentally ill.**
- **Effect on food production**
  - A **loss in biodiversity** can have vast **adverse effects on food production.**
- **Economic effects**
  - **Loss in biodiversity** → **adverse economic effects.**
  - **Eg,** If **bees lost** → **decline in crop yields** → **collapse in GDP** → **famine.**
- **Loss of traditional medicinal plants and herbs**
  - If biodiversity loss continues at such a pace, the medicinal plants and herbs may be lost forever.
- **Increase in CO_2 emissions**
  - **capacity of forests and oceans to absorb CO_2 decreases** if their ecosystems are adversely affected.
- **Proliferation of pests**
  - **Eg, imbalances in ecosystems** → emergence of pests that damage crops.

UN Convention on Biological Diversity:

- At the 1992 Earth Summit in Rio de Janeiro, Biodiversity was acknowledged as a crucial part of the sustainable development agenda.
- Aimed at **protecting the diversity of life and restoring already degraded ecosystems was signed.**

Aichi Targets

- Part of the **Strategic Plan for Biological Diversity (2011-2020).**
- **20 targets** to slow down the destruction of the planet's biodiversity.

2 CHAPTER Conservation of Biodiversity

Need

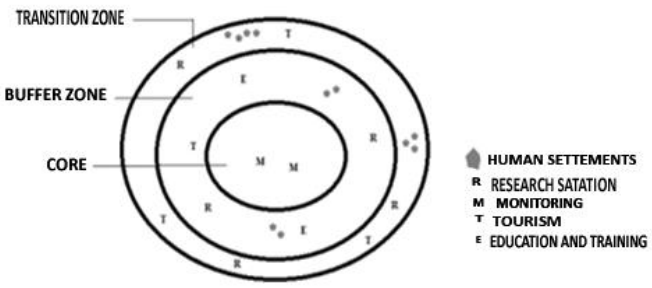
- to **preserve continuity of food chains.**
- **ensures the sustainable utilization of life support systems** on earth.
- **potential use to the scientific community.**
- A reservoir of **wild animals and plants is preserved**, thus enabling them to be introduced, if need be, in the surrounding areas.
- immediate benefits to society such as **recreation and tourism.**
- serves as an **insurance policy for the future.**
- **Preventing loss of genetic diversity**
- **Saving species from extinction**
- **Protecting ecosystems from damage** and degradation

In situ/ On-site Conservation

- Means the **conservation of genetic resources in natural populations of plant or animal species.**
- Comprises ~**4% of the total geographical area** of the country.

Biosphere Reserve

- Notified either by the state or the central governments.
- Government can include them under the **UNESCO's Man and Biosphere (MAB) Programme** after its establishment as a biosphere reserve.
- **Zones of Biosphere Reserve:**



  - **Core zone:**
    - comprises a **strictly protected ecosystem** that contributes to the conservation of landscapes, ecosystems, species and genetic variation.
  - **Buffer zone:**
    - Area surrounding the core areas

- **used for activities compatible with ecological practices** that can reinforce **scientific research, monitoring, training and education**.

- **Transition zone:**
  - part of the reserve where the **greatest activity is allowed**,
  - foster **economic and human development** that is **socio-culturally and ecologically sustainable**.

- **Functions of Biosphere Reserve:**

Biosphere Reserve		
Conservation	**Development**	**Logistic Facilities**
In situ Conservation of Biodiversity	**Sustainable Economic Development of the conserved region and dependent population**	**Provides a site for local, regional and global Reserch and monitoring**

- **18 Biosphere Reserves in India** out of which 11 reserves have been enlisted in the UNESCO's MAB programme and 7 are domestic reserves

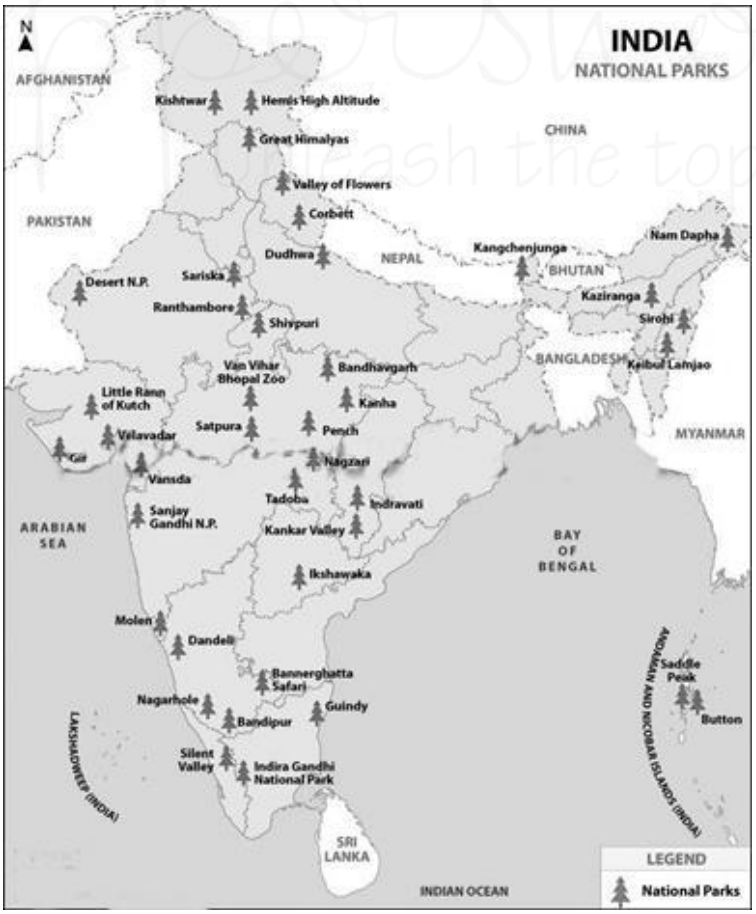
* A complete list of Biosphere reserves has been given at end of the book (in Appendix)

National Parks

- Areas set by the government to conserve the natural environment.
- Have **more restrictions as compared to a wildlife sanctuary.**
- **Boundaries are fixed** and defined.
- **Objective -** to protect the natural environment of the area and biodiversity conservation.
- **No human activity** allowed.
- **Grazing** of livestock and **private tenurial rights not permitted.**
- Species mentioned in the Schedules of the Wildlife Act are **not allowed** to be **hunted** or captured.
- Cannot be downgraded to the status of a 'sanctuary'.
- Can be declared by both Central Government and State governments.
- No alteration of the boundaries shall be made except on a resolution passed by the State Legislature.

National Parks in India:

- **Total no.- 105**
- **Total area** - 43,716 sq.km (**~1.23 % of India's overall geographic area.**)
- **State having maximum National Parks- MP** (11 NPs)
- **First** National Park - **Jim Corbett National Park, Uttarakhand**
- **Largest** - **Hemis National Park**
- **Smallest** - **South Button National Park** (Andaman & Nicobar islands)



* List of important National parks has been given in the Appendix at the end of the book

Wildlife Sanctuaries

- Any area notified by the State Government to constitute as a sanctuary if such area is of adequate ecological, faunal, floral, geomorphological, natural or zoological significance.
- Used for the **purpose of protecting, propagating or developing wildlife or its environment.**
- Some **restricted human activities are allowed** inside the Sanctuary.
- **Safe from hunting, predation or competition.**
- Safeguarded from extinction in their natural habitat.
- **Certain rights of people** living inside could be **permitted but strictly regulated.**
- **Settlements not allowed** (few exceptions: tribal settlements do exist).
- **Sanctuary can be promoted to National Park but not vice versa.**
- **566 existing wildlife sanctuaries** in India - area of **122420 km2,** (**3.72% of the geographical area** of the country). (Wildlife Institute of India).

Comparison of National Park, Wildlife Sanctuary and Biosphere Reserve		
National Park	**Wildlife Sanctuary**	**Biosphere Reserve**
Attention is not given to biotic community as whole. Rather Conservation is connected to habitats for particular wild animal species.	Attention is not given to biotic community as whole. Conservation Rather is species oriented such as citrus pither Greater Indian bustard etc.	Attention is focused on biotic community as a whole. Thus, conservation is ecosystem oriented.
The approach is not based on scientific principle	The approach is not based on scientific principles	The approach is based on sound scientific principles
The size ranges from 0.04 to 3,162 sq. kms.	The size ranges from 0.61 to 7,818 sq. kms.	Size well over 5.670 sq. kms.
Boundaries circumscribed by state legistation.	Limits are not sacrosanct.	Boundaries incumscribed by state legislation
No biotic interference permissible except in buffer zone	Limited biotic interference occurs	No biotic interference permissible except in buffer zone
Tourism is not only permissible, but is often encouraged	Tourism is permissible	Normally tourism is not permissible.
Research and scientific management are lacking	Research and scientific management are lacking	Research and scientific management are carried out
Due attention is not given gene pool conservation of economic species, particularly of plants.	Proper attention is not given to gene pool conservation of economic species, particularly of plants.	Due attention is given to conservation of plants as well as animals species.

Conservation Reserve & Community Reserves

- **Protected areas -** typically act **as buffer zones/ connectors / migration corridors between** established **national parks, wildlife sanctuaries and reserved and protected forests** of India.
- Introduced in the **Wildlife protection act, 2003.**
- **IUCN Category V (conservation reserves) and VI (community reserves)** protected areas.

A. Conservation reserves

- **Area owned by the state** government near national parks and sanctuaries for conservation purposes.
- Regulator- **conservation reserve management committee.**
- Declared **by state government**
- Generally **uninhabited and completely owned by the Government of India** but used for subsistence by communities
- **Ist Conservation reserve- Thirupudaimaruthur conservation reserve in Tirunelveli, Tamil Nadu.**
- **97 Conservation reserves**- **44483 km2,** (**0.14%** of the geographical area of the country).

B. Community Reserve

- **Notified by state government**
- Any community land or private land, the **members of that community agree to offer for protecting the fauna and flora,** as well as their traditions, cultures and practices.
- Aim- **to improve the socio-economic conditions of the people** living in such areas as well as conserving wildlife.
- Regulator- **community reserve management committee.**
- **214 Community reserves** in india- **1302 km2** (**0.04%** of the geographical area of the country).

Sacred Groves in India

- Comprises **patches of forest or natural vegetation-** from a few trees to forests of several acres- **dedicated to local folk deities.**
- **Hunting and logging - strictly prohibited** here.
- **Sustainable** forest usage like **honey collection and deadwood collection allowed.**
- Protected under **WildLife (Protection) Amendment Act, 2003.**
- Mention in **ancient texts like Kalidaasa's Vikramorvawsiyam.**

Marine Protected Areas

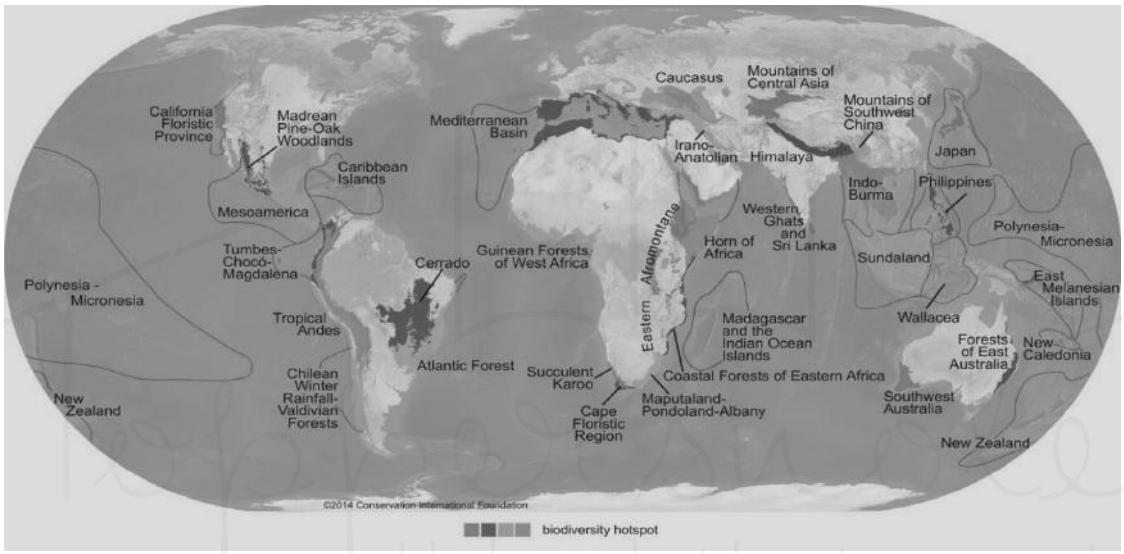
- A **space in the ocean where human activities are more strictly regulated** than the surrounding waters - like parks we have on land.
- Notified under **Wild Life (Protection), Amendment Act, 2003**
- Given **special protections** for natural or historic marine resources by local, state, territorial, native, regional, or national authorities.
- **Total 129** MPAs (25 Peninsular region, 100 A&N Islands, 4 Lakshadweep).
- **Classification:-**
  - **Category I:** includes **National Parks and Sanctuaries** having entire areas in intertidal/sub-tidal or mangroves, coral reefs, creeks, seagrass beds, algal beds, estuaries, lagoons
  - **Category II:** includes **Islands,** which have major parts in marine ecosystem and some part in terrestrial ecosystem
  - **Category IIIA:** includes **sandy beaches** beyond intertidal line but occasionally interacting with the seawater
  - **Category IIIB:** includes **evergreen or semi evergreen forests** of islands

Hope Spots

- **Ecologically significant ocean areas** designated for protection u**nder a global conservation campaign** overseen **by Mission Blue**, a non-profit organization founded by Sylvia Earle.
- Scientifically identified as **critical to the health of the ocean.**
- **Can be existing MPAs or new areas** where more action is needed.
- Can be **large or small,** but they all provide hope due to
  - A **special abundance or diversity of species**, unusual or representative species, habitats, or ecosystems
  - Particular **populations of rare threatened**, or endemic **species**
  - A site with the **potential to reverse damage from negative human impacts**
  - The **presence of natural processes** such as major migration corridors or spawning grounds
  - **Significant historical, cultural, or spiritual values**
  - **Particular economic importance** to the community
- **Total 85 Hope Spots** worldwide.
- Hope spots in **Indian Ocean:**
  - **Andaman Islands**
  - **Chagos Archipelago**
  - **Lakshadweep Islands**
  - **Maldive Atolls**
  - **Agulhas Front**

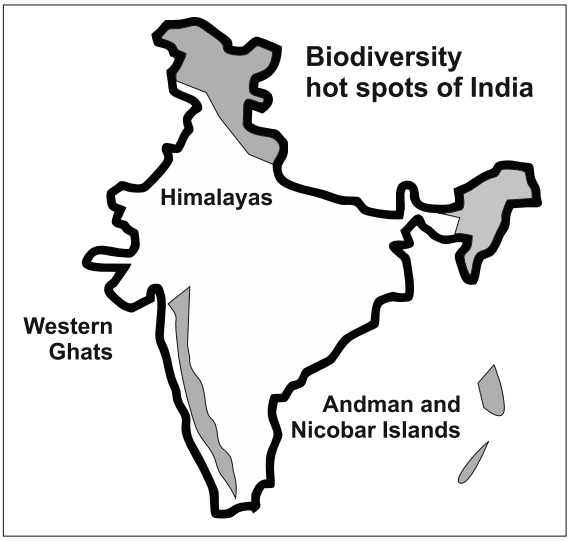
Biodiversity Hotspots

- Regions with **high species richness and a high degree of endemism.**
- **Term coined by** British biologist **Norman Myers -** defined it as a biogeographic region characterized by exceptional levels of plant endemism and by serious levels of habitat loss.
- **2 criteria** to qualify as a hotspot:
  - Contain **at least 1,500 species of vascular plants found nowhere else** on Earth (known as "endemic" species).
  - Have **lost at least 70 % of its primary native vegetation.**
- **Total 36 biodiversity hotspots** (2.5% of Earth's land surface), yet more than **50% of the world's plant species** and over **42% of all terrestrial vertebrate species** are endemic to these areas.



Need for conservation of biodiversity hotspots

- Home to around 2 billion people, including some of the world's poorest, many of whom rely directly on healthy ecosystems for their livelihood and well-being.
- Provide crucial ecosystem services for human life, such as provision of clean water, pollination and climate regulation.
- Hold some of the highest human population densities on the planet.
- Conservation promotes sustainable management of these essential natural resources and supports economic growth.



Biodiversity hotspots in India

1. **The Himalayas**
   - **Comprises North-East India, Bhutan, Central and Eastern parts of Nepal.**
   - Have **163 endangered species** which includes the Wild Asian Water Buffalo, One-horned Rhino; and as many as 10,000 plant species, of which 3160 are endemic.
2. **Indo – Burma Region**
   - Area - 2,373,000 km².
   - **Known for endemic freshwater turtle species**, most of which are **threatened with extinction**, due to over-harvesting and extensive habitat loss.
   - **1,300 different bird species**, including the threatened **White-eared Night-heron, the Grey-crowned Crocias, and the Orange-necked Partridge.**
3. **The Western Ghats**
   - Present along the **western edge of peninsular India** and **covers most of the deciduous forests and rainforests.**
   - **Known for the globally threatened flora and fauna** represented by 2**29 plant species, 31 mammal species, 15 bird species, 43 amphibian species, 5 reptile species and 1 fish species.**
   - UNESCO mentions that "Of the total 325 globally threatened species in the Western Ghats, 129 are classified as Vulnerable, 145 as Endangered and 51 as Critically Endangered."
4. **Sundaland**
   - Lies in **South-East Asia and covers Singapore, Thailand, Indonesia, Brunei, and Malaysia.**
   - This region is **famous for its rich terrestrial and marine ecosystem.**
   - Comprises **25,000 species of vascular plants,** of which 15,000 are found only in this region. Andaman & nicobar islands are part of Sundaland hotspot.

Nature Reserves

- **Reserved and managed for purposes of conservation** and to **provide special opportunities for study or research.**
- May be **designated by government institutions** in some countries, or by **private landowners,** such as charities and research institutions.
- IUCN categories depending on the level of protection afforded by local laws.

Reserved and Protected forests

- **Term introduced in the Indian Forest Act, 1927.**
- **Land rights** typically acquired (if not already owned) and **owned by the Government of India.**
- **Declared** by the respective **state governments.**
- **Difference between Reserved and Protected forests:**
  - **Reserved forests-** All activities like **hunting, grazing, etc. banned** unless specific orders are issued otherwise.
  - **Protected forests-** All activities like **hunting and grazing in protected areas are sometimes permitted** to dwelling communities who sustain partially or wholly from forest resources or products. All activities are permitted unless it is prohibited.
- **Protected forests - 2 kinds - demarcated** protected forests and **undemarcated** protected forests, based on whether the limits of the forest have been specified by a formal notification.
- **Protected forests (upgraded to) → wildlife sanctuaries → national parks.**

Preservation plots

- **Miniature nature reserves** intended **for the conservation of the natural flora and fauna** of a certain region.
- **Ex -**Establishing Permanent Preservation Plots in Bannerghatta National Park.

Tiger Reserves

- **Project Tiger** was launched by the Government of India in the year **1973 to save the endangered species of tiger** in the country.
- Total **53 Tiger Reserves** -