macaque has hair around the face. Bird life in India is both rich and colourful. Tiger is the national animal, peacock is national bird. Pheasants, geese, ducks, mynahs, parakeets, pigeons, cranes, hornbills and sunbirds are found in forests and wetlands.

What is Biodiversity ?

The term **biodiversity** was coined by Walter G. Rosen in 1985. It has been defined variously such as "the richness in variety and variability of species of all living organisms in a given region (habitat)". A concise definition of biodiversity is "the totality of genes, species, and ecosystems in a region (IUCN, UNEP, 1992).

According to the U.S. Office of Technology Assessment (1987), biological diversity is "the variety and variability among living organisms and the ecological complexes in which they occur". As shown in Figure 18.3, this concept can b subdivided at **three levels** as follows :

1. Genetic diversity

At finer levels of organisation, biodiversit includes the genetic variation within species, bot among geographically separated populations an among individuals within single population.

2. Species diversity

Biodiversity at its most basic level includes th full range of species on earth, fro microorganisms such as viruses, bacteria an protists through the multi-cellular kingdoms o plants, animals and fungi.

3. Community/Ecosystem diversity

On a wider scale, biodiversity includes variation in the biological communities in which specie live, the ecosystem in which communities exis and the interactions among these levels.

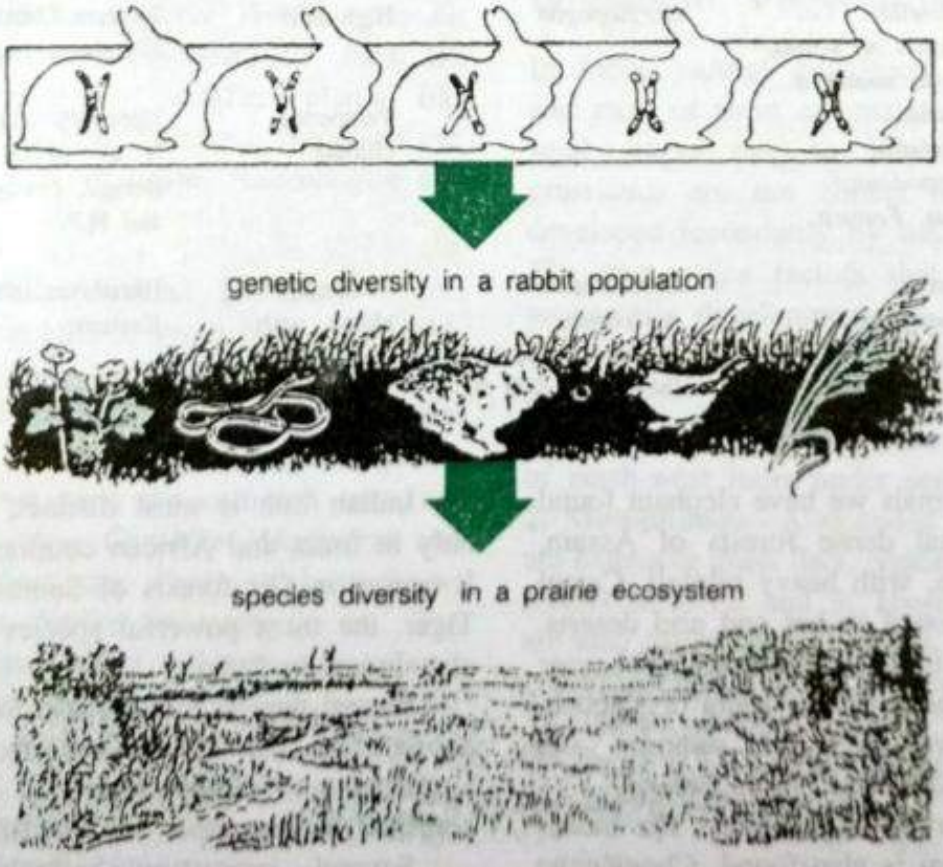

Fig. 18.3. Different levels of biodiversity. Genetic diversity refers to genetic variation found within each species; Species diversity includes the range of species in any ecosystem; Community/Ecosystem diversity refers to the variety of habitat types and ecosystem processes extending over a given region.

Alpha diversity

This refers to number of species in a single community. This diversity comes closest to the popular concept of species richness and can be used to compare the number of species in different ecosystem types.

Beta diversity

This refers to the degree to which species composition changes along an environmental gradient. Beta diversity is high for example, if the species composition of moss communities changes at successively higher elevations on a mountain slope, but is low if the same species occupy the whole mountain side.

Gamma diversity

This applies to larger geographical scales and defined as "the rate at which additional species are encountered as geographical replacements within a habitat type in different localities. Thus gamma diversity is a species turnover rate with distance between sites of similar habitat or with expanding geographic areas".

Global Biodiversity

Approximate numbers of species (plants, animals, microorganisms) which have been identified and described from all over the world (Gibbs, W. 2001) are as follows :

Major taxonomic group	Number of identified species
Higher plants	270,000
Algae	40,000
Fungi	72,000
Bacteria (including cyanobacteria)	4,000
Viruses	1,550
Mammals	4,650
Birds	9,700
Reptiles	7,150
Fish	26,950
Amphibians	4,780
Insects	1,025,000
Crustaceans	43,000
Molluscs	70,000
Nematodes and other worms	25,000
Protozoa	40,000
Others	110,000

The known and described species of organisms on the earth is between 1.7 and 1 million which in fewer than 15% of the actu number. The predicted number of total speci varies from 5 to 30 million (Gaston, 199 averaging at 14 million. About 61% of the know species are insects.

Why Biodiversity is Rich in Tropics ?

The reasons are as follows :

(1) Over geological times the tropics have had more stable climate than the temperate zone In tropics, therefore, local species continue to live there itself, whereas in temperate the tend to disperse to other areas.

(2) Tropical communities are older tha temperate ones and, therefore, there has bee more time for them to evolve. This coul have allowed them greater degree o specialisation and local adaptation to occur

(3) Warm temperatures and high humidity in mos tropical areas provide favourable condition for many species that are unable to survive in temperate areas.

(4) In tropics, there may be greater pressure from pests, parasites and diseases. This does no allow any single species to dominate and thu there is opportunity for many species to co-exist. On the contrary in temperate zone there is reduced pest pressure due to cold and there is one or a few dominating species that exclude many other species.

(5) Among plants, rates of outcrossing appear to be higher in tropics. Higher rates of outcrossing may lead to higher levels of genetic variability.

(6) Tropical areas receive more solar energy over the year. Thus tropical communities are more productive or greater resource base that can support a wider range of species.

Conservation of Biodiversity

Popular interest in protecting the world's plant and animal species has intensified during the last 20 years. Both, scientists and general public have

Option value

This value of a species is its potential to provide an economic benefit to human society at some point in the future. The growing biotechnology industry is finding new species to tackle pollution, and fight problems of cancer, AIDS etc.

Existence value

This is assigned to protect wildlife. People value charismatic animals such as lion, panda, birds etc. in direct way to contribute money to conservation organisations. Governments also spend money on conservation.

Bioethics and Conservation

Besides economic arguments put to justify the protection of biodiversity, there are also strong bioethical arguments for the same. These ethical arguments have roots in the value systems of most religions, philosophies, and cultures and thus can be easily understood by general public. They appeal to a respect for life, a reverence for the living world, a sense of intrinsic value in nature, and a concept of divine creation. Ethical arguments for conserving biodiversity appeal to the nobler instincts of people, and are based on widely held truths. People will accept these arguments on the basis of their belief systems. Following are the key ethical arguments put for conservation of biodiversity.

Key ethical arguments

Several ethical arguments can be made regardless of their economic value. The following assertions based on the intrinsic value of species are important for conservation of biodiversity.

(1) Each species has a right to exist. Each species has value for its own sake, an **intrinsic value** unrelated to human needs.

(2) All species are interdependent. The loss of one species may have far reaching consequences for other members of community.

(3) Humans must live within the same ecological limitations as other species do.

(4) People must take responsibility for their actions.

(5) People have a responsibility to future generations.

(6) Resources should not be wasted.

(7) A respect for human life and human diversity is compatible with a respect for biodiversity.

(8) Nature has spiritual and aesthetic values that transcend economic value.

(9) Biodiversity is needed to determine the origin of life, and finally.

(10) **Deep ecology.** There has been change in human life style during the 20th century. As stated by Aldo Leopold (1949) "a thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise". One of the most well-developed environmental philosophies is described in *"Deep Ecology Living As If Nature Mattered"* by Devall and Sessions (1985) and Sessions (1987). Deep ecology begins with the premise that all species have value in themselves, and that humans have no right to reduce this richness. Since present human activities are destroying the earth's biodiversity, existing political, economic, technological and ideological structures must be changed. One of the most important changes involves enhancing the life quality of people, emphasising improvement in environmental quality, aesthetics, culture, and religion, rather than higher levels of material consumption. Deep ecology urges professional biologists, philosophers, and all concerned people to escape from their narrow, everyday concerns and to act and live "as if nature mattered".

Causes of Extinction

The most serious aspect of the loss of biodiversity is the extinction of species. Communities can be degraded and reduced in area, but as long as the original species survive, the communities still have the potential to recover. However, once a species is eliminated, the unique information contained in its DNA and the special contribution of characters that it possesses are unlikely ever to be repeated again. Once a species goes extinct, its chances for further evolution are lost. A species is

needs.

1. Habitat Destruction

The primary cause of the loss of biodiversity is not direct human exploitation but the habitat destruction that inevitably results from the expansion of human populations and human activities. The greatest destruction of biological communities has occurred during the last 150 years with human population increasing from 1 billion in 1850, to 2 billion in 1930, to 5.3 billion in 1990, and an estimated figure of 6.5 billion by the year 2000. Habitat loss is the primary threat to majority of vertebrates currently facing extinction. In many countries, particularly on islands and where human population density is high, most of the original habitat has been destroyed. More than 50% of the wildlife habitat has been destroyed in 49 out of 61 Old World tropical countries (IUCN, UNEP 1986). In tropical Asia, fully 65% of the wildlife habitat has been lost, with particularly high rates of destruction in Bangladesh (94%), Hong Kong (95%), Sri Lanka (85%), Vietnam (80%), and India (80%).

In many cases, the factors causing habitat destruction are the large industrial and commercial activities, associated with a global economy, such as mining, cattle ranching, commercial fishing, forestry, plantation, agriculture, manufacturing, and dam construction, initiated with the goal of making a profit. Huge amounts of habitat are lost each year as the world's forests are cut down. Rain forests, tropical dry forests, wetlands, mangroves and grasslands are threatened habitats and leading to desertification.

2. Habitat Fragmentation

Habitats that formerly occupied wide areas are now often divided up into pieces by roads, fields, towns, canals, powerlines etc. Habitat fragmentation is the process where a large, continuous area of habitat is both, reduced in area and divided into two or more fragments. When habitat is destroyed there is often a patchwork of habitat fragments left behind. These fragments are often isolated from one another by a highly modified or degraded landscape. Habitat fragments differ from the original habitat in two ways. One, fragments have a greater amount of edge for the area of habitat, and second, the centre of each habitat fragment is closer to an edge. Habitat fragmentation may limit the potential of species for dispersal and colonisation. It also reduces the foraging ability of animals. Habitat fragmentation causes such edge effects as microclimatic changes in light, temperature, wind etc.

3. Habitat Degradation and Pollution

Some activities may not affect the dominant species in the community, but other species are greatly affected by such habitat degradation. For example, physical degradation of forest habitat by uncontrolled ground fires, might not kill the trees, but the rich perennial wild plant community and insect fauna on the forest floor would be greatly affected. Boating and diving in coral reef areas degrade the fragile species. The most subtle form of habitat degradation is environmental pollution, the most common causes of which are pesticides, industrial chemicals and wastes, emissions from factories and automobiles, and sediment deposits from eroded hill sides. Effects of pesticide pollution, water pollution and air pollution on environment are well known. Problem of acid rains and global climate change are also well known and are of global concern.

4. Introduction of Exotic Species

Habitat destruction, fragmentation, and degradation have obvious harmful effects on biodiversity. But even when biological communities are intact, significant losses can be taking place due to changes caused by human activities. Three such changes are the introduction of exotic species,

increased levels of diseases, and excessive exploitation of particular species by people. The three chief factors responsible for introduction of exotic species are, European colonisation, horticulture and agriculture, and accidental transport. The great majority of the exotic species do not become established in the introduced new places. However, some of the species are able to establish in new area. Such successful exotic species may kill or eat native species to the point of extinction, or may so alter the habitat that many natives are no longer able to persist. The effect of exotic species is maximum on islands. Disease causing microorganisms, if introduced to new virgin areas may cause epidemics and native species are eliminated completely.

5. Disease

Human activities may increase the incidence of disease in wild species. The extent of the disease increases when animals are confined to a nature reserve rather than being able to disperse over a large area. Also, animals are more prone to infection when they are under stress. Animals held in captivity are also more prone to higher level of disease.

6. Overexploitation

Increasing human population has escalated the use of natural resources. Methods of harvesting have been dramatically modified to have maximum gains. In traditional societies, there existed some controls to prevent overexploitation in several ways. In contrast to this, in much of the world today resources are exploited as rapidly as possible. Overexploitation of resources also occurs when a commercial market develops for a previously unexploited or locally used species. The best example is trade in furs. Overexploitation threatens about one-third of the endangered vertebrates in the world, as well as other species. Growing rural poverty, increasingly efficient methods of harvesting and the globalisation of the economy combine to exploit species to the point of extinction. Even if a species is not completely eliminated by overexploitation the population size may become so low that the species is unable to recover.

7. Shifting or Jhum Cultivation

Some rural people destroy biological communities and hunt endangered species because they are poor and have no land of their own. In many countries there is extreme inequality in the distribution of wealth, with the majority of wealth (money, good farmland, timber resources etc.) owned by a small percentage of the population. The local poor people with a traditional way of life in rural areas have often established local systems of rights to natural resources. These local people are quite distinct from settlers who have arrived more recently and not closely linked to the land. In fact tropical areas of the world have had particularly a long association with human societies, since the tropics have been free of glaciation and are particularly amenable to human settlement. People have lived in every terrestrial ecosystem for thousands of years as hunters, fishermen, gatherers and farmers.

A common pattern in many countries of the developing world is that local farmers are forced off their land by large landowners and business interests, often backed up by the government, the police, and the army. The local farmers often have no choice except to move to remote undeveloped areas and attempt for their livelihood through **shifting cultivation**. This commonly practiced agricultural system, known also as **Swidden agriculture**, **slash-and-burn agriculture**, and **jhum cultivation** greatly affects forest structure and species composition by creating a mosaic of forest patches of different ages. In shifting cultivation, plots of natural tree vegetation are burnt away and the cleared patches are formed for two or three seasons, after which their fertility goes down to a point where adequate crop production is no longer possible. The trees are cut down, the fallen material is burnt, and crops are planted in nutrient-rich ash. After two or three harvests, the nutrients are washed out of soil by the rain. The farmer then abandons this patch and cuts down a new patch of forest trees elsewhere for crop production.

This system, **jhum cultivation** in North-Eastern India is practiced in these areas because the farmers are unwilling to spend the time and money required to develop more permanent forms

9. Protected area (km^2) 112,378

of threatened animal species. This includes 105 endangered, 51 vulnerable, and 257 critically endangered animal species.

Hot Spots of Indian Biodiversity

N. Myers in 1988 introduced the term **hot spots** for the geographical regions particularly rich in endemic, rare and threatened species found in relatively small areas but facing significant threats to habitat loss. To qualify as a hot spot the area must contain 0.5% (i.e. 1500) of the world's 3,00,000 plant species and should have lost 70% or more of its primary vegetation.

Biodiversity hot spots were originally identified by Norman Myers in 1990s. A hot spot (also written as hotspot) is an area which faces serious threat from human activities and supports a unique biodiversity with representatives of evolutionary processes of speciation and extinction. It is also defined as a geographical zone or ecological niche with a large number of endemic plants. Myers *et. al.* (2000) identified 25 terrestrial hot spots of biodiversity all over the world, a habitat of about 133,149 endemic species of higher plants representing about 44% of the world's total vascular plant species. Out of 25 hot spots of the world, 15 are tropical rain forest regions such as Hawaii, Colombian Choco, West Ecuador, Uplands of West Amazonia, Atlantic forest area of Brazil, Eastern Madagascar, Peninsular Malaysia, East Himalayas, North Borneo, Philippines, Queensland Australia and New Caledonia. The remaining host spots as California Floristic Province, Central Chile, Ivory coast, Cape Floristic Province, East Arc forests of Tanzania, Western Ghats, Sri Lanka and Southwest Australia) are in other climatic ecosystems. The number of hot spots in the world has now increased to 34 (just 1.4 per cent 4 the world land but supporting 60 per cent of species of plants on the earth). Of the 34 globally identified biodiversity hotspots, India harbours **four hotspots**. These are Eastern Himalaya, Indo-Burma, Western Ghats and Sri Lanka, and Sundaland (Andaman & Nicobar Islands). The main attributes of these hotspots are given in Table 18.7.

The rate of deforestation in these areas is very high and ecosystems have reached at a fragile stage. The highest concentration of species is found in these areas. In addition to these, special hot spots are the mangroves, wetlands and swamps.

Myers et al (2000) recognised nine **leading hot spots** (Tropical Andes, Sundaland, Madagascar, Brazils Atlantic Forest, Carribbean, Mesoamerica, Mediterranean Basin, Indo-Myanmar and Philippines) which contain 30% of all plants, 25% of all species in four vertebrate groups, and cover only 0.7% of earth's land surface. The leading hot spots are richer in endemics than other hot spots. The eight **hottest hot spots** on the basis of numbers of endemics species/area ratios are Madagascar and Indian Ocean Islands, Philippines, Sundaland, Brazils Atlantic Forests, Carribbean, Indo-Myanmar, Western Ghats and Sri Lanka, and Eastern Arc Mountains and coastal forests of Tanzania and Kenya.

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Among the 34 hot spots of the world, two Indian bioiversity hotspts (Western Ghats and Eastern Himalayas) extend into neighbouring countries–Western Ghats into Sri Lanka, and Eastern Himalayas into Myanmar constituting Indo-Myanmar (Burma) region. In Eastern Himalayas, numerous primitive angiosperm families as Magnoliaceae and Winteraceae with primitive genera like *Magnolia* and *Betula* are found. Asian Elephants, Indian tigers and lion-tailed macaque are found in the Western Ghats.

The Himalaya and the Western Ghats are the two Indian **mountain biodiversity global** hotspots. These both show rich and unique biodiversity in terms of rich species endemism. The richness and uniqeness of biodiversity in Himalayan hotspot is shown in Table 18.8.

The ecosystems of the Western Ghats include the tropical wet evergreen forests, the montane everygreen forests, moist deciduous forests etc. The Shola grassland ecosystems are unique of this region. Attributes of Western Ghats biodiversity are shown the Table 18.9

In addition to these two, there are about 40 other sites in different biogeographic zones of India which have high degree of endemism and genetic diversity. These are as follows:

(1) Andaman group of islands
(2) Nicobar group of islands
(3) Agasthyamalai Hills
(4) Anamalai and High Ranges (Cardamom Hills)
(5) Palni and Highway Mountains
(6) Nilgiris, Silent Valley - Wyanaad - Kodag
(7) Shimoga - Kanara
(8) Mahabaleshwar - Khandala Ranges
(9) Konkan - Raigad
(10) Marathwada - Satpura Ranges
(11) Tirupati - Cuddappa - Nallamalai Hills
(12) Vizagapatnam — Ganjam — Jeypore Hi
(13) Southern Deccan (Leeward side)
(14) Chotanagar Plateau
(15) Kathiawar - Kutch
(16) Rajasthan - Aravalli
(17) Khasia - Jaintia Hills
(18) Patoki - Manipur - Lushai Hills
(19) Assam
(20) Arunachal Pradesh Himalaya
(21) Sikkim Himalaya
(22) Garhwal - Kumaon Himalaya

Biodiversity Conservation Strategies

The establishment of protected areas is one of the strategies used in the management of environmental resources. However, with environmental philosophy, terms, and approaches changing significantly in the past decade, the international community involved in protected areas policy, planning, and management considered it necessary to review the definition of a protected area, to ensure that the definition embraces the wide range of areas under or requiring protection. This definition was derived at the 4th World Congress on National Parks and Protected Areas, held in Caracas, Venezuela, February 1992.

A **protected area** is, therefore, defined as "an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means" (IUCN, 1994. P.7). The main purposes for establishment and management of protected areas are identified as :

- Scientific reasearch;
- Wilderness protection;
- Preservation of species and genetic diversity;
- Maintenance of environmental services;
- Protection of specific natural and cultural features;
- Tourism and recreation;
- Education;
- Sustainable use of resources from natural ecosystems; and
- Maintenance of cultural and traditional attributes.

Based on the possible mix of priorities that can be generated by the management objectives stated above, protected areas have been grouped into the following six categories (updated from the ten categories developed by IUCN in 1978):

- Category I : Strict Nature Reserve/ Wilderness Area - Managed mainly for science or wilderness protection (includes two sub-categories; Strict Nature Reserve - Ia, and Wilderness Area - Ib).
- Category II : National Park - Managed for ecosystem protection and recreation
- Category III : Natural Monument - Managed mainly for conservation of specific natural features
- Category IV : Habitat/Species Management Area - Managed mainly for conservation through management intervention
- Category V : Protected Landscape/Seascape - Managed mainly for landscape/seascape conservation and recreation
- Category VI : Managed Resource Protected Area - Managed mainly for the sustainable use of natural systems

To conserve rare and threatened species it is necessary to protect their natural habitats and specific measures are taken to present their unplanned exploitation and illegal trade. The two known methods of conservation, namely **in-situ** (conservation in its natural habitat) and **ex-situ** (conservation outside the natural area) have their own merits and demerits.

In-situ conservation

This is the conservation of genetic resources through their maintenance within natural or even human-made ecosystems in which they occur. Natural habitats are declared as protected areas. This system of protected areas includes different categories such as :

- Biosphere Reserves
- National Parks
- Wildlife Sanctuaries
- World Heritage Sites/Sacred Groves/National Monuments/Cultural Landscapes

ex-situ conservation

This is the conservation outside their habitats, which includes :

- Botanical Gardens/Arboreta/Herbal Gardens
- Seed (Germplasm) Banks
- Pollen Banks/Semen Bank/Ovum Bank
- Biotechnology Use (Tissue culture, Genetic engineering etc.)

Protected Areas

Protected areas can be established in many ways. The two most common mechanisms are, government action (often at a national level, but also regionally or locally) and purchases of land carried out by private conservation organisations. An increasingly common pattern is that of a partnership between the government of developing country in the tropics and international conservation organisations, multinational banks, and governments of developed countries. They provide funding, training and scientific and management expertise to establish protected areas in developing world. Such collaboration is accelerating, and the recently created 1.5 billion US dollar global environment facility, implemented by the World Bank and U.N. agencies is such an example.

The ICUN (1985) has developed the following system of classification for protected areas that range from minimal to intensive allowed use of the habitat by man:

Scientific reserves and strict nature reserves

They are strictly protected areas maintained for scientific study, education and environmental monitoring. As far as possible populations and the ecosystem processes are allowed to remain undisturbed.

National parks

They are large areas of scenic and national beauty maintained for scientific, educational and recreational use. They are not usually used for commercial extraction of resources.

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