UNIT 4: BIODIVERSITY AND ITS CONSERVATION

DEFINITION AND SIGNIFICANCE OF BIODIVERSITY

The earth holds a vast diversity of living organisms, which includes different kinds of plants, animals, insects, and microorganisms. The earth also holds an immense variety of habitats and ecosystems. The total diversity and variability of living things and of the system of which they are a part is generally defined as biological diversity, i.e. the total variability of life on earth. In other words it also refers to the totality of genes, species and ecosystems in a region. Biodiversity includes diversity within species, between species and of ecosystems. It can be partitioned, so that we can talk of the biodiversity of a country, of an area, or an ecosystem, of a group of organisms, or within a single species. The term biodiversity, the short form of biological diversity, was coined by Walter G. Rosen in 1985, however the origin of the concept go far back in time. Perception of biodiversity varies widely among different segments, such as biologists, sociologists, lawyers, naturalists, conservationists, ethnobiologists and so on. Thus, biodiversity issues have been unifying force among people of various professions and pursuits.

Biodiversity represents the very foundation of human existence. Besides the profound ethical and aesthetic implications, it is clear that the loss of biodiversity has serious economic and social costs. The genes, species, ecosystems and human knowledge which are being lost represent a living library of options available for adapting to local and global change. Biodiversity is part of our daily lives and livelihood and constitutes the resources upon which families, communities, nations and future generations depend. Biodiversity can be set in a time frame so that species extinctions, the disappearance of

ecological associations, or the loss of genetic variants in an extant species can be classed as loss of biodiversity. Similarly additions to biodiversity includes addition of new elements of life by mutation, by artificial breeding, by biotechnology or by ecological manipulation.

A large number of factors and forces are responsible for the steep decline in the earth's biodiversity during the last century. Most of these are caused due to tremendous increase in human population and this in turn resulted in the overexploitation of certain plant and animal resources for food, medicine, skin, fur, tusks, musk, etc., habitat loss and fragmentation, land use change and pollution. Concerns have been raised about the loss of biodiversity especially after the United Nations Conference on Environment and Development (UNCED) held at Rio de Janeiro in 1992, where loss of biodiversity was recognized as one of the most important problem of this century. The primary reason for the concern is the realization that biodiversity is being lost even before its size is known.

WORLD BIODIVERSITY SCENARIO

Man has made remarkable advancements in many fields of science but when it comes to recording and scientifically describing different kinds of plants, animals and microorganisms, there remains much more to be explored and recorded than they are known. The known and described number of species of all organisms on the earth is between 1.7 and 1.8 million, which is fewer than 15% of the actual number. The predicted number of total species varies from 5 to 50 million and averages at 14 million. Out of the total known species, about 60 % are insects, about 16 % are higher plants and only about 0.3 % are mammals. There are many more species that have not yet been

described, especially in the tropics. Information about bacteria, viruses, protists and Archaea is just fragmentary. However, new species are being discovered faster than ever before due to the efforts of projects like Global Biodiversity Information Facility and The Species 2000. The approximate number of species of different taxonomic groups, which have been identified and described from all over the world are given in Table 4.1.

Table 4. 1: Approximate Numbers of Species which have been Described and Identified from all over the World.

Group	Number of 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	26,959
Amphibians	4,780
Insects	1,025,000
Crustaceans	43,000
Mollusks	70,000
Nematodes and worms	25,000
Protozoa	40,000
Others	110,000

LEVELS OF BIODIVERSITY

Biological diversity includes three hierarchical levels:

(i) Genetic diversity,

(ii) Species diversity, and

(iii) Community and Ecosystem diversity.

These levels of biodiversity are interrelated, yet distinct enough to be studied separately to understand the interconnections that support life on earth.

Genetic Diversity

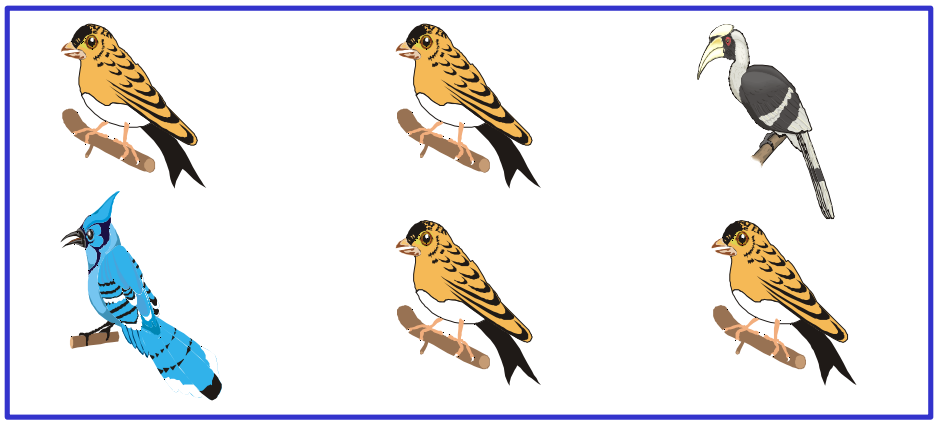
Each species, varying from bacteria to higher plants and animals, stores an immense amount of genetic information. For example, the number of genes is about 450-700 in Mycoplasma, 4000 in a bacterium (*Escherichia coli*), 13000 in fruit fly (*Drosophila melanogaster*), 32000-50000 in rice (*Oryza sativa*) and 35000 to 45000 in human being (*Homo sapiens*).

Genetic diversity refers to the variation of genes within species; the differences could be in alleles (different variants of same genes), in entire genes (the traits determining particular characteristics) or in chromosomal structures. The genetic diversity enables a population to adapt to its environment and to respond to natural selection. If a species has more genetic diversity, it can adapt better to the changed environmental conditions. Lower diversity in a species leads to uniformity, as is the case with large monocultures of genetically similar crop plants. This has advantage when increased crop production is a consideration, but can be a problem when an insect or a fungal disease attacks the field and poses a threat to the whole crop.

The amount of genetic variation is the basis of speciation (evolution of new species). It has a key role in the maintenance of diversity at species and community levels. The total genetic diversity of a community will be greater if there are many species as compared to a situation where there are only a few species. Genetic diversity within a species often increases with environmental variability.

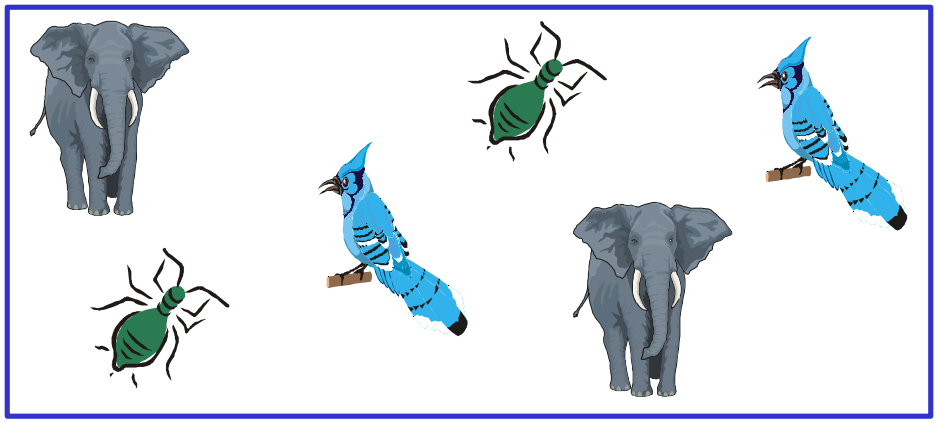
Species Diversity

Species are distinct units of diversity, each playing a specific role in an ecosystem. Therefore loss of species has consequences for the ecosystem as a whole. Species diversity refers to the variety of species within a region. Simplest measure of species diversity is species richness, i.e. the number of species per unit area. The number of species increases with the area of the site. Generally, greater the species richness greater is the species diversity. However, number of individuals among the species may also vary resulting into differences in evenness, or equitability, and consequently in diversity. Suppose we are having three sample areas. In the sample area one, there are three species of birds. Two species are represented by one individual each, while the third species has four individuals (Figure 4.1). In the second sample area that has the same three species, each species is represented by two individuals. This sample area shows greater evenness, and there are equal chances for a species being represented in a sample. The second sample area will be considered more diverse than the first. In the third sample area, the species are represented by an insect, a mammal and a bird. This sample area is most diverse, as it comprises taxonomically unrelated species. In this example, we find equal number of species but varying number of individuals per species. In nature, both



Sample area 1

Sample area 2



Sample area 3

Fig. 4.1 The different sample areas showing species richness (sample area 1), species evenness (sample area 2) and diversity due to unrelated species (sample area 3).

the number and kind of species as well as the number of individuals per species vary, leading to greater diversity.

Community and Ecosystem Diversity

Diversity at the level of community and ecosystem has three perspectives. Alpha diversity (within community diversity) refers to the diversity of organisms sharing the same community/habitat. A combination of species richness and equitability/evenness is used to represent diversity within a community or habitat. Species frequently change when habitat or community changes. The rate of replacement of species along a gradient of habitats or communities is called beta diversity (between-community diversity). Species composition of communities may vary along environmental gradients, e.g. altitudinal gradient, moisture gradient, etc. Higher the heterogeneity in the habitats in a region or greater the dissimilarity between communities, higher is the beta diversity. Diversity of the habitats over the total landscape or geographical area is called gamma diversity.

Ecosystem diversity describes the number of niches, trophic levels and various ecological processes that sustain energy flow, food webs and the recycling of nutrients. It has a focus on various biotic interactions and the role and function of keystone species. Studies in temperate grasslands have shown that diverse communities are functionally more productive and stable, even under environmental stresses such as prolonged dry conditions. The number of habitats or ecosystems can vary within a geographical area. The number of habitats/ecosystems present in a region is also a measure of biodiversity.

USES OF BIODIVERSITY

Humans derive many direct and indirect benefits from the living world. Biodiversity is the source of food, medicines, pharmaceutical drugs, fibres, rubber and timber. The biological resources contain potentially useful resources as well. The diversity of organisms also provides many ecological services free of charge that are responsible for maintaining ecosystem health. The uses of biodiversity are briefly described below.

Source of Food and Improved Varieties

Biodiversity is of use to modern agriculture in three ways: (i) as a source of new crops, (ii) as a source material for breeding improved varieties, and (iii) as a source of new biodegradable pesticides.

Of the several thousand species of edible plants, less than 20 plant species are cultivated to produce about 85% of the world's food. Wheat, corn and rice, the three major carbohydrate crops, yield nearly two-third of the food sustaining the human population. Fats, oils, fibres, etc. are other uses for which more and more new species need to be investigated.

The commercial, domesticated species are crossbred with their wild relatives to improve their traits. Genes of wild species are used to confer new properties such as disease resistance or improved yield in domesticated species. For example, rice grown in Asia is protected from the four main diseases by genes received from a single wild rice species (*Oryza nivara*) from India.

Drugs and Medicines

Biodiversity is a rich source of substances with therapeutic properties. Several important pharmaceuticals have originated as plant-based substances. Examples of plant-derived

substances developed into valuable drugs are: Morphine (*Papaver somniferum*), used as an analgesic; Quinine (*Chinchona ledgeriana*) used for the treatment of malaria; and Taxol, an anticancer drug obtained from the bark of the yew tree (*Taxus brevifolia, T. baccata*). Currently, 25% of the drugs in the Pharmacy are derived from a mere 120 species of plants. But, throughout the world, traditional medicines make use of thousands of plant species. Plants can also be used for the manufacture of innumerable synthetic products, called botanochemicals.

Aesthetic and Cultural Benefits

Biodiversity has also great aesthetic value. Examples of aesthetic rewards include ecotourism, bird watching, wildlife, pet keeping, gardening, etc. Throughout human history, people have related biodiversity to the very existence of human race through cultural and religious beliefs. In a majority of Indian villages and towns, plants like *Ocimum sanctum* (Tulsi), *Ficus religiosa* (Pipal), and *Prosopis cineraria* (Khejri) and various other trees are planted , which are considered sacred and worshipped by the people. Several birds, and even snake, have been considered sacred. Today, we continue to recognize plants and animals as symbols of national pride and cultural heritage.

Ecosystem Services

Biodiversity is essential for the maintenance and sustainable utilization of goods and services from ecological systems as well as from the individual species. These services include maintenance of gaseous composition of the atmosphere, climate control by forests and oceanic systems, natural pest control, pollination of plants by insects and birds, formation and protection of soil, conservation and purification of water, and

nutrient cycling, etc. These ecosystem services have been valued in the range of 16 to 54 trillion (10^{12}) US dollars per year.

BIOGEOGRAPHICAL CLASSIFICATION OF INDIA

Distribution of flora and fauna at any place is largely governed by the latitude, longitude, altitude, geology and climate of that region. Specific areas can be marked on the basis of distribution of distinctive flora and fauna and are known as Biogeographic zones. Each biogeographic zone has several habitats, biotic communities and ecosystems. In India, we are endowed with a rich diversity of the ten biogeographically distinct regions due to varying physical conditions and species groupings. A large number of species that are found in these zones are endemic (only found locally) or exclusive to India. About 33% of the flowering plants recorded in India are endemic to our country. Indian region is also notable for endemic fauna. For example, out of the recorded vertebrates, 53% freshwater fishes, 60% amphibians, 36% reptiles and 10% mammalian fauna are endemic. A very high number of amphibian species are endemic to Western Ghats. The endemic species are concentrated mainly in north-east, Western Ghats, north-west Himalaya and Andaman and Nicobar Islands. However, the biological diversity of many ecosystems still remains poorly explored in India. These ecosystems include the deep oceans, wetlands and lakes, and terrestrial habitats such as the tree canopy and soil of tropical rain forests.

The various Biogeographic zones of India are shown in Figure 3 and the details of these zones given below:

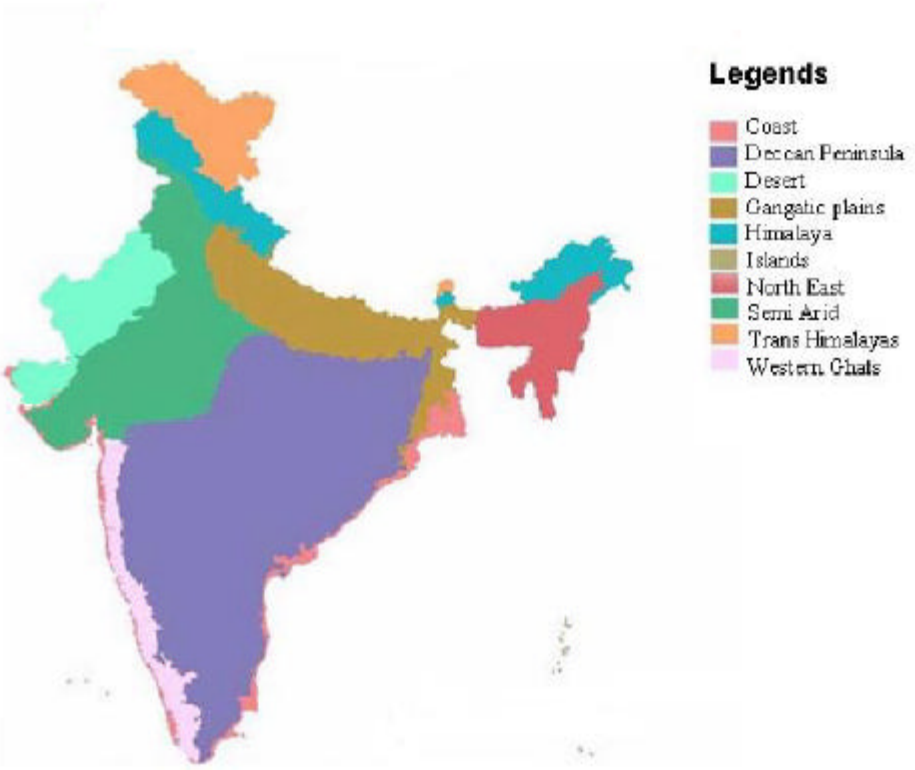


Fig. 4.2 Biogeographical regions of India

Zone 1 : Trans Himalayan

Trans-Himalayas, meaning beyond the Himalayas, covers an estimated land area of 186,200 km^2 and includes the Indian region of Ladakh in Jammu & Kashmir State, and Lahaul-Spiti of Himachal Pradesh. The entire zone is a high-altitude (4,500 to 6,600 m above mean sea level) cold desert falling in the rain shadow of the main Himalayas range. This zone is composed of Tundra Valley, Lakes and Marsh lands. The landscape is characterized by a distinct lack of natural forests, the vegetation being primarily sparse alpine steppe, showing a high degree of endemism. Along the riverbanks and valleys in Ladakh, some greenery does exist with willows, poplars, wild roses and many herbaceous

plants and shrubs having colonized the land, and even extending up the mountain slopes. Most of the vegetation is, however, stunted.

The largest number of wild sheep and goats in the world found here. The common animals found in this zone are great Tibetan sheep (*Ovis ammon hodgsoni*), the urial or shapu (*Ovis orientalis*), the bharal or blue sheep (*Pseudois nayaur*), the *ibex (Capra ibex*), the Tibetan antelope (*Pantholops hodgsoni*, which is better known as the chiru) the Tibetan gazelle (*Procapra picticaudata*), pikas, marmots and Tibetan hares, the snow-leopard or ounce and the Pallas cat, Indian wolf and the lynx.

Zone 2: Himalayas

Extending some 236,300 km^2 in the Indian region and accounting for nearly seven per cent of the country's total surface area, this zone extends over the states of Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, Sikkim and Arunachal Pradesh. Outside India, Pakistan, Nepal and Bhutan also fall within this zone. Intense rainfall, steep slopes and infirm soils make the Himalayan mountains extremely vulnerable. In addition to this cultivation of steep slopes, livestock grazing, tourism and deforestation for fuel and timber combine to devastate the Himalayas. The Himalayas, generally divided into four sectors: the north west, west, central and east, encompasses extreme habitat types, ranging from arid Mediterranean and temperate in the western parts, to warm, moist, evergreen forests in the east. Currently there are 56 protected areas in this zone and these cover roughly five per cent of the total surface area.

Attitudinally and longitudinally, the Himalayas can be grouped into three distinct habitat types:

a) **The low altitude foothills:** Predominantly sub-tropical mixed deciduous forests, merging into stands of chir pine at around 1,000 m and then gradually to oak at slightly higher altitudes. Much of the faunal component of this region, east to west, bears a close affinity to that of the Indian peninsula to the south.

b) **The temperate habitat type:** Above the foothills, roughly between 1,500 and 3,500 m, a complex mix of broad-leaved and coniferous vegetation, with its characteristic faunal community that also shows distinct peculiarities in the western, central and eastern Himalayas. Here one can see musk deer, black and brown bears, several pheasants, mountain sheep, goats and deer. The west Himalayas has a rich herbivore structure in the temperate ecozone, while the central Himalayas lacks species like the ibex and the markhor. The east Himalayas has more luxuriant forest with exceptionally high endemic flora. The animals like the red panda, binturong and several lesser cats are also found in the area. Of the existing 56 protected areas in the Himalayas, at least 41 lie in the temperate sector either completely, or partly.

c) **The sub-alpine habitat type:** Above the middle level temperate sector (higher than 3,500 m) birch, rhododendrons, junipers, dwarf bamboo and a mixture of open meadows and scrub-dotted grasslands are generally found. The western part is very dry, but in the moist east the tree-line is higher. Above 5,000 metres rock and snow dominate the landscape, and mark the ultimate limit of vegetation. As habitat types change, a noticeable transformation takes place in the faunal community as well. The higher reaches house several threatened species such as the ibex, shapu, wolf and snow leopard. Nearly half the 56 protected areas in the Himalayas extend partially or extensively into the high-altitude sub-alpine.

Zone 3: Desert

In the Indian subcontinent, deserts, with an area of about 225,000 km^2 account for just under seven percent of the total land area. Better known as the Great Indian Desert, this arid and extreme habitat spreads over western Rajasthan and the Great Rann of Kutchh in Gujarat. The Indian desert zone has been divided into two distinct sub-divisions, the larger Thar desert region which covers 180,000 km km^2 in the state of Rajasthan, and the Rann of Kutchh, covering some 45,000 km^2 of western Gujarat.

(1) **The Thar:** This shows a good extent of endemism in its faunal structure. The desert cat, desert fox, the winter-visiting houbara bustard and several sandgrouse species, few reptiles are found only in the Thar. Blackbuck, chinkara, the Indian wolf, caracal, great Indian bustard can also be seen here.

(2) **Rann of Kutchh**: In contrast to the sandy Thar, the Rann of Kutchh portion of the Indian desert is primarily composed of salt flats, flanked by extensive grasslands and thorn scrub, gradually merging southwards into the cultivated Kathiawar peninsula of Gujarat. Both, the Little and the Great Ranns, with very similar vegetation communities, have been grouped together under the Rann of Kutchh sub-division of the Indian desert zone. Every monsoon, the Ranns are prone to flooding by brackish or saline water from the sea. The plants in this zone have adapted to a saline-marshy environment; such plants are known as halophytes. The Great Rann is best known for its huge breeding colony of lesser flamingoes, as also a host of other ground-nesting birds that breed here and perhaps nowhere else in the Indian region. The Little Rann is the only home of the wild ass in the Indian peninsula. Houbara bustards, sandgrouse and other birds are also found here.

Three large protected areas have been declared in the Indian desert zone. Two of these are in the Rann of Kutchh while the Desert National Park is located in the Thar.

Zone 4: Semi- arid zone

The Semi-arid zone, a transition from true desert to semidesert, scrub and stunted forests, is spread over low mountain ranges. East of the Indian desert and west of the Gangetic Plain, the Semi-arid Zone encompasses a total area of 508,000 sq. km, covering nearly 15 percent of India's area. Included are the extreme southern portions of Jammu and Kashmir, a narrow belt of lower Himachal Pradesh, the states of Punjab and Haryana, Rajasthan (west of the desert), Gujarat (west of the Great Rann) and the western parts of Madhya Pradesh. This zone can broadly be divided in northern region and southern region.

The northern region of this zone houses the flat, alluvial deposits of the Indus river drainage system. Intensely irrigated and cultivated, this northern stretch, known as the Punjab Plains, includes Haryana and Punjab, the southern margins of Jammu & Kashmir and Himachal Pradesh or what are the western most parts of the bhabar and the Shivalik mountains. The outskirts of Delhi as also the western end of Uttar Pradesh and a part of the Bharatpur district in Rajasthan fall within the Punjab Plains belt. The region comprises predominantly cultivated flatlands, interspersed with a network of wetlands -- marshes and rivers. This region is the home to some of India's most magnificent grasslands and sanctuary for a most charismatic bird, the great Indian bustard. The most famous wildlife area here is the Keoladeo Ghana Bird Sanctuary in Bharatpur. Harike in Punjab and Sultanpur in Haryana are other well-known wetland reserves of the region.

In marked contrast to the northern parts of the Semi-arid Zone, the southern expanse is less cultivated. This half includes all of Rajasthan (east of the desert, excluding parts of Bharatpur), northwestern Madhya Pradesh, and Gujarat (including the Kathiawar peninsula but not the two Ranns) up to the Tapti river, the southernmost extent of the Semi-arid Zone. The Aravalli and the Vindhya mountain ranges dominate the central portions of this zone, while the black-cotton Kathiawar peninsula of Gujarat characterises the southern sprawl. An interesting feature of the zone is the heavy rainfall region of Mount Abu in the southern Aravallis. Here several plant and animal species bear close affinity to the Western Ghats. Plants which are found here belong to the genus *Acacia*, *Anogeissus, Capparis, Grewia* etc. On the slopes of the Aravallis and associated broken mountain ranges, there are pure stands of *Anogeissus pendula* forest, almost restricted to this area. The herbivores in this area include nilgai, blackbuck, chowsingha or four horned antelope, chinkara or Indian gazelle, sambar and spotted deer, the last two being more or less restricted to the forested mountain ranges and valleys.

In this zone tiger, leopard, Asiatic lion, wolf, jackal, and karakul are found. Two of the finest tiger reserves - Ranthambore and Sariska -- are located in the Aravallis. On the whole, it can be stated that while the Semi-arid Zone does not exhibit any great endemism, it nevertheless holds viable populations of several species of conservation criticality today. Besides those mentioned above, others include the sloth bear, Lesser Florican, the Great Indian Bustard, crocodile, alligator, several turtles and also waterfowl, both resident and migratory.

Zone 5: Western Ghats

Along the west coast of India -- beginning from the Surat Dangs at the western extremity of the Satpuras in south Gujarat, for over 1,500 km to the southern tip of India in Kerala -- stretch the Western Ghats, a mountain range second only to the Himalayas in magnificence. The Ghats form the catchment area for the complex peninsular Indian river system that drains almost 40 per cent of India, the second largest tropical evergreen and semi-evergreen forest belt of the sub-continent. A wide climatic (rainfall and temperature) and geographical (altitude and associated mountain spurs) gradient exists in this zone. This is manifested in a tremendous diversity of plant communities and animal associations. From the coastal plains along the western flanks, the zone rises up to a maximum altitude of 2,735 m in the south, while falling gradually (sharply in a few places) along the eastern side, towards the dry Deccan Peninsula.

These climatic and geographical gradients have resulted in major habitat variations in this Zone. There are extensive rolling grass-hills in the south-central portions of the Ghats

Of the total area of 160,000 km^2, just less than one-third is currently considered to be forested and only about nine per cent (15,000 km^2) is estimated to be tropical evergreen forest. The rest are moist and dry deciduous forests, dominated by teak.

The Western Ghats zone covers barely five per cent of India's area, but its biological richness can be best understood when one realizes that 27 per cent of all the species of higher plants recorded in the Indian region are found here (about 4,000 of 15,000 species). Further, almost 1,800 species are endemic to the region. The Nilgiri-Travancore-Anamalai-Palni-Cardamom hill areas in the southern parts of the zone exhibit the highest degree of endemism. Further, several interesting plant associations are

observed in the evergreen forests of the zone. There are montane 'shola' forests, riverine or swamp forests and nearly half a dozen other evergreen-species associations, mostly observed in the southern half of the zone, where numerous ancillary mountain ranges converge to produce a region of exceptional diversity.

Though this zone has healthy populations of much of the animal species characteristic of peninsular India e.g. tiger, elephant, gaur, sloth bear, panther and several species of deer, it also exhibits a fairly good degree of endemism among primates, ungulates, carnivores, rodents, squirrels and several birds. Amongst amphibia, most of the species and nearly half the genera are endemic, while a good degree of endemism is visible also amongst reptiles, fish and insects, most faunal endemism and restriction being only in the central and and southern parts of the zone. Presently, of all the Bio-geographic zones, The Western Ghats with 44 Sanctuaries and National Parks, covering some 15,935 km^2 has the highest percentage of protected areas.

Zone 6: Deccan Peninsula

With an area of 14,21,000 km^2, the Deccan Peninsula extends over 43 per cent of India's landmass, spreading over eight states. Though the massive zone is more or less homogeneous, at least three principal habitat types are easily recognised. These are deciduous forests, thorn forests and scrublands. Additionally there are pockets of semi-evergreen and evergreen forests, mainly in the mountain range known as the Eastern Ghats.

In the north, the dominant deciduous tree species are *Shorea robusta* (sal), *Tectona grandis* (teak), *Terminalia* , *Anogeissus* and *Chloroxylon* etc. South of the river Krishna, in the Karnataka plateau, Tamil Nadu plains and adjoining mountains, dry, thorny species

such as *Acacia*, *Hardwickia* and *Albizia* dominate the landscape. The Deccan Zone can be divided into five distinct sub-divisions, based upon floral communities and general topography:

(1) **The Chota Nagpur Plateau**: A moist region in the north-eastern parts of the zone, which includes southem Bihar, Jharkhand, northern Orissa and parts of West Bengal, extreme eastern Madhya Pradesh, parts of Chhatisgarh, the southern margins of Uttar Pradesh, south of the Gangetic Plain. Forests of sal dominate the landscape here, interspersed with bamboo stands. The total area of the Chota Nagpur deciduous forests is 217,000 km^2, almost half of which lies in Jharkhand and Bihar. Simlipal and Palamau are the two best known, and extensively protected areas in the Chota Nagpur portion of the Deccan Zone. This region holds good populations of animals like tiger, sloth bear, elephant, gaur, besides a host of other herbivores.

(2) **The Central Highlands**: With an area of 287,000 km^2, incorporates the Satpura - Maikal and the Vindhya-Bagelkhand mountain ranges, traversing the states of Madhya Pradesh, Chhatisgarh and northern Maharashtra, besides small off-shoots in southern Uttar-Pradesh and western Bihar. Kanha and Bandhavgarh stand out as beacons of good wildlife management of this region. Like the Chota Nagpur area, the Central Highlands too are dominated by sal forests, though towards the south, such as in the Melghat tiger reserve of Maharashtra, sal vanishes and teak takes over. The forest is predominantly deciduous, with patches of semi-evergreen in the low valleys. The maximum elevation here is about 1,400 m. These highlands are also characterized by the absence of elephants which dominate the animal community of the Chota Nagpur region.

(3) **The Deccan Plateau North:** An area of 341,000 km^2 comprises basically dry open scrub and thorn forest, which includes the bulk of Maharashtra, and portions of Andhra Pradesh and Karnataka. In the northern margins of this sub-division, rich tiger habitats still exist. Nawegaon, Tadoba and Nagzira in Maharashtra and Nagarjunasagar in Andhra Pradesh are some examples of viable forest belts in this subdivision. Most other protected areas of this plateau comprise open, thorny scrub with a wildlife community which typifies drier regions -blackbuck, nilgai, chinkara and the great Indian bustard, for instance.

(4) **The Deccan Plateau South**: This forms the largest sub-division of the Deccan Zone, with an area of 378,000 km^2, spread over Andbra Pradesh, Tamil Nadu, Karnataka, and a tiny bit of Maharashtra. The Krishna river forms the northern boundary of this sub-division most of which is dry and thorny scrub, dominated by *Albizia*, *Hardwickia* and *Acacia* associations. On the whole, this southern plateau is the most highly cultivated and least protected of all the areas of the Deccan Zone.

(5) **The Eastern Highlands:** With an area of 198,000 km^2, this is the smallest of the five sub-divisions of the Deccan Zone. However, biologically it is the richest region in this zone. Included here are the northern parts of the Eastern Ghats and several associated hill ranges. The floral structure is predominantly tropical semi-evergreen and evergreen forests with few patches of temperate flora at the higher altitudes (between 900 - 1,200 m) in the central portion. Widespread populations of elephant, gaur and a vital pocket of wild buffalo herds are found here. Tigers are also found in some of the forest reserves of this sub-division.

Zone 7: Gangetic Plain

The Gangetic Plain extends along the foothills of the Himalayas, from Uttar Pradesh eastwards through Nepal, Bihar, West Bengal and parts of coastal Orissa. The entire area comprises a vast, flat, alluvial expanse, both to the north and south of the river Ganges, and its many tributaries that cut southward through the Himalayas. Eastwards, this zone extends into Bangladesh and coastal Burma. With an area of 359,400 km^2, roughly 10 per cent of India's total landmass, the Gangetic Plain is one of the largest distinctive habitat zones of the subcontinent. The central hill ranges of the Vindhyas and Aravallis form the southern boundary of the Gangetic Plain into which the Shivaliks and the bhabar regions of the Himalayan foothills to the north have also been included. The area was once the heartland of the Indian wilderness, but has long since been converted to a vast man-dominated landscape.

Known to be one of the world's most fertile regions, the Gangetic Plain is the most densely populated of the 10 habitat zones. Nearly 300 million people, accounting for over 30 per cent of India's population reside in this zone. Only in the narrow northern belt, flanking the Himalayan massif in the Shivaliks and bhabar, can one still see bits of natural forests and grasslands. The region is dotted with innumerable lakes and marshes. Nearly 90 per cent of the Gangetic Plain has been significantly altered, the natural vegetation having long been converted into cropland.

At one time elephant, rhino, swamp deer, wild buffalo, tiger and many other wild animals were widespread over the Gangetic Plain. Small numbers of these survive today in the few remaining protected terai grasslands such as Dudhwa and in the Shivalik jungles of

the north. A good part of the last surviving populations of Bengal florican are to be found in this zone.

In the wetland habitat of this zone are found over 20 species of turtles, non-gregarious Gangetic dolphin, crocodiles and alligators, and several species of migratory waterfowls only during the winters. In this huge zone of 359,400 km^2 there are only 25 protected areas, which accounts for only about 1.3 per cent of the area.

Zone 8: North east Zone

Contiguous with the Gangetic Plain, the northeast comprises six of the famous 'Seven Sisters' - the states of Assam, Manipur, Mizoram, Meghalaya, Nagaland and Tripura. The total area of the Northeast is 171,423 km^2, or about five per cent of India's land area. Nearly 40 per cent of the area of this zone, amounting to just under 70,000 km^2, is presently forested. The northeast is amongst the most biodiversity rich regions of the world. Ironically, the northeast also happens to house the largest number of endangered species out of all the zones in India.

The Brahmaputra valley, a continuation of the Gangetic plain of Bengal in the west, is the dominating feature of this zone, its periphery being dotted with moist grasslands, swamplands and forests. It is in this region that protected areas such as Manas and Kaziranga are found. These hold appreciable populations of herbivores including rhinoceros, wild buffalo, gaur, swamp deer, hog deer, pygmy hog, elephant and the rare and endangered hispid hare. The valley is also a vital migratory passage for waterfowl.

Biologically, the Northeast can be divided into the two sub-zones. The extensive flood plains, grasslands and swamps to the north and south of the Brahmaputra, which cover 65,000 km^2 (about 38 per cent) of the northeast; and the highly forested Assam Hills,

which extend over 106,209 km^2. Closer to the Brahmaputra, the alluvial grasslands and swamps are moist and dependent upon the course of the river at different times of the year. Flooding during the monsoons covers huge expanses of these plains, forcing much of the wildlife, and people, to disperse higher up. Further away from the river, the grasslands become drier and there is a gradual transition into deciduous woodlands and lush, evergreen forests. The forests in the eastern parts of the Brahmaputra valley are more evergreen than those in the west. *Shorea assamica* and *Dipterocarpus macrocarpus*, are found only in the north of the river. Among animals, the stump-tailed macaque and the hoolock gibbon can be seen only to the south while the well-known golden langur, hispid hare and pygmy hog are restricted to areas north of the river.

Though referred to as the Assam Hills, barely 13,000 km^2 of this sub-zone lie in Assam proper, and the greater area spreading over the five states of Manipur, Meghalaya, Mizoram, Nagaland and Tripura. It is here in the diverse habitat and climatic conditions that the richest faunal and floral communities are found. The Khasi-Jaintia Hills of Meghalaya are, in fact, regarded as one of Asia's richest botanical treasure troves. There are more species of small carnivores and of birds such as hombills and laughing thrushes in the Assam Hills than anywhere else in the world.

Barely 3,000 km^2 or below two per cent of the area is protected, making it amongst the least protected zones of the Indian region. There are six national parks and eighteen sanctuaries in the area. Also, very little is known about most of the species, their distribution and natural history.

Zone 9: The Coasts

Starting at the Pakistan border, the Indian shoreline extends over nearly 5,500 km, from Gujarat in the west, down along the Konkan and Malabar coasts, around Kanyakumari and then up along the Coromandel coast to Bengal's Sundarbans, to continue into Bangladesh. This zone exhibits unparalleled topographical diversity throughout its length with Mangrove swamps, tidal creeks, mudflats, sandy beaches, coral shores, cliffs and jagged rocky stretches adorn the Indian subcontinent.

Several species of dugongs (sea cow), marine turtles, estuarine crocodiles and myriad waders are found on the shore and near-shore habitat. Species of crabs, lobsters, oysters, jellyfish, puffer fish, octopus, sea slugs, mudskippers, several species of snakes and monitors are found extensively. Salt tolerance is a vital characteristic of the plants of coastal belts and mangroves are unquestionably the most successful examples of such adaptation. Over 2,000 species of organisms, ranging from bacteria, fungi, lichens, plants, protozoa, crustaceans, insects, reptiles, birds and mammals are closely associated with the Indian mangroves, and many are yet to be recorded. Of India's approximately 5,500 km long coastline, less than 500 km receives protection under the National Park and Sanctuary network. The east coast is somewhat better protected than the west.

Zone 10: The Islands

The Andaman and Nicobar group is the major and better known of the Indian islands. This is a largely north-south running archipelago, with a total of 348 islands, stretching over a length of nearly 600 km. The total land area of these islands is 8,327 km^2. The Lakshadweep group consists of 25 islands in three clusters, with a total land area of a mere 109 km^2.

The Andaman group is the largest, with a total of 324 of the 348 islands, accounting for 6,491 km^2 or over 75 per cent of the total area of all the islands. Island habitats, on account of their isolation, harbour a phenomenal degree of endemic species of plants and animals. The Andaman and Nicobar islands are one of the three dominant tropical, moist evergreen biozones of the subcontinent and their biological diversity, and endemism, is best observed in the variety of plants, birds and perhaps insects although they are poorly documented. The dominant mammal groups are bats and rodents. The principal endemic mammals are the dugong or sea-cow, the Nicobar crab-eating macaque and the Nicobar tree shrew, of which there are different races in the Little and the Greater Nicobar islands. Of the 255 species and subspecies of birds recorded in the islands, as many as 112 are endemic. Some of these are the Nicobar Megapode, the highly endangered Andamans Grey Teal, the Narcondam Hornbill (found only on the 7.0 km^2 volcanic Narcondam island), the Nicobar Pigeon, the Nicobar Parakeet, Andaman Wood Pigeon and Crested Serpent Eagle. The presence of these species in the dense, evergreen jungles is a valuable indicator of the ecological health of the habitat. A considerable degree of endemism is observable in the amphibian and reptiles as well, though the ecology and the range of these two groups is poorly documented. The saltwater crocodile is restricted to a few creeks and estuaries in the Greater Nicobar and in some of the Andaman Islands. Several species of turtles are found here viz. Green turtle, hawksbill turtle and leathery turtles. Most of these are endemic. In addition to this the mangrove, estuaries and lagoons in these islands are found more than 600 species of fish and more than 135 species of coral communities.

The greatest variety and endemism is noticed in the floral composition of these islands. A bewildering ten per cent of the 15,000 species of higher plants recorded in the Indian region are totally restricted to this 8,000 km^2 archipelago. Nearly 2,200 species have been found here, and more than 200 of these are strictly restricted to the islands. A great variety of palms and tree ferns, species of *Dipterocarps* and several types of orchids are found here, however, many more species await discovery, as the region has barely been explored so far. Nearly 100 protected areas are present which cover some 700 km^2 or just over eight per cent of the total zonal area.

MEGACENTERS OF BIODIVERSITY AND HOT SPOTS

Biodiversity is distributed heterogeneously across the Earth. Some areas are full with biological variations (e.g. tropical forests) others are virtually devoid of life (e.g. some deserts and polar regions) and most fall somewhere in between. The regions where a large number of species are found are described as megacentres of biodiversity or mega diversity zone. India is recognized as one of the World's 12 mega diversity zones. India has over 45,000 species of flora and 75,000 species of fauna. India contributes nearly 8 % species to the global biodiversity inspite of having only 2.4 % of the land area of the world. The number of species of different taxonomic groups, described from India, is shown in Figure 4.3.

Norman Myers developed the 'hot spots' concept in 1988 to designate priority areas for *in situ* conservation. The hotspots are the richest and the most threatened reservoirs of plant and animal life on earth. The key criteria for determining a hot spot are:

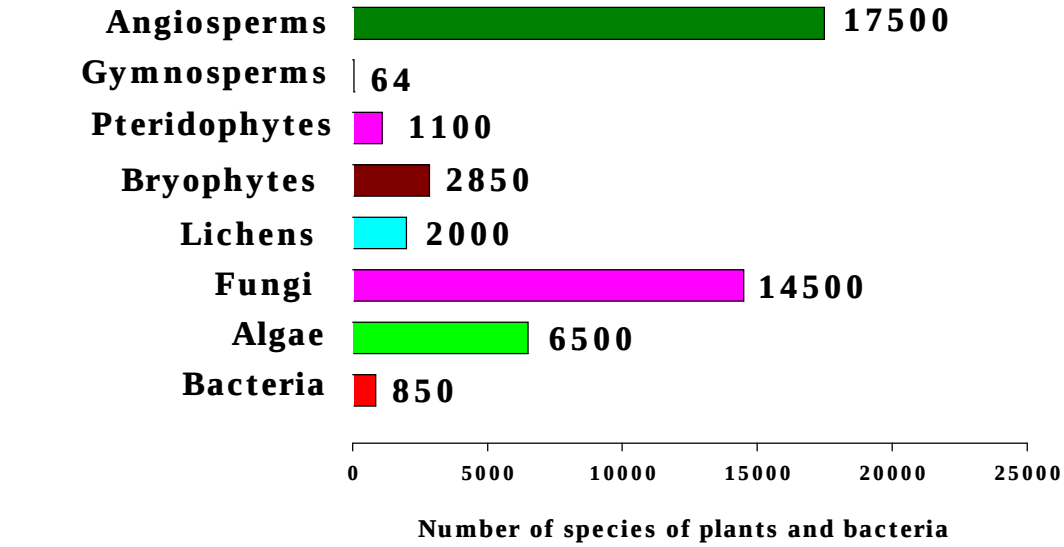
(1) Number of endemic species, i.e. the species which are found nowhere else, and

(2) Degree of threat which is measured in terms of habitat loss.

Twenty-five terrestrial hot spots for conservation of biodiversity have been identified worldwide. Their approximate locations are shown in Figure 4.4. These hot spots together now cover 1.4% of the earth's land area. Tropical forests appear in 15 hot spots, Mediterranean-type zones in five, and nine hot spots are mainly or completely made up of islands. As many as 16 hot spots are in the tropics. About 20% of the human population live in the hot spots.

Among the 25 hot spots of the world, two (Western Ghats and Eastern Himalayas) are found in India, and these extend into the neighboring countries also. These areas are rich in flowering plants, also in reptiles, amphibians, swallow-tailed butterflies and some mammals; and also show a high degree of endemism. The eastern Himalayan hot spot extends to the north-eastern India, and Bhutan. The temperate forests are found at altitudes of 1780 to 3500 meters. Many deep and semi-isolated valleys found in this region are exceptionally rich in endemic plant species. Besides being an active centre of evolution and rich diversity of flowering plants, the numerous primitive angiosperm families (e.g. *Magnoliaceae* and *Winteraceae*) and primitive genera of plants like *Magnolia* and *Betula* are found in eastern Himalayas.

In the Western Ghats region the forests at low elevation (500 m above mean sea level) are mostly evergreen, while those found at 500-1500 meter height are generally semi-evergreen forests. The Agastyamalai hills and the Silent Valley, the new Amambalam Reserve, are the two main centres of diversity.



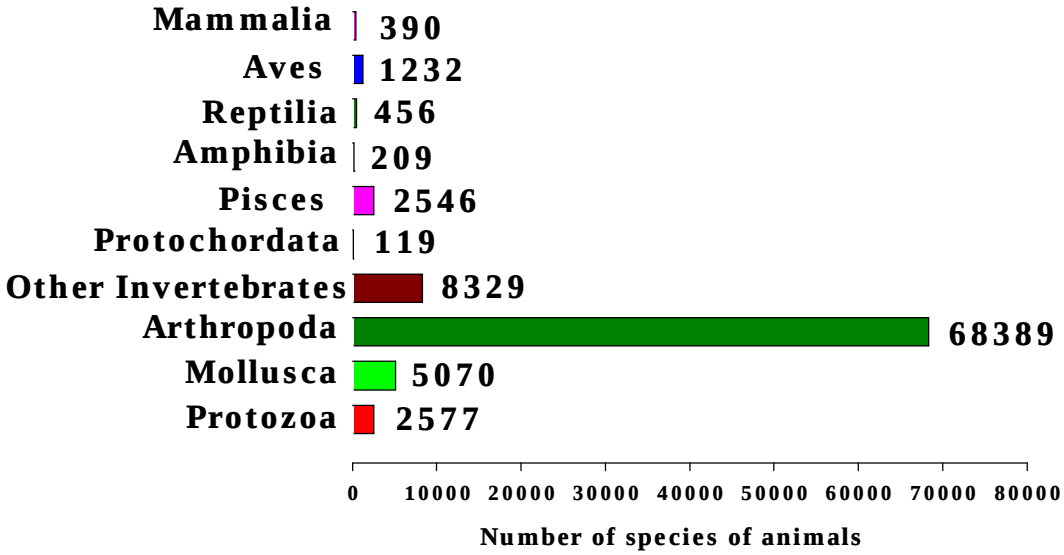
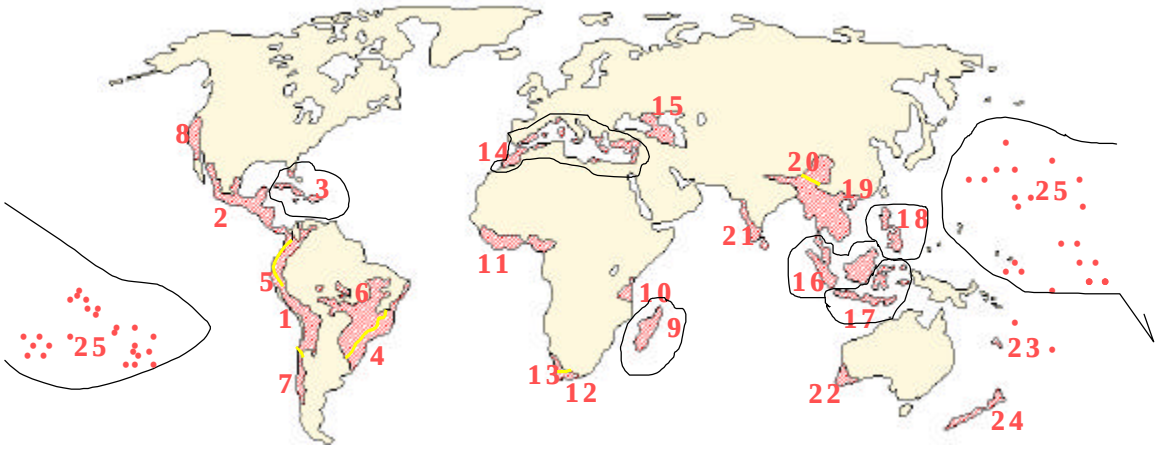


Fig. 4.3 Number of plant and animal species in different groups in India



1.Tropical Andes, 2. Mesoamerica, 3. Caribbean, 4. Brazil's Atlantic Forests, 5. Choco/Darien/Western Ecuador, 6. Brazil's Cerrado, 7. Central Chile, 8. California Floristic Province, 9. Madagascar, 10. Eastern Arc & Costal Forests of Tanzania/Kenya, 11. West African Forests, 12. Cape Floristic Province, 13. Succulent Karoo, 14. Mediterranean Basin, 15.Caucasus, 16.Sundaland, 17. Wallacea, 18. Philippines, 19.Indo-Burma, 20. South-Central China, 21. Western Ghats/Sri Lanka, 22. Southwest Australia, 23. New Caledonia, 24. New Zealand, 25. Polynesia/Micronesia

Fig. 4.4 The terrestrial biodiversity hot spots

THREATS TO BIODIVERSITY

Important factors leading to extinction of species and consequent loss of biodiversity are: habitat loss and fragmentation, introduction of non-native species, overexploitation, soil, water and atmospheric pollution, and intensive agriculture and forestry.

Habitat Loss and Fragmentation

The destruction of habitats is the primary reason for the loss of biodiversity. When people cut down trees, fill a wetland, plough a grassland or burn a forest, the natural habitat of a species is changed or destroyed. These changes can kill or force out many plants,

animals, and microorganisms, as well as disrupt complex interactions among the species. A forest patch surrounded by croplands, orchards, plantations, or urban areas is an example of fragmented habitats. With the fragmentation of a large forest tract, species occupying deeper parts of forests are the first to disappear. Overexploitation of a particular species reduces the size of its population to an extent that it becomes vulnerable to extinction.

Disturbance and Pollution

Communities are affected by natural disturbances, such as fire, tree fall, and defoliation by insects. Man-made disturbances differ from natural disturbances in intensity, rate and spatial extent. For example, man by using fire more frequently may change species richness of a community. Then, some human impacts are new, never before faced by biota, e.g. the vast number of synthetic compounds, massive releases of radiation or spillover of oil in sea. These impacts lead to a change in the habitat quality. Pollution may reduce and eliminate populations of sensitive species. For example, pesticide linked decline of fish-eating birds and falcons. Lead poisoning is another major cause of mortality of many species, such as ducks, swans and cranes, as they ingest the spent shotgun pellets that fall into lakes and marshes. Eutrophication (nutrient enrichment) of water bodies drastically reduces species diversity.

Introduction of Exotic Species

New species entering a geographical region are called exotic or alien species. Introduction of such invasive species may cause disappearance of native species through changed biotic interactions. Invasive species are considered second only to habitat destruction as a major cause of extinction of species. Exotic species are having large

impact especially in island ecosystems, which harbour much of the world's threatened biodiversity. A few examples are:

(1) Nile perch, an exotic predatory fish introduced into Lake Victoria (South Africa) threatens the entire ecosystem of the lake by eliminating several native species of the small Cichlid fish species that were endemic to this freshwater aquatic system.

(2) Water hyacinth clogs rivers and lakes and threatens the survival of many aquatic species in lakes and river flood plains in several tropical countries including India.

(3) *Lantana camara* has invaded many forest lands in different parts of India, and strongly competes with the native species.

Extinction of Species

Extinction is a natural process. Species have disappeared and new ones have evolved to take their place over the long geological history of the earth. It is useful to distinguish three types of extinction processes.

Natural extinction: With the change in environmental conditions, some species disappear and others, which are more adapted to changed conditions, take their place. This loss of species which occurred in the geological past at a very slow rate is called natural or background extinction.

Mass extinction: There have been several periods in the earth's geological history when large number of species became extinct because of catastrophes. Mass extinctions occurred in millions of years.

Anthropogenic extinction: An increasing number of species is disappearing from the face of the earth due to human activities. This man-made mass extinction represents a

very severe depletion of biodiversity, particularly because it is occurring within a short period of time.

The World Conservation Monitoring Centre has recorded that 533 animal (mostly vertebrates) and 384 plant species (mostly flowering plants) have become extinct since the year 1600. More species have gone extinct from the islands than from the mainland or the oceans.

The current rate of extinction is 1000 to 10000 times higher than the background rate of extinction. Some interesting observations about the current loss of species are:

(1) From ten high-diversity localities in tropical forests covering 300,000 km^2, some 17,000 endemic plant species and 350,000 endemic animal species could be lost in near future.

(2) The tropical forests alone are losing roughly 14000-40000 species per year (or 2-5 species per hour).

(3) The earth may lose up to 50% of the species by the end of the 21^{st} century, if the current rate of loss continues.

Susceptibility to extinction

The characteristics of species particularly susceptible to extinction are: large body size (Bengal tiger, lion and elephant); small population size and low reproductive rate (Blue whale and Giant panda). Feeding at high trophic levels in the food chain (Bengal tiger and Bald eagle), fixed migratory routes and habit (Blue whale and Whooping crane) and localized and narrow range of distribution (woodland caribou; many island species) also make the species susceptible to extinction.

The IUCN Red List Categories

The IUCN Red List is a catalogue of taxa that are facing the risk of extinction. It is important to understand that the Red List aims to impart information about the urgency and scale of conservation problems to the public and policy makers. The uses of the Red Lists are:

(1) Developing awareness about the importance of threatened biodiversity;

(2) identification and documentation of endangered species;

(3) providing a global index of the decline of biodiversity;

(4) defining conservation priorities at the local level and guiding conservation action.

The World Conservation Union (formerly known as International Union for the Conservation of Nature and Natural Resources, IUCN) has recognized eight Red List Categories of species: *Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Lower Risk, Data Deficient, and Not Evaluated.* These categories are defined in Table 4.2. The species which are threatened with extinction are included in Vulnerable, Endangered, or Critically Endangered category.

Species with small world populations that are not at present endangered or vulnerable but are at risk are called *rare*. These species are usually localized within restricted geographical areas or habitats or are thinly scattered over a more extensive range.

The IUCN Red List System was initiated in 1963 and since then evaluation of the conservation status of species and subspecies is continuing on a global scale. The 2000 IUCN Red List is the most comprehensive inventory of the global conservation status of

plant and animal species. It uses a set of criteria, relevant to all species and all regions of the world, to evaluate the extinction risk of species and subspecies. The 2000 Red List contains assessments of more than 18,000 species, 11,000 of which are threatened. The Red List also provides information to international agreements such as the Convention on Biological Diversity and the Convention on International Trade in Endangered Species of Wild Fauna and Flora.

STATUS OF THREATENED SPECIES

There are 11,046 species (5,485 animals, and 5,611 plants) listed as threatened (Critically Endangered, Endangered, or Vulnerable) on the 2000 Red List. Of these, 1,939 are listed as Critically Endangered (925 animals, and 1,014 plants). The percentages of threatened species of Angiosperms and four vertebrate groups categorized as Critically Endangered, Endangered, Vulnerable and at Lower Risk are shown in Figure 4.5 Of the species evaluated for risk in these major groups, 17-22% are critically endangered, and 34-51% are vulnerable. According to the Red List, in India, 44 plant species are critically endangered, 113 endangered and 87 vulnerable. Amongst animals, 18 are critically endangered, 54 endangered and 143 vulnerable (Figure 4.6). Some examples of threatened species in India are given in Table 4.3.

Table 4. 2 The IUCN Threat Categories.

Red list categor	Definition
Extinct	A taxon is Extinct when there is no reasonable doubt that the last individual has died.
Extinct in the wild	A taxon is Extinct in the wild when exhaustive surveys in known and/or expected habitats, have failed to record an individual.
Critically endangered	A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future.
Endangered	A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future.
Vulnerable	A taxon is Vulnerable when it is not Critically Endangered or Endangered, but is facing a high risk of extinction in the wild in the medium-term future.
Lower risk	A taxon is Lower Risk when it has been evaluated and does not satisfy the criteria for Critically Endangered, Endangered or Vulnerable.
Data deficient	A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction.
Not evaluated	A taxon is Not Evaluated when it has not yet been assessed against the above criteria.

Table 4. 3 Examples of Threatened Species in India

Category	Plants	Animals
Critically Endangered	*Berberis nilghiriensis*	*Sus salvanius* (Pigmy hog)
Endangered	*Bentinckia nicobarica*	*Ailurus fulgens* (Red Panda)
Vulnerable	*Cupressus cashmeriana*	*Antilope cervicapra* (Black buck)

CONSERVATION OF BIODIVERSITY

We know that ecosystems are undergoing change due to pollution, invasive species, overexploitation by humans, and climate change. Most people are beginning to recognize that diversity at all levels - gene pool, species and biotic community is important and needs to be conserved. We should not deprive the future generations from the economic and aesthetic benefits that they can derive from biodiversity. The decisions we make now, as individuals and as a society, will determine the diversity of genes, species and ecosystems that remain in future. We may appreciate the fact that the most effective and efficient mechanism for conserving biodiversity is to prevent further destruction or degradation of habitats by us. We require more knowledge to conserve biodiversity in reduced space and under increased pressure of human activities. There are two basic strategies of biodiversity conservation, *in situ* (on site) and *ex situ* (off site).

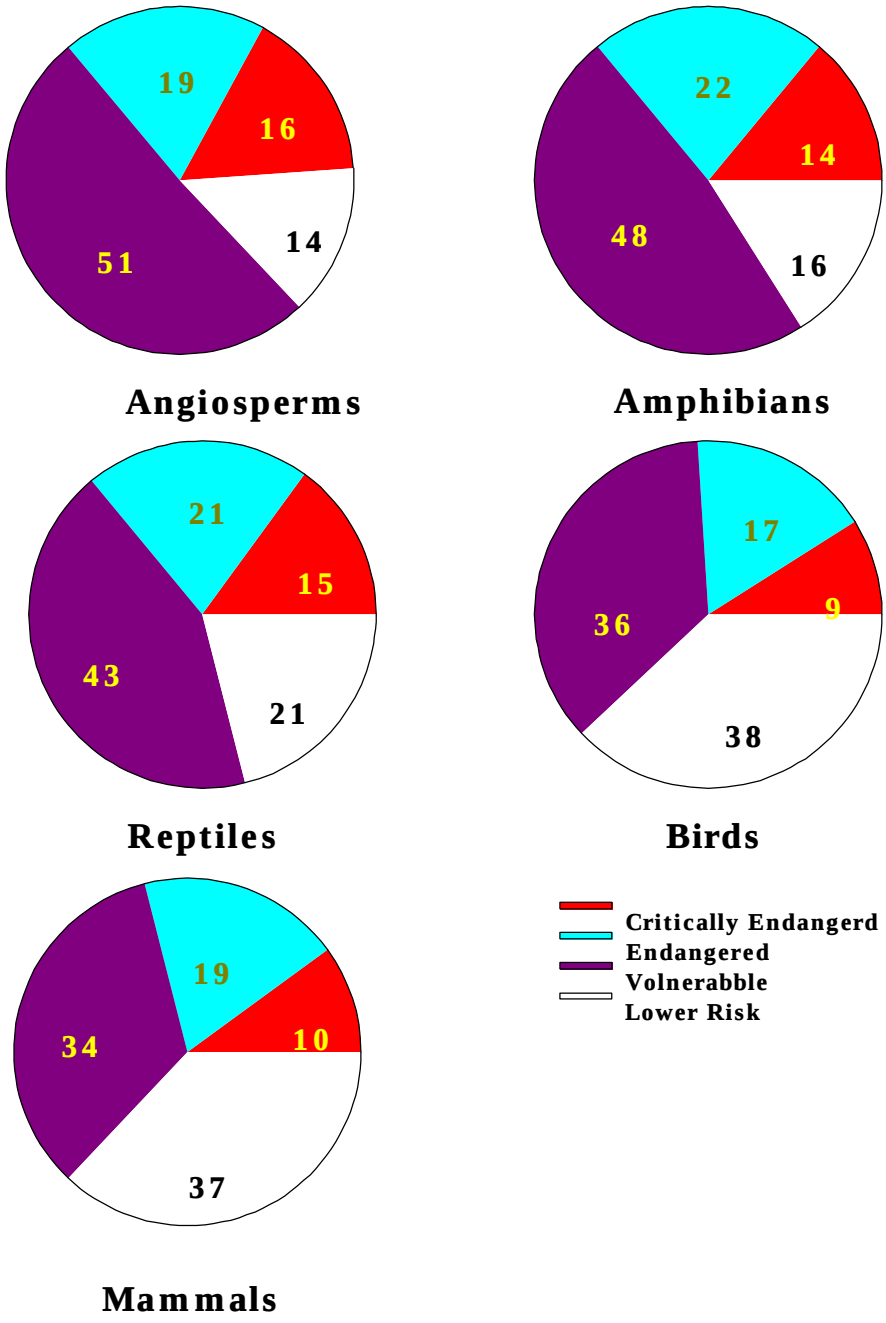


Fig. 4.5 The percentage of threatened angiosperms, amphibians, reptiles, birds and mammals categorized as Critically Endangered, Endangered, Vulnerable and at Lower risk

In situ Conservation Strategies

The *in situ* strategy emphasizes protection of total ecosystems. The *in situ* approach includes protection of a group of typical ecosystems through a network of protected areas.

Protected areas: These are areas of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources. These are managed through legal or other effective means. Examples of protected areas are National Parks, and Wildlife Sanctuaries. World Conservation Monitoring Centre has recognized 37000 protected areas around the world. As of September 2002, India has 581 protected areas (89 National Parks and 492 Wildlife Sanctuaries), covering 4.7% of the land surface as against 10% internationally suggested norm. The Jim Corbett National Park was the first National Park established in India.

Some of the main benefits of protected areas are:

(1) maintaining viable populations of all native species and subspecies;

(2) maintaining the number and distribution of communities and habitats, and conserving the genetic diversity of all the present species;

(3) preventing human-caused introductions of alien species; and

(4) making it possible for species/habitats to shift in response to environmental changes.

Biosphere Reserves: Biosphere reserves are a special category of protected areas of land and/or coastal environments, wherein people are an integral component of the system. These are representative examples of natural biomes and contain unique biological communities. The concept of Biosphere Reserves was launched in 1975 as a part of the

UNESCO's Man and Biosphere Programme dealing with the conservation of ecosystems and the genetic resources contained therein. Till May 2002, there were 408 biosphere reserves located in 94 countries. There are 13 biosphere reserves in India and are shown in Figure 4. 7. In India, Biosphere Reserves are also notified as National Parks.

A Biosphere Reserve consists of core, buffer and transition zones. The natural or core zone comprises an undisturbed and legally protected ecosystem. The buffer zone surrounds the core area, and is managed to accommodate a greater variety of resource use strategies, and research and educational activities. The transition zone, the outermost part of the Biosphere Reserve, is an area of active cooperation between reserve management and the local people, wherein activities like settlements, cropping, forestry and recreation and other economic uses continue in harmony with conservation goals.

The main functions of biosphere reserves are:

(1) **Conservation**: to ensure the conservation of landscapes, ecosystems, species and genetic resources. It also encourages traditional resource use.

(2) **Development**: to promote economic development, which is culturally, socially and ecologically sustainable.

(3) **Scientific research, monitoring and education**: the aim is to provide support for research, monitoring, education and information exchange related to local, national and global issues of conservation and development.

Sacred forests and sacred lakes: A traditional strategy for the protection of biodiversity has been in practice in India and some other Asian countries in the form of sacred forests. These are forest patches of varying dimensions protected by tribal communities due to religious sanctity accorded to these forest patches. The sacred forests represent islands of

pristine forests (most undisturbed forests without any human impact) and have been free from all disturbances; though these are frequently surrounded by highly degraded landscapes. In India sacred forests are located in several parts, e.g. Karnataka, Maharashtra, Kerala, Meghalaya, etc., and are serving as refugia for a number of rare, endangered and endemic taxa. Similarly, several water bodies (e.g. Khecheopalri Lake in Sikkim) have been declared sacred by the people leading to protection of aquatic flora and fauna.

Ex-situ Conservation Strategies

The *ex-situ* conservation strategies include botanical gardens, zoos, conservation stands, and gene, pollen, seed, seedling, tissue culture and DNA banks. Seed gene banks are the easiest way to store germplasm of wild and cultivated plants at low temperature in cold rooms. Preservation of genetic resources is carried out in field gene banks under normal growing conditions.

In vitro conservation, especially by cryopreservation in liquid nitrogen at a temperature of –196 ^{o}C, is particularly useful for conserving vegetatively propagated crops like potato. Cryopreservation is the storage of material at ultra-low temperature either by very rapid cooling (used for storing seeds) or by gradual cooling and simultaneous dehydration at low temperature (used for tissue culture). The material can be stored for a long period of time in compact, low maintenance refrigeration units.

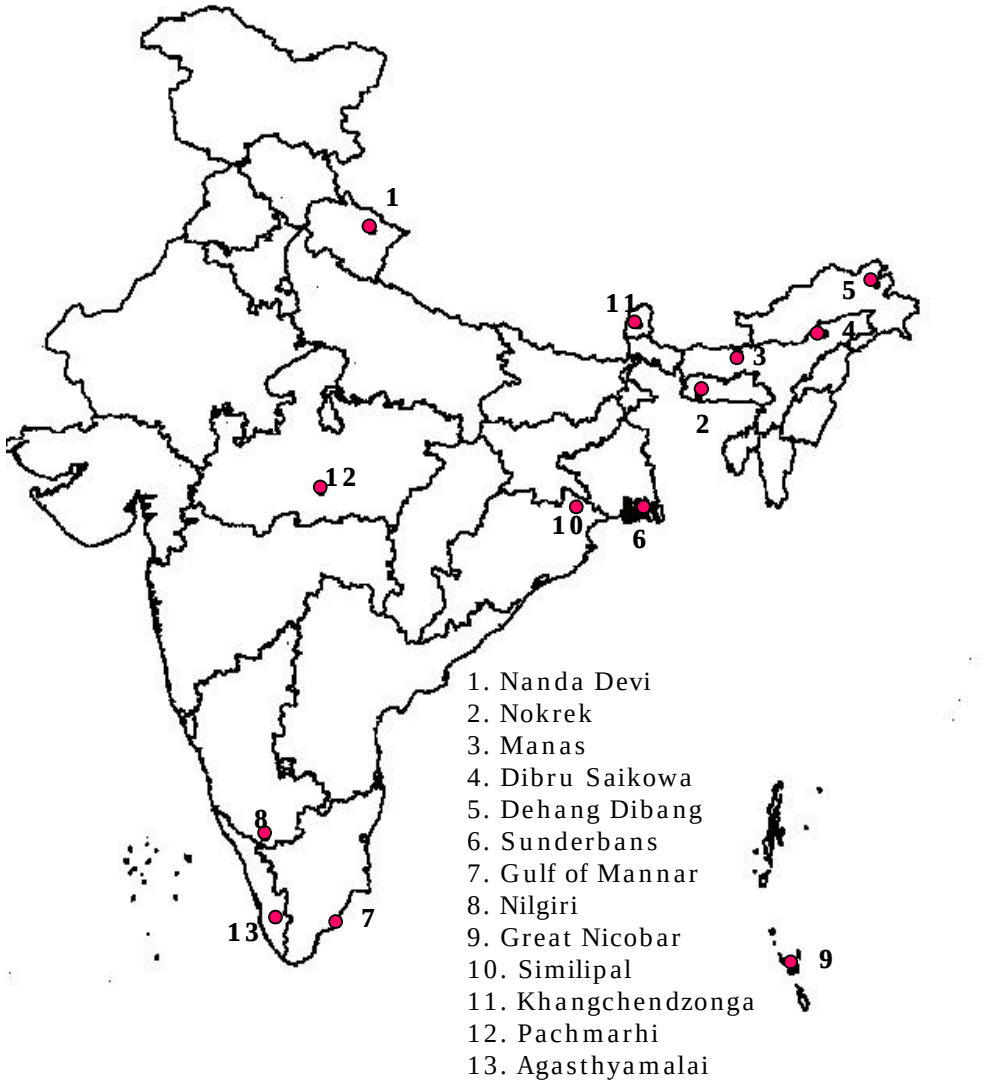


Fig. 4.7 The Biosphere Reserves in India

Conservation of biological diversity in botanical gardens is already in practice. There are more than 1500 botanical gardens and arboreta (botanical gardens where specific tree and shrub species are cultivated) in the world containing more than 80,000 species. Many of these now have seed banks, tissue culture facilities and other *ex situ* technologies. Similarly there are more than 800 professionally managed zoos around the world with

about 3000 species of mammals, birds, reptiles and amphibians. Many of these zoos have well-developed captive breeding programmes.

The conservation of wild relatives of crop plants and the off-site conservation of crop varieties or cultures of microorganisms provide breeders and genetic engineers with a ready source of genetic material. Plants and animals conserved in botanical gardens, arboreta, zoos and aquaria can be used to restore degraded land, reintroduce species into wild, and restock depleted populations.

International efforts for conserving biodiversity

The Earth Summit held in 1992 at Rio de Janeiro resulted into a Convention on Biodiversity, which came into force on 29 December 1993. The convention on Biodiversity has three key objectives:

(1) Conservation of biological diversity,

(2) Sustainable use of biodiversity, and

(3) Fair and equitable sharing of benefits arising out of the utilization of genetic resources.

The World Conservation Union and the World Wide Fund for Nature (WWF) support projects worldwide to promote conservation and appropriate development of Biosphere Reserves.

Biodiversity conservation in India

Indian region has contributed significantly to the global biodiversity. India is a homeland of 167 cultivated species and 320 wild relatives of crop plants. It is the centre of diversity of animal species (zebu, mithun, chicken, water buffalo, camel); crop plants (rice, sugarcane, banana, tea, millet); fruit plants and vegetables (mango, jackfruit,

cucurbits), edible diascoreas, alocasia, colocasia; spices and condiments (cardamom, black pepper, ginger, turmeric); bamboos, brassicas, and tree cotton. India also represents a secondary centre of domestication for some animals (horse, goat, sheep, cattle, yak, and donkey) and plants (tobacco, potato and maize).

The Ministry of Environment and Forests is carrying out the in situ conservation of biodiversity through Biosphere Reserves, National Parks, Wildlife Sanctuaries and other protected areas. The joint forest management systems involve forest departments and local communities. This enables the tribal people and local communities to have access to non-wood forest products and at the same time protect the forest resources.

The National Bureau of Plant, Animal and Fish Genetic Resources has a number of programmes to collect and conserve the germplasm of plants and animals in seed gene banks, and field gene banks for *in vitro* conservation. Botanical and zoological gardens have large collections of plant and animal species in different climatic regions of India

The land races and diverse food and medicinal plants are also being conserved successfully by the tribal people and women working individually or with various non-governmental agencies. The women particularly have an important role in the conservation of agrobiodiversity. In India, a programme is underway to develop a system of community registers of local informal innovations related to the genetic resources as well as natural resource management in general.