11. BIO-DIVERSITY

Meaning and Definition

The term 'bio-diversity' (biological diversity) was first used by **Lovejoy** (1980) and is most commonly used to describe the number of species. All species, from the smallest micro organisms to the great blue whales, are biological resources. Living things are generally classified into five kingdoms : Monera, Protista, Fungi, Plantae, and Animalia. The word 'bio-diversity' has become synonymous with life on earth. **DeLong** (1996) states "Bio diversity is an attribute of an area and specifically refers to the variety among living organisms, assemblages of living organisms, biotic communities, and biotic processes, whether naturally or modified by humans."

Biological diversity, or **bio-diversity** refers to the variety of life forms that inhabit the earth. The United States Office of Technology Assessment (1987) defines biological diversity as "the variety and variability among living organisms and the ecological complexes in which they occur." This concept can be sub-divided into three levels : (1) genetic diversity, (2) species diversity, and (3) ecosystem diversity.

1. Genetic diversity refers to the variations among the members of a single population of a species. Each member has unique **genotype,** the individual's complement of **genes,** the fundamental physical units of heredity that transmit information from one cell to another and thus from one gerieration to another. The heredity material of an organism is known as its **germ plasm.** The sum of all the genes present in a population of organisms is known as a **gene pool.**

2. Species diversity describes the variety of species within a region. We often think of bio-diversity at the level of species diversity, the millions of distinct species that inhabit this planet. Scientists have formally identified approximately 1.4 million species. But this number represents only the species that they have named and categorized. Researchers have studied just 3% of these. The fact is that we do not even know how many species exist, not even to the nearest order of magnitude. Estimates of the total number of species range from 5 to 100 million, most of them microbes, insects, and tiny sea organisms. Only estimated 1% of all species is larger than a bumble bee. According to **Terry Erwin,** a biologist at the Smith Sonian Institution who conducted a famous study in the tropical rainforest of Panama in the early 1980s. There exists a tremendous number of previously unknown beetle species. On the basis of this study he estimated the total number of insect species done at 30 million. **Edward O. Wilson** and **Paul Ehrlich** (1991), both famous biologists, estimated that there may be as many as 100 million species.

Wilson and Ehrlich pointed out that little study has been devoted to nematodes, fungi, mites, and bacteria, each of which is highly diverse, containing undescribed species that may total in the hundreds of thousands.

3. **Ecosystem diversity** refers to the number and distribution of variety of habitats, biotic communities, and ecological processes in the biosphere. Some entire ecosystems, such as rainforests and coral reefs are just as endangered as the individual species that inhabit them.

Keystone Species

Within biological communities, some species may be important in determining the ability of large number of other species to persist in the community. These crucial species have been termed **Keystone species.** (Paine, 1966; Terborgh, 1986; Howe, 1984). To protect keystone species is a priority for conservation efforts, because if a keystone species is lost from a conservation area, numerous other species might be lost as well. For example, the severe decline and extinction of many species of pteropid bats, or flying foxes, in the Old World tropics had a dramatic effect upon many important plant species in the islands of the Pacific and Indian Oceans. Some biologists fear that the loss of flying fox species invites an ecological disaster that could profoundly affect human societies in these regions. Flying foxes are widespread throughout the Old World Tropics. About 50 species of the genus *Pteropus* are concentrated in the islands of the South Pacific where they are the only pollinators and seed dispersers for hundreds of species of tropical plants. Many plant species are entirely dependent upon bats for pollination and seed dispersal. Extinction of flying foxes is thus potentially devastating for these bat-dependent plant species of economic value to local and international markets. Such plant species include important timber species like ebony and mahogany, medicinal plants, and plants yielding fibres, dyes, and other products. Wild bananas are also bat-pollinated.

Many tropical insect species appear to be highly specialised in their feeding behaviour, subsisting on just one or a few related plant species. Extinction of each tropical plant species potentially results in an extinction cascade, with an additional loss of 10-30 insect species.

Among the most obvious keystone species are top predators, since they are often important in controlling herbivore populations. In many localities where gray wolves have been hunted to extinction by man, deer populations have exploded. The deer have then severely over grazed the habitat, eliminating many herbaceous plant species. The loss of these plants was detrimental to the deer and to other herbivores, including the insect community that fed on the plants.

The importance of a keystone species may hinge on highly specialised relationship between the keystone species and other organisms. In many tropical forests, fig trees and fig vines appear to be keystone species in the functioning of vertebrate communities. Fig flowers are pollinated by small, highly specialised fig wasps, which mature inside the developing fig fruit. Figs also provide a reliable source of food to primates, birds, and other fruit eating vertebrates. Thus, fig trees are a keystone species.

Distribution of Bio diversity

At its simplest level, diversity can be defined as the number of species found in a community, a measure known as **species richness.** Diversity is "a single statistic in which the number of species and evenness are compounded."

According to the World Conservation Monitoring Centre, WCMC, 1993 there exist 1.6 million

identified species, world wide. A large number unidentified, if it is done, are likely to be 17 million species, about 11 times more than those known at present.

Table 11.1 : No. of Species Worldwide

Species	Nos.
Insects	751,000
Plants	248,000
Other animals	281,000
Fungi	69,000
Protists	30,000
Algae	26,000
Bacteria	4,800
Viruses	1,000

Bio-diversity reigns supreme in the tropics and sub-tropics for the following reasons :

1. Over geological times the tropics have had a more stable climate than the temperate zones. In tropics, therefore, local species continued to live there itself, whereas in temperate zone they tend to disperse to other areas.
2. Tropical communities are older than temperate ones and, therefore, there has been more time for them to evolve. This could have allowed them greater degree of specialisation and local adaptation to occur.
3. Warm temperatures and high humidity in most tropical areas provide favourable conditions 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 not allow any single species to dominate and thus there is opportunity for many species to co-exist. On the contrary, in temperate zones 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 out crossing 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.

In the tropics, the following areas reveal a rich bio diversity : (*i*) tropical rainforests, (*ii*) coral reefs, and (*iii*) wetlands.

(*i*) Tropical rainforests : These forests are unparalleled in terms of number of species. Covering just 7% of the earth's surface, they are home to nearly half of all known species. According to the U.S. National Academy of Sciences, a typical patch of rainforest about 10 sq. km. contains as many as 1500 species of flowering plants, 750 tree species, 400 bird species, 150 butterfly species, 100 reptile species, 60 amphibian species, and an unknown number of insect species.

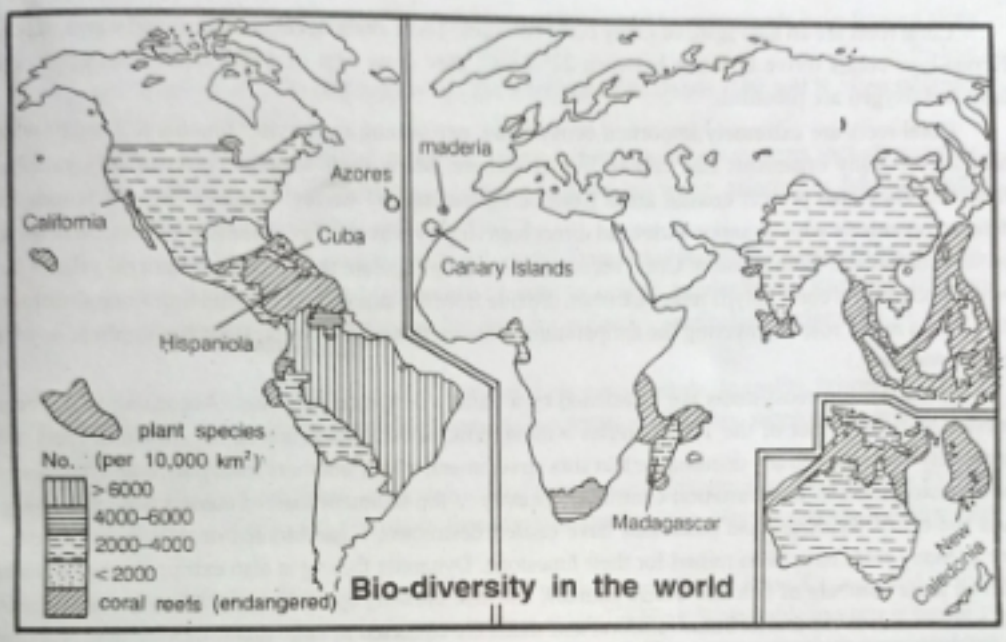

Fig. 11.1 : Global Bio diversity

Tropical rainforests perform invaluable ecosystem services. They help to moderate both global and regional climate. They are an important global sink for carbon dioxide. Large stretches of forest may help to offset global warming. At the regional level, the tropical forests play an important role in the hydrological cycle. Forests also hold the soil in place, minimizing erosion.

People in the developed world have benefitted greatly from the products of the tropical rainforests : pharmaceuticals, woods, fibres, fruits, nuts, vegetables, spices, gums, resins, oils, etc.

The tropical rainforests have been reduced by almost one-half their original area. Between 1981 and 1990, an estimated 9% of the world's tropical forest was lost. Some tropical forests have faced especially intense pressure, 98% of the tropical dry forest along the Pacific Coast of Central America is gone Massive deforestation continues in Brazil. Logging and agricultural expansion have destroyed over 95% of Brazil's once extensive Atlantic coastal rainforests and coniferous Araucaria forests in the south. Countries including Benin, Cote d'Ivoire, El Salvador, Ghana, Haiti, Nigeria, Togo have lost all their rainforests.

***(ii)* Coral reefs :** Coral reefs have been called the "rainforests of the oceans" because of the abundance and diversity of life found there. Australian's Great Barrier Reef (2000 km. long) is the world's largest coral reef ecosystem, containing more than 3000 animal species. The richest, most diverse coral reefs in the world are found in the Indo-West Pacific. These reefs contain more than 2,000 species of fish, 5,000 species of molluscs, 700 species of corals, and countless species of crabs, sea urchins, brittle stars, sea cucumbers, and worms. The diversity of coral reefs is largely due to great numbers of fish species many as yet unidentified. The reef building coral animals make this spectacular ecosystem possible.

Coral reefs are an aggregate of many coral colonies. These reefs develop in clear and warm waters. Herma-type corals thrive in water between 22°-28°C, they grow best in warm shallow waters where light and oxygen are plentiful.

Coral reefs are extremely important ecosystems, performing many vital functions. They provide habitats for many organisms that cannot live elsewhere. Many reefs support commercially valuable fisheries. They also protect coastal areas from being battered by waves. Lagoons provide homes for delicate organisms which cannot withstand direct battering by waves. This sheltering effect also helps to protect coastal soil from erosion. Coral reefs may also help regulate the amount of mineral salts in the world's oceans. As coral polyps remove carbon dioxide from the atmosphere to build limestone skeletons, they play a major role in lowering the temperature of the earth's surface in fact that has implications for global warming.

These unique ecosystems are threatened by a variety of human activities. According to a recent survey, reefs in 93 out of the 109 countries with significant coral reefs are damaged. Coral reefs are especially vulnerable to any disturbance that stirs up sediment, which smothers coral polyps and interfexes with photosynthesis. Deforestation contributes heavily to the sediment load of coastal waters. Sewage and run-off of fertilizers and pesticides have caused destructive algae blooms or poisoning of some reefs: Many reefs have been mined for their limestone. Dynamite fishing is also extremely destructive, killing large numbers of fish and others animals, and also blowing apart the coral infrastructure. Reefs also fall victim to the tourist industry. Coral and shells are collected in large quantities for sale. Nuclear testing is perhaps the most violent of human activities that affect coral. Coral reefs are also threatened by massive bleaching, now considered. The greatest threat to reefs worldwide. Scientists believe that bleaching of reefs is harbinger of global warming.

The worst hit areas include the Great Barrier Reef of Australia, the Philippines, Indonesia, Malaysia, Japan, Palau, Maldives, Tanzania, Seychelles, Belize, Ecuador and Florida.

With bleaching incidences becoming quite frequent, concern about their vulnerability to global warming has grown sharply. A widely lifed 1993 report asserted that 10% of the world's reef were dead another 30% were likely to die by 12012. Another study published in 2000 painted an even more scary picture by stating that 27% of the world's reefs have been lost. Another 14% are expected to die over the next decade and a further 18% would perish between 2010 and 2030, unless comprehensive efforts are made to protect them.

In India, coral reefs are on the verge of extinction. Marine pollution and global warming have played havoc with the country's reefs. According to latest data the following percentage of reefs—*i.e.* 80% in Lakshadweep, 60% in Gulf of Mannar and 30% in Gulf of Kachchh have been bleached.

Since adverse effects of global warming cannot be immediately countered, actions to save the reefs should be centred around making them protected zones. Practices such as fishing with explosive or cyanide should be banned. Saving measures also include preventing the run-off of sewage and fertilizers, which spur the proliferation of algae that then choke the reefs. However, most scientists believe that complete coral recovery is not possible as the government has failed to stop industries from polluting oceanic environment.

3. Wetlands : Wetlands are transitional zones between land and water. They are among the most

biologically interesting and productive but least understood habitats. Many wetlands have formed along river banks or near river deltas.

The presence of water is the distinguishing characteristic of wetlands. The soil is often saturated long enough to become anaerobic.

There are two major categories of wetlands : inland (fresh water ecosystems include marshes, swamps, riverine wetlands and bogs) and coastal (either fresh or salt water, affected by tides; *e.g.* tidal salt marshes, tidal fresh water marshes, and mangroves).

Fresh water marshes are areas of incredible diversity. Dominated by emergent grasses and sedges, wild rice, etc. they have a high pH high levels of nutrients, high productivity, and high rates of decomposition. Marshes are very important habitats for wildlife, particularly migratory birds and waterfowl.

'Swamp' may evoke feelings of repulsion or dread for many people, in reality, however, they are hauntingly beautiful. Swamps are dominated by woody vegetation. Reptiles, amphibians and fish are common denizens of swamps.

Riverine or **riparian wetlands,** commonly called flood plains, undergo periodic flooding. During flooding, they receive a high input of nutrients from the surrounding area. Hardwoods are the dominant vegetation.

Bogs are generally found in cooler regions such as north-eastern United State, Canada, and British Isles. Some tropical countries, such as Indonesia, possess extensive bogs. Water table in a bog is typically high. The water is static and the land is permanently waterlogged. The oxygen supply is soon depleted and there is a slow rate of decomposition. Peat deposits accumulate. Nutrients remain locked up in plant and animal matter and are not quickly recycled through the ecosystem. Consequently, the productivity of a bog is low.

Dried peat burns well, and has been used for fuel for centuries. It is also harvested for use as humus to improve the soil, or for use in potting compost. Destruction of peat bogs may have implications for global warming, as, when dug it releases carbon into the atmosphere.

Coastal wetlands exhibit great variety. **Tidal salt marshes** occur along the coastlines of the mid-latitudes, and are replay by **mangroves** in the subtropics and tropics. They are formed near river mouths, in bays, along protected coastal plains, and around protected lagoons. Salt tolerant grasses are the dominant vegetation in salt marshes. These wetlands are very productive ecosystems but much of the primary productivity is washed out with the tides and is utilized by aquatic communities.

Tidal fresh water marshes combine features of tidal salt water marshes and inland fresh water marshes. But species diversity is very high because of the absence of salt stress. Tidal fresh water marshes are used by more birds than any other type of marsh.

The **mangrove swamp** is the dominant type of coastal wetland in tropical and sub-tropical regions. It is a forested wetland. Mangroves cover approximately 16 million hectares world wide, with the largest concentration in tropical Asia. The largest mangroves in the world is the Sundarbans, along the lower Ganges Delta in Bangladesh. Mangrove is a general term referring to any tree that can survive partly submerged in the relatively salty environment of coastal swamps. Mangrove swamps protect shorelines from the erosive force of ocean tides and minimize storm damage. They also protect coral reefs and other off-shore areas from land-based pollution.

Both coastal and inland wetlands are valuable reservoirs of bio-diversity. They are important nesting and feeding habitats for birds and water fowl and nurseries for fish and shell fish.

Wetlands throughout the world are threatened. Australia and New Zealand have lost over 90% of their wetlands. In the United States over half of the original wetlands have been lost. Mangrove swamps have been significantly reduced in size in Africa, Latin America, and Western Asia. Logging to produce pulpwood and charcoal and conversion to aquaculture ponds are the chief threats.

Wetlands in India

Ramsar Convention defines wetlands as "areas of marsh or fen, peat-land or water, whether artificial or natural, permanent or temporary, with the water that is static or flowing, a fresh brackish or salt including areas of marine water, the depth of which at low tide does not exceed six meter." Mangroves, corals, estuaries, bays, creeks, flood plains, sea grasses, lakes, etc. are covered under the definition. At present, there exist 66 wetlands covering 22 states in the country. Besides, 35 mangrove areas have been identified for intensive conservation and management. Mangroves in India comprise 69 species under 42 genera and 28 families. India is home to some of the best mangroves in the world. Two mangrove species are endemic to India. One species, namely *Rhizophora annaimalayana* occurs in Pichavaram (Tamilnadu), while another species *Heritiera Kanikensis* exists only in Bhitar-Kanika (Orrisa). Sundarbans (West Bengal) have been included in the World List of Biosphere Reserves by UNESCO.

Table 11.2 : Mega Diversity Countries and their Species Richness

Country	Plants	Mammals	Birds	Reptiles	Amphibians	Fresh water fish
1. Brazil	56,000	524	1622	468	517	73,000
2. Colombia	51,000	456	1815	520	583	77,500
3. Indonesia	37,000	515	1531	511	270	1400
4. Mexico	30,000	450	1050	717	284	468
5. Australia	15,638	282	751	755	196	183
6. India	71,700	350	1258	408	206	750
7. China	39,000	499	1244	387	274	1010
8. Madagascar	12,000	105	253	300	178	75
9. Peru	20,000	344	1703	298	241	855
10. Papua New Guinea	21,000	242	772	305	200	282
11. Ecuador	21,100	271	1559	374	402	744
12. USA	18,956	428	768	261	194	790
13. Venezuela	21,070	288	1360	293	204	1250
14. Malaysia	15,000	286	738	268	158	600
15. South Africa	23,420	247	774	299	95	153
16. Dem. Rep. Congo	11,000	415	1094	268	80	962
17. Philippines	12,000	201	556	193	63	330

Source : Mittermeier et al. (1997)

India as a Mega-Diversity Nation

India is one of the 17 mega-diverse countries which together possess 60-70 percent of the world's bio-diversity. Seventeen countries *i.e.* Bolivia, Brazil, China, Colombia, Costa Rica, Democratic Republic of Congo, Ecuador, India, Indonesia, Kenya, Madagascar, Malaysia, Mexico, Peru, Philippines, South Africa and Venezuela have formed the Group of Like—Minded Mega diverse Countries (LMMC) which holds nearly 70% of the global bio-diversity.

The biological richness of India is shown in the following table :

Table 11.3 : Number of Species in India and the World

Group	No. of Species in India	No. of Species In the World	SI/SW %
Mammals	350	4,692	7.6
Birds	1224	9,702	12.6
Reptiles	408	6,550	6.2
Amphibians	197	4,552	4.4
Fishes	2546	21,730	11.7
Flowering Plants	15,000	250,000	6.0

India has many endemic plant and vertebrate species. Among plants, species endemism is estimated at 33%. North east India, Western Ghats and the Himalayas are rich in endemism. A small pocket of endemism also occurs in the Eastern Ghats. The Gangetic plains are generally poor in endemics, while the Andaman and Nicobar Islands contribute at least 220 species to the endemic flora of India. The Agastyamala Hills, Silent Valley and New Amarambalam Reserve and Periyar National Park (all in the Western Ghats) and the Eastern and Western Himalayas have been identified as important areas for conservation action by the WCMC.

Endemism among mammals and birds is relatively low. Only 44 species of Indian mammal have a range that is confined entirely to within Indian territorial limits. Four endemic species for conservation significance occur in the Western Ghats : (*i*) Lion tailed mocaque, (*ii*) Nilgiri leaf monkey, Nilgiri Langur, (*iii*) Brown Palm Civet, and (*iv*) Nilgiri tahr.

Only 55 bird species are endemic to India, concentrated in areas of high rainfall. They are located mainly in eastern India along the mountain chains, Western Ghats, and the Andaman and Nicobar Islands.

In contrast, endemism in the India reptilian and amphibian fauna is high. There are around 187 endemic reptiles, and 110 endemic amphibian species, 8 amphibian genera are not found outside India. The most notable among the endemic amphibian genera is the monotypic *melanobrachus* which is restricted to the Anaimalai Hills.

Extinction of Species

The most serious aspect of the loss of bio-diversity 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 goes extinct, its chances for further evolution are lost. A species is considered extinct when no member of the species remains alive anywhere in the world.

There have been six major episodes of extinction during the past geological times.

1. Ordovician (500 million years ago) when 50% animal families, including many trilobites, were eliminated.

2. Devonian (400 million years ago) when 30% of animal families, including agnathan and placoderm fishes and many trilobites became extinct.

3. Permian (250 million years ago) when again 50% of animal families, including over 95% of marine species, many trees, amphibians, most bryozoans and brachiopods, and all trilobites were eliminated.

4. Triassic (180 million years ago) when 35% of animal species, including many reptiles and marine molluscs, were eliminated.

5. Cretaceous (65 million years ago) when ruling reptiles (dinosaurs) and many marine species, including many foraminiferans and molluscs, became extinct, and

6. Pleistocene (1 million years ago) when large mammals and birds became extinct.

All these extinctions were the result of major changes occurring on Earth, Present-day extinctions, although not so extensive, are serious enough to merit concern. These are caused entirely by human being. The present spell of extinction is different from the earlier ones because renewals are not in sight. While there is some idea about endangered species, authentic data on the species that have become extinct in the present spell is not available.

Human activity is a major threat to bio-diversity. The first noticeable effects of human activity on extinction rates can be seen in the elimination of large mammals from Australia, North and South America at the time Europeans first colonised these continents. For thousands of years the natural grasslands and forests in North and Central America, Europe and Asia have been steady reduced to create pastures and farmlands to supply human needs. The highest species extinction rates during historic times have occured on islands.

Looked at on a geological time scale, the planet's bio-diversity has always been faced with threats of one form or another. But, at present, the threat is more pronounced than every species loss is said to be 27,000 every year. The main reason behind this loss is degrading natural habitats. An assessment of bio-diversity data from 102 countries done by United Nations Environment Programme indicates that in the most densely populated 51 countries (averaging 168 people per sq. km.), 5.1% of bird species and 3.7% of plant species were threatened. On the other hand, in the 51 less populated countries (averaging 22 people per sq. km.), the proportions of threatened species were only half as high at 2.7% and 1.8% respectively. (—April 30, 2002 Down to Earth)

(Majority of the world's gene banks are situated in or near the richest regions of bio-diversity.)

The protection of rare species is an important focus of conservation efforts. **Rare** species are considered to be especially vulnerable to extinction. A species may be considered rare if it occupies a narrow geographical range, like the Venus's fly trap (*Dionaea muscipula*) occurring only in the Savanna plains of the coastal plains of North and South Carolina in eastern U.S.A. A species may also be considered rare if it occupies only one or a few specialised habitats, e.g. salt marsh cord grass (*Spartina patens*) is found only in salt marshes. Finally, a species may be considered rare if it is found only in small populations. A species that is found in only a single geographical area and nowhere else is termed **endemic** to that area.

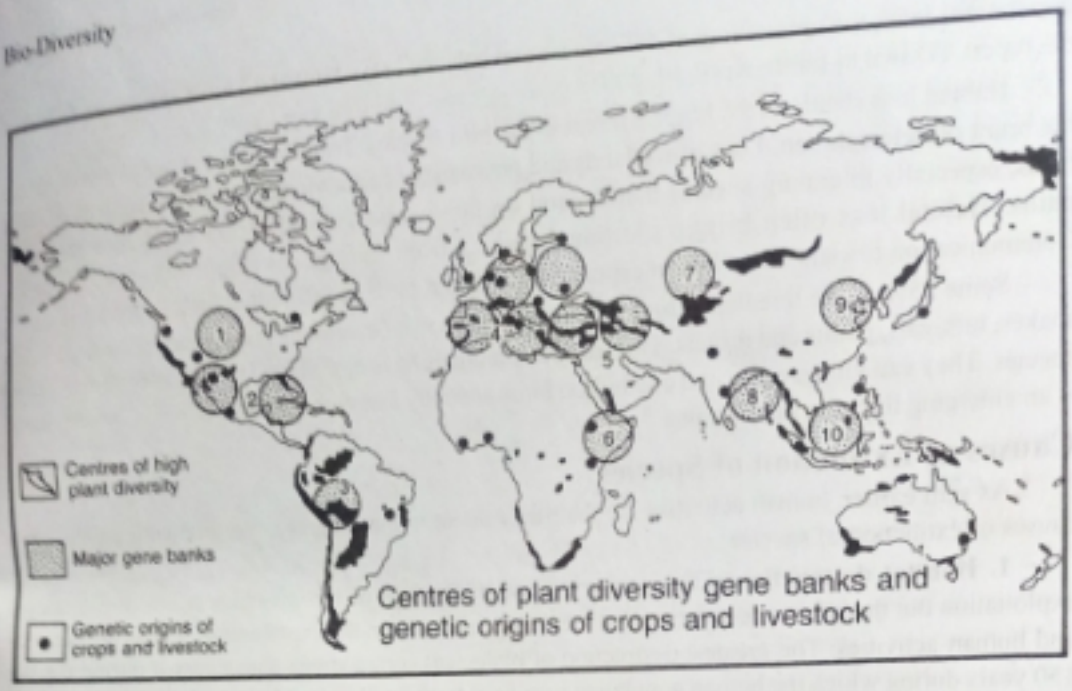

Fig. 11.2 : Centres of plant diversity, gene banks and genetic origins of crops and livestock

To highlight the legal status of rare species for the purpose of conservation, the IUCN (1984, 1988) has established the following five main conservation categories :

1. **Extinct** species that are no longer known to exist in the wild.

2. **Endangered** species that have a high likelihood of going extinct in the near future.

3. **Vulnerable** species that may become endangered in the near future because of decreasing size of their population.

4. **Rare** species that have small total number of individuals often due to limited geographical ranges or low population densities.

5. **Insufficiently known** species that probably belong to one of the conservation categories but are not sufficiently well known to be assigned to a specific category.

Mace and **Lande** (1991) have proposed a three level system of classification based on the probability of extinction :

1. **Critical species** with a 50% or greater probability of extinction within five years or two generations, which ever is longer.

2. **Endangered species** with a 20% probability of extinction within twenty years or ten generations.

3. **Vulnerable species** with a 10% probability of extinction within hundred years.

Bird species, in particular, face a wave of extinction not seen on the earth since the dinosaurs became extinct some 65 million years ago, according to a report from the Worldwatch Institute. Pressures from a human population of more than 6.2 billion have put about 12% of the world's 9800 bird species of the risk of extinction, states the report *Winged Messengers : The Decline of Birds*. "Declining bird

populations mark the unravelling of delicate natural balance" says **Howard Youth,** one of the authors of the report. (Down to Earth, April 30, 2003).

Habitat loss stands as the biggest threat to the bird species. Tropical species have in particular felt the brunt of deforestation. Loss of wetlands and grasslands is also wiping out critical habitats of many birds, especially migrating species that depend on these areas for and shelter along their migratory paths. Habitat loss often brings additional threats from human developments, such as roads. Communication fowlers alone kill an estimated 40 million birds in the United States each year.

Some 25% of the threatened bird species are at the risk because of non-native species, including snakes, rats, cats, plants and insects. Till date, these animals have contributed to the extinction of 22 bird species. They can kill an estimated one billion birds annually just within United States. Climate change is an emerging threat to bird species.

Causes of Extinction of Species

As said earlier, human activities are the major threat to bio-diversity, the following are the chief causes of extinction of species :

1. Habitat destruction : The primary cause of the loss of bio-diversity 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 during which the human population increased from 1 billion in 1850 to 6 billion in 2000 A.D. Loss of habitat is the primary threat to majority of vertebrates currently facing extinction. In many countries, particularly on islands, and in densely populated areas, 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 (14 CN, UNEP, 1986). In tropical Asia 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, large industrial and commercial activities such as mining, cattle ranching, commercial fishing, forestry, plantation, agriculture, manufacturing, etc. have been the major factors causing habitat destruction. Huge amounts of habitat are lost each year as the world's forests are cut down. Rainforests, tropical dry forests, wetlands, mangroves and grasslands are threatened habitats.

2. Habitat fragmentation : Habitat fragmentation is the process where a large continuous area of habitat is reduced and divided into pieces by roads, fields, towns, canals, power lines, etc. When habitat is destroyed there is often a patch work of habitat fragments left behind. These fragments are often isolated from one another by a highly modified or degraded landscape. Habitat fragmentation may limit the potential of species for dispersal and colonisation. It also reduce the foraging ability of animals. Habitat fragmentation causes such edge effects as micro-climatic 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. Similarly, boating and diving in coral reef areas degrade the fragile species. The most subtle form of habitat degradation is

environmental pollution caused by pesticides, industrial wastes, chemicals, emissions from factories and automobiles, etc.

4. Introduction of exotic species : Even when biological communities are infacts, significant losses can take place due to introduction of exotic species. European colonisation, horticulture and agriculture, and accidental transport are the chief factors introduction of exotic species. The great majority of the exotic species do not become established is the new places, however, some of the species are able to establish in new area. Such exotic species may kill native species to the point of extinction, or may so alter the habitat that many native species are no longer able to persist. The effect of exotic species is maximum on islands.

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 dispersed over a large area. Animals are more prone to infection when they are under stress. Animals kept in capitivity are also more prone to higher level of disease.

6. Over exploitation : Increasing human population has escalated the use of natural resources. In earlier times, there existed some controls to prevent over exploitation of resources, but now resources are being exploited rapidly. Growing rural poverty, increasing efficient methods of harvesting, and the globalisation of the economy combine to exploit species to the point of extinction. Over exploitation threatens about one third of the endangered vertebrates in the world, as well as other species.

7. Shifting cultivation : Some tribal groups practise shifting cultivation also called 'slash and burn' agriculture known by different names in different localities, *e.g.* 'Jhum' in north-eastern India, 'Swidden' in Europe, 'Ladang' in Malaysia and Indonesia, 'Caingin' in Philippines, etc. Shifting cultivation greatly affects forest structure and species composition. Plots of natural tree vegetation are cut clear and burnt away, and cleared patches are planted with crops for two or three years. When fertility declines, such plots are abandoned and new patches are cleared for cultivation. Jhum cultivation is the most common system practised by roughly five lakh tribal families. It has resulted into soil erosion and loss of fertility.

8. Over harvesting and illegal trade : Butterflies, parrots, lizard skins, rhinoceros horns, tortoise shells, orchids, elephant tusks, corals, and cacti all are part of the huge global trade in wildlife and wildlife products. Illegal trade in rare species is a serious drain on wild populations, driving them toward extinction. The World Wildlife Fund estimates that over 600 species of animals and plants worldwide face extinction as a result of the wild life trade, while another 2,300 animals and 24,000 plants are endangered.

9. Selective breeding : In many areas of the world modern crop hybrids have replaced naturally occuring strains and traditional strains bred by formers over centuries. It has resulted in the loss of rare and potentially valuable genes that carry traits such as resistance to pests or disease. The indespread use of hybrid strains are probably the most serious threat facing modern agriculture. Loss of genetic variability is a problem in domesticated animals as well as plants. In U.S.A. nearly half of the existing breeds of livestock are in danger of extinction.

Threatened Species

The World Conservation Monitoring Centre (WCMC) has evaluated and described threats to about 60,000 plant and 2000 animal species in its series of Red Data Books. Threatened species include those

which are endangered, vulnerable, and rare in IUCN categories. The great majority of the species on these lists of Red Data books are plants. However, there are also species of fish (343), amphibians (50), reptiles (170), invertebrates (1355), birds (1037), and mammals (497).

India contains 172 species of animal considered globally threatened by IUCN, or 2.9% of the world's total number of threatened species. These include 53 species of mammal, 69 birds, 23 reptiles and 3 amphibians. India contains globally important population of some of Asia's rarest animals such as the Bengal Fox, Asiatic Cheetah, Marbled Cat, Asiatic Lion, Indian Elephants, Asiatic Wild Ass, Indian Rhinoceros, Markhor, Gaur, Wild Asiatic Water Buffalo, etc.

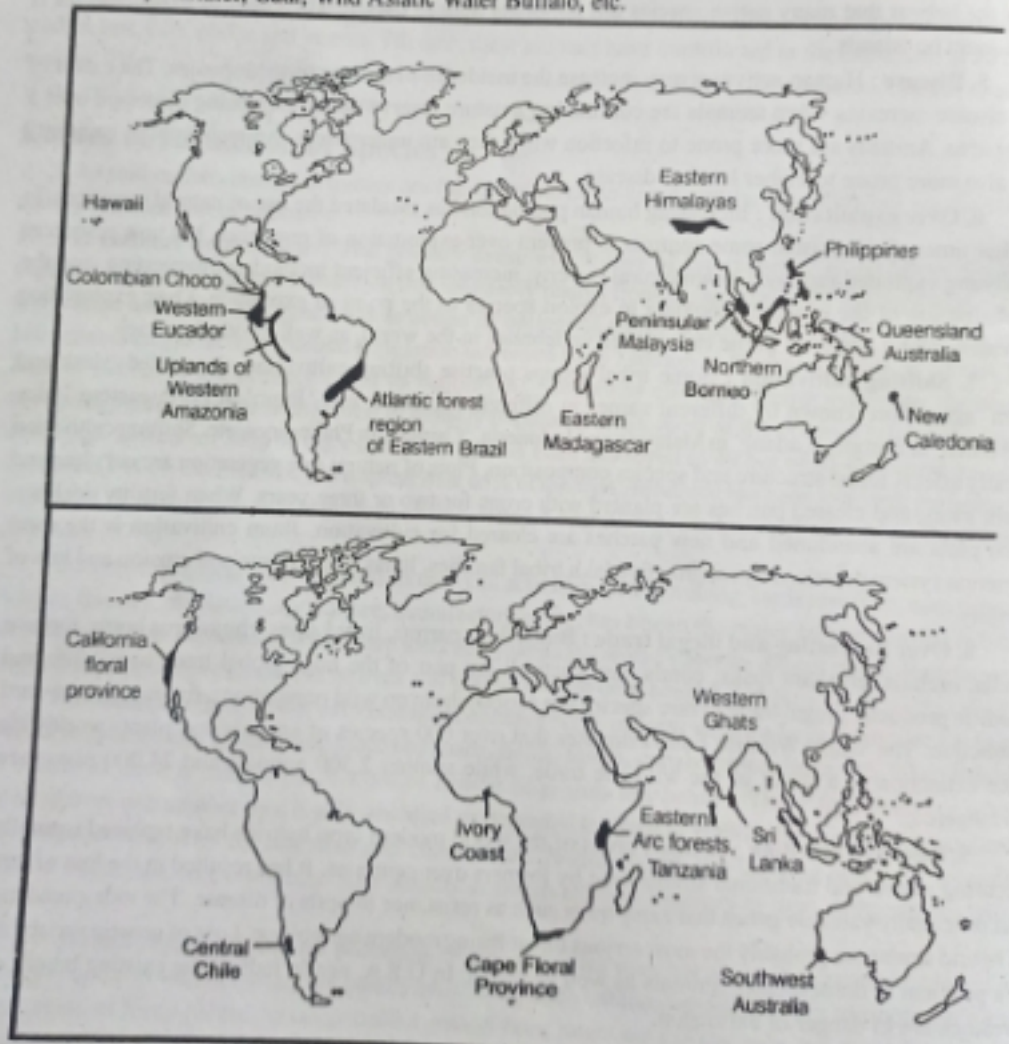

Fig. 11.3 : 'Hotspots' of high endemism and significant threat of imminent extinctions. (A) Twelve tropical rainforest hotspots. (B) Eight hotspots in other climatic ecosystems.

On priority basis, attempts have been made to identify tropical areas of the world that have rich bio diversity and a high level of endemism, and are under immediate threat of species extinction and habitat destruction—so called hotspots for preservation.

Myers (1988) identified 12 hotspots that together include 14% of the world's plant species in only 0.2% of its total land surface. Later, Myers (1991) included 8 non-forest habitats—four in the tropics, and four outside the tropics in Mediterranean type climates.

Conservation of Bio-diversity

Conservation of bio-diversity is advocated by all globally. Besides being of great economic value, bio-diversity is important from the viewpoint of ecology. It ensures the health of the biosphere by conserving soil, plant cover, water, chemical composition of air, and with the regulation of climate. Bio-diversity is the bed rock of biomass production, processing, and utilization, and the use of animals for food, energy, traction, and other purposes. This resource, though renewable, could also become finite because of the threat posed by human interference in the natural habitat. If this happens, the entire human civilization will be in jeopardy. (T.N. Khushoo, 1993). Therefore, while the human race cannot exist without bio-diversity, the latter can exist without the human race. Bio-diversity has to be saved for the long-term benefit and well being of the biosphere, including the human race.

The arguments in support of preserving biological resources and maintaining maximum biological diversity fall into five categories : (1) ecosystem services, (2) benefits to agriculture, medicine and industry, (3) aesthetics, (4) ethical considerations, and (5) evolutionary potential.

1. Ecosystem services : Ecosystems perform many services, such as chemical and nutrient cycling and soil generation, which are beneficial to humans. For example, each year, earth worms carry 2-63 metric tons of soil to the surface of each hectare of land, effectively aerating the soil. Eliminating living resources may hinder the ability of ecosystems to perform vital functions.

2. Benefits to agriculture, medicine and industry : Biological resources benefit agriculture in several ways. The genes of wild crop relatives may hold valuable characteristics, which, when introduced into crop species, can dramatically increase yields. Wild species are also the source of "new" food crops. Of the 80,000 edible plant species on earth, only a small percentage have been used as a food crop, and just 8 supply 75% of the human diet. Similarly, most of the protein from livestock is derived from just a domesticated animals. Thus, the global human diet is dependent on a few species. Agriculture also benefits from pollinating organisms such as bees and other insects. Without them, many vegetables and fruits would not be produced.

Many important pharmaceuticals originated from biological sources. Moreover, biological resources are valuable as a source of medicines and drugs. Animals also provide valuable medicinal commodities, including hormones, thyroid extracts, and estrogens.

Industry—tourism, recreation, and manufacturing realizes significant economic benefits from biological resources. Parks, reserves, and wild life sanctuaries are becoming increasingly popular as places to view and enjoy wild species. Manufacturing industries owe a tremendous economic debt to biological resources.

3. Aesthetics : Biologically rich areas such as the tropical rainforests are often considered most awe-inspiring regions of the earth. Wild species imbue the earth with much of its beauty, grandeur and mystery.

4. Ethical Considerations : There are strong bio-ethical arguments for the protection of bio-diversity, which have there roofs 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 bio-diversity appeal to the nobler instincts of people, and are based on wildly held truths. Some of the key ethical arguments for conservation of bio-diversity are given as under :

1. Each species has a right to exist. Each species has a value for its own sake, an intrinsic value, unrelated to human needs.
2. All species are inter-dependent. 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 bio-diversity.
8. Nature has spiritual and aesthetic values that transcend economic value.
9. Bio-diversity is needed to determine the origin of life.
10. Deep ecology begins with the premise that all species have value in themselves, and that humans have no right to reduce this richness. For enhancing the quality of life of people, there is need to emphasise improvement in environmental quality, aesthetics, culture and religion rather than higher levels of material consumption. Deep ecology urges professionals and all concerned people to escape from their narrow, everyday concerns and to act and live "as if nature mattered."

5. Evolutionary potential : Michael E. Soule and **Bruce A. Wilcox,** the noted conservation biologists, opine that cessation of significant evolution of new species of large plants and animals is more shocking than the unprecedented wave of extinction of species. All of the previous arguments are strong and convincing reasons to preserve bio-diversity now and in future.

Management of Biological Resources

A Historical Perspective

One of the earliest known gardens of exotic species was a collection of medical plants established by the Chinese Emperor Shen Nung, about 2,800 B.C. In the tenth and eleventh centuries, the Islamic Moors of the Iberian Peninsula created gardens of plants from distant places like India for the purpose of pleasure, inspiration and study. During the Middle Age in Europe and the Middle East, collecting and cultivating fruit trees and ornamentals was seen as a way of recreating Eden. In the seventeenth and eighteenth centuries, the study of medicinal plants became quite popular throughout Europe and eventually led to the establishment of botanical gardens in England, France, Scotland, Russia, etc. In the United States also privately owned