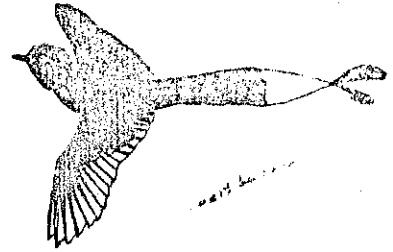




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ROLE OF PROTECTED AREAS IN CONSERVATION

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Role of Protected Areas in Conservation

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TRADITIONS of conservation are deeply rooted in the Indian civilization. The subcontinent, therefore, harbours nature reserves that range in date from the hunting-gathering times to the 1980s and in size from a small serpent grove in the middle of a village to a national park of some thousands of square kilometres.

The rationale for the protection afforded to living creatures in these reserves has also been changing with time, from the need to propitiate divine forces to providing game for the royal hunt and lately for the preservation of wild animals for their own sake. It is only in the last few years, however, that we have come to realize that man must protect nature to ensure his own well-being and that his self-interest is tied in with the preservation of not just a handful of species of current economic utility, but of the biological diversity as a whole. The one person who has played a greater role than all others in India in spreading an awareness of this value of the total spectrum of biological diversity is Dr B.P. Pal. We therefore deem it a great privilege to be called on to pay a tribute to him in the form of this essay.

We thought it would be most fitting if our essay focusses on the extent, the distribution and the conservation of the biological diversity of the Indian subcontinent, particularly in terms of the role of protected areas in this context. The total number of animal species described so far from the India adds up to 80,000; of these 67,000 are insects, 4,000 molluscs,

6,500 other invertebrates, 1,400 fishes, 140 amphibians, 420 reptiles, 1,200 birds and 340 mammals (Zoological Survey of India, 1980). Another 20,000 species of flowering plants have been described from India (Chatterjee, 1939). This implies that about 5 to 8% of the known species of animals and flowering plants occur in India with a land surface of only 2.2% of the world. It is certain that there would be many further additions when the little-studied invertebrates and lower plants are better investigated. Thus, Jain (1984) estimates that India harbours 20,000 species of fungi, 5,000 of algae, 1,600 of lichens, 2,700 of bryophytes and 600 of pteridophytes. The known 80,000 species of animals too would surely increase to 150,000 or so when invertebrates (especially those of smaller sizes and from habitats such as forest canopy), are more carefully looked at. It is therefore quite safe to estimate that India must harbour at least 200,000 species of living organisms. The challenge before us is to conserve this heritage of diversity for generations to come and the time for it is now. For any delay will only mean an irreversible loss of this precious biological heritage.

While we may save a few hundred, or at most a few thousand, of these species in botanical and zoological gardens and in deep freezers, it is clearly impossible to conserve the entire gamut of this tremendous variety through such artificial means. This can only be approached through the conservation of their natural habitats where they live as members of a community knit together in a web of life. Thus, the banks of fast-flowing Himalayan rivers, the rocks in the intertidal zone of the sea coast, and the north-facing slopes of Aravalli hills harbour their own assemblage of living organisms. These ecosystems are the natural units that go to constitute the biosphere, and the conservation of the total spectrum of our biological diversity has to depend on the conservation of these individual ecosystems over the subcontinent. Some of these ecosystems are very restricted in occurrence, as for instance the spray zones at the bases of large waterfalls, while others such as the flat arid plains of Rajasthan desert are very widely distributed. In order to reduce the tremendous complexity of pattern of distribution of ecosystems, we club together similar ecosystems into broad biome types such as tropical rain forests or hill streams. Of these, biomes such as tropical rain forests are zonal, i.e. coincide with broad climatic zones, while others like the hill streams are azonal. These latter, the azonal biomes, are almost always represented by elements in many distinct geographical regions of the country, as in the case of the hill streams in Nilgiris, Annamalais or Khasi hills. The zonal biomes may sometimes occur over a single contiguous region—for instance, the desert scrub of Rajasthan. In other cases, they may occur in more than one geographical region, as in the wet evergreen forests of the Western Ghats, the north-east India and the Andaman and Nicobar Islands. When representatives of a particular biome type occur in different geographical regions, they harbour species which may be different from each other because of divergent evolutionary

histories. Thus, the rain forests of Western Ghats harbour the Nilgiri langur and the liontailed macaque, while those of the north-east harbour the golden langur and the hoolock gibbon. Conservation of the total spectrum must therefore be based on conservation of various zonal and azonal biomes in each of the geographical regions of the subcontinent.

The current status of conservation of natural biological communities representing the different biomes, zonal as well as azonal, in the different geographical regions of the country then becomes the central matter of our concern in this essay. Operationally, this task is best approached by dividing the country in terms of coverage by different vegetation types to represent the zonal biomes of different geographical regions (Puri *et al.*, 1983). We can then investigate the extent of persistence of natural vegetation representing each zonal vegetation type, as also of azonal biomes, especially those related to water courses, freshwater and brackish-water bodies and marine coastal areas. This provides the basis on which we can then suggest a strategy for the conservation of the entire range of biological diversity of the country.

MATERIALS AND METHODS

One of us (VMMH) has been involved in a programme of mapping the vegetation of most of the peninsular India as a part of the team of the French Institute, providing an opportunity for extensive first-hand field observations. These have been supplemented by an analysis of these vegetation maps (Gausson *et al.*, 1961 to 1973, 12 sheets), the maps of Himalayan vegetation by Schweinfurth (1957), the forest atlas of India (Das Gupta, 1976), the maps based on satellite imagery by the National Remote-Sensing Agency (1983), and Kawosa *et al.*, (1983). We have also had the advantage of access to as yet unpublished maps based on satellite imagery by Bellan (1985). The locations of protected and undisturbed areas of vegetation was determined on the basis of maps prepared by the Forest Survey of India (1982). Our suggestions on key areas of conservation are based on the extensive work of a committee of Indian Man and Biosphere programme (1982) and correspondence and discussions with a large number of knowledgeable naturalists, scientists and managers. Details of this data-base and its deficiencies will be discussed elsewhere in detail (Meher-Homji *et al.*, under preparation).

STATUS SURVEY

Arid Tracts

Calligonum Series and *Prosopis-Salvadora-Capparis* Series. This, the driest type of vegetation of India, covers regions of Rajasthan, Punjab

and Jammu with less than 450 mm of annual precipitation and 9 to 11 dry months. It extends over large tracts of flat terrain (over 300,000 km²) so that the environmental regime has a low level of heterogeneity. In this unfavourable, rather homogeneous regime, the levels of diversity are low, so that only 550 species of flowering plants have been recorded from this vast tract (Blatter and Halberg, 1918; Blatter, 1908; Jain and Deshpande, 1960; Kapadia, 1954). The flora has definite links with the north-African desert with 15% Saharo-Sindian, 18% Sudano-Rajasthanian and 9% tropical Indo-African elements. The element restricted to India is only 12% (Legris and Meher-Homji, 1968). This whole tract is quite unfavourable to human habitation, except where irrigation has been brought in. But because of the low productivity of vegetation and the considerable grazing pressure, the natural vegetation has been totally wiped out. Only some degraded natural vegetation persists over about 0.5% of the area. The two major nature reserves of this tract are the Desert National Park near Jaisalmer and the Wild Ass Sanctuary of the Rann of Kutch. These parks hold the key to the conservation of this biota and should emphasize recreation of the natural biota through protection, and if necessary by deliberate reintroductions. Apart from these the region also has a number of small wetlands in Jammu and Punjab with protection as wildlife sanctuaries.

Acacia-Capparis Series. This dry type of vegetation covers the semi-arid tracts of northern Karnataka, Maharashtra, Saurashtra and foothills of Aravallis in Rajasthan with 400 to 850 mm of annual rainfall and 7 to 9 months of dry season. It too extends over large tracts of flat terrain (170,000 km²) with a rather homogenous environment. As with the previous vegetation series, the level of diversity in this unfavourable, homogenous environmental regime is quite low, so that only 500 species of flowering plants have been recorded from this large tract (Santapau and Raizada, 1955; Vaidya, 1967). This is a transitional zone constituting the eastern limit of distribution of many Sudanian species (11-14%) and western limit of distribution of the Indo-Malayan species (10-14%). The indigenous Indian element is about 28% (Legris and Meher-Homji, 1968). The natural vegetation of this series is, if anything, even more completely decimated than that of the previous series, in spite of moderate human densities, the degraded vegetation covering a measly 0.4% of the potential area. The only protected areas are the tiny Velavadar National Park (17.8 km²), well known for its blackbuck population in Saurashtra, the coral reef and mangrove areas of the Pirotan island off the coast of Saurashtra, and the wetland of Nal Sarovar in Gujarat. These must become nuclei of recreating the biota of this region.

Semi-Arid Tracts

Anogeissus pendula-*Acacia senegal* Series, *Anogeissus pendula*-*Acacia*

catechu Series and *Anogeissus pendula*-*Anogeissus latifolia* Series. This dry vegetation extends over much of Rajasthan and north-western Madhya Pradesh with 400 to 900 mm of annual rainfall and 7 to 10 months of dry season. It covers a wide extent of flat land as well as hill tracts of Aravallis of over 240,000 km², and the total number of species of flowering plants recorded is of the order of 700 (Kaushik, 1969; Majumdar, 1971; Maheshwari, 1963; Sharma, 1978). These series are also a meeting ground for the western and eastern elements, so that it has 10% Sudano-Rajasthanian, 8% Saharo-Indian and 17% Indo-Malayan elements. Elements peculiar to India make up 27% of the flora (Legris and Meher-Homji, 1968). This tract is moderately favourable to human occupation. This coupled with low productivity of vegetation and intense grazing pressures has left only about 2% of the potential area under forest cover and a further 1% under degraded natural vegetation. Traditionally, patches of such vegetation have received protection as "orans" or sacred groves dedicated to deities such as Jogamaya in the Aravallis, and many of these still persist. This biome is exceedingly rich in larger wild mammals such as antelopes, deer, panther and tiger and three of the protected areas—Sawai Madhopur, Sariska and Shivapuri—are old princely hunting reserves. So is the Keoladev Ghana National Park at Bharatpur, a wetland famous for enormous concentrations of waterfowl. This biome also includes the important Chambal wildlife sanctuary in Rajasthan and Uttar Pradesh, one of the few protected areas of riverine habitat. These five hold the key to the long-term conservation of this biota; but we should also keep alive the smaller traditional preserves like orans.

Acacia-*Anogeissus latifolia* Series. This so-called Deccan thorn forest of Maharashtra occurs in regions of 600-800 mm of rainfall and 7 to 8 dry months a year. In common with the dry zone series described earlier, this vegetation is almost totally gone with around 2% of the potential area of 98,000 km² remaining under degraded vegetation. There are no protected areas whatsoever representing this vegetation type, and it is imperative that at least one reserve be set up immediately in the hills of Marathwada region of Maharashtra to reconstitute this community.

Anogeissus latifolia-*Hardwickia binata* Series. This dry series, in regions with an annual rainfall of 500 to 1,200 mm and 6 to 8 dry months, occurs in two disjunct regions, on the dry plateau of Karnataka and Andhra Pradesh and in the Satpura-Mahadeo Hills and Vindhyas belt of Maharashtra and Madhya Pradesh. It covers an area of 120,000 km², but has a low diversity with only 475 recorded species of flowering plants; about 25% of these are Indo-Malayan, 45% being indigenous (Vajravelu and Ramakrishnan, 1967; Legris and Meher-Homji, 1968). It is somewhat better preserved than the other dry series described so far because of the hilly nature of some of the tract; thus 9% of the potential area is still under forest cover,

with another 4% under degraded vegetation. The only major reserve representing this type is the Nagarjunasagar tiger reserve of 3,568 km² in Andhra Pradesh. One may also note the Tungabhadra and Ranabennur sanctuaries in Karnataka, both much smaller and with little natural vegetation. There is no reserve at all in the northern portion in Satpura-Vindhya-Mahadeo hills where at least one needs to be set up urgently.

Albizia amara-Acacia Series Albizia amara-Chloroxylon-Anogeissus latifolia Series and Manilkara-Chloroxylon Series These three series of dry vegetation extend over parts of coastal plains of Tamil Nadu and Andhra Pradesh, as well as over the plateau regions of Andhra Pradesh and Karnataka where a rainfall of 500 to 1,500 mm has an annual regime with two distinct peaks during the south-west and north-east monsoon. In this unfavourable and fairly homogenous environment, the diversity is low, the number of angiosperm species recorded being only around 400. Of these about 20% are characteristic of the region and a further 20% are more widely distributed but restricted to India (Mathew, 1970; Sebastine and Henry, 1980; Balasubramanyan, 1975; Legris and Meher-Homji, 1968). As with preceding dry tract series the forest cover is utterly decimated with less than 1% of the potential area of over 200,000 km² being under degraded vegetation. The only nature reserves of note are related to the aquatic habitats. Thus there are three well-known heronaries—at Vedanthangal in Tamil Nadu, Ranganathittu in the course of Kaveri river in Karnataka, and the Pulicat lake in Andhra Pradesh. There are also smaller heronaries, often right in the middle of villages, as in the case of Kokre-Bellur in Karnataka. In all these cases the villagers have traditionally given full protection to the breeding birds, apparently in recognition of the value of bird guano as fertilizer. Another exceptional reserve is the Guindy Deer Park now inside Madras City, stressing the intimate relation between conservation areas and habitation that has been possible in this country. The Point Calimere coastal wildlife sanctuary is particularly valuable as a habitat for migratory birds. There is a proposal to conserve the coral islands of Gulf of Mannaar as a marine biosphere reserve. This is vital. The small but excellent patch of mangrove at Peechavaram near Pondicherry also needs protection. Finally, we must urgently set up some reserves embracing the hilly tracts of this region for protection and restoration of the terrestrial biota of this dry tract.

Other Deciduous Forest Biomes of the Peninsula

The deciduous forest biomes of the peninsula covering vast tracts are a little better preserved than the drier forests of arid and semi-arid zones considered above. Developed in a more favourable environmental regime and in many cases associated with a topographically more heterogenous terrain, they exhibit higher levels of overall diversity with 700-800 species of

flowering plants in case of many series. A large proportion of these, 48-58% are restricted to India, while the Indo-Malayan elements make up 20-30% of the flora (Legris and Meher-Homji, 1968). The deciduous forest biome is rich in larger wild mammals and has thereby attracted considerably better protection. A number of the reserves were earlier hunting preserves of princes, and are now being protected as sanctuaries, tiger reserves and national parks.

Anogeissus latifolia-Terminalia and *Anogeissus latifolia-Terminalia-Cleistanthus* Series. These vegetation series with an annual rainfall of 700-1,500 mm and 5 to 8 months of dry season are distributed in a broad east-west base from Rajasthan through Madhya Pradesh to Andhra Pradesh and Orissa over an area of 220,000 km². About 11% of this remains under forest cover and 3% under degraded vegetation. There are a few reserves totalling about 2,000 km² protecting this vegetation type, the two notable ones being the Nawegaon National Park and the Nagzira wildlife sanctuary in the Bhandara district of Maharashtra, the two together covering only 270 km². These should obviously become nuclei for a stronger effort at conservation of this biome.

Terminalia-Anogeissus latifolia-Tectona Series. This dry deciduous forest biome extends in a north-south orientation over a large tract of 360,000 km² in a rainfall regime of 800 to 1,800 mm a year. It occurs in a narrow strip immediately to the east of the crestline of the Western Ghats, and in a broader strip to the east of semi-arid tracts of peninsular India from Kanyakumari in the south to a little north of the Vindhyas. In addition there are a few isolated occurrences, as on Girnar hills in Saurashtra. Occurring in a moderately favourable and moderately heterogeneous environment, it displays medium levels of diversity, the number of species of angiosperms recorded being 800 (Sharma *et al.*, 1978; Subba Rao and Kumar, 1967; Kapoor and Kapoor, 1973; Shah *et al.*, 1971; Shah, 1967; Malhotra and Moorthy, 1971). The natural vegetation in the strip near the Western Ghats is a little better preserved; that on the peninsula is largely destroyed except on a few hills here and there. A total of 7% occurs as forest, but a part of this is teak plantations, and another 7.5% is degraded vegetation. Important nature reserves flanking the Western Ghats include Mundanthuraj near the southern tip, and Bandipur, Nagarhole and Mudumalai at the base of the Nilgiris. Gir, famous for its lions, in Saurashtra and Panna National Park in Madhya Pradesh are the other significant conservation areas. Bandipur, Nagarhole and Mudumalai along with the eastern slopes of the Nilgiri hills and Talamalai plateau will form a substantial area of over 1,000 km² that will be protected as part of the proposed Nilgiri Biosphere Reserve. Kolleru lake bird sanctuary is a wetland included within this tract.

Tectona-Terminalia Series and *Tectona-Terminalia-Adina-Anogeissus* Series. These dry deciduous forest biomes are distributed in a belt from the

northernmost tracts of the Western Ghats to the central Indian plateau on the east of the sal forests with a rainfall of 1,100 to 2,500 mm, covering an area of about 190,000 km². Lying largely in hilly terrain this vegetation type is moderately preserved, about 25% occurring as forest and another 10% as degraded forest. The key areas for conservation of these vegetation types are the Indravati National Park and the Kutru wildlife sanctuary in Bastar, well known for their wild buffalo populations, and the Tadoba National Park in Chandrapur district of Maharashtra. The *Tectona-Terminalia-Adina - Anogeissus* series of the northern Western Ghats and Satpuras is protected in the Purna National Park in the Dangs; it is vital that the natural vegetation of this tract be preserved and not sacrificed on the altar of teak plantations

Tectona-Dillenia-Lagerstroemia lanceolata-Terminalia paniculata Series. This moist deciduous forest biome of regions with an annual rainfall of 2,000-4,000 mm extends over parts of the west coast and eastern side of the Western Ghats from Kerala to Maharashtra. Developed in a favourable environmental regime in a tract of considerable heterogeneity, this region is rich in diversity with as many as 1,500 species having been recorded (Santapau, 1960); of these, 52% are restricted to the Indian region, while 30% are of Indo-Malayan affinity (Legris and Meher-Homji, 1968). It covers a potential area of 50,000 km², of which some 16% remains under forest, much of it teak plantations, and another 8% under degraded vegetation. The coastal vegetation is largely destroyed by the thick human populations, the only remnants being a few sacred groves in many parts. On the Ghats the key areas for its conservation include the Neyyar and Parambikulam sanctuaries in Kerala, Annamalai sanctuary in Tamil Nadu, parts of Nagarhole and Wynaad sanctuaries of the proposed Nilgiri Biosphere Reserve, the much-disturbed Dandeli wildlife sanctuary in Karnataka, and Radhanagari wildlife sanctuary in Maharashtra. Along with these, pockets of vegetation on coast now preserved as sacred groves should also continue to enjoy protection. There is, for instance, an excellent patch of mangrove preserved as a sacred grove in Sindhudurg district of Maharashtra, while the west coast mangroves have almost totally disappeared everywhere else.

Shorea-Buchnanian-Cleistanthus Series, *Shorea-Syzygium operculatum-Toona-Symplocos* Series and *Toona-Garuga* Series. These moist deciduous forest biomes totalling an area of 144,000 km² in the rainfall range of 1,400 to 2,000 mm a year extend over parts of hilly, largely tribal tracts of Madhya Pradesh, Andhra Pradesh and Orissa. The level of diversity is moderately high, with 850 species of angiosperms having been recorded (Panigrahi and Chowdhury, 1964). About 25% of the potential area is still under forest cover, and 5% under degraded forest. The Simlipal Tiger Reserve of 300 km² is the key conservation area, which must be strictly protected, especially against forestry operations. There are no reserves representing *Toona-Garuga* vegetation series; these must be created.

Shorea-Terminalia-Adina Series This moist deciduous forest biome in the annual rainfall regime of 1,000-2,000 mm extends over nearly 200,000 km² in the sub-Himalayan tracts from Uttar Pradesh to Assam and on the central Indian plateau through Madhya Pradesh and Bihar. The diversity levels are moderate, 700 species of angiosperms having been recorded (Sen Gupta and Ram Lal, 1973; Saxena, 1970). Of these, 45% are restricted to India, and 25% represent Indo-Malayan elements (Legris and Meher-Homji, 1968). Being hilly, and earlier malarial, this biome is moderately preserved with about 25% under forest cover and another 7% in degraded condition. The Corbett and Dudhwa National Parks in Uttar Pradesh, Jaldapara in West Bengal and Manas in Assam are important reserves of the sub-Himalayan tract, while the Kanha National Park in Madhya Pradesh and the Palamau Tiger Reserve in Bihar are significant in preservation of this type of vegetation from the central Indian region. Together these cover over 3,000 km². Also, Champaran in Bihar and Neora valley in West Bengal, are urgently in need of conservation.

Shorea-Cleistanthus-Croton Series and *Shorea-Dillenia-Pterospermum* Series. These series of deciduous sal forest with an annual rainfall of 1,000 to 2,000 mm extend over an area of 100,000 km² in the plains of Bihar, Orissa and West Bengal. These are thickly settled agricultural tracts and the natural vegetation has been thoroughly destroyed so that less than 4% of the potential area remains under forest and another 3% or so under degraded vegetation. Only 400 or so species have been described from this tract (Mallick, 1966; Rao and Banerjee, 1970). The Dalma wildlife sanctuary of 193 km² is the largest and the most significant nature reserve representing these vegetation types. There is a need to set up at least small nature reserves representative of the natural vegetation of the settled plains where the biome can be reconstituted. The estuarine ecosystems of this tract are represented in the Bhitarkanika Sanctuary of Orissa, and most significantly in the Sundarban Tiger Reserve at the mouth of the Ganges in West Bengal. The latter, extending over 2,585 km², is vital to the conservation of the remarkable biota of the mangrove forests, as well as the moist deciduous forest in the hinterland.

Bridelia-Ficus glomerata-Syzygium Series This series of semi-evergreen forest vegetation in a rainfall regime of 2,000 to 5,000 mm with a dry period of 7 to 8 months extends over upper slopes of the Maharashtra Western Ghats and some ranges of Girnar and Aravalli hills. In this hilly terrain about 40% of the potential area out of a total of 2,750 km² remains under forest and another 30% under degraded vegetation. The floristic diversity is moderately high, 1,100 species of flowering plants having been recorded (Bhandari and Mehta, 1978; Jan 1967; Rao and Kanodia, 1962-63). Mount Abu wildlife sanctuary, with an area of 112 km², is the most significant nature reserve of this vegetation type.

Evergreen Forest Biomes of the Western Ghats

The hill chain of the Western Ghats in peninsular India is notable for the high levels of rainfall ranging from 2,000 to 8,000 mm a year spread over 5 to 10 months. The result is a luxuriant evergreen forest developed in a regime of favourable and topographically highly diverse environment. The dry months are fewest and the hills highest in the southern portion of the Ghats, with rainfall being restricted to fewer and fewer months and the hills rising less and less as one passes north. This belt of evergreen forest is today isolated from the much larger belt of evergreen forest in south-east Asia; so also are the higher peaks of the Western Ghats from similar montane areas in the Himalayas. Favourableness of the environment, topographic heterogeneity and isolation have all encouraged high levels of species diversity coupled with a substantial degree of endemism in this biome. Thus as many as 2,000 species of angiosperms have been recorded from the southernmost series of *Cullenia-Mesua* and *Palaquium* with 26% of the elements being Indo-Malayan, 40% restricted to the Western Ghats and another 26% restricted to the Indian region. The montane shola forests possess over 60% restricted to the Western Ghats, with 20% tropical montane and 5% Indo-Malayan elements (Fischer, 1921; Vajravelu and Joseph, 1971; Legris and Meher-Homji, 1968). The levels of diversity tend to decrease in the northern series with only 1,700 species known from the *Dipterocarpus-Mesua-Palaquium* series and a mere 400 from the northernmost *Memecylon-Syzygium-Actinodaphne* series (Saldanha and Nicholson, 1976; Puri and Mahajan, 1960). The levels of endemism also fall slightly with diversity in the northern series, with about 30% of elements endemic to the Western Ghats, and another 30% restricted to the Indian region. The evergreen forest biome of the Western Ghats with a total of some 3,500 species of angiosperms, 1,500 of them endemic, is thus a region of considerable value for the preservation of India's biological diversity (Mani, 1974).

Cullenia-Mesua-Palaquium Series. This series extends on the western side and along the crestline of the Western Ghats in Kerala and parts of Tamil Nadu. It has developed in a rainfall regime of over 3,000 mm a year, with less than 4 dry months. This is biologically the richest of the series; but has been depleted considerably through conversion to plantations of rubber, tea, cardamom, etc., and cultivation of tapioca, so that only about 15% of the potential area of 20,000 km² retains its forest cover. About 1,000 km² of this is protected in nature reserves, the most significant of these being Kalakadu in Tamil Nadu (223 km²), Periyar (777 km²) and Silent Valley (90 km²) in Kerala. It is hoped that New Ambarambalam and Nilambur Kovilakam forests adjoining the Silent Valley will soon be protected as a part of the proposed Nilgiri biosphere reserve. Most of the river courses of this biome no longer possess natural biotas; Manimuthar in Kalakad, Kunthipuzha in the Silent Valley and Karimpuzha in New

Ambarambalam being the important exceptions which must be preserved on a long-term basis

Montane Sholas The montane evergreen forests and grasslands that occur above an altitude of 1,800 metres in the Western Ghats are a very special biome. Its typical representatives occur in the High Ranges, Palanis, Annamalais and Nilgiris; an analogous *Gordonia-Schefflera-Meliosma* series occurs on the high hills of Karnataka. This vegetation is notable for the occurrence of Sino-Himalayan elements such as *Rhododendron*. It has been drastically altered by wholesale plantations of wattle, tropical pines and other commercial species so that no more than 5% of the potential area of 5,000 km² now retains its natural biota. The two major reserves protecting this biota are Eravikulam in Kerala and the Upper Nilgiri plateau in Tamil Nadu.

Dipterocarpus-Mesua-Palaquium Series. This series extends along the west coast and Western Ghats of southern Karnataka in a regime of an annual rainfall of more than 2,000 mm and a dry period of 4 to 6 months. Of its potential area of 20,000 km² some 26% remains under forest cover. There are a few wildlife sanctuaries, namely Pushpagiri, Mukambika, Shettyhally, Someshwar and Sharavathy Valley, but these areas afforded only minimal protection. A larger area of 620 km² near Kudremukh proposed to be set up as a satellite biosphere reserve should become the most significant conservation area for this series.

Persea-Holigarna-Diospyros Series. This series extends along the west coast and Western Ghats of northern Karnataka and Goa in a regime of annual rainfall of 2,500 to 3,000 mm with 6 months of dry period. Of its potential area of 12,500 km² more than 35% appears under forest cover. However, this is a region of low hills where many of the interior valleys are under settlement, and therefore under human pressure, both of the rural population and of the forest-based industry such as plywood and matchwood. There is therefore little of undisturbed natural forest and no significant nature reserves. This rich biota calls for serious protection at least in small patches as in the wildlife sanctuaries of Goa.

Memecylon-Actinodaphne-Syzygium Series. This series extends along the west coast and Western Ghats of northern Karnataka and Maharashtra in a region of more than 3,000 mm of rain a year with 6 to 7 dry months. As with the previous series, accessibility has led to substantial pressure on the natural vegetation throughout this region, so that although some 24% of the potential area of 5,000 km² is still under forest cover, there is little undisturbed forest and few nature reserves. A substantial area of at least 100 km² or more must be protected in the Koyna catchment as representative of this vegetation series. Another notable tract that needs continuing full protection is the sacred grove of Bhima-Shankar of 2 km² in Pune district currently threatened by the construction of road.

Himalayas and Hill Tracts of the North-east

The great mountain chain of the Himalayas with its associated hill tracts in the north-eastern India is the biological treasure trove of the country. The tremendous altitudinal range of these hills and their wide expanse coupled with the large range in rainfall from very dry conditions at the western edge on Jammu and Kashmir to the wettest place on earth in Meghalaya have created an unparalleled diversity of environments in this region. Furthermore this region sits at the junction of several biogeographic realms so that it has amongst its biota elements with the mediterranean, temperate European, Sino-Himalayan, Sino-Indian and Indo-Malayan derivation (Legris and Meher-Homji, 1968). Given the dissected mountain topography and the scope for geographical isolation, it is not surprising that this region is rich in endemic elements. Chatterji (1939) estimates that it possesses over 3,000 endemic species of dicotyledons alone. Legris and Meher-Homji (1968) conclude that the indigenous element is dominant with 40%, as against 25% of the Indo-Malayan element. Furthermore they show that the indigenous element is somewhat less in the semi-evergreen and moist deciduous series, about 33%, with another 30% of Indo-Malayan elements.

Our data for the Himalayas is weaker, with little first-hand field experience. The vegetation maps available for this region are also much less detailed; and the topography renders the interpretation of the satellite imagery rather complicated. Nevertheless, we will summarize here the available information.

(a) The tropical moist deciduous and evergreen forests, in regions with an annual precipitation of more than 2,500 mm, spread over a potential area of 113,000 km² are restricted to the lower altitudes of the north-east. They have been extensively replaced by settled cultivation or affected by shifting cultivation. The traditions of conservation of this vegetation, once prevalent amongst tribals, have largely broken down and the increased pressure of the forest-based industry as well as population is playing havoc with it. About 25% of this vegetation remains as closed canopy forest and another 7% as degraded vegetation. There are no large well-protected areas representing the tropical wet evergreen forests. The important reserves of tropical moist deciduous forest include the Kaziranga National Park (430 km²) in Assam, Intangki (202 km²) in Nagaland, and Balaphakram in Meghalaya. Keibul Lamjo of Manipur (40 km²) is an important wetland habitat. There are several smaller sacred groves.

(b) The subtropical forests of Himalayas range from the dry evergreen sclerophyllous forest of the north-west Himalayas in the rainfall regime of 500 to 1,000 mm a year and an altitude of 300 to 1,500 metres, and the subtropical chir-pine forest in the rainfall regime of 1,300 to 3,000 mm a year and an altitude of 1,000 to 1,800 metres over much of the entire Himalayan tract, to the subtropical broad-leaved hill forest of eastern Himalayas in a rainfall regime of over 2,200 mm a year and an altitude range of 1,000 to 2,000 metres. These forests are

better preserved with 60% of the potential area of 65,000 km² being under forest and another 12% under degraded vegetation. There are however few good reserves protecting this biota, the largest being Govind Pashu Vihar of 320 km² in the Uttara Kashi district of Uttar Pradesh. Obviously serious attempts need to be made to conserve this biome.

(c) The temperate forests of the Himalayas range in altitude from 1,800 to 3,000 metres. At the lower annual rainfall of 1,300-2,000 mm and altitudes of 1,800 to 3,300 metres it is a mixed oak and coniferous forest, while at an annual rainfall of 1,000-1,800 mm and higher altitudes of 2,000 to 2,800 metres it is a coniferous forest with a distribution stretching all the way from Kashmir to the eastern Himalayas. The wet temperate forest in the rainfall regime of over 3,000 mm a year and at altitudes of 1,700 to 2,750 metres is restricted to the outer ranges in the eastern Himalayas. The potential area under these forests is 61,000 km², of which 60% still persists. They are, however, quite inadequately protected, the major conservation areas being Kistwar (200 km²), Overa-Aru (212 km²), Gulmarg (180 km²) and Dachigam (141 km²) in Kashmir, Shikari Devi (213 km²) in Himachal Pradesh, Kedarnath (478 km²) and parts of Govind Pashu Vihar (total: 320 km²) in Uttar Pradesh. The rich wet temperate forest of the north-east must be totally protected in at least two or three reserves, the most significant being Namdapha, a proposed biosphere reserve of 233 km² in Arunachal Pradesh, and the Nagaland Central Forests of 104 km².

(d) The subalpine altimontane forests lie below the snow slides on sheltered slopes from Kashmir to the eastern Himalayas at altitudes from 2,900 to 3,500 metres. Of the potential area of 50,000 km², only about 15% retains forest cover. Clearly, this biome is in need of urgent protection. It is protected through the Henus High Altitude National Park (150 km²) of Ladakh, and Kedarnath sanctuary (478 km²) of Uttar Pradesh. The proposed Nanda Devi Biosphere Reserve must play an important role in conserving this biota.

(e) Alpine scrub and meadows cover higher reaches of Himalayas in the altitude range of 3,500 to 4,900 metres. This biome suffers especially from overgrazing and tourism. The Valley of Flowers (90 km²) and the Govind Pashu Vihar National Parks of Uttar Pradesh are the only nature reserves protecting this biota.

(f) The alpine steppes over altitudes of more than 4,500 metres are a very fragile environment, included in several high-altitude reserves of Ladakh and Kashmir (Sang Gauri, Henus, Overa-Aran and Kistwar) as well as the Singalila National Park of West Bengal.

Island Ecosystems

India possesses two major groups of islands, those of Andaman and Nicobar and those of Lakshadweep. The former are crucial to our conservation effort,

harbouring some of the best preserved wet evergreen, moist deciduous and mangrove forests of the country because of their isolation. Thothathari (1960, 1962) has recorded a total of 1,000 species of flowering plants from this island group of 6,840 km². More than 220 of these species are endemic to these islands; and another 300 or so are restricted to the Indian region as a whole. About 15% of the species are elements shared with Burma and the north-east. Over 80% of the islands still retain their natural vegetation, but this is threatened by a whole range of pressures from forest-based industry, foreign trade, military and growing human settlements. It is essential that we now decide to set aside the following as a nature reserve system of these islands: Saddle Peak in North Andamans (32 km²), Jarwa area in South and Middle Andamans (721 km²), North Middle and South Button Islands in Middle Andamans (3.8 km²), Mount Harriet Island (46.6 km²), Interview island, Tarmugli group of coral reef islands as well as the Narcodam Island (7.38 km²).

The Lakshadweep groups of islands are notable for their coral reefs. Along with Pirotan Island in the Gulf of Kutch, Krusadai and other islands of the Gulf of Manaar, and the Tarmugli group in Andamans, several islands of Lakshadweep must be identified to conserve this most diverse and stable of marine habitats.

CONCLUSIONS

Nature conservation in India is an old yet vigorous tradition attempting to come to terms with the understanding and realities of the day. It is imperative that the programme should now address itself more forcefully to two priorities, namely, of preserving not just tigers, rhinos and blackbuck, but biological diversity as a whole, and of involving the local population positively in the conservation effort. To this end, we must develop a network of nature reserves properly representative of all the biological community types of the country. An assessment of this objective has been a major purpose of the material presented above; this is summarized further in Table 1. As this table brings out, nature reserves cover only 2.9% of the total area of the country; this should be increased to 5% at least. Furthermore, many reserves are only so in name, for instance the large Dandeli Wildlife Sanctuary in Karnataka is totally devastated by the giant Kali hydel project situated right in its centre. We therefore need to qualitatively improve the kind of protection accorded to biological diversity in all the nature reserves, with an emphasis on conservation of the biota as a whole. Other features that emerge from this table are the sad plight of our arid and semi-arid tracts, and the urgent need to strengthen the network of nature reserves in the Himalayas and the north-eastern hill tracts.

Apart from the larger reserves, we should not lose sight of the smaller ones down to tiny sacred groves which yet preserve rare species of plants. Thus

Table 1. Extent of potential area, closed canopy forest, forest including degradation stages, and nature reserves in major zones over India. Area is in thousand square kilometres. Except in the last row, the percentage is to the total area of that column. The ratio is that of the percentage of the actual to the percentage of the potential. For India as a whole the percentage is given in terms of the total area in the last row of the table

Zone		Potential	Closed canopy	All forest	Nature reserves
Arid	Area	481.3	0	2.2	8.2
	Percentage	17.2	0	0.1	10.0
	Ratio	—	0	0.006	0.6
Semi-arid	Area	670.0	17.6	31.4	7.8
	Percentage	23.9	5.1	6.7	9.6
	Ratio	—	0.21	0.28	0.4
Peninsular deciduous	Area	1291.2	195.5	283.3	50.0
	Percentage	46.1	56.6	60.7	61.6
	Ratio	—	1.23	1.32	1.34
Peninsular evergreen	Area	62.0	14.1	16.4	3.6
	Percentage	2.2	4.1	3.5	4.4
	Ratio	—	1.86	1.6	2.0
Himalaya	Area	290.5	112.3	129.0	10.9
	Percentage	10.4	32.6	27.7	13.4
	Ratio	—	3.13	2.66	1.29
Andaman and Nicobar	Area	6.8	5.5	5.5	0.8
	Percentage	0.2	1.6	1.3	1.0
	Ratio	—	8.0	6.5	5.0
India as a whole	Area	2801.8	345.0	467.8	81.2
	Percentage	—	12.3	16.7	2.9

Mohanan and Nair (1981) described recently a new leguminous climber, the first record of its genus in India, *Kunstleria keralensis*, from a sacred grove in the thickly settled plains of Kerala. We must plan our nature reserve network to include a whole series of such protected areas necessarily smaller in size where population densities are higher, but nevertheless covering the entire countryside.

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