NATIONAL BIODIVERSITY STRATEGY AND ACTION PLAN

Western Ghats Ecoregion

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Preface

Conservative estimates place the number of species of microorganisms, plants and animals in the Western Ghats in the range of 10,000-15,000. Roughly 40% of these could be endemic. Such a magnitude of biodiversity, and the array of threats faced by the various components of biodiversity have together ranked the Western Ghats amongst the 25 biodiversity hot-spots in the world.

The Western Ghats have had a nearly 50 million year history. The past 12,000-15,000 years have witnessed the gradual entry of human beings into this ecoregion leading to a lot of changes in the magnitude and distribution of biodiversity. Whatever patterns of biodiversity distribution that are apparent today in the Western Ghats have had one or another form of human influences. This needs to be borne in mind while conservation strategies are being outlined.

Although the Western Ghats represent the tropical rainforest biome, there is a considerable amount of seasonal variation from the north to south. Generally, there are 5-8 dry months in the northern half of the Western Ghats as against the nearly 10 months of rainfall in the south. Further, the longer dry season in the north, especially in northern Karnataka, Goa and Maharashtra (the Sahyadri Ghats), has rendered the rainforests in this region more fragile than that in the south. Recent human impacts have been reflected rather heavily in the northern forests than in the southern forests.

Human interferences throughout the Western Ghats have modified the once continuous tropical rainforests into a heterogeneous mosaic of evergreen, semi-evergreen and moist deciduous formations. The possibility that many of the rainforest species of plants and animals that are restricted in range to the southern Western Ghats were once present in the north as well is very strong.

Despite all changes that the ecoregion has undergone, the Western Ghats are still a 'nature monument' that has sustained an exceptionally high magnitude of biodiversity and provided immense ecosystem services providing clean air and water. The Biodiversity Strategy and Action Plan that has been outlined for the ecoregion has therefore kept the biodiversity wealth and the long years of ecosystem services that have been provided by the hills and forests of the Western Ghats in main focus.

The Biodiversity Strategy and Action Plan has been structured such that in the first section it reflects both the magnitude and distribution of biodiversity as apparent today

highlighting the major reasons for the loss of biodiversity and possible means to mitigate the losses. The second section outlines the process adopted, listing the various recommendations made by the 200 or so participants (without any prejudice), the names and addresses of the contributors and appendices of species lists. Issues that emerged repeatedly throughout the process of preparation of the draft - through brainstorming and peer review, have been consolidated into the Strategy and Action Plan. It is hoped that the Strategy and Action Plan thus prepared is an honest representation of both scientific and public perceptions of the problems and prospects of biodiversity conservation in the Western Ghats ecoregion that can be meaningfully integrated with the National Biodiversity Strategy and Action Plan for India.

1.0 Executive Summary

1.1 Introduction

In 1999, the Ministry of Environment and Forests, Government of India, prepared a National Policy and Macrolevel Action Strategy for Biodiversity through a consultative process. The document was a macro-level statement of policies, gaps and strategies needed for conservation and sustainable use of biological diversity. It was however felt necessary to prepare detailed action plans at sub-state, state, regional and national levels based on this framework document. Towards this end, the Ministry has accessed funding from the Global Environment Facility (GEF) for preparing the National Biodiversity Strategy and Action Plan (NBSAP).

The NBSAP project envisages the assessment and stock taking of biodiversity-related information at various levels, including distribution of endemic and endangered species and site-specific threats and pressures. Key features of this project include emphasis on gender sensitive decentralised planning, and the use of interdisciplinary working groups to involve all sectors concerned with biodiversity conservation. Detailed action plans (at sub-state, state, and regional levels) so prepared will be consolidated to develop the national level action plan.

Government agencies, non-governmental groups and village communities are already contributing towards conservation of biodiversity. However, there is still a need to consolidate and coordinate these efforts, to launch new initiatives to plug the gaps in information and action, to put developmental processes and planning on a more ecologically sound footing, and to promote people's management of their surrounding natural resources.

Such a process of consolidation and new initiatives through a series of plans and strategies at local, state and national levels, cannot be successful without public participation. It is proposed to prepare the NBSAP through a process of widespread consultation and participation across India (Source: National Biodiversity Strategy and Action Plan: A Call for Participation).

1.2 Brief background

The Western Ghats ecoregion is comprised of a hill chain running north-south between the river Tapti and Kanyakumari. The 160,000sq km thus defined form a part of 6 south Indian states viz., Gujarat, Maharashtra, Goa, Karnataka, Tamilnadu and Kerala. The ecoregion experiences an average annual rainfall of 2500 mm. Subject to the geographical orientation and topography, rainfall is locally much higher crossing 10,000 mm a year.

Topographically, the highest and most rugged parts of the Western Ghats are in the south – roughly south of 13 degrees north latitude. Hills here rise more than 1800 m ASL; the peaks reaching over 2600 m in the Nilgiris and Anaimalais. Unlike the Himalayas, the underlying rocks in the southern Western Ghats (Goa and southwards) are archaean dating back to 2 billion years.

The Western Ghats are amongst the 25 biodiversity hot spots globally identified. The ecoregion is known for its high levels of biodiversity and endemism. For instance, excluding the migratory birds, there are 938 species of vertebrates in the Western Ghats, 36% being endemic (Table 1.1). Eleven per cent of the more than 330 species of butterflies in the Western Ghats are endemic. Similarly, nearly 40% of the 4000 species of flowering plants are endemic. The diversity in many other groups of animals and lower plants remain to be fully understood.

Table 1.1 Distribution of endemic vertebrates in the Western Ghats

Class/States	**GU**	**MH**	**GO**	**KA**	**TN**	**KE**	**WG**
Mammals	0	1	1	8	10	12	**14**
Birds	2	9	13	17	19	18	**19**
Reptiles	4	13	17	36	71	69	**97**
Amphibians	3	19	9	50	44	65	**94**
Fishes	2	30	7	50	43	72	**116**
Total	11	72	47	161	187	236	**340**
Per cent	**3.0**	**21.0**	**14.0**	**47.0**	**55.0**	**70.0**	

(For source see latter sections)

Around 200 species of flowering plants found in the Western Ghats find a place in the *Red Data Books* prepared in the nineties by the Botanical Survey of India. Many of these plants are endemic to the Western Ghats. Endangered mammals in the Western Ghats include the Tiger, Elephant, Nilgiri tahr, Liontailed macaque, Nilgir langur, Slender loris, Brown palm civet, Malabar civet, Nilgiri marten, Grizzled giant squirrel, Spiny dormouse

and others. Of the 78 species of Indian birds identified as 'globally threatened' by the Salim Ali Centre for Ornithology and Natural History, the Nilgiri Wood Pigeon, Lesser Adjutant Stork and Nilgiri Laughing Thrush are known from the Western Ghats. The pigeon and the laughing thrush are endemic.

Very little is understood of species extinctions in the Western Ghats. It is presumed that a large number of species of endemic trees are already locally extinct in the Western Ghats. Local extinctions are widespread making the ranges of many species of endemic plants and animals disjunct in the Western Ghats. Amongst higher animals, the Redfaced Malkoha once known from the Western Ghats of Kerala and Tamilnadu is probably extinct. The malkoha is presently known only from Sri Lanka.

The magnitude of biodiversity, endemism and local extinctions in the Western Ghats render it a hot spot of biodiversity. Added to this are the several indigenous forest dwelling human communities who have traditionally evolved with the tropical forests and mountain ecosystems in the Western Ghats. As an effort to conserve this ecologically important and fascinating hill ecosystem, an ecoregional Biodiversity Strategy and Action Plan is a must.

1.3 Scope

The term 'biodiversity' is being taken in its holistic sense, to encompass the following levels, including related ecological and evolutionary processes:

Natural ecosystems: eg. forests, mountains, grasslands, wetlands, etc.

Wild species and varieties: species of plants, animals and microorganisms existing in their natural state and the genetic variation within each of these species.

Agricultural ecosystems: eg. farmlands, pastures, capture fisheries, aquaculture.

Domesticated species and varieties: species of crops, livestock (including poultry), captive-bred fish, pets, and micro-organisms in *ex situ* collections and the genetic variation within each of these species (source: National Biodiversity Strategy and Action Plan: A Call for Participation).

1.4 Objectives

- Conservation of biodiversity of all kinds listed above
- Sustainable use of biological resources, implying their use in such a manner as will not imperil their long-term existence, or will not in other ways threaten biodiversity
- Social, economic, ethical, cultural, scientific and economic dimensions, including gender relations and equity.

(Source: National Biodiversity Strategy and Action Plan: A Call for Participation)

1.5 Contents

The Strategy and Action Plan consists of

1. A detailed profile of the Western Ghats ecoregion including origin, history, physiography, biodiversity and human ecology
2. A discussion of the various factors responsible for loss of biodiversity and continued pressure on biodiversity
3. An outline of the various recommendations made for the conservation and sustainable use of biodiversity/biological resources both published and unpublished
4. A specific action plan for the ecoregion
5. An outline of the process involved in the development of the action plan and
6. Appendices including lists of species, etc.

1.6 Brief discussion of methodology adopted

The methodology adopted is as follows:

- Review of literature
- Interviews and discussions with individual scientists and others with knowledge of the Western Ghats
- Sourcing data and information through the internet
- Preparation of background paper and circulating the same for inputs and comments
- Brainstorming meetings with scientists, activists, students of law, forest department officials, other government and non-government agencies, industrialists and representatives of tribal organisations

- Posting the minutes of the meetings on the world wide web (**http://ces.iisc.ernet.in/hpg/cesmg/nbsap1.html**,**http://ces.iisc.ernet.in/hpg/cesmg/nbsap2.html**,**http://ces.iisc.ernet.in/hpg/cesmg/nbsap3.html**)and soliciting comments
- Circulating questionnaires
- Peer review of the draft strategy and action plan
- Adoption of comments/suggestions that emerged during the peer review and
- Finalising the action plan.

2.0 Profile of the Western Ghats Ecoregion

2.1 Geographic profile

The Western Ghats, also known as the Sahyadri Hills, are well known for their rich and unique assemblage of flora and fauna (Blanford, 1901; Gadgil, 1980; Myers *et al*, 2000). Myers *et al* (2000) have included the Western Ghats amongst the 25 biodiversity hot-spots identified in the world. Arising abruptly from the narrow Konkan and Malabar coasts, these hills run 1600 km north-south between the river Tapti in Gujarat and Kanyakumari in Tamilnadu (c. 8 degrees N to 20 degrees N) covering an area approximately equal to 160,000 sq km.

In the east, they slope gently towards the Deccan Plateau. The northernmost segment that extends into Gujarat merges in the east with the Dangs. In the Nilgiris, Palnis and parts of Karnataka, the Western Ghats extend considerably eastwards, locally merging with the Eastern Ghats. Towards the south, the hill chain is divided into two by the Palghat Gap rendering a physically homogeneous high altitude plateau into two rather distinct biogeographic units viz., the Nilgiris complex in the north and the Anaimalai-Palnis complex in the south.

The distance between the hills and the Arabian sea in the west varies. Some parts of the central Western Ghats (especially in coastal Karnataka), rise almost straight out of the sea. Further south the hills become steeper. For here are found the highest peaks viz., Anaimudi (Anaimalai Hills) and Doddabetta (Nilgiri Hills), reaching 2695 and 2637m ASL respectively. Apart from these, peaks reaching heights of over 2000 m are present in Palnis, High Wavy Mountains and Grass Hills, all south of the Palghat Gap.

Climatic conditions in the Western Ghats are highly variable relative to the altitude and physical proximity to the Arabian sea and the equator. Whereas rainfall peaks of 6000 mm and above per year, are known in the western aspect, annual rainfall as low as 1000 mm are frequent in the east taking the average to around 2500 mm. Interestingly, the total amount of rainfall received and the spread are not often correlated. Areas in the northern Western Ghats (in the State of Maharashtra) receiving the highest rainfall (occasionally over 10,000mm) experience dry weather over more than half the year. On the contrary, areas receiving much less rainfall in Kerala and closer to the equator experience rain

almost all through the year. Much of the rainfall is received during the southwest monsoon season. Peak period of rainfall is July-August. Further, it has been observed that the coldest periods in the southern Western Ghats coincide with the wettest (Pascal, 1988).

The Western Ghats experience a tropical climate being warm and humid during most of the year. Mean temperature varies from 20 degrees C in the south to 24 degrees C in the north (Nair and Daniel, 1986). The higher elevations however experience subtropical climates, occasionally experiencing frost, especially in the Nilgiris, Palnis and Anaimalai Hills.

Geologically the Western Ghats may be divided into two segments. The hills north of the Krishna basin (largely Maharashtra and Gujarat - the 'Sahyadris') with fragile basaltic rocks are results of the same processes that gave rise to the Deccan trap. Isolated, conical, flat-topped hills occur here with steep sides, marked with striations. They seldom rise beyond 1500 m. South of the Krishna basin is the region of precambrian archean crystalline hard rocks (nearly 2000 million years old granites, schists, gneisses, quartzites, etc. Nair and Daniel, 1986). Soils vary from humus rich peat in the montane areas to laterite in the lower elevation and high rainfall belts. Soils are generally acidic.

Western Ghats are well drained by both east and west flowing rivers. Rivers flowing west are generally more torrential than those flowing east. Important east flowing rivers include Malaprabha, Ghataprabha, Hiranyekeshi, Vedganga, Dudhganga and Bhogavati in the north and the tributaries of the river Cauvery such as Bhavani in the south. West flowing rivers of significance are Purna, Oranga, Daman Ganga (Gujarat), Terekhol, Karli, Kalna, Talpona, Tilari, Ulhas, Tansa (Maharashtra), Mandovi, Khandepar, Zuari, Surla, Mundhirchi (Goa), Kali, Sharavathy, Aganashini, Sitanadi (Karnataka), Malampuzha, Periyar, Neyyar (Kerala) and others.

2.2 Socio-economic profile

Traditionally, an agro-forestry-based economy thrived in the Western Ghats. International trade in spices started more than 3000 yBP. While there are a large number of other enterprises such as stone quarrying, mining and generation of hydro-electric power that have currently overshadowed the traditional agrarian economy, agro-industries have had a major role in the creation of employment and livelihood opportunities throughout the Western Ghats.

Subsistence economy in the Western Ghats is gradually dwindling for much of the hill dwelling tribals have sought employment in the local private and government sectors. And as shown in Table 2.4 (the section 2.3 that follows), the proportion of people classified as scheduled tribes is less than 5% in the four biodiversity rich states viz., Goa, Karnataka, Tamilnadu and Kerala (in fact the population classified as scheduled tribes in the states of Goa, Tamilnadu and Kerala is hardly 1%). Table 2.1 provides a general profile of tribals and tribal occupation in the Nilgiri Biosphere Reserve which amounts to around 40% of all protected areas in the Western Ghats.

Table 2.1a Distribution and occupation of the tribes of the Nilgiri Biosphere Reserve

Tribe	**Distribution**	**Occupation**
Allar	Eranad (Mallapuram)	Agricultural labour
Adiyan	Wyanad Mysore	Field labour Hill cultivation
Aranadan	Nilambur Hills	Hunting (monkeys) Labour Forest cultivation
Cholanaicken	Nilambur valley	Hunting-gathering Fishing (poisoning)
Edanadan Chetti	Wyanad plateau Gobichettipalayam Attapadi	Agricultural labour Collecting yam Artisan
Irular (9000)	Gudalur	Hunting-gathering
Kader	Wyanad	Cultivation Labour
Katunaicken	Wyanad	Collecting tubers Hunting (monkeys)
Kanaladi (800)	Wyanad Mysore	Oracles Fire walkers
Karimpalan	North Malabar	Shifting cultivation Axemen Collecting wild pepper
Kunduvadiyan (1400)	Wyanad	Labour

Contd..

Tribe	Distribution	Occupation
Kurichian	Wyanad	Agriculture Hunting
Kurumba	Wyanad Gudalur Attapadi Begur Kakanthode Ainurumnigudi Murkali Nagarhole	Agriculture Hunting-gathering Fishing
Kota (1500)	Nilgiris	Artisan Cultivation
Mandatan Chetti	Wyanad	Agriculture
Mudugar	Attapadi	Agriculture
Malamalasar	Wyanad	Hunting-gathering
Malasar	Wyanad	Hunting-gathering
Malayan	Mannarkad	Collection of wild resources Agricultural labour
Paniya (5200)	Wyanad Coorg Mysore Nilgiris	Agricultural labour
Pani Yerava	Coorg	Hunting
Panjani Yerava	Coorg	Collecting NTFP
Pathiyan	Wyanad	Agricultural labour
Soliga	Satyamangalam Chamrajnagar	Collecting NTFP Cultivation Herdsmen
Toda (1250)	Nilgiris plateau	Pastoral
Thatchanandan (1500)	Sultan's battery	Collecting NTFP
Urundavan	Wyanad	Agricultural labour Collecting NTFP
Urali	Satyamangalam	Agricultural labour Collecting NTFP
Wyanadan Kader (1700)	Wyanad	Collecting NTFP

Source: SACON. Figures in parantheses denote approximate population in 1995.

Table 2.1 b Distribution of the tribes of Northern Western Ghats (Maharashtra)

Tribe	Distribution
Bhil	Dhule, Nandunbar
Pawara	Dhule, Nandunbar
Konkana	Nandunbar, Nasik
Mahadeo koli	Nasik, Thane, Ahmednagar
Malhar koli	Thane, Raigad
Warli	Thane
Katkari	Raigad, Pune, Satara, Ratnagiri
Thakar	Thane, Raigad, Pune

Source: Sanjeev B. Nalavade (pers.communication)

2.3 Political profile

The Western Ghats ecoregion is politically part of 6 states viz., Gujarat, Maharashtra, Goa, Karnataka, Tamilnadu and Kerala. Around 40 districts, in part or full, may be treated as those that form part of the Western Ghats landscape (Table 2.2). Of these, Mysore and Coimbatore are amongst the 100 districts with the highest scheduled caste population in the country. With the exception of Goa, the 5 states, within whose political limits the Western Ghats extend, are amongst the 15 most populous states in the country. Tables 2.2-2.4 provide the details of human population in the 6 states as per the Census 2001.

Table 2.2 District-wise human population of the Western Ghats Ecoregion (Census 2001)

State	District	Total population	Population density	Decadal growth of population (%)	
				1981-91	1991-2001
Gujarat	Dangs	186,712	106	26.77	29.58
	Surat	4,996,391	653	36.29	47.04
	Valsad	1,410,680	465	25.87	29.66
Maharashtra	Nasik	4,987,923	321	28.73	29.51
	Thane	8,128,833	850	56.62	54.86
	Dhule*	430,000	130	-	-
	Nandurbar	-	-	-	-
	Pune	7,224,224	462	32.85	30.58

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State	District	Total population	Population density	Decadal growth of population (%)	
				1981-91	1991-2001
	Sindudurga	861,672	165	6.56	3.55
	Raigad	2,205,972	308	22.76	20.89
	Satara	2,796,906	267	20.24	14.10
	Ratnagiri	1,696,482	207	11.92	9.87
	Sangli	2,581,835	301	20.45	16.85
	Kohlapur	3,515,413	457	21.67	17.54
Goa	North Goa	757,407	436	16.08	14.89
	South Goa	586,591	298	17.04	13.93
Karnataka	Belgaum	4,207,264	314	20.30	17.40
	Uttara Kannada	1,353,299	132	13.66	10.90
	Shimoga	1,639,595	193	15.11	12.90
	Udipi	1,109,494	286	9.42	6.88
	Dakshina Kannada	1,896,403	416	15.98	14.51
	Chickmagalur	1,139,104	158	11.57	11.98
	Hassan	1,721,319	253	15.98	14.51
	Kodagu	545,322	133	5.75	11.64
	Chamrajnagar	964,275	189	14.99	9.16
	Mysore	2,624,911	383	24.84	15.04
Kerala	Kannur	2,412,365	813	16.63	7.13
	Kasarkode	1,203,342	604	22.78	12.30
	Kozhikode	2,878,498	1228	16.69	9.87
	Mallapuram	3,629,640	1022	28.87	17.22
	Wyanad	786,627	369	21.32	17.04
	Palghat	2,617,072	584	16.52	9.86
	Trissur	2,975,440	981	12.20	8.70
	Ernakulam	3,098,378	1050	11.42	9.09
	Pattanamthitta	1,231,577	467	5.60	3.72
	Idukki	1,128,605	252	10.45	6.96
	Kottayam	1,952,901	884	7.71	6.76
	Allapuzha	2,105,349	1489	7.28	5.21
	Kollam	2,584,118	1037	10.68	7.33
	Thiruvanantha puram	3,234,707	1476	13.50	9.78

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State	District	Total population	Population density	Decadal growth of population (%)	
				1981-91	1991-2001
Tamil Nadu	Nilgiris	764,826	300	12.70	7.69
	Coimbatore	4,224,107	566	14.65	20.40
	Theni	1,094,724	357	12.98	4.33
	Dindugal	1,918,960	317	12.54	8.99
	Virudunagar	1,751,548	409	16.71	11.92
	Tirunelveli	2,801,194	411	12.53	11.97
	Kanyakumari	1,669,763	992	12.43	4.34

*as per 1981 Census

Note: The report of the Working Group on Hill Area Development Programme / Western Ghats Development Programme for the Tenth Five Year Plan (2002-2007) Government of India, Planning Commission, June 2001 considers Ahmednagar (Maharashtra), Dharwad (Karnataka), Erode and Madurai (Tamil Nadu) as districts of the Western Ghats region.

Table 2. 3 Districtwise distribution of human population density

Density	Number of districts
Less than 200	6
201-400	15
401-600	5
601-800	2
801-1000	5
More than 1000	6

Table 2.4 Human population in the 6 Western Ghats states with the proportion of SC/ST

State	Population as per 1991 census			Population projection for 2001		
	Total	SC	ST	Total	SC	ST
Gujarat	41309582	3060358 (7.4%)	6161775 (14.9%)	49194000	3644463 (7.4%)	7337822 (14.9%)
Maharashtra	78937187	8757842 (11.1%)	7318281 (9.27)	92314000	10241959 (11.1%)	8558448 (9.27%)
Goa	1169793	24364 (2.1%)	376 (0.03%)	-	-	-
Karnataka	44977201	7369279 (16.4%)	1915691 (4.26%)	52922000	8670993 (16.4%)	2254080 (4.26%)
Tamilnadu	55858946	10712266 (19.2%)	574194 (1.0%)	62400000	11966667 (19.2%)	641432 (1.0%)
Kerala	29098518	2886522 (9.9%)	320967 (1.1%)	32605000	3234359 (9.9%)	359645 (1.1%)

Source: Planning Commission-Government of India, 2001

2.4 Ecological profile

The Western Ghats are known for their highly varied landscapes. The overall variations in topography and the resultant local climate and types of ecosystems have all contributed to the complex patterns of distribution of biodiversity in the Western Ghats. The Palghat Gap, which is only 13 km wide at its narrowest point and 170m ASL, has also been considered by biogeographers to have an important role in this regard. Theory suggests that the Palghat Gap is the dried up course of a prehistoric river that drained westward before the origin of the Western Ghats (Radhakrishna, 1993). Professor Valdhya of the Jawaharlal Nehru Centre for Advanced Scientific Research (Bangalore) however is of the opinion that the Palghat Gap was formed due to volcanic activities some time in the early Cambrian (c. 500 myBP) (K A Subramaniam, pers comm).

Landscape elements in the Western Ghats that are higly localised include *Myristica* swamps. Limestone outcrops are known in the rainforests of the tropics. In India, such formations are rather rare. The single large limestone outcrop in the Western Ghats is found in Yan (Uttara Kannada district, Karnataka). Cascading waterfalls are largely restricted to the southern Western Ghats (southwards from Goa).

The Western Ghats of Maharashtra and Gujarat are rather different in structure and vegetation since they were modified by the volcanic eruptions that gave rise to the Deccan Traps. Western Ghats in Gujarat are restricted to 3 districts viz., Valsad, Surat and Dangs. Although this amounts to just 2% of the total geographic area, this segment of the landscape potentially supports 20% of all forests in the state. The forests are mostly dry-moist deciduous. Tropical rain forests, in the strict sense, are found southwards from Goa – south of c. 16 degrees north latitude (Rai, 2000).

Box 2.1

Relationships between the climate and vegetation

The changes in the vegetation are mainly determined by three major climatic gradients and local topographic variations.

1. Progress of monsoon rains from the coast towards the interior: the west-east gradient

The reliefs of the Ghats act as a barrier to the eastward movement of the cloud masses brought by the summer monsoon winds. These masses bring prodigious amounts of rainfall over the reliefs of the Ghats. For instance, in Agumbe (645 m) which is situated at the edge of the Ghats, the mean annual rainfall is 7460 mm, and in some years it exceeds 12000 mm in only 130 rainy days. Once this obstacle is crossed, rainfall decreases rapidly towards the interior of the plateau: from 7500 to 4000 mm within 15 km, and to 2000 mm in 50 km. Further north, towards the latitude of Goa, the decrease is even more drastic: 25 km after the summit of the Ghats the rainfall is insufficient to support the evergreen formations. Moist deciduous forests prevail here, and 30 km further east they are replaced by dry deciduous formations.

This decrease results in the isolation of moist formations which are confined to the humid regions with a rainfall of generally more than 2000 mm, i.e., in a narrow belt between the coast and 20-40 km beyond the Ghats' edge. However, in some cases, edaphic compensation (specially better moisture holding capacity of soils) enables the maintenance of evergreen formations even when the rainfall is somewhat lower - the 'kan' forests of the Karnataka plateau are an example of this phenomenon.

2. Lengthening of the dry season: south-north gradient

An important feature of the Western Ghats is that they form a more or less continuous chain of hills with a latitudinal extent of almost 12 degrees. This has few parallels in the tropical world (eastern part of Madagascar and Queensland in Australia). The monsoon, the very pulse of India, adds yet another dimension: the duration of the dry season gradually increases from one month in the southern part of the Ghats to over eight months north of Mumbai (Bombay). This gradient is determined by the dates of arrival and withdrawal of the summer monsoon. The monsoon generally arrives towards the end of May at the southern tip of India, in the first week of June at Tiruvananthapuram (Trivandrum), five days later it reaches Karwar, in another five days it has already crossed Mumbai and by the middle of June it is beyond Kutch. Thus, it takes only 10-15 days to cover the Indian peninsula from 8°N to the Tropic of Cancer. The monsoon begins to retreat by the end of September in North India but it takes nearly 15 days for the front to withdraw from Kutch to Ratnagiri which it reaches in the beginning of October; in another 15 days it covers 400 km, the distance separating Ratnagiri from Coondapur. The front passes through Mangalore at the beginning of November and Kozhikode in a fortnight, and reaches Kanniyakumari only in early December. Thus, the withdrawal is spread over a period of nearly two and a half months. The advance and specially the gradual withdrawal of the monsoon leads to a reduction in the rainy period from south to north, and consequently a concomitant lengthening of the dry season. This gradient is one of the key factors for understanding the variations in the floristic composition along the Ghats. The distribution patterns of the species clearly show that many species cannot thrive under prolonged dry periods. Thus, several species are not found north of the Shencottah-Ariankavu pass, while others disappear beyond the Palghat Gap. Hence, the number of endemic evergreen species, which are generally confined to a moist environment, diminishes from south to north in the Western Ghats. In the northern part of the Ghats, this gradient also determines the climatic limits beyond which the evergreen formations gradually give way to the deciduous forests. Evergreens here survive only under special edaphic conditions or at the higher elevations, where dew and mist provide additional moisture.

Contd…

3. Temperature-altitude gradient

The influence of the decreasing temperature with increased altitude is explicit only in those regions of the Ghats where the altitude is sufficiently high, i.e., from 700 or 800 m upwards. Generally, the mean temperature of the coldest month ranges from 25°C at sea level to 11°C at 2400 m. However, it must be noted that for the same elevation, the temperature may differ considerably from one place to another, depending on exposure or slope. This decrease in temperature influences two kinds of changes: (i) structural change from tall forests (canopy higher than 30 m) to stunted forests (canopy lower than 20 m or sometimes 15 m); (ii) floristic change as some species are unable to adapt to very low temperatures, which are optimal for others.

4. Climatic variations and endemism

The high degree of endemism in the evergreen forests of the Western Ghats can be attributed to the isolation of the Ghats from other moist formations and the prevailing drier climatic conditions in the surrounding areas. This isolation seems to have facilitated the process of speciation leading to: (i) phenomenon of vicariance between sister-species derived from a common ancestor, one of which thrives in the evergreen forests of the Ghats and the other in the adjacent dry regions (for example Diospyros assimilis in the moist evergreen forests and D. ebenum in dry forests) and (ii) the species so derived becomes an endemic. South of Kodagu the Western Ghats are comprised largely of high ranging hills with several enclaves, which formed ideal refugia for certain species when the climatic conditions became drier. Within the Ghats, the variation in the degree of endemism is mainly determined by: (i) the increase in the number of dry months from south to north and (ii) the decrease in temperature with increase in altitude. These two gradients also explain the numerous cases of vicariance encountered within the evergreen continuum. Local topographic variations add another dimension to the floristic diversity and endemism.

Source: Endemic Tree Species of the Western Ghats (India) French Institute of Pondicherry, 1997

The earliest attempt to classify Indian vegetation types was that of Champion in 1936 which was subsequently revised and enlarged in 1968 (Champion and Seth, 1968). This classification despite its widespread use in forest management has a number of limitations as discussed by Gadgil and Meher-Homji (1986). A major deficiency of Champion and Seth's work is a confusion between physical and anthropogenic influences, so that degradation stages of the same original climax vegetation are accorded the same status as distinct climatic climaxes. Further this classification employs an improper demarcation into northern and southern types, although in peninsular India latitude does not differentiate vegetation the way it does in Europe due to the sheltering effect of the Himalayan ranges. The classification also makes poor use of terms such as sub-tropical, dry evergreen and semi-evergreen (Gadgil and Meher-Homji, 1986).

Some of the broad vegetation types identified by Champion and Seth (1968) that characterize the Western Ghats are as follows:

Vegetation types	Distribution
South Indian moist deciduous forest	Dangs, Gujarat
Dry teak forest	
Dry savanna forest	
Dry deciduous scrub forest	
Bombay subtropical evergreen forest	Satara, Maharashtra; Belgaum, Karnataka
South Indian tropical moist deciduous forest	Uttara Kannada, Karnataka
Secondary moist bamboo brakes	
Western laterite semi-evergreen forest	
Southern wet montane forest	Nilgiris/Anaimalais, Tamilnadu and Kerala
Southern montane wet grassland	
Western tropical evergreen forest	Goa, Karnataka, Tamilnadu and Kerala
West coast tropical semi-evergreen	
Nilgiris subtropical evergreen forest	
Nilgiris subtropical hill savanna	
Southern tropical secondary moist deciduous forest	
South Indian dry deciduous forest	Throughout the eastern side of the Western Ghats

Source: Gadgil and Meher-Homji (1986).

Nagendra and Gadgil (1998) have identified 11 landscape elements (LSE) or vegetation mosaics, including anthropogenic, characteristic of the Western Ghats. The different LSEs and their extent are provided in Table 2.5.

Table 2.5: The 11 broad landscape elements/vegetation mosaics of the Western Ghats (Source: Nagendra and Gadgil,1998)

LSE No	Broad vegetation type	Extent (sq km)
1	Tropical dry deciduous forests + cultivation	714
2	Tropical moist deciduous forest + cultivation	143
3	Montane wet evergreen + moist deciduous forests + cultivation + monocultures	6915
4	Deciduous forests + scrub + savanna + cultivation	11,744
5	Eastern deciduous forests + scrub + savanna + cultivation	24,702
6	Extensive cultivation + patches of deciduous forests	36,960
7	Evergreen forests + moist deciduous forests + cultivation	51,900
8	Western evergreen forests + cultivation + plantations	25,830
9	Central-southern evergreen forests + cultivation	5856
10	Fragmented evergreen forests + cultivation	2151
11	Evergreen forests	104

2. 5 Brief history

Peninsular India was part of the Gondwana land till about 150 million years ago, from which it split and started moving north. The northward drift which lasted about a 100 million years finally ended with the peninsula colliding with the Asian mainland 45 million years ago (Daniels, 1997a). Major geologic transformations took place as the peninsula moved northwards. Soon after detachment from the Gondwanaland, the Indian peninsula drifted over the Reunion Hotspots - localised volcanic centres in the earth's lithosphere, 200-300 km across, which have remained active for several million years (Radhakrishna, 1991). It was this event which happened some 120-130 million years ago that resulted in the uplift of the Western Ghats. Subsequently, there were a series of volcanic eruptions until around 65 million years ago giving rise to the extensive Deccan Traps. These volcanic episodes to a large extent moulded the northern third of the Western Ghats. Since the Western Ghats are the result of domal uplift, the underlying rocks are ancient - around 2000 million years old. The oldest of these rocks are found in the Nilgiris and the high ranges of the Western Ghats.

The uplifted crust of the earth bears a central axial region of weakness coinciding with the track of upliftment. Peninsular India broke along its line of weakness, and the western segment drifted westward into the sea (a process known as faulting), giving rise to the present day hill chain, the Western Ghats and the west coast. This happened during the Eocene (between 45 and 65 million years ago), even before India became part of the Asain mainland. At this time the peninsula also experienced a marked eastward tilt permanently changing the pattern of drainage. The western faulting led to 'river capture' and diversion of the easterly drainage to the west in many instances. The rivers Sharavathy and Kali in Karnataka are two classical examples of westerly diversion of drainage due to uplift and faulting (Radhakrishna, 1991). The Western Ghats thus represent a tectonically active region with high rates of uplift, high summit altitudes, steep slopes, deep gorges and large potential energy for erosion and correspondingly high sediment yields (Radhakrishna, 1991).

In summary, by the time peninsular India ended its northward drift and collided with the Asian mainland, the Western Ghats were very much in place. The series of events that followed the rise of the Western Ghats include the development of their present topographic feature some 15 myBP– a steep and vertical western face as against a

gradually sloping eastern aspect, the monsoon rainfall pattern in the peninsula, evolution of waterfalls and torrential streams (Radhkrishna, 1991 & 1993).

Very little fossil evidence exists to reconstruct the prehistoric biodiversity of the Western Ghats. What we do know is that the flora of the Western Ghats share elements with Africa, Madagascar and South America (eg., Family Bignonaceae; *Vinca rosea*, etc). Many species of invertebrates including a few species of butterflies are also shared with South America and Africa (Harish Gaonkar, pers. comm). Amongst freshwater fishes there are a few genera (*Notopterus, Barilius, Rasbora, Puntius, Labeo, Clarias, Mastacembelus, Aphanius*) that are common to India and Africa represented by one or more species in the Western Ghats (Hora, 1944). Species of amphibians (especially caecilians) and reptiles (snakes in the genus *Boiga* for instance) may well have been there ever since the Western Ghats came into being. However, most species of land birds and mammals that are seen in the Western Ghats today were essentially derived from the eastern Himalayan-Malayan complex as has been pointed out by Hora (1949). Birds seem to have colonised peninsular India only after it split from Gondwanaland (Daniels, 1997a). Mammals came in much later.

After India became part of the mainland Asia, rapid colonisation by the ancestors of modern life forms apparently took place. Thus we have in India representatives of the Palearctic, Ethiopian and Oriental biodiversity. Of these, the Western Ghats have sheltered a greater proportion of taxa that are more typically Oriental with considerable Malayan affinity. Such a remarkable assemblage of Malayan biodiversity in the Western Ghats, absent from much of the intervening areas, has led to a lot of theories and speculation (Hora, 1937, 1944, 1949 & 1953).

As early as the 1930s Sunder Lal Hora, one of India's foremost icthyologists, intrigued by the disjunct distribution of freshwater fishes in peninsular India, began his quest for a plausible explanation. He later postulated the popular Satpura Hypothesis (Hora, 1944, 1949 and 1953). Hora (1953) traced a pathway through the Satpura hill ranges as the sole migratory route of certain species of freshwater fishes that colonised the Western Ghats from the Himalayan-Malayan region some 12-15 million years ago. He had also made an attempt to draw in parallel solutions to what he called an 'anomalous' distribution by comparing distribution patterns in other faunal groups (Hora, 1949). While Hora's hypothesis is of interest, its exclusiveness in the biogeographical study of the biodiversity

of the Western Ghats can be questioned (Mani, 1974 and the many papers therein; Daniels, 1997a and 2001a). The main drawback of the Satpura Hypothesis is that it primarily takes into consideration the migration of torrential stream fishes from Eastern Himalayas and Southeast Asia to the Western Ghats, without paying any attention to the many temperate (cold loving and high altitude) flora and fauna that have colonised and evolved in the Western Ghats. For instance, amongst the 19 species of birds that are endemic to the Western Ghats, about half are inhabitants of the higher elevations (Daniels, 1997a). Even amongst fishes, the apparent affinity between Western Ghats and Indo-Malaya discussed by Hora has been rendered irrelevant by recent systematic revisions (Daniels, 2001a).

Further, although the Satpura Hypothesis seems to explain the migration of Indo-Malayan hill stream fishes into the Western Ghats, many vertebrates that have colonised these hills do not conform to the theory. Not all groups of biodiversity in the Western Ghats are equally well represented by Indo-Malayan forms. Highest levels of endemism amongst Indian vertebrates is in amphibians and reptiles that we find in the Western Ghats. Recent herpetological studies in the Western Ghats have resulted in the discovery of many hitherto undescribed species of amphibians and reptiles. Taxonomists have ascribed to some of these species endemic generic names such as *Keralia* (treefrog – Rhacophoridae) and an yet to be named species of burrowing frog popularly called 'pig-nosed frog' might well belong to a family of frogs known only in Africa (Sushil K. Dutta, pers. comm). Other unique genera such as *Melanobatrachus* and *Nyctibatrachus* (frogs), *Salea* (lizards) and Uropeltidae, a family of burrowing snakes endemic to southwestern India and Srilanka, suggest that the community of amphibians and reptiles in the Western Ghats may have had a different evolutionary history. The southern half, in fact, being biogeographically more similar to Srilanka is considered as belonging to the Indo-Ceylonese/Sri Lankan biogeographic province (Blanford, 1901; Myers *et al*, 2000).

Speciation has been at different rates amongst the various groups of organisms in the Western Ghats. Around 1500 species of flowering plants and 340 species (36%) of all vertebrates are endemic. Amongst vertebrates, endemism is the highest in amphibians (78% species), followed by reptiles (62%), fish (53%), mammals (12%) and birds (4%) (Table 2.6).

Table 2.6 Endemic species of the Western Ghats

Group	Total species	Endemic species	% endemism
Angiosperms	4000	1500	38
Butterflies	330	37	11
Fishes	218	116	53
Amphibians	121	94	78
Reptiles	157	97	62
Birds	508	19	4*
Mammals	120	14	12

Source: Nair and Daniel (1986); Swengel (1991); Daniels (1992, 1993, 1997a&c); Dutta (1997); Das (1997); Easa (1998); Menon (1999); Nameer (1998); Kunte, *et al* (1999); Rema Devi – ZSI (pers comm); Gaonkar (1996); Johnsingh (2001).

* The percentage of endemic birds will be nearly 6.0 if the 324 resident species are alone considered.

Modern biogeographers feel that speciation in tropical landscapes was at its highest during the pleistocene glaciation (past 1.5-2.0 million years) (Haffer, 1974; Prance, 1982). Recent evidence of isolated extant populations of plants and animals, earlier considered as 'endemic' to the Western Ghats, in many hills in peninsular India suggest that there were many phases of colonisation/evolution and many different routes of immigration as well (Daniels, pers. observ). It is also apparent that such colonisation episodes continued till recently taking advantage of the changing climatic conditions during the Pleistocene. The many endemic subspecies of birds in the Western Ghats substantiate this claim (Daniels, 1997a).

As mentioned earlier, there is very little fossil evidence to trace prehistoric extinction of biodiversity in the Western Ghats. We therefore can only speculate the process of local extinctions based on the present day patterns of biodiversity distribution in the Western Ghats and the remaining parts of the peninsula. Recent history of species extinctions in the Western Ghats was certainly coincident with the climatic and human histories during the past 20,000 years. Studies have shown that during this period the Western Ghats experienced extended arid climate (Subash Chandran, 1997).

During the past 12,000-5,000 years there has been the maximum human interference due to settled agriculture and extensive transformation of habitats in and around the Western Ghats. Mesolithic or middle-stone-age sites dating back to this period have been unearthed along the coastal parts of Goa, Karnataka and Kerala (Subash Chandran, 1997). The rainforests were probably modified by humans much later somewhere around 3500 years ago when there was an extended dry period (Subash Chandran, 1997). Patchy

distribution of species, except those with populations which are isolated due to specialised habitat requirements such as high altitude forests, which are themselves patchily available, is a clear evidence of local extinctions during recent history. Examples of bird distribution that support this have been discussed elsewhere (Daniels, 1997a). Studies have also shown how human interference at the scales of landscapes have altered the patterns of distribution and habitat use in birds of the Western Ghats both during historical times and as late as about 100 years ago (Daniels *et al*, 1990a & 1992).

3.0 Current range and status of biodiversity

3.1 State of natural ecosystems and plant/animal species

Natural ecosystems in the Western Ghats may be broadly categorised as high elevation forests and grasslands, rainforests, deciduous forests, riverine and the dry rocky eastern terrains. The various vegetation types/landscape elements discussed in section 2.4 are distributed along this rainfall and altitudinal gradient in various stages of degradation. Much of the existing ecosystem diversity in the Western Ghats exist within the less than 10% of land within the Protected Areas system. While there are patches of natural and near natural vegetation types characteristic of the Western Ghats' ecosystem within private holdings also, these are occasional.

It is hard to find even a few hectares of land and water without one or the other form of human influence. Wherever strict protection measures have been enforced, as within the National Parks and Wildlife Sanctuaries, there are signs of forests recovering. However, such recovery has been only during the past 30-50 years. What we therefore see in the Western Ghats today is a mosaic of ecosyetems of varying extent and integrity represented by small (less than 200 sqm) to large (a few hundred hectares) patches of relatively less disturbed and more disturbed forests. Such fragemented vegetation patches are often widely separated from each other due to agriculture, monocultures, dams, and a range of other human enterprises. The net result is that the biodiversity within these fragmented ecosystems also present themselves as fragmented and isolated populations throughout their historical range. Patchy distribution of biodiversity (be it ecosystem or species) is the present scenario in the Western Ghats.

3.1.1 Flora

Nair and Daniel (1986) have in detail reviewed the vegetation and floristics of the Western Ghats (see also Subramanyam and Nayar, 1974). As early as 1904 Hooker had drawn attention to the distinct flora of the Western Ghats, which he called the Malabar floristic region (Nair and Daniel, 1986). The presence of Bambusae, Dipterocarpaceae, Guttiferae, Myristicaceae and Palmae (Arecaceae) has contributed to its distinctness. Amongst the various major vegetation types that Nair and Daniel (1986) have discussed are tropical evergreen forests, moist deciduous forests, dry deciduous forests, scrub

jungles, sholas, savannas including high rainfall savannas, peat bogs and *Myristica* swamps (Table 3.1).

Table 3.1 Vegetation types of the Western Ghats

Vegetation type	Distribution	Dominant flora
Tropical evergreen forests	200-1500 m ASL; 2500-5000 mm rainfall	Emergents up to 60m; *Acrocarpus, Aglaia, Artocarpus, Calophyllum, Canarium, Cullenia, Dipterocarpus, Holigarna, Knema, Myristica*, etc
Moist deciduous forests	500-900 m ASL; 2500-3500 mm rainfall	*Bridelia, Pterocarpus, Sterculia, Pterospermum, Lagerstroemia, Tectona, Terminalia*, etc.
Dry deciduous forests	300-900 m ASL; 1000-2000 mm rainfall	*Albizia, Anogeissus, Bauhinia, Buchnania, Butea, Dillenia, Emblica*, etc.
Scrub jungles	200-500 m ASL; 300-600 mm rainfall	*Acacia, Carissa, Capparis, Flacourtia, Gardenia*, etc.
Sholas	Above 1500 m ASL; medium to high rainfall	Short trees, 15-20 m high; *Actinodaphne, Elaeocarpus, Eunymus, Michelia, Rhodomyrtus, Schefflera, Symplocos*, etc.
Savannas	1700-1900 m ASL; medium to high rainfall	Grass; *Chrysopogon, Arundinella, Eulalia, Heteropogon*, etc
High rainfall savannas	Montane; Extremely high rainfall	Herbaceous to shrubby cover; *Ligustrum, Rhododendron, Anaphalis, Strobilanthes*, etc.
Peat bogs	Above 2000 m ASL; High rainfall	Grasses, sedges and mosses; Carex, *Cyanotis, Cyperus, Eriocaulon*, etc.
Myristica swamps	Sea level to around 600 m ASL, medium to high rainfall	*Myristica, Knema, Hydnocarpus, Lophopetalum*, etc.

Source: Nair and Daniel (1986).

Four thousand species of flowering plants are known from the Western Ghats (Nair and Daniel, 1986). The gymnosperm flora is represented by *Cycas circinalis* (Cycadales), *Decussocarpus wallichianus* (Coniferales) and *Gnetum ula* and *G. contractum* (Gnetales). Amongst the lower plants around 150 species of pteridophytes, 200 species of

bryophytes, 200-300 species of algae and 800 species of lichens are known. There are 600 species of fungi known from the Western Ghats (Nair and Daniel, 1986).

Fifty-six genera of flowering plants are considered endemic to the Western Ghats (Nayar, 1982). The validity of endemism at generic and higher taxonomic levels is however subject to systematic revisions (Daniels, 1997b). According to Nair and Daniel (1986) 2100 species of flowering plants are endemic to peninsular India, 'most' of which are 'confined' to the Western Ghats. More recent authors have suggested that there could be 1500 species of flowering plants endemic to the Western Ghats (Johnsingh, 2001). Although the exact number keeps varying with the author and time, what is of interest is that nearly 38% of all species of flowering plants in the Western Ghats are endemic (see Table 2.6). Further it is to be noted that 63% of India's evergreen woody plants are endemic to the Western Ghats (Johnsingh, 2001).

Nearly 650 species of plants in the Western Ghats are trees. These fall into 321 genera and 68 families. 352 species are endemic (B R Ramesh, French Institute, pers comm). Interestingly, endemism in trees is highest in the southern Western Ghats and endemic herbs are most diverse in the more seasonal north (Rev C J Saldanha, pers comm).

The Nilgiri mountains are considered as the most important centre of speciation of flowering plants in the Western Ghats (Blasco, 1970). 82 species are endemic to these hills. High levels of montane endemism is also seen in the Palni Hills (18 species) and Anaimalai Hills (13 species) (Nair and Daniel, 1986). These mountains are also unique in having a mosaic of montane forests and savannas often referred to as the 'shola-grassland' complex. The ecotones created therein are also very important habitats, especially for herbs and small shrubs (Daniels *et al*, 1995a). Although the origin and age of the shola-grassland complexes in the hills have been long disputed, recent studies have shown that they were in place for the past 50,000 years (Vasanthy, 1988; Sukumar *et al*, 1993; Prabhakar, 1994). The dynamics of the shola-grassland complexes in the higher elevations of the Western Ghats are rather poorly understood.

It has been observed that the endemic species in general predominate those south Indian flowering plants listed as endangered in the Red Data Books (Nayar and Sastry, 1987-1990; Daniels *et al*, 1995a). Besides geographical restrictedness, other inherent factors that render species of flowering plants vulnerable to extinction are specialised altitude, vegetation type, habitat and mcirohabitat preferences of individual species. Thus amongst

171 species of south Indian flowering plants listed in the Red Data Books, 41.5% are from the evergreen forests and 10% are from grasslands. 24.5% are restricted to altitudes above 1800 m ASL. 10% grow in rock crevices filled with humus, 9.4% are found in stream banks and 7.6% are epiphytic (Daniels *et al*, 1995a). Such altitudes, habitats and microhabitats are characteristic of the Western Ghats, implying a greater inherent vulnerability of the flora of these unique hill ranges. An example of specialised habitat/microhabitat users amongst flowering plants that probably have gone locally extinct during recent time is *Hubbardia heptaneuron*, a grass that once grew in the spray zone of the Jog Falls in the Western Ghats (Nair and Daniel, 1986; Rev. C J Saldanha, pers. comm.). This species of grass has recently been obtained form moist rocky habitats in Maharashtra (Prof Yadav, Kohlapur University, pers comm). There are many other examples of plants that are locally extinct (Table 3.2).

Table 3.2 Species of plants locally extinct from where first described yet rediscovered elsewhere in the Western Ghats

Species	Family
Cordia octandra	Boraginaceae
Madhuca bourdillonii	Sapotaceae
Calliandra cyanometroides	Leguminosae
Ceropegia maculata	Asclepiadaceae
Garcinia imberti	Clusiaceae
Palaquium bourdillonii	Sapotaceae
Pavetta praeterita	Rubiaceae
Syzigium bourdillonii	Myrtaceae
Nostolachma crassifolia	Rubiaceae
Nothopegia aureo-fulva	Anacardiaceae
Ellipanthus tomentosus	Connaracae
Litsea travancorica	Lauraceae
Cissampelopsis ansteadii	Asteraceae

Source: N Sasidharan pp70-78 in: Kumaravelu and Chaudhuri (1999)

Sukumar *et al* (1992), Daniels *et al* (1995b), Ganesh *et al* (1996), Krishnan and Davidar (1996), Pascal and Pelissier (1996), Ganesh and Davidar (1997 & 2001), Parthasarathy and Karthikeyan (1997), Ghate *et al* (1998) and Parthasarathy (1999 & 2001) are some of the recent studies on the ecology, diversity and distribution of flowering plant communities in the Western Ghats. In the Uttara Kannada disrict, there were 694 flowering plants (1m and above in height) representing 48 species in 2400 sqm of less disturbed humid forests as against 379 plants and 36 species in the more disturbed sites. Eighty four of the 200 species of woody plants sampled were exclusive to the humid

forests in sites of low human disturbance, 28 were exclusive to the sites of high human disturbance and 88 species were shared by the two (Daniels *et al*, 1995b). Small scale altitudinal changes in species composition are largely due to transition in vegetation types influenced by bioclimatic and edaphic factors (Ganesh *et al*, 1996; Parthasarathy, 2001). Shrub diversity in the Western Ghats is the highest in evergreen forests (Krishnan and Davidar, 1996).

Forest ecosystems with a mixture of open areas and different stands of evergreen, semi-evergreen and moist deciduous forests and riparian fringes are the most diverse in fern species in the southern Western Ghats (Sharma, 2001). Similarly, the greatest diversity of ferns is seen between 600 and 900 m ASL in the southern part of the Western Ghats. Epiphytic ferns are sparsely distributed. Rainfall and higher elevation influence the abundance and diversity of epiphytic ferns. Ferns with specialised habitat requirement such as humus rich soils in humid forests and those endemic to the Western Ghats are sparsely distributed too. Fern species in semi-evergreen and deciduous forests are more adaptive (Sharma, 2001).

Around 500 species of trees are considered 'evergreen'. About 45 species of these are found at altitudes above 2000m ASL of which 25 are endemic. There are around 500 species of trees inhabiting altitudes below 800m ASL. An equal number is known between 800 and 1500m ASL. While at elevations below 800m there are many deciduous and widespread species, between 800 and 1500m there are the maximum number of evergreen and endemic trees (Utkarsh Ghate, pers comm).

The distribution of trees in the major vegetation types of the Western Ghats is shown in Table 3.3. From the table it is evident that the families Myrtaceae, Rubiaceae and Euphorbiaceae are widespread along both the altitudinal and moisture gradients in the Western Ghats. The family with the most restricted distribution is Theaceae which is largely restricted to the high elevation sholas. Families Dipterocarpaceae and Lauraceae are more common in the moist forests.

Table 3.3 Distribution of trees in the different vegetation types of the Western Ghats

Family/ Vegetation	Shola	EVG	SEVG	MD	DD	SC-SV	MM
Theaceae	5						
Dipterocarpaceae		15	10		1		
Myristicaceae	1	4	2				
Lauraceae	25	50	25	5			
Rutaceae		5	10	5	5	5	
Meliaceae		20	25	15	10	5	10
Rubiaceae	5	20	25	15	10	7	5
Anacardiaceae		15	10	5	5	5	3
Myrtaceae	10	25	15	3	2	5	3
Combretaceae		3	5	5	4	5	2
Leguminosae		5	10	20	15	10	15
Euphorbiaceae	5	25	30	10	15	25	10
Arecaceae		3	5	1		3	3
Rhamnaceae			3	4	4	5	2

Source: Utkarsh Ghate (pers comm); Only the important families have been included.

EVG-Evergreen; SEVG-Semi-evergreen; MD-Moist Deciduous; DD-Dry Deciduous; SC-SV-Scrub-Savanna; MM-Man-made.

Box 3.1

Distribution of the evergreen and the semi-evergreen formations along the Western Ghats

The forest classification generally followed in India is that of Champion & Seth (1968), which was established for the entire subcontinent. Although this classification is very valuable, it fails to take into account the variations in the structure and floristic composition within the evergreen and semi-evergreen continuum of the Western Ghats. In fact, all these natural variations have been grouped under only eight types.

A more detailed classification was proposed to explain the structural and floristic variations in Western Ghats. The scheme presented here is a slightly simplified version of it. For instance, the highly localised formations such as the Myristica swamps of Travancore and facies of some forest types which sometimes cover vast areas, have not been included. The evergreen and semi-evergreen formations extending north of 16°N have also been grouped together although they may belong to at least two different types. Thus, 19 floristic types have been distinguished according to altitude: eight types in low elevation, five at medium elevation and three at high elevation. Dry evergreen forests found on the eastern slope of the Ghats, south of Palghat gap, account for other three floristic types. These types are named after the species selected for their abundance, or characteristic value, or both.

Wet evergreen forests - Low elevation types

1.Dipterocarpus indicus - Kingiodendron pinnatum - Strombosia ceylanica
2.Dipterocarpus indicus - Dipterocarpus bourdilloni - Strombosia ceylanica
3.Dipterocarpus indicus - Kingiodendron pinnatum - Humboldtia brunonis
4.Dipterocarpus indicus - Humboldtia brunonis - Poeciloneuron indicum
5.Dipterocarpus indicus - Persea macrantha
6.Dipterocarpus indicus - Diospyros candolleana - Diospyros oocarpa
7.Persea macrantha - Diospyros spp. - Holigarna spp.
8.Diospyros spp. - Dysoxylum malabaricum - Persea macrantha Medium elevation types
9.Cullenia exarillata - Mesua ferrea - Palaquium ellipticum - Gluta travancorica

Contd….

10.Cullenia exarillata - Mesua ferrea - Palaquium ellipticum
11.Mesua ferrea - Palaquium ellipticum
12.Poeciloneuron indicum - Palaquium ellipticum - Hopea ponga
13.Memecylon umbellatum - Syzygium cumini - Actinodaphne angustifolia
High elevation types
14.Bhesa indica - Gomphandra tetrandra - Litsea spp.
15.Schefflera spp. - Meliosma arnottiana - Gordonia obtusa
16.Litsea spp. - Syzygium spp. - Microtropis spp. Dry evergreen forets
17.Diospyros foliosa - Mitreophora heyneana - Miliusa spp. - Kingiodendron pinnatum
18.Diospyros foliosa - Mitreophora heyneana - Miliusa spp.
19.Diospyros ovalfolia - Memecylon lushingtonii - Olea glandulifera

Source: Endemic Tree Species of the Western Ghats (India) French Institute of Pondicherry, 1997

In the Kalakad-Mundanthurai Tiger Reserve, plants belonging to 42 families have been enumerated in the evergreen forests. Of these, Lauraceae dominates the canopy followed by Euphorbiaceae, Myrtaceae, Meliaceae and Rubiaceae when the number of species is considered. When density is taken into account, these forests are dominated by just two families viz., Myristicaceae and Sapindaceae (Parthsarathy, 2001). In the sholas of BR Hills it has been observed that the size of patch positively influences the number of tree species (Ganeshaiah *et al*, 1997).

The role of figs (*Ficus* spp) as 'keystone species' is well known from many tropical ecosystems. There are 27 species of figs in the Western Ghats of which 6 including *Ficus dalhousie* and *Ficus beddomei* are endemic (Ghate, 2000). Many species of insects (fig wasps), birds and mammals are known to heavily depend on figs for their growth and survival.

Flowering in *Cullenia exallirata* occurs during the dry season when there is scarcity of fruits in the forest. Six species of arboreal mammals and seven species of birds feed on the flowers. It is hence possible that *C. exallirata* is also a keystone species in the Western Ghats (Ganesh and Davidar, 1997). *Cullenia*-Lion-Tailed Macaque mutualistic association (eg see Parthasarathy, 2001) is rather important though not as rigid as considered to be by early naturalists (Ajith Kumar, pers comm).

Of 487 species of plants in the Red Data Books analysed for their specific ecological traits, it emerged that a significantly higher proportion of plants were fruit-bearing – their unit of dispersal being the fruit/pod than the seed per se (Lokesha and Vasudeva, 1997).

Symbiotic associations between frugivorous animals and fleshy fruit-bearing plants, is thus vital to the functioning of forest ecosystems in the Western Ghats.

Productivity of the rain forests in the Western Ghats of Karnataka has been studied by Rai (2000). Table 3.4 compares productivity in the rain forests of the Western Ghats with tropical rain forests elsewhere in the world.

Table 3.4 Comparison of Biomass and Productivity of Rainforests of Western Ghats with tropical Rainforests elsewhere

Attribute	Western Ghats	Other Rainforests
Above ground biomass	478.82 t/ha	233 – 560 t/ha
Root biomass	13.21 t/ha	13 – 72 t/ha
Litter production	3.917 t/ha/yr	5.5 – 23 t/ha/yr
Leaf litter	3.277 t/ha/yr	3 – 11.9 t/ha/yr
Leaf biomass	8.604 t/ha	8 – 20.25 t/ha
Leaf area index	9.845	6.4 – 7.8
Net primary productivity	7.7 – 11.7 t/ha/yr	13 – 32 t/ha/yr

Source: Rai (2000)

3.1.2 Invertebrates

Scientific research on the invertebrates of the Western Ghats has largely been restricted to a few groups of organisms. As with any other tropical region, the Western Ghats' invertebrate diversity is best known by the butterflies (Gaonkar, 1996; Kunte, 2000). Amongst other insects, ants of the Western Ghats are better studied for their habits and ecology (Gadagkar, *et al*, 1993; Basu, 1997; Pachpor, *et al*, 2000-2001). While there are a number of studies undertaken on other invertebrates throughout the Western Ghats, very few really address questions relating to ecology and biodiversity (eg Kumaraswami and Ambrose, 1994). Most of the studies on invertebrates are of a checklist nature or taxonomic.

A catalogue of the Zoological Survey of India titled 'List of Publications up to December 1995' does not include a single monograph on any group of invertebrates for the Western Ghats, per se. Interestingly, while there are such monographs for the Andaman and Nicobar Islands, very few attempts have been made (much less published) to understand the invertebrate diversity in the Western Ghats, even by premier institutions like the Zoological Survey of India.

Silent Valley, is probably the only locality in the Western Ghats wherein careful studies were undertaken on invertebrates. Reporting on the results of the multi-disciplinary expedition organised by the Geological Survey of India, Kerala Circle in January-February 1979, Pillai (1986) has listed, amongst what he describes as 'important groups of animals collected from Silent Valley', the following invertebrate groups: Nematahelminthes, Annelida, Crustacea, Collembola, Diplura, Thysanura, Odonata, Orthoptera, Phasmida, Dermaptera, Isoptera, Hemiptera, Thysanoptera, Neuroptera, Lepidoptera, Diptera, Dictyoptera, Hymenoptera, Coleoptera, Archnida, Myriapoda and Mollusca.

During the recent years, a couple of special issues of *Current Science* have been dedicated to biodiversity studies in the Western Ghats: volume 73(2) 1997 carried a special section on Biodiversity of Western Ghats and vol 80(3) 2001 was dedicated to Biological Diversity: Kalakad-Mundanthurai Tiger Reserve. The former carried a single article on ants (Basu, 1997) and the latter one on butterflies (Devy and Davidar, 2001) suggesting that we need to go a long way before we understand biodiversity - species richness and the factors governing it, in most other groups of invertebrates.

Studies in Uttara Kannada district by Gadagkar *et al* (1993) have suggested that ant species diversity in forests is linked to the woody plant species diversity. Elsewhere in the forests of Karnataka studies on ant communities have indicated that the common weaver ant *Oecophylla smaragdina* regulates the behaviour of other terrestrial ants that share its habitat. Whether such dominance by the weaver ant also has a bearing on the ant species diversity in the habitat is not yet clear (Basu, 1997). It has been observed that ants in the genus *Leptogenys* dominate terrestrial ant communities in the Western Ghats (Ali and Ganeshaiah, 1998).

Butterflies in the Western Ghats belong to five families, 166 genera and 330 species. Of these, 37 species are endemic (Gaonkar, 1996; see Annexure). The 330 species of butterflies depend on over 1000 species plants for feeding and breeding (Gaonkar, 1996). Diversity of butterflies in the Western Ghats is thus related not only to adult feeding habitats, but also larval food plants (Gaonkar, 1996; Kunte 2000; Kunte, 2000-2001). Comparative studies on butterflies using selectively logged and unlogged forests in Kalakkad-Mundanthurai Tiger Reserve has suggested that butterfly diversity tends to increase in selectively logged habitats. However, it has been pointed out that this increase

is due to the invasion by ubiquitous species at the expense of habitat specialists such as *Idea malabarica* (Devy and Davidar, 2001).

Larsen (1987-88) drew attention to the role of altitudinal variations in determining the distribution of butterflies in the Nilgiris. Gaonkar (1996) has identified 3 distinct biogeographical sections in the Western Ghats based on the distribution of butterflies and their host plants. The three sections are southern Western Ghats extending north from Kanyakumari till the Palghat Gap, the central Western Ghats starting north of the Palghat Gap and extending till the north of Goa and northern Western Ghats that includes Maharashtra and Gujarat. The southern Western Ghats are by far the richest with the highest number of endemic species. Almost all the species of butterflies known in the Western Ghats, occur within this section. The Western Ghats in Gujarat are the poorest with just 158 species of butterflies. The central Western Ghats are rather rich in butterfly species. While 249 species are known from the state of Goa, the Uttara Kannada district alone is known to harbour 300 species (Gaonkar, 1996; see Table 3.5 for more details).

Table 3.5 Distribution of butterflies in the Western Ghats

Geography	**Families and species**					
	Papilionidae	Pieridae	Nymphalidae	Lycaenidae	Hesperiidae	Total
India	107	109	521	443	321	1501
Western Ghats	19	33	96	101	81	330
Kerala	19	31	95	93	76	314
Tamil Nadu	19	31	94	97	75	316
Karnataka	19	29	92	98	78	316
Goa	18	27	70	78	56	249
Maharashtra	13	24	59	71	40	208
Gujarat	11	23	41	51	32	158

Source: Gaonkar (1996).

A few studies in the Western Ghats have paid attention to aquatic invertebrates including molluscs. During the early 1980s, a study of aquatic insects in the Nilgiris indicated that human interference in the upper Nilgiris has apparently reduced the diversity of species in seemingly undisturbed areas as Silent Valley (Thomas Burton, pers comm). A decline in the diversity of aquatic invertebrates has also been noticed elsewhere in the Western Ghats. Habitat loss and pollution in Pune City have been attributed as reasons for the decline of aquatic insects and molluscs (Raut *et al*, 2000-2001).

Currently, the Centre for Ecological Sciences, Indian Institute of Science (Bangalore) is conducting an extensive study of aquatic insects in the Western Ghats. The study focuses on community ecology of stream insects in 27 localities involving 216 sampling sessions representing the major regions, 17 river basins and vegetation types of the Western Ghats. The northernmost sampling point is Triambak in Nasik and the southernmost, Agashthyamalai, Trivandrum. Stream insects belonging to 13 orders, 53 families and 80 genera have been collected. Families such as isonychidae (Ephemeoptera: Mayflies) and blephariceridae (Diptera: Netwinged midges) which were hitherto believed to be palaearctic and known from the cold streams of the Himalayas were collected for the first time in the Western Ghats. A detailed community level analysis is underway. It is expected that the study will identify bioindicator species that will serve as valuable tools in monitoring the aquatic habitats of the Western Ghats (K A Subramaniam, pers comm).

Many parts of the Western Ghats are still poorly explored for their invertebrate biodiversity. At the workshop on 'Research priorities in tropical rainforests' held in Coimbatore (February 27-28, 2001) Dr N A Madhyastha (Centre for Malacology, Udipi/Karnataka) reviewed the status of malacological studies in the Western Ghats. According to him, most of the earlier works in the Western Ghats have under-represented the number of species of land and aquatic snails. His preliminary studies have suggested that Silent Valley and many other well preserved parts of the Western Ghats may well support over a 100 species of molluscs locally.

At the same workshop, Rajashekhar and Raghavendra (2001) presented an overview on the spiders of India. According to them, there are at least 200 species of spiders collected from the Western Ghats that have been housed in their collection. The spiders of the Western Ghats are dominated by the families Argyopidae (38%), Salticidae (26.2%), Thomisidae (11.9%), Oxyopidae (5.4%), Linyphidae (4.2%) and Hersilidae (2.9%) in terms of relative abundance.

3.1.3 Fishes

There are around 218 species of primary and secondary freshwater fishes in the Western Ghats. 53% of all fish species (116 species in 51 genera) in the Western Ghats are endemic (Talwar and Jhingran, 1991; Jayaram, 1999; Menon, 1999; Daniels, 2001a; Rema Devi – ZSI, pers comm) (see Annexure). As pointed out in the past by Hora (1937, 1944, 1949 & 1953), the hill stream fishes in the Western Ghats are of interest as their

patterns of distribution and diversity raise a number of biogeographical and ecological questions (Daniels, 2001a).

Besides scientific interest, freshwater fishes of the Western Ghats have a lot of economic value as food and ornamental fish. At least a 100 species, many being endemic, have been listed as having potential economic value by Goplakrishnan and Ponniah (unpublished). Such species are in the genera *Tor, Neolissochilus, Gonoproktopterus, Hypselobarbus, Labeo, Barbodes, Osteocheilus, Horabagrus, Mystus, Ompok, Silurus, Wallago, Clarias, Channa*, all considered as food and sport fishes and in the genera *Puntius, Danio, Rasbora, Barilius, Chela, Bhavania, Homaloptera, Travancoria, Balitora, Nemacheilus, Garra, Glyptothorax, Pristolepis, Aplocheilus, Tetradon, Macropodus, Etroplus*, etc., all of potential ornamental value (Daniels and Ouseph, unpublished; Gopalkrishnan and Ponniah, unpublished).

While some of the food/sport fishes reach large sizes – *Tor, Wallago*, etc exceeding lengths of 2 m and above, most are small. Species of *Danio, Barilius*, *Nemacheilus* and *Puntius* are very colourful. *Puntius conchonius, Danio malabaricus*, and *Brachydanio rerio* which have been popular throughout the world as ornamental fishes for the past 50 years naturally occur in the streams of the Western Ghats. Many other species like *Puntius fasciatus, Puntius aurulius, Puntius filamentosus, Chela sp, Macropodus dayi, Etroplus maculatus*, and *Tetrodon travancoricus*, for example, are widely collected from the Western Ghats and traded worldwide. In fact of the 320 species of Indian fish collected for aquarium trade (as listed by Marine Products Export Development Authority), nearly half occur in the Western Ghats. Of these 35-40 species are endemic.

Amongst the most ecologically interesting species of fishes in the Western Ghats are some of the torrent species of loaches and catfishes in the genera *Homaloptera, Bhavania, Travancoria*, *Parapsilorhynchus* and *Glyptothorax*. Torrent fishes are known to have highly reduced respiratory organs, since such waters have high levels of dissolved oxygen, and thus can be excellent bioindicators of aquatic pollution. They do not survive in slow moving and still or oxygen deficient waters. Their modified disc-like mouths limit their feeding regimes (Hora, 1944). Another species that has attracted a lot of scientific interest in the Western Ghats is a small blind catfish (*Horaglanis krishnai*) which is found only in the wells of certain parts of Kerala.

Patterns of distribution and diversity of freshwater fishes in the Western Ghats are rather poorly understood. This is mainly due to the widespread construction of lakes, reservoirs and dams and the subsequent introduction of food and sport fish during the past 200 years. Such an interference of humans in natural fish habitats has certainly disturbed the original community structure of fishes. What we hence see today, throughout the Western Ghats, are fish communities wherein there are naturalised 'exotics' including catla, rohu, mrigal, tilapia, etc competing and pushing out the native species. In fact, it may not be wrong to state that few other components of biodiversity than fish have really suffered the impact of introduced species.

Box 3.2 -Introduced and naturalised non-native fishes in the Western Ghats

Introduced fishes that have naturalised in the streams, reservoirs and other waterbodies throughout the Western Ghats have been a cause of concern. Such introduced sopecies are of two kinds: species of foreign origin such as *Oreochromis mossambicus* (African), *Gambusia affinis*, *Poecilia reticulata, Xiphiphorus helleri* (all live-bearers from Americas), *Salmo* spp and *Cyprinus carpio* (both from Europe), and major carps (*Catla, Labeo, Cirrhinus* and hybrids of these) of north Indian origin transplanted into pristine south Indian waterbodies including those in the Western Ghats for fishery purposes.

The main agents of such introduction in the Western Ghats are

- Sport fishing/angling in the hills starting with the colonial times (*Salmo* spp)
- Fishery purposes - first by fisheries department and subsequently by local fishermen in 'under-utilised' waterbodies (*Oreochromis*, major carps)
- Reservoir fishery, especially in dammed areas
- Aquarium industry - both accidental and deliberate introductions (*Xiphiphorus*, more recently Loricariid catfishes, etc)
- Malaria control (*Gambusia affinis, Poecilia reticulata*)

Presently, the aquarium industry is potentially the greatest threat in freely importing a variety of South American fishes including prolific catfishes (Loricariidae popularly traded as 'suckers' or '*Plecostomus*' which have already run wild in Kerala) and the aggressive piranhas viz., *Serrasalmus* spp. Several species of north Indian fishes that are popular in aquarium trade such as *Botia* spp and *Lepidocephalus* spp are now freely traded in south Indian urban areas including those in the vicinity of the Western Ghats. Chances of deliberate or accidental introductions of these and other non-native species in the aquatic habitats of the Western Ghats are rather high and of great concern.

Despite the human interference of freshwater habitats in the Western Ghats, there are still some discernable patterns of fish distribution and diversity. In general, the small and rapidly flowing hill streams support only a few species of specialised fish. Species poor fish communities are also seen in the higher elevation streams of the Western Ghats. Deep waters that are slow moving tend to support the highest diversity of fishes in the Western Ghats. Very deep waters as that in lakes, reservoirs and dams tend to be ideal for large sized and introduced species of fishes. They are not suitable for many smaller species that inhabit shallow, clear and rocky pools and streams. Throughout the Western Ghats, there are waterfalls. These waterfalls have created narrow, deep and clean pools of water which are inhabited by a number of large-sized fishes. From what little has been

understood of the distribution and diversity of freshwater fishes in the Western Ghats, it seems that the east flowing streams and rivers tend to be more diverse in fish species than those flowing west. The streams and rivers in the south are more diverse including a larger number of endemic species than those in the north. Whether, this is a genuine pattern or an artifact of inadequate studies needs to be looked into. For instance, Easa and Shaji (1997), based on a study of the freshwater fishes in the Kerala part of the Nilgiri Biosphere Reserve have suggested that the east and west flowing rivers in the region do not significantly differ in the number of species and those species exclusive to them – 69 species, 24 being exclusive to the east flowing rivers as against 68 species and 23 being exclusive to those flowing west.

3.1.4 Amphibians

One hundred and twenty one species of amphibians are known from the Western Ghats (Daniels, 1992). Of these, 94 species are endemic (Daniels, 1992, 1993 & 1997c; Dutta 1997) (see Annexure). The 121 species fall under 24 genera, six families and two orders (Inger and Dutta, 1986). The family ranidae (true frogs) has the largest number of species (49) amounting to 42% of the amphibian fauna of the Western Ghats. The next largest family is rhacophoridae (treefrogs) with 30 species (25% of the amphibian fauna) (Daniels, 1992) (Table 3.6).

Table 3.6 Taxonomic breakup of the amphibian fauna of the Western Ghats

Order	Family	Genera	Species
Anura (Frogs/Toads)	Bufonidae	*Ansonia*	2
		Bufo	10
		Pedostibes	1
	Microhylidae	*Kaloula*	1
		Melanobatrachus	1
		Microhyla	3
		Ramanella	6
		Uperodon	2
	Ranidae	*Micrixalus*	7
		Nyctibatrachus	11
		Indirana	8
		Limnonectes	7
		Fejervarya	2
		Hoplobatrachus	2
		Euphlyctis	2
		Rana	6
		Spaerotheca	4

Contd..

Order	Family	Genera	Species
	Rhacophoridae	*Philautus*	22
		Polypedates	3
		Rhacophorus	5
Gymnophiona (Caecilians)	Ichthyophidae	*Ichthyophis*	7
		Uraeotyphlus	5
	Caeciliidae	*Gegeneophis*	3
		Indotyphlus	1
2	**6**	**24**	**121**

Source: Daniels (1992 and 1997c); Dutta (1997); Ravichandran and Pillai (1999); Krishnamurthy (2001).

Note: This table does not include a few recently discovered amphibians. Recent changes in nomenclature of Indian amphibians, eg. Dutta (1992 and 1997); Das and Dutta (1998) and Indraneil Das (pers comm) have been adopted to replace those used in Daniels (1992) wherever appropriate. For a review of the recent nomenclatural changes in Indian amphibians, especially in the family ranidae, see Inger (1996).

The north-south ranges of the 121 species vary from extremely widespread to highly restricted. Of the species that are intermediate between the two extremes, some are patchily distributed, while others show a more continuous distribution. When the patterns are analysed on a latitudinal scale, it turns out that 8 species including *Bufo melanostictus, Microhyla ornata, Ramanella montana, Rana cyanophlyctis, Rana limnocharis, Rana tigerina, Tomopterna breviceps* and *Polypedates maculatus* are found over the entire range of the Western Ghats. These species are also widespread in the country. Fifty-four species are localized; known from only one latitudinal division. A good example of such species is *Ansonia ornata*. Of the remaining 55 species with wider ranges, 16 show continuous distribution while 39 are patchily distributed over their ranges (Daniels, 1992).

Interestingly, species restricted to south of 13 degrees N latitude are more frequently patchily distributed. There is also a greater representation of species that prefer moist forests in those with patchy distribution. Most species are found in the altitudinal range of 0-1200 m ASL. Highest diversity of species is at 800-1000 m (32 species) (Daniels, 1992). Number of species in any locality in the Western Ghats may however be low (Vasudevan *et al*, 2001).

Based on a brief study of amphibians in the hills of southern Kerala Robert Inger and colleagues had attributed the high levels of amphibian diversity in the Western Ghats to

the higher hills (Inger *et al*, 1987). However, more detailed analysis of amphibian distribution in the Western Ghats has suggested that widespread rainfall, shorter dry season and a more uniform local climate have contributed to the high levels of diversity and endemism than elevation per se (Daniels, 1992).

Most of the early studies of amphibians in the Western Ghats were in the form of faunal surveys wherein the type of habitats used and the preferred altitudes were merely mentioned as natural history notes (eg. See Rao, 1937; Pillai, 1986). The first ever attempt made to understand community structure and organisation of amphibians in the Western Ghats was that of Inger *et al* (1984 and 1987). However, the study was not exclusive to amphibians. It included amphibians as part of a larger study of herpetofauna. Such studies were popular in the West during the eighties (eg. Duellman, 1989).

Few studies have specifically focused on habitat use by amphibians. In the early 1990s, Daniels (1991) highlighted the role of habitat destruction in the loss of amphibians in the Western Ghats. He emphasised the need to protect leaf litter on the forest floor to preserve natural communities of amphibians. Later studies in parts of the Western Ghats have also supported this observation (Vasudevan, 1996; Easa, 1998). Further, litter plays a major role in the breeding success of certain species of treefrogs in the genus *Philautus* where direct development (without a free living tadpole stage) is known (Inger *et al*, 1987; Kanamadi, *et al*, 1996). At very local scales it has been observed that amphibian species richness is determined by the proximity to water – most species tending to aggregate closer to a source of water (Vasudevan *et al*, 2001).

In general, there are more species of terrestrial and arboreal amphibians in the Western Ghats than aquatic ones. In the southern Western Ghats, more species of frogs were found using herbs and shrubs than trees (Inger *et al*, 1987). Exposed rocks that are wet and slimy are very frequent in the Western Ghats. These are used both as resting and breeding sites by a number of amphibian species (Inger *et al*, 1987; Sekar, 1996).

Studies on neotropical amphibian communities have suggested that a majority of the species are nocturnal and arboreal, few being arboreal and diurnal. Also most species of terrestrial amphibians are nocturnal (Duellman, 1989). Such a pattern seems to hold true even in the Western Ghats (Daniels, pers. observ).

Very little information exists on the breeding strategies and tadpole ecology of amphibians in the Western Ghats. Whatever is available is often anecdotal and scattered.

That species of *Ramanella* breed in water collected in tree holes, *Rana leithi* and *Rana beddomi* breed in water dripping over vertical rock faces and that some species of *Philautus* (eg *P. variabilis*, Kadadevaru and Kanamadi, (2001)), develop directly from terrestrially laid eggs is often cited in literature (Inger *et al*, 1984 and 1987). A few studies have discussed habitat use by tadpoles in the Western Ghats (Sekar, 1992).

Duellman and Trueb (1986) while discussing reproductive strategies in amphibians have outlined 29 different modes of reproduction in anurans (frogs and toads). How many of these are found in the amphibian community of the Western Ghats is poorly studied. However, recent studies have shown that in *Philautus variabilis*, where direct development is known, female frogs have also demonstrated a form of parental care of freshly deposited eggs (Kanamadi, *et al*, 1996). Krushnameghe Kunte (pers. comm.) has observed the breeding behaviour of *Nyctibatrachus* species; in the northern Western Ghats. Male frogs hold territories on bushes overhanging water. Females lay eggs on leaves, which are then fertilised by the male, which sits gaurding more than one clutch of eggs within its territory. Such a breeding strategy is well-known in the neotropical glass frogs (family Centronelidae) (Duellman and Trueb, 1986; Daniels, pers. observ).

There is a remarkable diversity of caecilians in the Western Ghats. 16 out of 20 species known in India occur in the Western Ghats; all 16 being endemic (Dutta, 1997; Bhatta, 1998; Ravichandran and Pillai, 1999). Caecilians prefer moist soils rich in organic carbon (essentially derived from rotting wood and leaf litter). The highest diversity of species in any given landscape is noticed in the southern half of the Western Ghats (Bhatta, 1997). Interestingly, from the studies of Bhatta (1997) it emerges that caecilian diversity is as high in orchards of arecanut and coconut as in evergreen forests. This is attributed to the high moisture content of soil and the widespread practice of using very little inorganic fertilizers and pesticides in these man-made habitats.

3.1.5 Reptiles

157 species of reptiles including a species of crocodile *Crocodylus palustris* is known from the Western Ghats, majority being snakes. 97 species, representing 36 genera (2 genera of turtles/tortoises, 14 lizard genera and 20 genera of snakes) of all reptiles in the Western Ghats are endemic (Table 3.7; see Annexure). Endemism is highest amongst snakes, especially with the family Uropeltidae alone contributing 33 species. Amongst

lizards, dwarf geckoes (*Cnemaspis* spp) and skinks (*Ristella, Lygosoma, Mabuya* and *Scincella*) have the maximum number of endemic species (see Annexure).

Table 3.7 Taxonomic breakup of reptilian diversity in the Western Ghats

Group	No. of species	Endemic species
Turtles/tortoises	6	2
Crocodiles	1	0
Lizards	63	34
Snakes	87	61
Total	157	97

Source: Whitaker (1978); Das (1985 & 1997); Murthy (1985 & 1990).

Unlike the many detailed studies on the reptilian, especially lizard, communities of the neotropical forests (eg., Duellman, 1989), there are few studies in India. Probably the few detailed ecological studies of reptilian communities in the Western Ghats are that by Inger *et al* (1987) in the Ponmudi Hills of Kerala and Ishwar *et al* (2001) in Kalakad-Mundanthurai Tiger Reserve. Survey-type studies of reptiles in the Western Ghats have also provided some information on species diversity and habitat use in selected landscapes. Bhupathy and Kannan (1997) after surveying agamid lizards in the Western Ghats of Tamilnadu have discussed the habitat use in 13 species. They have observed a higher diversity of species in the moist deciduous forests. Another study reported by Easa (1998), after analysing the habitat use of 62 species in the Kerala Nilgiris, has also indicated that reptilian diversity is in general higher in the moist deciduous forests of the Western Ghats. As per this study, number of reptilian species is negatively correlated with altitude, but positively correlated with number of herbs, number of fallen logs and slope. That the reptile abundance declines with altitude has also been shown by Ishwar *et al* (2001) based on a recently concluded study in the Kalakad-Mundanthurai Tiger reserve. In this study, however, it has been suggested that mid-elevations of 1000-1100m ASL in the Western Ghats have the highest diversity of reptiles. This study has also revealed that the density of forest floor reptiles in the Western Ghats is generally low being 0.26 animal per 25 sq m. Further, of the 426 (5m x 5m) quadrats sampled in Kalakad-Mundanthurai, only 14.8% had reptiles in them.

50% of the reptilian species in the study reported by Easa (1998) are of snakes. Unfortunately, little is said of their habitat preference and diversity. Earlier studies in the Western Ghats by Inger *et al* (1987) suggested that more species and individual snakes

were found in terrestrial conditions. This is more in conformity with the studies reported by Duellman (1989) from the neotropics. Most neotropical rainforest snakes are terrestrial. Of these a greater proportion is of diurnal species. There is hardly any information on the diel activity patterns of snakes in the Western Ghats. It is interesting to note that snakes dominate the forest floor reptilian communities at altitudes of 1200m ASL and above (Ishwar *et al*, 2001).

3.1.6 Birds

Of all organisms, birds are the best studied in the Western Ghats. Beginning in the 1860s, British naturalists and planters were busy surveying the Western Ghats, collecting and describing the avifauna (Daniels, 1997a). Since then, several surveys have been undertaken by the Bombay Natural History Society (then led by Dr Salim Ali), the various state departments of forests, especially Kerala, many nature clubs and amateur birdwatchers. The net result is that we now know that there are 508 species of birds, represented by nearly 600 forms of resident and migratory birds (Daniels, 1997a).

The Western Ghats often rise abruptly from the sea and in many parts of their 1600 km length, the coasts are so narrow that it is often not possible to draw a line between what are strictly hills and the coast. As a result, many aquatic and shorebirds that might not otherwise qualify as birds of the Western Ghats have also been treated as belonging to the avifauna of this narrow ecoregion (Daniels, 1997a). Thus amongst the 508 species, 144 (28%) are aquatic birds including those which are found in the coastal habitats. A total of 324 species (64%) are resident. These are predominantly land birds. Nineteen species have been considered endemic to the Western Ghats (Table 3.8).

Table 3.8 Endemic birds of the Western Ghats

Nilgiri wood pigeon	*Columba elphinstoni**	Wynaad laughing thrush	*Garrulax delesserti*
Malabar parakeet	*Psittacula columboides**	Black-and-rufous flycatcher	*Ficedula nigrorufa*
Malabar hornbill	*Ocyceros griseus*	Whitebellied blue flycatcher	*Cyornis pallipes*
Whitecheeked barbet	*Megalaima viridis**	Nilgiri flycatcher	*Eumyias albicaudata*
Whitebellied treepie	*Dendrocitta leucogastra*	Broadtailed grass bird	*Schoenicola platyura*

Contd..

Malabar lark	*Galerida malabarica*	Whitebellied shortwing	*Brachypteryx major*
Greyheaded bulbul	*Pycnonotus priocephalus*	Malabar whistling thrush	*Myiophonus horsfieldii**
Rufous babbler	*Turdoides subrufus**	Nilgiri pipit	*Anthus nilghiriensis*
Rufousbreasted laughing thrush	*Garrulax cachinnans*	Crimsonbacked sunbird	*Nectarinia minima*
Greybreasted laughing thrush	*Garrulax jerdoni*		

Note: Daniels (1997a) treated 15 species as endemic. However subsequent taxonomic revisions and the present pattern of distribution have enlarged the list to include 19 species. Small and isolated populations of the species marked with an asterisk exist here and there outside the geographical limits of the Western Ghats in peninsular India. The broadtailed grass bird has been reported from Sri Lanka (Ali and Ripley, 1983; Daniels, 1997a). Harrison (1999) however treats the Sri Lankan records as 'vagrants'.

Broad patterns of distribution and diversity have been discerned in the birds of the Western Ghats. In general, most of the resident and typically forest birds are restricted in distribution to the Western Ghats southwards from Goa. Few endemic species extend north of Goa. In general, the endemic bird species of the Western Ghats are primarily birds of the rainforests and the higher elevation shola-grassland complexes (Daniels, 1997a). In Kerala, the presence of some of the endemic birds (Malabar grey hornbill, Rufous babbler and Crimsonbacked sunbird) indicate greater abundance of mammals such as Nilgiri langur, Lion-tailed macaque and Sambar (Prasad *et al*, 1998).

Locally, when equal areas are compared, there are more species of birds per unit area in the central parts of the Western Ghats, especially in the Uttara Kannada district. This is primarily due to mixing of migrants and generalist species of birds with the resident specialists and endemics. Wet evergreen forests and montane sholas, despite providing habitat to a number of specialists and endemic birds with greater conservation value, are comparatively less diverse in bird species than secondary/disturbed evergreen and moist deciduous forests (Daniels, 1996; Daniels *et al*, 1991 & 1992; Pramod *et al*, 1997a; Pramod *et al*, 1997b).

Human interference of forests has led to the disappearance of birds locally in the Western Ghats. However, when large landscapes are considered, species richness of the avifauna has remained stable during the past 100 years (Daniels *et al*, 1990a). Whereas the floristic composition of woody plants determine the nature of bird species that might inhabit a

forest in the Western Ghats, bird species diversity may be inversely related to woody plant species diversity, locally (Daniels, 1989 & 1996; Daniels *et al*, 1992). Monocultures in the Western Ghats may support an assemblage of birds as diverse as (or even more diverse than) evergreen forests. However, birds that inhabit the monocultures are often generalist habitat users drawn from a wide range of neighbouring habitats (Daniels *et al*, 1990b; Pramod *et al*, 1997b). Teak plantations may provide habitat to a number of species of birds in the Western Ghats (Daniels *et al*, 1990b). However, hole-nesting birds were found to avoid nesting on teak trees in monocultures (Bindu, 2001).

3.1.7 Mammals

One hundred and twenty species of mammals are known from the Western Ghats. Fourteen species are endemic (Table 3.9). The mammalian fauna of the Western Ghats is dominated by insectivores (11 species), bats (41 species) and rodents (27 species including the porcupine) (see Nameer, 1998). Few studies have however paid attention to the community structure and organisation of these small mammals in the Western Ghats although there have been attempts to review our understanding of the status and ecology of smaller cats and lesser carnivores (ENVIS 1998b; ENVIS Bulletin, 1999).

Table 3.9 Endemic mammals of the Western Ghats

Madras hedgehog	*Hemiechinus nudiventris*
Day's shrew	*Suncus dayi*
Salim Ali's fruit bat	*Latidens salimalii*
Wroughton's free tailed bat	*Otomops wroughtoni*
Lion-tailed macaque	*Macaca silenus*
Nilgiri langur	*Trachypithecus johnii*
Nilgiri Marten	*Martes gwatkinsi*
Malabar civet	*Viverra civettina*
Brown palm civet	*Paradoxurus jerdoni*
Nilgiri tahr	*Hemitragus hylocrius*
Jungle striped squirrel	*Funambulus tristriatus*
Bonhote's mouse	*Mus famulus*
Ranjini's rat	*Rattus ranjiniae*
Malabar spiny dormouse	*Platacanthomys lasiurus*

Source: Nameer, (1998); Johnsingh (2001). An additional species Kondana Field Rat (*Millardia kondana*) has been collected and described from near Pune by the National Institute of Virology. However, this species has not been included in any of the recently published checklists.

One of the first attempts made to understand the factors governing the distribution of wild mammals in the Western Ghats is that of Prasad *et al* (1979). According to this study, the

evergreen forests are particularly suited to frugivorous arboreal primates and squirrels while the deciduous forests offer the best habitat for the larger grazing herbivores like the gaur and deer. Drought resistant ungulates, particularly antelopes are specially adapted to the open dry scrub. This study was however limited to the state of Karnataka. Elsewhere in the Western Ghats of Karnataka, the distribution and biomass of large herbivores have been studied. From this study it emerged that the large herbivore biomass was highest in moist deciduous forests and adjacent teak plantations whereas it was the lowest in the dry deciduous forests (Karanth and Sunquist, 1992). Elsewhere in the southern Western Ghats, it was found that mammals were the predominant frugivores. They outnumbered frugivorous birds (Ganesh and Davidar, 1999).

Studies on other communities of mammals have been sporadic and more illustrative in nature. As mentioned before these studies have frequently addressed the smaller cats and lesser carnivores (eg Mudappa, 1999). Estimates of home ranges of civets and mongooses in the Western Ghats have suggested that the Indian Grey Mongoose (*Herpestes edwardsii*) and the Small Indian Civet (*Viverricula indica*) have monthly home ranges of 20.69-102 ha and 3.4-4.9 ha respectively (Kumar and Umapathy, 1999). In another study of small carnivores in the Nilgiris it was found that civets were the most abundant (especially in evergreen forests) followed by mongooses, cats and marten. Canopy opening and the consequent weed infestation in evergreen forests adversely affects the civets (Kumar and Yoganand, 1999).

At the scale of individual species, it has been found that endemic species of arboreal mammals including the spiny dormouse (*Platacanthomys lasiurus*) and the Nilgiri langur (*Trachypithecus johnii*) do not prefer evergreen forests that are either selectively logged or fragmented. The spiny dormouse is affected by habitat fragmentation (Mudappa *et al*, 2001). The food plants of the Nilgiri langur have been selectively lost in disturbed habitats (Sunderraj *et al*, 2001).

The endemic primate *Macaca silenus* (Lion-tailed macaque or LTM) is amongst the few carefully studied mammals in the Western Ghats. In 1985, the population of this primate in the state of Karnataka was estimated as 3000 (Karanth, 1985). More recent estimates have placed the numbers in Karnataka around 1000-2000 (Krishnamurthy and Kiester, 1998). A smaller population is known from Tamilnadu. Including the nearly 2000 individuals in Kerala, the population of LTM has been placed at 4000 (Kumar, 1997).

LTM is an inhabitant of evergreen rainforests, below 700 m ASL, with a home range of 1.25 sq km (Kumar, 1997). Shape of the patches of these forests has a significant effect on the population of LTM (Prasad *et al*, 1998). Krishnamurthy and Kiester (1998) have shown that an opening of 0.5 sq km may block the path of a moving troop of LTM.

The Nilgiri Tahr (*Hemitragus hylocrius*) exists in the higher elevations between Nilgiris and Ashambu Hills in the Western Ghats. Over this 400 km range, around 2000 animals are estimated to occur; 150 in the Nilgiris, 570-690 in Anaimalais, 890 in Eravikulam, 280-310 in Palni Hills and a handful over the rest of the range (Davidar, 1971, 1975 & 1978; Rice, 1984; Mishra and Johnsingh, 1998; Bala, 2001).

Elephas maximus (Asian Elephant) is another species of mammal that has attracted both scientific and popular interest (eg. Nair and Gadgil, 1980; Sukumar, 1985 & 1989). Recent estimates place the population of elephants in the states of Karnataka, Tamilnadu and Kerala at 12,500 (ENVIS, 1998a). A majority of this population is within protected areas in the Western Ghats (Table 5.1 & 5.2). Unlike the LTM, the elephant is more of a habitat generalist utilising a wide range of natural and man-made habitats in and around the Western Ghats.

The Tiger (*Panthera tigris*) is comparatively better studied amongst other large mammals. In the Western Ghats, the Tiger is presently restricted to states of Karnataka, Kerala and Tamilnadu. The exact population of this large and elusive cat is much less predictable than that of the Elephant, Nilgiri Tahr or LTM. Study of the natural food habits of larger carnivores in Nagarhole has suggested that the Tiger selectively preys on animals weighing more than 176 kg. Non-selective predation by the Tiger on other animals is more likely the result of prey scarcity (Karanth and Sunquist, 1995).

3.2 State of human-modified/agricultural ecosystems and domesticated species/varieties

"Over three millennia of forest utilisation and management by traditional societies, and the practice of state forestry, since the last 200 years, have moulded the forest ecosystems of the Western Ghats. Major vegetational changes here began with the migration of the agri-pastoral people, beginning in the middle of the 4th millennium BP. The pre-colonial times had mostly village oriented traditional landscape management. Since colonial times, the forestry became more state centred, paying scant consideration to traditional management and to other forces of history which moulded the Western Ghats landscapes.

The present landscape and vegetation of the region are replete with reflections of history which may be of great ecological interest" (Subash Chandran, 1997).

The Western Ghats first came under human influences during the palaeolithic or old stone age some 12,000 years ago (see Table 3.10). Stone tools used by palaeolithic people have been excavated in the river valleys of Palakkad, Mallapuram and Dakshina Kannada districts in the Western Ghats. Elsewhere, palaeolithic artifacts have been found in and around Mysore, Chickmagalur and Shimoga districts of western Karnataka (Subash Chandran, 1997).

Table 3.10 Chronology of human ecological events in the Western Ghats

Years before Present	Era	Ecological events
> 12,000	Palaeolithic	Hunting and gathering
12,000-5000	Mesolithic	Hunting-gathering, use of fire, forest decline and increase in savanna
5000-3000	Neolithic	Agri-pastoralism in the Deccan, vegetaion change in the Nilgiris, coastal deforestation, use of iron, Harappan and Deccan immigrants into the Western Ghats
3000-1000	Megalithic	Agri-pastoralism, Western Ghats neoliths, shifting cultivation, decline in primary forests, sacred groves, extraction of spices and timber
1000-200	Historical	European trade, extraction of timber for ship-building, increase in spice trade, organised agriculture, shifting cultivtion continues
200-100		Increased timber harvest, state forestry begins, Shifting cultivation regulated, natural teak depleted, Plantations initiated
100-		Timber harvest intensified, timber stocks depleted, Conservation by state, mines, dams, townships

Source: Subash Chandran (1997).

Mesolithic sites (12,000-5000 ybp) have been discovered around the river Mandovi in Goa. Charcoal beds dating back to 5000 ybp in Tenmalai (southern Western Ghats) suggest that humans burnt forests around this time. During the new stone age (5000-3000 ybp) there were domesticated cattle, sheep and goats in and around the Western Ghats. Whereas rainfed crops including millets and horse gram were cultivated, in Maharashtra the Jorwe people cultivated wet rice (Subash Chandran, 1997).

Shifting cultivation was apparently the form of agriculture that predominated the Western Ghats till recently (see Table 3.10). Crops such as *Eleucine coracana, Cajanus cajan,*

Ricinus communis, Panicum sumatrense, etc were mainly cultivated in this traditional system of agriculture (Subash Chandran, 1997).

The use of fire to clear forests for cultivation has had a major influence on the forests of the Western Ghats. The spread of bamboo and deciduous trees in the region would have been aided by this human practice. Widespread occurrence of fire tolerant trees such as *Acacia catechu, Careya arborea, Dalbergia latifolia, Dillenia pentagyna, Schleichera oleosa, Tectona grandis, Treminalia spp* and *Xylia xylocarpa* suggests this (Subash Chandran, 1997).

According to Prabhakar (1994) the Nilgiri hills were colonised by humans, the *Todas*, as early as 200 BC. The British Colonists spread over most of the Western Ghats in the late seventeen hundreds and early eighteen hundreds. Much of the exotic flora, especially those of temperate origin, came into the hills after this.

While analysing the landscape features of the Western Ghats and the corresponding distribution of vegetation using GIS and remote sensing tools, Menon and Bawa (1997) have found an overall loss of forests between 1920 and 1960. They estimated that the loss of forests in the southern Western Ghats around this time was at the rate of 0.07% per year. The rate of forest loss has since increased to 0.33% per year during the period 1960-1990. In the state of Kerala alone, in a period of 30 years, there has been a 47% decline in evergreen-semi-evergreen forests (Prasad, 1998).

One of the major forms of human interference to vegetation and flora in the Western Ghats is the building of dams. According to published sources, there could be hundreds including small and big dams, with Maharashtra alone having 631 (Nair and Daniel, 1986).

Hill agroecosystems in the Western Ghats are today dominated by estates chiefly of tea, coffee, rubber and monocultures of various tree species, including the oil palm that was introduced lately. Available estimates indicate that above an altitude of 1500 m in the Western Ghats, there are 750 sq km of tea plantations. A total of not less that 1500 sq km are under coffee and 825 sq km under cardamom. It has also been highlighted that the Nilgiri district with a total area of 2549 sq km has around 1000 sq km under various forms of cultivation (Nair and Daniel, 1986).

The impact of growing coffee in the Western Ghats has been studied to some extent. According to legend, the *arabica* variety of coffee was introduced at the beginning of the

17th century by a Muslim pilgrim, Baba Budan, who brought 7 coffee seeds from Yemen and planted them in his hermitage in Chickmagalur (Karnataka). Coffee plantations were then introduced into Kodagu (Coorg). Large scale planting of coffee in the Western Ghats began in 1854 when the British established themselves in Coorg and planted coffee near Mercara (Ramakrishnan *et al*, 2000).

Coffee plantations in general have led to the loss of biodiversity throughout the Western Ghats. However, the habit of coffee plants growing best in partial shade and the traditional system adopted by people have together favoured a greater diversity of native trees in the coffee dominated agroecosytems of Kodagu (Ramakrishnan *et al*, 2000).

Casuarina plantations first appeared in Uttara Kannada district between 1868 and 1869. Till then the forest plantations were of native species (Buchy, 1996). Teak was first raised as monocultures in 1840 (Buchy, 1996). The first teak plantation in Kerala was established in Nilambur in 1844 (Basha *et al*, 1997). Over the years, eucalypts, cinchona, wattle, rubber, clove, etc, have displaced extensive patches of natural forests throughout the Western Ghats.

The impact of monocultures on the biodiversity of the Western Ghats has been little understood. In the Uttara Kannada district, monocultures were found to support as diverse a community of birds as natural forests (Daniels *et al*, 1990b). The bird assemblage may however include a greater number of generalist species than the natural forests (Daniels *et al*, 1990b; Pramod *et al*, 1997b). As mentioned above, teak when raised as a monoculture fails to attract hole-nesting birds (Bindu, 2001).

Apart from the introduction of commercially important plants, there have been invasions by a number of aggressive alien plant species during the past 200 years in the Western Ghats. Important amongst these are *Lantana camara* (var *aculeata*), *Eupatorium odoratum*, *Mikania cordata*, *Parthenium hysterophorus*, etc. Wattle (*Acacia* sp) once introduced for the extraction of tannin in the higher hills is today a major threat to the sholas and grasslands at these altitudes. The impact of these exotic plants has been reason for a lot of debate. Contrary to general predictions, the presence of *Lantana camara* has not been detrimental to woody plant species diversity in the BR Hills (Murali and Shetty, 2001).

A large number of ornamental plants of temperate origin have also run wild in the higher elevations of the Western Ghats. For instance, Matthew (1969) reported 600 such species

from the Palni hills and around Kodaikanal. Similarly, Lengerke and Blasco (1989) have reported 400-500 species from the Nilgiris (see Prabhakar, 1994).

Human influences have had an adverse impact on the diversity of flowering plants in humid forests of the Western Ghats (Daniels *et al*, 1995b; Parthasarathy, 2001). In the Uttara Kannada district, lack of coppicing ability in conjunction with their use in the plywood/matchwood industry has led to the disappearance of several evergreen species of trees such as *Syzigium gardneri* and *Myristica malabarica* at sites with high levels of human disturbance. With villagers concentrating on harvests of trees in the height class of 4-8m as poles, and commercial interests mostly extracting trees above 16m height, there was a reduction of around 45% across all height classes between sites of low and high levels of disturbance (Daniels *et al*, 1995b). Unique landscape elements such as the *Myristica* swamps gave way to cultivation of rice. Along with the swamps, trees such as *Myristica fatua var magnifica*, *Gymnacranthera carnatica*, *Semecarpus auriculata* and the palm *Pinanga dicksonii*, disappeared locally (Subash Chandran, 1997).

Selectively logging forests in the Western Ghats has had differential influence on biodiversity. When evergreen forests are thus disturbed, the woody plant species diversity has shown a gradual decline. This has been accompanied by the selective loss of certain species of greater economic value and an overall reduction in forest biomass (Daniels *et al*, 1995b). Other organisms have responded to human disturbance of evergreen forests rather differently. Selective logging (consequently lower tree and canopy density) has locally increased the diversity of butterflies (Devy and Davidar, 2001), lizards (Ishwar *et al*, 2001) and birds (Daniels, 1989; Daniels *et al*, 1992) in the Western Ghats.

Domesticated biodiversity in the Western Ghats has been documented by various agencies including National Bureau of Plant Genetic Resources, National Bureau of Animal genetic Resources and the many ICAR institutions and agricultural universities. Greatest diversity of cultivars is known in rice (*Oryza sativa*) (see Table 3.11). *Sannakki* known only in the remote hills of Uttara Kannada is a localised fragrant rice. Landraces are also common amongst millets (*Setaria italica, Echinocloa spp, Panicum spp, Eleusine coracana*), pulses (*Cajanaus, Lablab, Dolichos, Cicer*, etc), oilseeds (*Cocus nucifera, Calophyllum inophyllum, Ricinus communis, Arachis hypogea*), tubers (*Dioscorea spp, Ipomoea batatus, Amorphophallus spp, Colocasia spp, Manihot esculenta, Maranta spp*), vegetables (gourds, greens, *Solanum torvum*, etc) bananas,

spices (especially *Piper spp, Capsicum annuum, Zinziber officinalis, Curcuma spp, Myristica fragrans, Elettaria cardamomi, Syzigium aromaticum, Cinnamomum spp*), a variety of horticultural crops including *Anacardium occidentale, Musa paradisea, Psidium guajava, Citrus spp, Emblica officinalis, Phyllanthus acidi, Averrhoa blimbi, Tamarindus indicus, Hevea brasiliensis, Coffea arabica, Thea sinensis, Garcinia indica, Artocarpus spp, Anona spp, Ananas comosus, Zyziphus jujuba, Syzigium jambolana, Syzigium jambos, Inga dulce, Ferronia elephantum, Spondias mangifera, Mangifera indica, Punica granatum, Moringa pterygospermum, Sesbania grandiflora* and ornamental flowering plants (*Jasminum spp, Hibiscus spp, Impatiens spp, Cana spp, Ixora spp*, etc).

Table 3.11 Traditional cultivars of rice from Kumta taluk, Uttara Kannada district, Karnataka

Name	Status	Name	Status
Banka	Rare	*Karabele*	Rare
Sannapandya	Rare	*Karichitka*	Rare
Halagempi	Rare	*Biliekka*	Rare
Jaddubatta	Rare	*Sannabatta*	Frequent
Chitka	Common	*Bantvala*	Common
Dasala	Rare	*Doddapandya*	Rare
Bilikabbaga	Rare	*Aryahalaga*	Rare
Rangoon	Frequent	*Karikagga*	Common
Pandya	Frequent	*Jattu*	Rare
Theppadarya	Rare	*Shetki*	Rare
Siddasali	Rare	*Vale jadda*	Rare
Hurutaga	Rare	*Ajaga*	Frequent
Jaddikempi	Rare	*Kanchuti*	Rare
Bilibatta	Rare	*Kannuru*	Rare
Tebbal	Rare	*Mullare*	Rare
Karibatta	Rare	*Masakaai*	Rare
Kundara	Rare	*Kumbharajadda*	Frequent
Mugenbelaga	Rare	*Mottahalaga*	Rare
Ratnachooda	Rare	*Sundari*	Frequent
Halaga	Common	*Aryakempi*	Rare

Source: M D Subash Chandran, pers comm.

In the southern extreme, jack fruits (*Artocarpus integrifolius*) are locally seggregated into *koolan, varikai, chembarthi varikai, thein varikai*, etc. Similarly, bananas common (and endemic) in the Western Ghats include *nendran, matti, midukka, poovan, chevvalai, kadalli, pulichan, monthan, peyyan, malai valai, yelakki bale*, etc. A detailed discussion of crop diversity in the Western Ghats is not within the scope of the present document.

However, what is important is that the long lists often presented by academic institutions and NGOs need validation. Many local varietal names are synonyms (the result of variations in local language, dialects and gender differences). Further, a good proportion of the listed varieties, no longer exist locally.

Amongst domesticated animals, cattle, buffaloes, goats, sheep, pigs, dogs, cats, rabbits, chicken, geese, ducks, turkeys, guineafowl and pigeons have been maintained and bred in selected pockets of the Western Ghats. Amongst goats breeds endemic to the Western Ghats ecoregion include *Marwari* (Kerala), *Chigu* and *Beetal* (both from Maharashtra). Sheep breeds native to the ecoregion are *Mandya* (Karnataka), *Coimbatore, Nilgiri* and *Vembur* (all from Tamilnadu). Hill cattle are locally preserved in Uttara Kannada (*Malnad Gidda*), Kerala (*Vechuri*) and in Tamilnadu (*Malaimaadu*). These breeds are small sized and hardy showing resistance to some of the diseases that take epidemic toll of other domesticated and hybrid cattle in south India. In general, compared to plants, there is much less selective breeding practised in animals and as a result much of what we see presently are mixed breeds often due to interbreeding and attempts of deliberate 'improvement' by cross-breeding with exotic breeds. It is interesting that there are ferral buffaloes and cattle in certain parts of the Western Ghats well adapted to the hills and humid climatic conditions.

4.0 Statement of problem relating to biodiversity

The magnitude of biodiversity in any landscape is primarily correlated to its area and the diversity of ecosystems and habitats available within its limits. During the early seventies, it was shown by E.O.Wilson and Robert H. MacArthur through their still popular theory of 'island biogeography' that size and isolation of islands (and island like terrestrial habitats as well) play a major role in the size and composition of species assemblages. These principles apply very well to the Western Ghats ecoregion, which starting with its isolation from the Himalayas during prehistoric times has suffered gradual shrinkage of primary habitats leading to fragmentation and transformation into a great variety of secondary habitats. The net result is that there has been a considerable decline in biodiversity throughout the Western Ghats.

Loss of biodiversity needs to be assessed at two broad scales. The first involves the drastic reduction in numbers of species that once inhabited a given habitat or ecosystem or landscape or ecoregion. Such change is readily noticed and often used in monitoring biodiversity at any of the above geographical scales. The second is often more difficult to recognise. It involves a qualitative change. Qualitative changes may be seen in populations leading to skewed sex ratios, adult/juvenile ratios, etc. The net result is loss in genetic diversity within a species. Qualitative changes may also be seen in plant and animal communities wherein the total number of species in the flora or fauna under observation may remain the same (may even increase at times). The taxic composition of the community may however be drastically modified. Modifications are expressed as replacement of specialised habitat users by generalist species. Native species are displaced by exotics. The proportion of endemics to non-endemics tends to fall in such communities. In many instances, the diversity at higher taxic levels as that of genera, families, orders, classes and phyla tend to get reduced. All the above forms of biodiversity loss have been observed in the Western Ghats ecoregion (Daniels, 1989, 1991 & 1992; Daniels et al, 1990a&b, 1991, 1995b; Devy and Davidar, 2001; Gadagkar et al, 1993; Ishwar et al, 2001; Krishnamurthy and Kiester, 1998; Kumar, 1997; Kumar and Yoganand, 1999; Murali and Shetty, 2001; Pramod et al, 1997a&b; Sunderraj and Johnsingh, 2001; Vasudevan et al, 2001).

Root causes for the present loss of biodiversity in the Western Ghats are anthropogenic and manifold. Human impacts on biodiversity in the Western Ghats have been direct as that due to collection, harvest and poaching and indirectly through habitat destruction. Direct extraction of biodiversity, live or dead, has led to decimation of population leading to the various forms of quantitative losses discussed above. A variety of plants of economic importance and animals such as elephants, tigers, larger herbivores, birds and reptiles have locally disappeared due to this reason. The supposed medicinal value of the Nilgiri langur soon decimated local populations in many parts of its restricted range in Tamilnadu and Kerala. Mistaken identity led to the loss of the Liontailed macaque as well. Poaching of vertebrates for the pet trade, as trophies and for animal products such as skin, bones, tusks, claws, horns, feathers, etc continue to take a heavy toll of biodiversity in the Western Ghats.

Indirectly, biodiversity of plants has suffered extensively from pressures of exotic plants and domesticated animals. Other human induced loss of plant biodiversity is effected by alternate land use including monocultures, cultivation, dams, mining, etc. Animal biodiversity in the Western Ghats has similarly suffered due to pressures from domesticated plants and animals and the human-induced population rise of secondary and invasive species of animals. For example, rats, palm squirrels, crows, Indian mynas and other invasive species of vertebrates which were uncommon in the hills 30-40 years ago have proliferated thanks to anthropogenic factors directly competing and displacing native biodiversity in the southern Western Ghats (Daniels, pers observ).

Indirect loss of biodiversity, once again, is effected through quantitative and qualitative reduction of habitats. Habitat shrinkage and fragmentation restricts the range and area of occupancy of most species. For most species in the Western Ghats, with the exception of the urban adapted species, the available habitats are not adequate in extent. Such restriction leads to a greater rate of human-animal conflicts.

Whereas quantitative loss of habitats is being contained through various conservation initiatives, qualitative loss continues in the Western Ghats. Chief forms of qualitative loss of habitats include change of flow, depth and turbidity in aquatic habitats, opening of canopy (often due to selective logging), dense undergrowth choking regenerating plants, loss of old and mature trees offering roosting and breeding sites to hole nesting birds and mammals, loss of trees bearing fleshy fruits, etc. The net result of qualitative changes in

habitats has led to ‘empty habitats’ throughout the Western Ghats. Such habitats are apparently ‘excellent’ as might be inferred from maps and satellite images. They are however devoid of the species of plants and animals that once inhabited them.

Ultimately, whether it is fire or the use of inorganic pesticides or invasive species, indirect and widespread loss of biodiversity in the Western Ghats is due to depletion of habitat. The depletion can be quantitative, qualitative or both. Good examples of quantitative loss of habitats in the Western Ghats can be seen in the shola-grassland complexes, torrential streams and waterfalls, freshwater (*Myristica*) swamps, and lowland rain forests (Subash Chandran, 1997; Prasad, 1998; Menon and Bawa, 1997). According to Ramesh *et al* (1997) and Menon and Bawa (1997) the overall loss of forests in the Western Ghats was 0.07% per year between 1920 and 1960 which since rose to 0.33% per year till 1990. In the state of Kerala alone 47% of the evergreen and semi-evergreen forests were lost during the past 30 years (Prasad, 1998).

Qualitative loss of habitats in the Western Ghats has not been estimated. What may be inferred from satellite data can best indicate gross changes ih habitat quality (for instance changes in depth of water or canopy density). Finer changes that take place at micro-scales (eg., under the canopy in dense forests) remain to be understood.

The factors that lead to qualitative and quantitative loss of biodiversity in the Western Ghats are many. The following have been identified as those of immediate concern (in the order of decreasing importance).

1. Grazing pressure
2. Demand for fuelwood
3. Demand for small timber
4. Fire, especially when recurrent
5. Demand for green manure
6. Encroachment
7. Demand for Non-timber forest produce
8. Poaching and smuggling
9. Development projects
10. Land use practices
11. Pesticides
12. Soil erosion and water logging
13. Increase in population density
14. Pilgrimage
15. Mining and quarrying

5.0 Major actors and their current roles relevant to biodiversity

5.1 Government

Precolonial rulers had set up hunting reserves in many parts of India. However, hunting reserves in the Western Ghats were largely those established by the British in the 19th century. The Nilgiri Hills where there were large British colonies were the first to have hunting reserves in the Western Ghats. Such reserves were used either as exclusive fishing reserves or as general game reserves. Exotic fishes including species of trouts were introduced in the Nilgiris at this time. There were also attempts to introduce game birds such as pheasants, popular in Europe, into the hunting reserves in the Nilgiris. The Nilgiri Wildlife and Environment Association was first established in 1879 as the 'Nilgiri Game Association' primarily to facilitate hunting by the British.

With the taking over of the forests and wildlife by the British, restrictions on shifting cultivation first came in in 1848 (Buchy, 1996). Subsequently, the Madras Government banned shifting cultivation in 1860 (Subash Chandran, 1997). Following this, the free grazing of cattle in the Western Ghats by the hill-dwellers was restricted by the Cattle Trespassing Act – 1871 (Buchy, 1996). Forests in the Western Ghats were brought under the management of the state – the system of reserved forests was established thereafter (see Table 3.10). Attempts were also made to conserve natural populations of plants under selective human pressure. For instance, harvest of the tali palm *Corypha umbraculifera* used for extracting starch by the *kumri marati* during seasons of low food availability was regulated. In the Uttara Kannada district (which has the largest population of the species today) the forest department outlined a Working Plan – No 10: Honnavar Tali Palm Forest Working Plan, 1906 – to conserve the palm (Buchy, 1996).

Loss of forests has reduced extensive stretches of vegetation to small, often widely separated patches. Nair and Daniel (1986) first drew attention to the importance of a system of Protected Areas (PAs) wherein the floristic diversity of the Western Ghats might be conserved. Patches of vegetation are today preserved within a network of PAs in the Western Ghats. However, the extent and quality of these patches are not truly representative. Gadgil and Meher-Homji (1986) have reviewed the status of the various natural vegetation types represented in the existing PAs. Their study has shown that all the vegetation types characteristic of the Western Ghats, especially the northern types,

have not been equally protected within the existing PA system. The Bombay Subtropical Evergreen Forests characterised by the *Memecylon-Actinodaphne-Syzigium* series and the West Coast Tropical Evergreen-Semi-evergreen forests characterised by *Persea-Holigarna-Diospyros* series are hardly represented. Studies in Kerala have raised the question as to whether endemic plants enjoy adequate representation within the PAs in the Western Ghats (Prasad *et al*, 1998).

The system of PAs in the Western Ghats includes the Nilgiri Biosphere Reserve, the first and largest Biosphere Reserve in India, 13 National Parks and 45 Wildlife Sanctuaries. The largest National Park is Bandipur with an area of 874 sq km and the largest Wildlife Sanctuary is in the Anaimalai hills having an area of 841.49 sq km. The 58 PAs together cover an area of 14,140.36 sq km**.** This amounts to 8.8% of the Western Ghats. Of these, Bandipur, Periyar and Kalakad-Mundanthurai are Project Tiger Reserves (Ministry of Environment and Forests, 1998). Some of the PAs in Karnataka, Tamilnadu and Kerala have also been designated as Project Elephant Reserves (Tables 5.1 & 5.2).

Table 5.1 Distribution of PAs in the Western Ghats.

State	Protected Area	Extent in sq km	Status
Gujarat	Bansda (Vansda)	23.99	National Park (NP)
	Purna	160.84	Wildlife Sanctuary (WLS)
Maharashtra	Sanjay Gandhi (Borivili)	86.96	NP
	Kalsubai	361.71	WLS
	Tansa	304.81	WLS
	Bhimashankar	130.78	WLS
	Chandoli	308.97	WLS
	Karnala	4.48	WLS
	Koyna	423.55	WLS
	Phansad	69.79	WLS
	Rhadanagiri	351.16	WLS
	Sagareshwar	10.87	WLS
Goa	Molem	107.00	NP
	Bondla	8.00	WLS
	Cotigao	85.65	WLS
	Madei	208.00	WLS
	Molem	133.00	WLS
	Netravalli	211.00	WLS

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State	Protected Area	Extent in sq km	Status
Karnataka	Kudremukh	600.32	NP
	Nagarhole	643.39	NP*
	Bandipur	874.00	NP*
	Anshi	250.00	NP
	Bhadra	492.46	WLS
	BR Hills	539.52	WLS
	Brahmagiri	181.29	WLS
	Dandeli	843.16	WLS
	Ghataprabha	29.78	WLS
	Gudavi	0.73	WLS
	Mookambika	247.00	WLS
	Nugu	30.32	WLS*
	Pushpagiri	102.92	WLS
	Sharavathi Valley	431.23	WLS
	Shettihalli	395.60	WLS
	Someshwara	88.40	WLS
	Talakaveri	105.59	WLS
Tamilnadu	Indira Gandhi	117.10	NP*
	Mudumalai	103.24	NP*
	Mukurthi	78.46	NP*
	Indira Gandhi	841.49	WLS*
	Kalakkad	223.58	WLS
	Mudumalai	217.76	WLS*
	Mundanthurai	567.38	WLS
	Sriviliputtur	465.20	WLS
Kerala	Silent Valley	89.52	NP*
	Eravikulam	97.00	NP
	Periyar	350.00	NP*
	Aralam	55.00	WLS
	Chimmony	90.00	WLS*
	Chinnar	90.44	WLS*
	Idukki	70.00	WLS*
	Neyyar	128.00	WLS
	Parambikulam	285.00	WLS*
	Peechi-Vazhani	125.00	WLS
	Peppara	53.00	WLS
	Periyar	777.00	WLS*
	Shendurney	100.32	WLS
	Thattekadu	25.16	WLS
	Wayanad	344.44	WLS

Source: Anon (2000). Asterisk indicates those Protected Areas which are in part or full declared as Project Elephant Reserves (ENVIS, 1998).

Table 5.2 Project elephant reserves and estimated elephant populations in the Western Ghats

Reserve	Area (sq km)	Elephant Population
Nilgiris-Eastern Ghats	11,000-12,000	5000-6300
Nilambur-Silent Valley-Coimbatore	2500	500-956
Anaimalai-Parambikulam	3000-5700	1000-1600
Periyar	3000	1500-2000
Total	19,500-23,200	8000-10,856

Source: Asian Elephant Research and Conservation Centre (1998); ENVIS (1998a)

Note: The estimates of both reserve area and populations of elephants provided by the two sources vary considerably. About 6000 sq km of these reserves are actually outside the limits of the Western Ghats yet contiguous. An estimated 682-2100 elephants occur in these areas.

Project Elephant, a scheme sponsored by the Government of India, has designated 10 elephant reserves in the country of which 4 are in the Western Ghats. The 4 reserves also contain a mosaic of vegetation types and ecosystems harbouring high diversity of flora and fauna. For each elephant reserve a perspective plan has been provided which identifies the spatial integrity, important corridors, conservation issues and recommended action. The Asian Elephant Research and Conservation Centre (AERCC, 1998) has set up a GIS database for 39 forest divisions comprising the 4 resrves in the Western Ghats. The AERCC has also established a database on the demography and mortality of elephants and human-elephant conflicts within these resrves.

Since the launch of the tiger conservation movement and the 'Project Tiger' in India, the tiger has made a dramatic recovery. Improvement in the quality of habitat and available prey has been considerble not only within the Project Tiger reserves, but also outside in Anamalais and Nagarhole in the Western Ghats (Karanth, 1997).

Further to managing the system of PAs and initiatives such as afforestation, eco-development and JFM, the state departments of forests have mooted programmes that specifically address conservation of endangered vertebrates. Chief amongst these is the annual wildlife census organised by the forest departments. These censuses have enabled the closer monitoring of the status of some of the endemic and endangered mammals of

the Western Ghats. Programmes on captive breeding and *ex situ* conservation of such mammals and reptiles have also been coordinated by the forest departments through zoos. The Ministry of Environment and Forests (MoEF/Government of India) has established 'Taxonomic Chairs' to build capacity in taxonomy in students throughout the country. The first chair for plant taxonomy has been established for the Western Ghats at TBGRI.

Box 5.1 -**REPORT ON CONTRIBUTION OF DEFENCE MANAGED AREAS IN BIODIVERSITY CONSERVATION**

Defence Managed Areas are necessarily well protected and remain practically occur in undisturbed because of isolation and security provided to them. Some of these areas encompass the known biodiversity 'Hot Spots' of the world i.e. Eastern Himalayas and Western Ghats. This gives locational advantage for biodiversity conservation in these fragile ecosystems.

Drastic changes in land use pattern associated with urbanization have resulted in an immense impact on those fringe areas of human habitations where forests are situated. An important role is played by the Defence Services in protecting the forests that may act as sources of plant and animal biodiversity, and may also serve as forest islands and as migratory corridors

The defence's real estate comprises cantonments, depots, training academies and military farms. Their true ecological status and potential can only be established after detailed studies by experts. With large areas of wilderness maintained as buffer zones and a tight system of security precluding unauthorized entry of men or cattle, they even have the potential of 'captive breeding' areas with fully assured environmental security.

NATIONAL DEFENCE ACADEMY (NDA), PUNE - A CASE STUDY

Pune city is situated at 18 deg 31' N lat. & 73 deg 51' E long., at the junction of the Deccan Plateau and the Western Ghats. NDA is situated about 15 km southwest of Pune. NDA estate is spread over 3208 ha. Campus is moister, and houses taller (10-15m) forest and scrub, prone to fire. Total 120 tree species were recorded from the area. The study reveals that species richness as well as percentage wildness of trees at NDA is comparable with Sinhagad that supports a good forest patch which is also a low impact area.

NDA campus is surrounded by a small chain of continuous or discontinuous hillocks, forming a part of the Sahyadri range. A number of streams run down in the valley making ravines and forming good habitats for the wildlife. Steep gradients at the end of the valley provides natural habitat for birds of prey like Eagles. While areas near Peacock Bay provide excellent habitat for waterbirds. Animals like common mongoose are very common in the ravines. On the valley slopes and thickly forested areas, wild boar is also a common animal inhabiting the area. Birds are the most abundant organisms in the area. We have recorded about 75 species of birds during our project duration. The birds which are dependent on grasslands are seen to dominate the community. Birds like the spotted dove, little brown dove, rose ringed parakeet are commonly observed. Another bird which is frequently seen on the plateaus is the peafowl.

The grassy plains shelter a variety of smaller mammals like black naped hare and a few wild animals. Three striped palm squirrel is having ideal habitat on trees that are scattered in the grassy plains. Herbivores like spotted deer, muntjac (barking deer) are common inhabitants of the wide spread grasslands. They are observed very frequently during the dry months. They find safer place in the thickets formed by different plant species. The grasslands along with rocks and crevices in the streams are a habitat for reptiles. It is mentioned that many species of snakes are surviving in the area.

The low impact forested areas of NDA support more number of habitat specialist butterfly species. Over 40 species of butterflies were recorded from the area. Vetal Hill near Pune has witnessed loss of four tree species due of impact of biotic factors. It is important to note that these species are still common at the sites in the low impact zone (NDA). At this juncture the importance of those forests that are protected by Defence Services needs to be carefully assessed.

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This highlights the point that Defence Services-protected forests enjoy a high degree of protection that assist in conservation of various floral and faunal components, and possibly the overall biodiversity. In the light of recent observations and since the practice of maintaining sacred groves is degenerating at the face of urbanization, we may be correct in suggesting that Defence Services-protected forests may emerge as 'modern sacred groves' (potential for developing into habitat refuges in future). Studying further these forests vis-à-vis other protected and unprotected forests may elucidate the presently neglected potential of the Defence Services-protected forests as floral and faunal conservation areas. Defence Services with technical inputs from NGOs and academic institutions can effectively create protected areas outside the national parks and sanctuaries for biodiversity conservation.

Source: Patwardhan, *et al.* In: Ganeshaiah *et al* (2001) pp. 685-688.

5.2 Research institutions, NGOs and citizen's groups

A series of permanent plots have been established and monitored by Centre for Ecological Sciences (Nilgiris), Pondicherry University (Anamalais and Kalakad-Mundanthurai) and Institut Francaise (Kodagu). These permanent plots are yielding comparative data on the vegetation and floristic dynamics of a range of ecosystems in the Western Ghats (eg see Sukumar *et al*, 1996).

The Centre for Ecological Sciences at the Indian Institute of Science first mooted the idea of deploying student power and creating a college teachers network for inventorying and monitoring biodiversity (Gadgil 1996 a&b). In 1994, a Western Ghats Biodiversity Network was launched with the participation of 18 colleges and 2 NGOs. Over the next 3 years nearly 30 teachers mainly from the departments of botany and zoology (including a few from statistics and economics) and 300 students participated in this research programme. Each college team consisted of one or two teachers and 6-10 students. With a collective input of 120-200 days per year, the teams were able to sample heterogeneous areas (c. 25 sq km) consisting of 6-12 habitat types. The net result is that data was obtained on distribution and ecology of 1500 species of flowering plants and 212 species of birds (Utkarsh Ghate pp19-35 in Hussain and Achar, 1999).

The Western Ghats Biodiversity Network, involved knowledgeable local persons while sampling biodiversity. The combined efforts went into creating People's Biodiversity Registers (PBR) throughout the Western Ghats (Gadgil *et al*, 1996). PBR are meant to be tools that aid the conservation, sustainable utilisation and equitable sharing of benefits – the three goals of the *Convention on Biological Diversity*.

Several non-government organisations (NGOs) such as Kerala Sasthra Sahitya Parishad (KSSP), and Action for Community Organisation, Rehabilitation and Development

(ACCORD) Nilgiris, are actively involved in the conservation of biodiversity in the Western Ghats by involving the local human communities. The M. S. Swaminathan Research Foundation has established a Community Agrobiodiversity Conservation Centre in Wyanad (Kerala) to promote the conservation and sustainable use of native crop and medicinal plant diversity. The Foundation for Revitalisation of Local Health Traditions (FRLHT/Bangalore) has created a network of Medicinal Plant Conservation Areas (MPCAs) throughout the Western Ghats. These patches of forests serve in protecting not only the medicinal plants, but also the traditions of people that have evolved around the conservation and use of such plants.

Other major NGOs and organisations involved in scientific research and/or activism related to the conservation of biodiversity in the Western Ghats include Bombay Natural History Society (BNHS), Gujarat Ecological Society (Baroda), Ashoka Trust for Research in Ecology and Environment (ATREE/Bangalore), Kalpavriksh (Pune), RANWA (Pune), Nilgiri Wildlife and Environment Association (Ootacamund), Palni Hills Conservation Council (PHCC/Kodaikanal), Zoo Outreach Organisation (Coimbatore), Anamalais Wildlife Association (Pollachi), Care Earth, Chennai, Anamalais Biodiversity Association (Valparai), 'Appiko' (Uttara Kannada), etc.

Besides the Centre for Ecological Sciences (IISc/Bangalore) there are a number of government supported institutions, such as Tropical Botanical Garden and Research Institute (TBGRI/Trivandrum), Kerala Forest Research Institute (KFRI/Thrissur), Salim Ali Centre for Ornithology and Natural History (SACON/Coimbatore), Zoological and Botanical Survey of India, Wildlife Institute of India (Dehra Dun), Salim Ali Centre for Ecology and Environmental Studies (Pondicherry University), Madurai Kamaraj University, Manonmanian-Sundranar University (Tamil Nadu), Calicut University (Kerala), Pune University, Kuvempu University (Karnataka), Kohlapur University (Maharashtra), Goa University, Bharathiar University (Coimbatore), Bharathidasan University (Trichy), Mangalore University and others, undertaking research and biodiversity conservation measures in the Western Ghats.

Amongst international agencies, the Institut Francaise, Pondicherry, has contributed enormously to the study of climate, soils, palyonology, vegetation and plant biodiversity in the Western Ghats. The UK based Birdlife International in collaboration with BNHS

has launched a programme to identify 'Important Bird Areas' (IBA) in the Western Ghats.

Box 5.2 - **Conservation Assessment and Management Plan (CAMP) Workshops**

The Zoo Outreach Organisation and the Conservation Breeding Specialist Group India (Coimbatore) in collaboration with other institutions and NGOs has conducted a series of CAMP workshops covering a wide range of plants and animals in India. In all, 2500 species of Indian plants and animals have thus been assessed. The following is a summary of those directly relevant to the Western Ghats.

Theme	Year	Location	No. species assessed
Medicinal plants of southern India	1995, 1996, 1997	FRLHT, Bangalore	141
Soil invertebrates of southern India	1997	ZSI, Chennai	94
Indian amphibians	1997	Utkal University, Bhubaneshwar	202
Indian reptiles	1997	State Forest Service College, Coimbatore	450
Indian mammals	1997	IISc/JNC Bangalore	372
Indian fishes	1997	NBFGR, Lucknow	327
Endemic orchids of the Western Ghats	2000	IFGTB, Coimbatore	104

Source: CAMP Summaries 1995-2000, Zoo Outreach Organisation (2000).

5.3 Local communities

In the Western Ghats, systems of biodiversity conservation have passed through three major phases viz., sacred sites, hunting sites and Protected Areas (Wildlife Sanctuaries and National Parks). Sacred sites are typical of small scale societies largely practising subsistence economies. These are characterised as self-organised conservation systems as opposed to hunting preserves of the elite or the system of Protected Areas which are conservation systems organised by the state apparatus (Gokhale *et al* pp365-396 in: Ramakrishnan *et al*, 1998).

Historically forests in the Western Ghats were protected, managed and used by local communities in a sustainable way. Traditional conservation reserves such as *menasukan* (pepper forests) wherein people harvested wild pepper is a good example (Subash Chandran, 1997). Besides hunting-gathering restrictions, there was the system of sacred forests throughout pre-colonial history and in the Western Ghats they were locally called *devrai* (Maharashtra), *deverakadu* (Kodagu), *kavu* (Kerala) and *kan* (Uttara Kannada). These sacred forests are still present throughout the Western Ghats, although as relicts (Subash Chandran, 1997). The importance of sacred groves as conservation sites and

their role in preserving some of the rare and endangered plants in the Western Ghats have received considerable scientific attention (eg see Gadgil and Vartak, 1975 & 1976).

Integration of the local systems of forest management with Community Forestry and Joint Forest Management (JFM) has been analysed and presented in a comprehensive manner by Ravindranath *et al* (2000). Whereas the general practice in participatory forestry is to adopt degraded forests, in the Western Ghats of Karnataka, good forests have been brought under this system of management. There are 23 village communities in the Western Ghats of Karnataka who have been thus managing forests for a long time. Hunasur a semi-evergreen-moist deciduous forest patch of 120 ha has been protected by village communities for the past 100 years. In another village, Kugwe, 194 ha of forests are being similarly protected for 100 years. Community management of these good forests have resulted in a vegetation stand of 62 species/255 t/ha biomass and 43 species/210 t/ha biomass in Hunasur and Kugwe respectively (Ravindranath *et al*, 2000).

Box 5.3 - **Sacred groves in Kerala**

In Kerala, a total of 761 sacred groves have been identified of which only 361 are above 200 sqm (0.02 ha). Of these, 285 are less than 0.5 ha. Only 11 sacred groves in the state are more than 5 ha in extent. A total of 722 species of plants in 128 families and 474 genera have been enumerated in these sacred groves. 154 species of plants in these sacred groves are endemic to the Western Ghats. Of these some are widespread in the sacred groves eg., *Holigarna armottiana* (211 groves), *Artocarpus hirsutus* (186 groves), *Hydnocarpus pentandra* (151 groves), *Vateria indica* (114 groves), *Gnetum ula* (92 groves), *Cinnamomum malabathrum* (76 groves) and others are more restricted in their distribution. Those endemic species with restricted distribution in the sacred groves are *Blepharistemma membranifolia* (7 groves), *Buchnania lanceolata* (7 groves), *Casearia wynaadensis* (1 grove), *Gymnacranthera farquhariana* (9 groves) and *Syzigium travancoricum* (3 groves). Amongst those species included in the Red Data Books, *Kunstleria keralensis* has been recorded in 7 groves and *Pterospermum reticulatum* in 18 groves.

The 761 sacred groves represent different vegetation types including *Myristica* swamps, lowland evergreen and disturbed evergreen forests and deciduous forests. Sacred groves are unfortunately under great human pressure that they are likely to perish if strict measures of conservation are not adopted immediately. In Kerala alone, there has been so much loss that the present extent of sacred groves amounts to a mere 1.2% of what there was during the beginning of the 19th century.

Source: K Balasubramanyan and N C Induchoodan pp59-64 in: Kumaravelu and Chaudhuri (1999).

5.4 Donors

International donor agencies including Japanese, British, Swedish, Norwegian and Danish have supported conservation and sustainable development research in the Western Ghats during the past 25 years. Important donors such as Danish International Development Agency (DANIDA) have supported research and development in the Western Ghats, especially in the state of Karnataka for more than twenty years. In fact,

during its formative years, the Foundation for Revitalisation of Local Health Traditions (FRLHT), an NGO dedicated to research on medicinal plants in the Western Ghats, was sponsored by DANIDA. Other international donor agencies that have contributed extensively to research and conservation in the Western Ghats include the World Bank, Swedish International Development Authority (SIDA), Norwegian Agency for Development co-operation (NORAD), Overseas Development Aid (ODA) and OECD-Japan. At smaller scales, the MacArthur Foundation, Pew Foundation, US Fish and Wildlife Service, Oriental Bird Club, National Geographic Society and others have supported research in the Western Ghats.

5.5 Industry and corporate sector

Major stakeholders representing the industrial and corporate sectors in the Western Ghats are the planters. Important amongst these are Tata Tea Estates, Hindustan Lever Ltd, Parry-Agro Industries and Bombay-Burma Trading Company. These national and multinational companies have extensively cultivated tea and coffee throughout the Western Ghats of Karnataka, Kerala and Tamilnadu. Over the years, these companies have taken various conservation initiatives such as (in stages) resorting to the use of organic fertilisers and pesticides, providing alternate sources of fuel to estate employees, allowing patches of forests (abandoned coffee and cardamom plantations) to regenerate, encouraging biodiversity research within their estate limits and establishing genetic gardens and 'biodiversity plots' for the regeneration of native plants and as biodiversity refugia. More recently, representatives of the major companies have come together and formed the Anaimalai Biodiversity Conservation Association (ABCA) – a registered body comprised of planters and other local residents in Valparai (Anamalai Hills, Tamilnadu). Such environmental associations have been created in other parts of the Western Ghats (eg., Megamalai, Manjolai) and efforts are being made by the ABCA to network these local associations.

Box 5.4 - **Biodiversity conservation within private/corporate estates**

The Anaimalais Biodiversity Conservation Association (ABCA) is a young, voluntary effort by the nature lovers of the town of Valparai with the overall objective to conserve and enhance the natural biodiversity of the Anaimalais. This association, largely spearheaded by the officials of the plantation companies of the area, hopes to achieve its objective by involving experts, officials of the relevant departments, representatives of the media, and also through networking with other hill-based associations such as the Palani Hills Conservation Council and the Nilgiri Wildlife Association.

One of the major efforts of conservation in the Anaimalais is by Hindustan Lever Limited. The company has undertaken the regeneration of a small patch of shola forest (biodiversity plot) in a place called Injiparai, in the Anamalais. This process, which is supported by ongoing long-term research is being carried out by research scholars of the Indian Institute of Science and Wildlife Institute of India. Another laudable effort in the same region is by Parry Agro, which is ensuring availability of fuelwood to its employees by making available alternate sources of fuel and planting fuel trees.

6.0 Gap analysis

6.1 Gaps in information

Whereas there exists a fair amount of information on the diversity, distribution and ecology of vertebrates (especially larger mammals and birds) and higher plants in the Western Ghats, except butterflies, all invertebrates, lower plants and microorganisms are not even fully discovered and identified. Major gaps in information therefore exist in the taxonomy and ecology of hundreds of such species in the Western Ghats.

Quantitative loss of habitats and hence changes in landscape features have been recognised through maps and remote sensed data. However, qualitative changes in habitats and micro-habitats that subtly play a role in the loss of biodiversity in the Western Ghats are still poorly understood.

One of the reasons for the loss of biodiversity in the Western Ghats that has been of great concern is the use of inorganic fertilisers and pesticides. The loss of many lower groups of animals, especially aquatic invertebrates, has been attributed to overuse of pesticides (Thomas Burton, pers comm). The concern that inorganic chemicals may have played a role in the loss of amphibian species in the Western Ghats was generally accepted (Daniels, 1991). Although the impact of inorganic pesticides on human health has not been seen as a matter of widespread concern, the recent articles about the cashew plantations and use of systemic insecticides in Kasargodu, Kerala published in *The Hindu* (July 22, 2001) has raised a number of serious questions. Unfortunately, careful studies covering different altitudinal and rainfall zones in the Western Ghats for inorganic pesticide and fertiliser loads – in soil, water, plant/animal tissues, and microorganisms, is lacking.

Data on human use and misuse of forests, especially on issues like fodder, green manure (for example, in arecanut plantations of Karnataka, banana and rice cultivation in Tamilnadu), etc is deficient. Such data has to be in the context of vanishing common and grazing lands, as well as governmental programmes that award ownership rights to tribals (*pattas*) as part of the tribal developmental programmes.

Grazing by cattle supposedly owned by tribals (who are in fact paid labourers of absentee landlords) as that in the Nilgiri Biosphere Reserve, for instance, is a major problem.

However, a careful assessment of cattle population in the Western Ghats and grazing pressures is lacking. Similarly, the usefulness of low intensity grazing for the regeneration of herbaceous vegetation has also not been scientifically assessed.

6.2 Gaps in vision: the case of Silent Valley

Soon after Convention on Biological Diversity (CBD) was adopted in 1992, there were a number of initiatives throughout the world to blend interests of development with biodiversity conservation planning. India became Party to the CBD in early 1994. Since then, the Government of India (Ministry of Environment and Forests) held wide ranging consultations with sectoral ministries, departments of the central and state governments, NGOs and a range of other stakeholders to delineate policies and programmes for conservation action. As a result, in February 1997, the draft National Policy and Action Strategy was outlined. In 1998, the Ministry of Environment and Forests, submitted the first National Report 'Implementation of Article 6 of the Convention on Biological Diversity in India' to the CBD Secretariat. This report summarised (governmental and non-governmental) conservation efforts in the country pre- and post CBD. Following this, in 1999, the Macro-level Action Plan for biodiversity conservation at the scale of the country was developed. Presently, the Ministry of Environment and Forests, Government of India has launched a country-wide programme namely the 'National Biodiversity Strategy and Action Plan (NBSAP)'. envisages integrating plans developed at various scales – small districts to large ecoregions, such as the Western Ghats which cut across states, thematic issues of immediate relevance to biodiversity such as wild faunal diversity, domesticated biodiversity, livelihoods etc. Most importantly, the NBSAP is proposed to be developed through a consultative and participatory planning process involving all major stakeholders. As part of the NBSAP, the strategy and action plan for the Western Ghats Ecoregion was developed through a process that ensured participation of a range of stakeholders including, Kurumba tribals in the Nilgiris, representatives of the traditional health care system, government departments notably the Forest Department, NGOs, naturalists, lawyers, scientists and representatives of agroindustries.

Human populations within the 44 districts that comprise the Western Ghats vary considerably; with the population density being the highest (over 1400 people per square kilometer) in certain districts of Kerala. Despite such immense human pressure, the Western Ghats support a large fraction of India's biodiversity; including 4000 species of

flowering plants (1500 being endemic), 330 species of butterflies (37 being endemic) and excluding the migratory birds, 937 species of vertebrates (340 being endemic). Of the 650 species of trees found in the Western Ghats, 350 are endemic.

Much of the biodiversity in the Western Ghats owe their continued survival to the system of Protected Areas (National Parks and Wildlife Sanctuaries). There are 58 Protected Areas in the Western Ghats (13 National Parks and 45 Wildlife Sanctuaries) covering a little less than 9% of the total area (The Silent Valley amounts to only 0.64% in this system). Although this figure is higher than the country average of around 5%, there is scope for bringing in more area under this system in the Western Ghats. Such an effort would render the biodiversity thus protected more representative of the Western Ghats as a whole.

The state of Kerala, thanks to its position near the equator, its widespread rainfall and varied topography is the richest in biodiversity amongst the six Western Ghats states. 250 of the 350 species of trees endemic to the Western Ghats are known from the state. Amongst vertebrates, 66% of all species endemic to the Western Ghats occur in Kerala. It is this rich biodiversity that led to the creation of a protected area network in the state (15 National Parks and Wildlife Sanctuaries) covering about 7% of the state's total geographic area. Considering the very high human population density in most of the districts that comprise the Western Ghats in Kerala, it is absolutely necessary that this 7% of land under the system of Protected Areas be left solely for the purpose of biodiversity conservation.

The Silent Valley National Park despite its small geographical extent attracted considerable attention not only from naturalists and scientists in India, but also those abroad due to its significant biodiversity and endemism. Early expeditions identified a number of new species of plants and animals for the first time in Silent Valley. These included vertebrates such as the toads, *Ansonia rubigina* and *Bufo silentvalleyensis.* It is also worthwhile to note that with the exception of the white-breasted laughing thrush, all the birds endemic to the Western Ghats occur in and around the Valley. In short, one may confidently state that the Silent Valley National Park is singly the most representative component of the Western Ghats both in terms of topography and vegetation and the dependent biodiversity.

It is not just the lion-tailed maccaque (as alleged by a minister in Kerala) that has been holding up Silent Valley for 30 years from a seemingly prosperous hydro-electric project, but in fact it is the magnitude of biodiversity – of plants, invertebrates and vertebrates protected therein. Relative to its small size (about 90 square kilometers) amounting to a mere 0.05% of the total area of the Western Ghats, the biodiversity of Silent Valley is phenomenal. A good majority of the 224 species of vertebrates endemic to the Western Ghats and known from the state of Kerala is sheltered within this small, protected area.

Almost 15 years after Silent Valley was declared a National Park, and included as part of the core zone of India's first and largest biosphere reserve, the Nilgiri Biosphere Reserve, the decision taken by the government of Kerala to revive its dam building mission has come as a rude shock (*The Hindu*, July 21 & July 24, 2001).

During the deliberations of the NBSAP Western Ghats Ecoregion, a number of action points addressing biodiversity conservation and sustainable use emerged. While some of these points were for the Western Ghats in general, others were specific to the respective states that constitute the ecoregion. Major concerns of relevance to the state of Kerala were as follows:

- Kerala is one of the first states to formally constitute a state level Biodiversity Committee. However, the said committee is more or less dormant.
- It was strongly felt that conservation programmes, however well planned, are often influenced by political priorities and the tenure of the government.
- Biodiversity conservation is an issue that has deep and strong linkages with socio-economic and cultural dimensions. When programmes are proposed on a single point agenda, they not only fail but also cause irreparable losses. Given the complexity of the issues in conservation, mechanisms that can effectively address all facets of biodiversity conservation need to be evolved. Such mechanisms should necessarily be transparent.
- It was also strongly felt that biodiversity is 'wealth' that has been handed over to us by our forefathers, only to be safeguarded and handed over to the future generations.
- Despite the bulk of knowledge accumulated over the years of biodiversity in Kerala, there is still a great need for basic research especially amongst lower organisms. The need to develop databases on little known groups of organisms was also stressed upon.
- Fragmentation of forests due to various developmental processes has emerged as a major threat.
- The loss of biodiversity through activities primarily influenced by poverty was highlighted. The need to generate income through ecofriendly enterprises and rehabilitate certain populations after careful evaluation was stressed.
- Human wildlife conflict resolution needs to be immediately addressed. Loopholes in the implementation of existing laws have to be eliminated.

In the light of the aforesaid issues, the case of Silent Valley needs to be carefully assessed. To start with, it has to be acknowledged that Silent Valley represents the last few patches of undisturbed biodiversity-rich tropical rainforests in the Western Ghats. What follows this is the perception of a large section of people of Kerala that, the valley is a treasure that needs to be safeguarded for future generations. This includes satisfying not only the sentimental and aesthetic aspirations of the people of Kerala, but also the wider interests of scientists who are still curious to understand the complexity of the Valley's ecosystem.

The Silent Valley has stood as a model for the whole world - where the voices of people was heard and a major crisis averted. The Save Silent Valley campaign also successfully instilled confidence to various environmental movements across the world. Ironically, at a time when the whole nation has embarked to develop a National Biodiversity Strategy and Action Plan, with utmost care to include all stakeholders through a transparent process, it is indeed unfortunate that the National Park which stands as an inspiration is under dire threat, from its supposed guardians. The case of Silent Valley is a clear instance of lack of vision!

(Source: Modified version of an article by R J Ranjit Daniels and Jayshree Vencatesan submitted to *The Hindu*, Chennai)

6.3 Gaps in policy and legal structure

The Wildlife (Protection) Act of 1972 (and its 1991 Ammendment) and the Forest Conservation Act (1980) have generally governed the conservation of forests and wildlife. There are however, nearly 200 other Indian laws and policies which directly or indirectly relate to the management of environment and biodiversity (for an illustrative list see Annexure 5). It is important that the other relevant laws/policies are made available to a wider audience (including students of law) who are not aware of the existence of such an array of legal instruments that concern the management of environment and biodiversity, especially outside the system of protected areas.

Box 6.1 - **Acts/Policies of relevance to biodiversity conservation in the Western Ghats**

Destructive Insects and Pests Act 1914
Indian Forests Act 1927
Sugarcane Act 1934
Agricultural Produce (Grading and Marketing) Act 1937
Coffee Act 1942
Rubber (Production and Marketing) Act 1947
Import and Export Control Act 1947
The Factories Act 1948
Tea Act 1953
Hill Area (Preservation) Act 1955
Prevention of Cruelty to Animals Act 1960
Cardamom Act 1965
Wildlife (Protection) Act 1972
Tobacco Board Act 1975
Coconut Development Board Act 1979
Forest Conservation Act 1980
Air (Prevention and Control of Pollution) Act 1981
National Wildlife Action Plan 1983
National Oilseeds and Vegetable Oils Development Board 1983
Spices Board (Cess) Act 1986
Environment Protection Act 1986
National Dairy Development Board Act 1987
National Forest Policy 1988
New Seed Development Policy 1988
Wildlife (Protection) Act 1972 - Amemdment 1991
Foreign Trade (Development and Regulation) Act 1992
Seeds Act 1996
Plant Varieties Bill 2001

Source: Government of India/Ministry of Environment and Forests (1998); Bashir (2000); *The Hindu*, August 10, 2001; Gujarat Ecological Society (unpublished information).

Research and monitoring of wildlife and PA is amongst the provisions of the National Wildlife Action Plan 1983. Unfortunately, these provisions are neither widely known nor appropriately implemented. The salient objectives of the Wildlife Action Plan 1983 (as listed by Bashir, 2000) are provided below.

Objectives of the National Wildlife Action Plan 1983

1. Establishment of a representative network of Protected Areas (provides for scientific management, representativeness, adequate geographic distribution)
2. Management of PA and habitat restoration (provides for development of management systems, building up professional cadre, restoration of degraded habitats)
3. Wildlife protection in multiple use areas (includes production forests and pasture lands)

4. Rehabilitation of endangered and threatened species
5. Captive breeding programmes
6. Wildlife education and interpretation
7. Research and monitoring
8. Domestic legislation and international conventions - review and update statutory provisions providing protection to wildlife and regulating all forms of trade, participate in international conventions
9. National Conservation Strategy
10. Collaborate with voluntray bodies.

The Wildlife (Protection) Act 1972 does not however concern domesticated and exotic biodiversity. Further, a remarkable ommission of the wildlife policy and law (which is not also addressed by the forest policy and law) is the failure to address wildlife damage, apart from a few provisions in the Wildlife (Protection) Act 1972 for the removal or destruction of individual problem animals. Funds available for compensating wildlife damage as that in Project Elephant and Project Tiger are only limited (Bashir, 2000).

Species that are under direct threat of extinction due to human pressures are protected by inclusion under one of the 5 schedules of the Wildlife (Protection) Act 1972 and to a lesser extent by the 'negative' export list. One of the shortcomings of these schedules/lists is the inaccuracy of nomenclature adopted. Listing biodiversity by their generic names may be appropriate (as that might include even species in less danger of extinction) while declaring them as 'protected'. However, it is extremely dangerous to list species only by their generic names while allowing export or domestic harvests. For instance, the Department of Indian Systems of Medicine and Homeopathy, Government of India, Ministry of Health and Family Welfare, in its letter DO No Z 18020/4/97 dt March 16, 1998 has enclosed a list of 29 medicinal plants (listed below) recommended by the committee of the Ministry of Environment and Forests for inclusion in the first negative list of exports to become effective from April 1998 (as per the minutes of the meeting of Committee held on 5.2.98).

Acontium spp	*Aquilaria malaccensis*	*Coptis teeta*
Gentiana kurroo	*Hardostachys grandiflora*	*Podophyllum hexandrum*
Swertia chirata	*Panax pseudoginseng*	*Picrorhiza kurrooa*
Dactylorhiza hatagirea	*Ceropegia spp*	*Cycas beddomei*
Frerea indica	*Gnetum spp*	*Nepenthes khasiana*
Paphiopedilium spp	*Pterocarpus santalinus*	*Renanthera inschootiana*
Vanda coerulea	*Coscinium fenestratum*	*Kampheria galanga*
Saussurea costus	*Rauvolfia serpentina*	*Cyatheaceae spp*
Cycadaceae spp	*Dioscorea deltoidea*	*Euphorbia spp*
Orchidaceae spp	*Taxus wallichiana*	

Subsequently, responding to a request by the Bombay Kariana, Colour and Chemical merchants' Association that the Ministry of Envionment and Forests, Government of India should not insist on a legal procurement certificate for a list of 223 species of plants, the Ministry has stated the following (DO No 3-2/93-WL-I dt October 4, 2000):

" (1) Export of 29 species that are in the negative list under the export policy will continue to be banned. Only cultivated stocks of such species could be allowed subject to a certificate from the DFO of the division in whose area the nursery from which the cultivated stocks have been acquired exists.

(2) The export of plants included in the list of critically endangered and vulnerable species circulated by the Ministry on 3.1.1997 annexed with this letter would be permitted for export, subject to issue of a legal procurement certificate from the Division from whose jurisdiction the stocks have been acquired for purposes of export. Remaining species be allowed for export by Regional Offices/Sub-regional Offices without insisting on legal procurement certificate. Of course, due care will be taken to ensure that the consignment for export does not contain either the plant products from 29 species which are banned for export, and 114 species in respect of which LPC is required from the concerned DFOs".

What is of concern is that the 114 'species' annexed to this Government Order include *Nardostychus* species, *Aconitum* species, *Atropa* species, *Aristolochia* species, *Angioptoris* species, *Drosera* species, *Coptis* species, *Gnetum* species, *Osmunda* species, *Acorus* species, *Artemisia* species, *Ephedra* species, *Hydnocarpus* species, *Ceropegia* species, *Cyathea* species, *Cycadacea*, *Rhododendron* species and *Euphorbia* species. Most of these genera of plants are well represented in the Western Ghats. The genus *Ceropegia* has the largest number of species listed in the Red Data Books prepared by the

Botanical Survey of India. *Ceropegia mysorensis* and *Ceropegia beddomei* have been recently recommended as critically endangered species to be included in the Red Data Books (Government of India, Botanical Survey of India ref CNH/JD/VTP/2001 dt July 2, 2001 circulated following the BSI workshop on 'Validation of threatened plants of India' held at Southern Circle Office, Coimbatore on May 15-16, 2001). Further, the genus is included in the proposed negative list (see above) and represented significantly amongst rare and threatened plants in the northern Western Ghats (see Annexe 3.4).

There are other such examples of species proposed to be included in the Red Data Books such *Euphorbia mayuranthii* which have been ironically treated generically in the Ministry's order. Such treatment provides immense scope for obtaining legal procurement certificates for a range of species including critically endangered ones under the title '*Ceropegia* species or *Cyathea* species', etc.

6.4 Gaps in institutional and human capacity

- ✓ **Inadequate presence and spread of pressure groups/movements in the Western Ghats to address contentious environmental issues such as mining and inorganic pesticide use**: Enviromental activism is often required to create a greater sense of awareness amongst citizens and caution amongst policy makers and administrators. One time actions and movements are not adequate as has been clearly illustrated in the case of Silent Valley.
- ✓ **Lack of taxonomic expertise, especially for lower organisms**: Taxonomic research in lower organisms including microorganisms, lower plants and invertebrates require a greater investment in infrastructure and capacity building. Often, taxonomists of this kind require visiting and working in foreign museums and laboratories. Presently, there is very little scope for such activity in India. This should be a concern at least for biodiversity hot-spots as that of the Western Ghats region.
- ✓ **Inadequate presence and involvement of trained socio-ecologists, anthropologists and economists in biodiversity research**: It has become mandatory that information on human societies directly or indirectly connected with any landscape/ecosystem be also gathered while ecological surveys/Environmental Impact Assessments are conducted for better conservation and developemt planning. While socio-ecological studies have gained popularity in India, most often the field personnel involved in the process of obtaining relevant data are neither qualified experts or adequately trained.

Of all available techniques, Participatory Rural Appraisal (PRA) has been widely used in such exercises. However, more often one finds that the PRA is a mere ritual in biodiversity research.

- ✓ **Inadequate linkages for concerted action amongst academicians and activists**: There still exists a wide gap between scientists/academicians and activists. While the focus and mandate of the two groups tend to widely vary, sound information need to be fed to activists if activism is to be effective. After all, it is the activist who reaches out to the policy maker and citizens in general more effectively than the scientist/academician. The Coimbatore-based Zoo Outreach Organisation (ZOO) has over the years organised several CAMP and similar brainstorming workshops by bringing together scientists, managers, amateurs and activists. The ZOO has also been successful in linking a wide spectrum of concerned citizens on biodiversity conservation issues in the Western Ghats. It is essential that more such linkages are identified and strengthened.
- ✓ **Poor understanding and implementation of existing legal instruments**: For a better understanding of the existing legal instruments (see Section 6.2) institutions and NGOs undertaking biodiversity studies need inputs of students of law or practising lawyers. Unfortunately, few institutions/NGOs working in the Western Ghats have either a qualified legal expert on its faculty on a full-time or part-time basis.
- ✓ **Non-availability of reliable maps, especially Survey of India toposheets and spatial data for conservation planning**: Non-availability and inaccessibility of topo-sheets and satellite imageries for research is a major deterrent to biodiversity conservation planning. Further, the Protected Area maps and available vegetation maps neither specify the co-ordiantes nor make evident the projection.
- ✓ **Lack of transparency and coordination amongst institutions/organisations working in the area of conservation**: A lot of research/studies in the Western Ghats are mere duplication incurring undue expenditure that could have been avoided. This is primarily due to lack of commitment on the part of the researcher/organisation to first explore what's going on elsewhere. Secondly, in many cases, unfortunately though, there is little co-operation between individuals/institutions when it involves sharing of information. There is apparently a sense of insecurity amongst individuals

and institutions/organisations when it concerns sharing of information (including published information).

- ✓ **Inadequate capacity to undertake holistic research in the Western Ghats**: It has become popular to talk of 'integrated' or 'multi-disciplinary' research and GIS as a tool in field research. Unfortunately, what is to be intergrated, when and where is often not spelt out. For instance, studies of avian ecology have merely focussed on the availability of food plants or nesting sites, study of medicinal plants have focussed on taxonomy and ethnobotany not on biology and ecology of species, etc. Field studies based on the principles of landscape ecology and conservation biology are still meagre in the Western Ghats.
- ✓ **Inadequate capacity in planning and implementing action research**: The contention by the Forest Departments that research rarely feeds into management is clearly due to indaequacy in planning. A lot of field studies undertaken in the Western Ghats, especially those by MSc and MPhil students is 'opportunistic' with little purpose than obtaining the degree. A majority of the institutions offering opportunities for field research do not offer appropriate courses in statistics and field methods. Thus, results obtained from hard-work and well-funded studies remain unfit for conservation planning and action.
- ✓ **Lack of capacity for documenting and effectively propogating successsful models of conservation action**: Many institutions, especially NGOs working in the Western Ghats have succeeded in developing models of conservation action at small geographical scales. There have certainly been success stories in integrated farming, participatory forestry, grazing regulation, medicinal plant conservation, fodder and fuelwood development, soil erosion management and water conservation here and there throughout the Western Ghats that have not been effectively documented and publicised. As a result, there has been little scope for follow up action and the projects have just remained one-time success stories.

7.0 Major strategies to fill the gaps/enhance/strengthen ongoing measures

7.1 Protected Areas

The VI Plan catered to 15 Tiger Reserves in India under the Project Tiger programme. Besides this, there were two other schemes of the Central Government that supported National Parks and Sanctuaries. One scheme called 'Assistance for the development of National Parks and Sanctuaries' that continued from V Plan addressed the wildlife reserves generally. The other known as 'Assistance for management/development of National Parks of national and international importance' was launched in the VI Plan for selected Protected Areas only. In the VII Plan however, these two schemes were restructured to cover selected PAs.

During the annual Plan 1991-92, and subsequently through the VIII Plan, the scheme viz., 'Assistance for the development of National Parks and Sanctuaries' has continued with the following main objectives:

1. To ensure proper development/management of the Protected Areas in different states and Union Territories
2. To improve management capacity by strengthening infrastructure for protection and enforcement
3. To develop the wildlife habitat by countermanding the limiting factors and improvement of habitat by land and vegetation treatment and enrichment of plantation by animal fodder species
4. To set up nature interpretation facilities and extension programme in order to promote conservation awareness
5. To promote wildlife research directed at improving management practices
6. To develop measures in buffer zone to promote compatibility between the Protected Area and the adjacent communities.

As per information provided by the Ministry of Environment and Forests, Government of India, during the VIII Plan (1992-95), an annual average of Rupees Ten Crores have been distributed as financial assistance under the scheme amongst all the Indian states and

Union Territories where there are Protected Areas. The scheme was evaluated for the first time in 1997. The following are the major concerns of the evaluation (Anon, 1997).

Protected Area	Concerns
Nagarhole NP	▪ Utilisation of funds - except during the year 1995-96, the sanctioned funds were fully utilised. During 1995-96, nearly Rs. 4,75,000 had not been utilised out of the sanctioned Rs.8,00,000. The reason for this under-utilisation was stated as the late release of funds. ▪ Field visit impressions and suggestions - management was not adequate. There was an urgent need for more jeeps and guns for protection. The overall condition of the habitat was found good. 7-8 tanks had to be desilted in the southern part. A few tanks were to be created in the north-eastern part. It was suggested that fruit and fodder species be planted in Anechowku, V.Hosalli and Metikuppe ranges which otherwise lack food for wild animals. There were nearly 7000 tribals living in 52 settlements within the Park. Since they had little civil/basic facilities, it was suggested that rehabilitation would be the best option. Grazing was a serious problem in northern parts. It was recommended that the management should take up intensive programmes which help the surrounding villages in getting fodder at least partially. There was severe load on the park due to the firewood requirements of the local villages. It was recommended that apart from enforcing the law, the management should draw up a scientific scheme to meet this demand in a phased manner. It was felt that an interpretation centre and library be set up in Nagarhole which would carry out some R & D work for the benefit of park management. The entire Park was protected by an once-established elephant prevention trench through the Project Elephant Scheme. This trench should be maintained properly.
Bhadra WLS	▪ Utilisation of funds - the overall utilisation of the Central share was satisfactory. Comparitively, small amount of funds went unspent during 1994-95 and 1995-96 (Rs.1,60,000 and Rs.63,000 respectively). The amount of Rs.1.68 crores which was released for acquistion of land for rehabilitation during 1996-97 has been deposited with the Revenue Department (District Administration). The whole rehabilitation process was under progress with the leadership of the district administration. ▪ Field visit impressions and suggestions - boundary was not demarcated with either fences or trenches. There was a need for elephant-proof trenching. Poaching and smuggling were frequent especially in Tanigebail and Lakkavalli ranges. The villages in the northern part of the sanctuary were entirely dependent on the PA for firewood. It was suggested that the management took positive steps to deal with this problem. It was suggested that the coffee planters be banned from depulping in perennial rivers. More than 75% of the tanks needed desiltation. The rehabilitation process which was underway needed speeding up with more active participation of the state government.

Protected Area	Concerns
Indira Gandhi NP and WLS	▪ Utilisation of funds - during the span of 1993-94 and 1995-96 Rs 1.30 lakh remained unspent out of the Rs 7.7 lakh sanctioned for the IG WLS. Rs 3.65 lakh were sanctioned for the IG NP during the year 1996-97. Out of this Rs 2.77 lakh was utilised. It was stated that the late release of funds was the reason for under-utilisation. ▪ Field visit impressions and suggestions - Habitat management was good. Fire was reported as a major problem in the eastern part. It was suggested that more check dams, gully plugs and plantations be created to curb the intensive soil erosion problems in the Amaravathy and Valparai Ranges. Grazing by domestic animals of the adjacent village was a problem. It was recommended that the problem be managed with participatory programmes in the buffer zone. Smuggling and poaching were reportedly serious in some parts, especially in Pollachi and Amaravathy borders. Ganja was reportedly cultivated near Manjampatty.
Parambikulam WLS	▪ Utilisation of funds - except during the year 1995-96, funds have been under utilised in all years starting 1992-93 till 1996-97. ▪ Field visit impressions and suggestions - the WLS is naturally well-protected. More than 1/3rd of the sanctuary was covered by teak plantations. Thinning operations were being carried out every year. The northern part of the sanctuary was observed having shortage of water. It was suggested that the marshy areas which were found around the park could be used for developing water holes and tanks. It was felt that extensive teak plantations led to food scarcity for wild animals during summer. It was suggested that fruit trees be planted in these areas. The plan of the government of Kerala to have one more dam project viz. Kuriyarkutti - Karapara, within the sanctuary area posed a threat.
Overall lacunae	▪ Lack of orientation, motivation and training amongst the staff below the DCF cadre. ▪ Late release of funds by the Central Government. ▪ Most of the field level staff (guards and watchers) were maintained on a temporary and monthly paid basis. ▪ The maximum rate fixed for labourers by the Government was very low (PWD standards). ▪ The fear of labour union in handling labourers exists especially in the state of Kerala. ▪ The slow communication between higher and middle level management.

The following tables summarise the evaluation of Centrally Sponsored Schemes : Development of Parks and Sanctuaries (Anon, 1997).

Evaluation of centrally sponsored schemes: NP and WLS - Indicators (Anon, 1997)

Indicators	Nagarhole NP	Bhadra WLS	Indira Gandhi NP and WLS	Parambikulam WLS
Habitat Development				
Protection against encroachment	Good	Satisfactory	Satisfactory	Good
Protection against grazing	Satisfactory	Satisfactory	Satisfactory	Good
Protection against soil erosion	Good	Satisfactory	Good	Satisfactory
Protection against fire	Good	Good	Satisfactory	Good
Protection against flood	Good	Good	Good	Good
Protection against epidemics	Satisfactory	Satisfactory	Satisfactory	Satisfactory
Protection against invading weeds	Satisfactory	Satisfactory	Satisfactory	Satisfactory
Steps to improve the availability of food	Satisfactory	Satisfactory	Satisfactory	Satisfactory
Steps to provide drinking water for wildlife	Good	Satisfactory	Good	Satisfactory
Steps to provide fodder for grazing wildlife	Satisfactory	Unsatisfactory	Satisfactory	Unsatisfactory
Rehabilitation process (if any)	-	Good	-	-
Preparation of management plan	Satisfactory	Good	Good	Still being prepared
Abandoning the commercial works	Good	Good	Good	Unsatisfactory
Alternative fuel arrangement for villagers	Unsatisfactory	Unsatisfactory	Unsatisfactory	-
Boundary protection	Good	Satisfactory	Good	Good
Infrastructure Development				
Captive breeding facilities	No	No	Yes	No
Whether the Park has a resident consultant	No	No	No	No
General vigilance squad	Good	Good	Good	Good
Special purpose squad	No	No	No	No
Compensation for people affected	Satisfactory	Satisfactory	Satisfactory	Satisfactory
Arms for protection	Good	Satisfactory	Satisfactory	Good
Veterinary facilities	Satisfactory	No	No	No
Status of roads	Good	Satisfactory	Satisfactory	Satisfactory
Staff quarters	Good	Good	Satisfactory	Good
Communication				
Telephones	Yes	No	Yes	Yes
Post	Yes	Yes	Yes	Yes
Wireless systems	Good	Satisfactory	Satisfactory	Satisfactory
Vehicles	Need more	Enough	Need more	Enough

Contd..

Indicators	Nagarhole NP	Bhadra WLS	Indira Gandhi NP and WLS	Parambikulam WLS
R & D Activities				
Census	Good	Good	Good	Good
Vegetation survey	Satisfactory	Good	Satisfactory	Satisfactory
Wild animal survey	Satisfactory	Good	Satisfactory	Satisfactory
Boundary demarcation	Good	Unsatisfactory	Good	Good
Research activities	No	No	Yes	No
Interpretation centre	No	Yes	Yes	Yes
Educative programmes	Good	Good	Good	Good

Manpower and infrastructure as in 1997 (Anon, 1997)

Attribute	Nagarhole NP	Bhadra WLS	IGNP&WLS	Parambikulam WLS
Staff				
DCF	1	1	1	1
ACF	3	2	1	1
RFO	7	4	12	4
Foresters	28	15	35	21
Guards	73	43	49	45
Watchers	20	2	30	6
Elephant maintenance	74		20	
Others including drivers	33	12	24	42
Accessories/infrastructure				
Single barrel gun	5	1	NA	
Double barrel gun	44	20	NA	
Revolver	1	2	NA	5
Rifle	16	6	NA	16
Tractor			1	
Jeep	5	6	4	5
Car	1	1		
Truck		1	4	
Motorbike				
Boat	3	2		2
Bus	5		1	1
Van		2	1	
Total area (sqkm)	643.39	492.46	108 & 958	285

NA=Information not available

A recent study of the Wynaad Wildlife Sanctuary has looked at the following:

- Land occupancy and other subsistence uses of the sanctuary
- Wildlife depredation on human life and property
- Commercial uses of the sanctuary

The study revealed important differences between communities in their reliance on the Wynaad sanctuary's resources, their experience of wildlife damage, and their perceptions of the sanctuary and of conservation, generally. Additionally, major inconsistencies between government policy and practice were identified. The study has concluded that the magnitude of commercial and subsistence landuses is inconsistent with the sanctuary's conservation objectives. It is argued that it will be difficult to implement exisiting conservation policies and laws without great increase in human and financial resources which are unlikely to be made available. Further more, some of the land uses that are incompatable with the sanctuary's objectives can probably never be removed. The alternative is to consider modifying conservation policy and law to accommodate and manage varied land uses, for example through a protected landscape approach. There is thus need to expand the range of Protected Area categories in India. There is also need for far greater investment in wildlife damage control and compensation in the sanctuary if greater local support for conservation is to be developed (Basheer, 2000).

The Western Ghats occupy 4.8% of the country's land area. The system of Protected Areas in the Western Ghats represent only around 9% of the biogeographic zone (Rodgers and Panwar, 1988). Protected Areas within the jurisdiction of the state Forest Departments and managed by the provisions of the Wildlife (Protection) Act 1972 and Forest Conservation Act 1980 should continue as such. Major gaps in terms of representativeness of ecosystems/species communities within Protected Areas need to be addressed and filled, wherever appropriate, by adding more area to the existing system. Considering the more than 90% of the Western Ghats that is outside the legally protected system, there is certainly scope for expanding the Protected Area Network. However, newer areas that are to be included should be carefully assessed for their biodiversity wealth, socio-economic sensitivity and administrative feasibility (eg. Ramesh *et al*, 1997; Ramesh and Swaminath, 1999). Whereas some of the Protected Areas, as those supported by Central aid, may seem to have adequate manpower and infrastructure, many are

under-staffed and under-equipped. Such PA(s) should be identified and supported in a phased manner.

7.2 Biodiversity outside Protected Areas

More than 90% of the Western Ghats ecoregion is under little legal protection. Barring the Reserved Forests and some high security areas as that within defence establishments (see Box 5.1) or hydro-electric project limits, much of the area outside the Protected Areas in the Western Ghats are vulnerable to degradation due to alternate land use, unplanned development and over-exploitation of land, water and biodiversity. These areas need to be managed in a way that they complement the system of Protected Areas. Further, there is a great scope for developing models of participatory biodiversity conservation (especially the involvement of NGOs), sustainable utilisation of natural resources (biodiversity) and sharing of benefits through recognition of traditional knowledge and practices and rewarding. The much cherished values of Article 8(j) of the Convention on Biological Diversity and the equity provisions that are hoped to be legalised in the ratification of the National Biodiversity Bill should guide conservation of biodiversity outside the system of Protected Areas in the Western Ghats. The suggestion by Bashir (2000) that newer categories of Protected Areas be created is most appropriate in this context. A concerted effort, as that suggested above, will effectively lessen the undue pressure being directed on the state Forest Departments as 'guardians' of biodiversity.

During the year 2001, the Ministry of Environment and Forests, GOI notified Mahabaleshwar (Maharashtra) as an Ecologically Sensitive Zone (ESZ). The Supreme Court has now directed that Matheran Plateau (Mahrashtra) be declared a ESZ too (source: Protected Area Update, August 2001).

NGOs are pleading that a portion of the northern Western Ghats complex involving the states of Karnataka, Goa and Maharashtra be declared as the 'Sahyadri Ecologically Sensitive Area' (SESA). Proposals for the SESA have been drafted considering the provisions in the Environment Protection Act, 1986 (Section 3(2)(c) and Environment Protection Rules, 1986 (Sections 5 (iv) (v) & (vi)).

The area proposed to be declared as SESA comprises the Sahyadri forest belt in Uttara Kannada and Belgaum districts from Kali river in the south to Tillari river in the north, east Goa (the entire protected area segment from Madei to Cotigao sanctuaries, all

adjoining Karnataka) and south Maharashtra (Kohlapur and Sindhudurg districts from Tillari river in the south to Radhanagiri sanctuary in the north (14 deg 52' - 16 deg 28' N; 73 deg 49'-74 deg 46' E).

It is recommended that the SESA is kept free of industrial activities, mining (including renewal of leases), dams and reservoirs, diversification and expansion of existing industries, felling trees and agro-horticulture that might harm the ecology of the landscape.

The SESA envisages the bringing in of a landscape under protection of one Central Act which renders conservation of the region holistic as against protecting isolated patches as parks and sanctuaries. Such declaration as per the Environment Protection Act, 1986 provides enough scope for sustainable and flexible management plans to be drawn up for the conservation and protection of the area. Declaration of an area as eco-sensitive does not lead to displacement of people. Under the provisions of the Environment Protection Act, the area benefits the highest degree of legal protection.

A detailed account of the proposed SESA is available with the National Committee for Protection of Natural Resources, Dharwad, Karnataka.The State of Karnataka is entering its second phase of the NORAD aided Indo-Norwegian Environment Programme (INEP). SESA could be in part or full covered by this programme.

7.3 Basic research

Greatest lacuna in basic research is in the taxonomy and ecology of lower organisms, especially microorganisms. The Western Ghats are the home to a large diversity of microorganisms including fungi and to a variety of primitive plants such as lichens and mosses. Research in these groups of organisms has barely gone beyond taxonomy. Amongst studies involving the lower organisms, microbiology has gained more popularity than others. For instance, in Kerala, rhizophere soil and young roots along with ectomycorhizal (ECM) fructifications were collected and studied from monoculture plots of *Eucalyptus tereticornis, E. grandis, E. camaldulensis, E. pellita, E. urophylla and E. digitata*. The study revealed the presence of ECM fungi such as *Pisolithus tinctorius, Scleroderma citrinum, S. verrucosum* and *Ramaria* sp. Arbuscular mycorhizal fungi (AM) isolated were *Glomus fasciculatusm, G. mossae, G. botyoides, G. geosporum, G. claroideum, G. melanosporum, G. versiforme, G. intraradices* and *G. leptothecum*. *Gigaspora* species asscoiated with eucalypts include *Gi. marginata, Gi.*

decipines and *Gi. albida*. *Scutellospora gregaria, S. reticulata, Acaulospora scorbiculata, A. bireticulata, Sclerocystis dussi, S. microcarpus,* etc were the other AM fungi isolated from the rhizosphere of eucalypts. Total spore count of AM fungi varied from 125-477 per 10 gm of rhizosphere soil. The highest count was found in *E. europhylla* and the lowest in *E. digitata*. Root colonisation by AM fungi varied from 8% in *E. digitata* to 54.5% in *E. tereticornis*. It is possible that some of the ECM fungi be selected and utilised in the planting stock improvement of eucalypts in Kerala (K K Sheeba and C Mohanan: in Ganeshaiah *et al*, 2001b pp80-81).

The impact of fire on soil microflora has been studied in the Chinnar Wildlife Sanctuary in Kerala. It was found that 23 species of fungi belonging to 15 genera occurred in the burnt plots. Twenty species in 11 genera were found in the unburnt plots. *Aspergillus restrictus, A. glaucus, A. kanagawaemsis* and *Trichoderma hamatum* were the predominant fungi in fire affected plots. *Aspergillus flavus, A. fumigatus, A. parasiticus* and *Fusarium* sp were the dominants in unburned plots. *Aspergillus niger* was amongst the dominants in both treatments. Actinomycetes and bacteria in both burnt and unburnt soils decreased in density with soil depth. However, in the case of arbuscular mycorhizae, it was observed that the burned plots had a greater number of spores than the unburned plots (N Ratheesh and C Mohanan: in Ganeshaiah et al, 2001b pp51-52).

7.4 Research to feed into management plans

The Tamilnadu Forest Department is conducting preliminary laboratory and field trials with fast growing native and exotic species of trees that could be raised by farmers. Similarly, the scope of using alternate sources of timber (especially Eucalyptus as timber species) is also being experimented. Such alternative resources might enable reduction of pressure on natural forests for fuelwood and timber.

The Department of Indian systems of medicine and homeopathy, Government of India, Ministry of Health and Family Welfare, under its 'Central Scheme for Development of Agro-techniques and Cultivation of Medicinal Plants', has launched a country-wide project viz., 'Utilisation of agro-techniques on medicinal plants and linkages with the growers and Ayurvedic drug industry'. Under this programme 34 institutions/universities have been identified and funded for research on selected species of native medicinal plants. This programme has been on since 1997 (Government of India, Ministry of Health and Family Welfare, Department of Indian systems of medicine and homeopathy - DO

No Z 18020/4/2000 -MP Cell dt January 17, 2000). Around 140 species of medicinal plants are being covered by this scheme. More plants that are native to the Western Ghats should be added based on the recommendations of botanical institutions and NGOs such as FRLHT that are working on medicinal plant conservation in southern India.

Since 1993, FRLHT has initiated a pioneering collaborative programme in response to the crisis of dwindling medicinal plant resources. FRLHT in collaboration with the State Forest Departments, local NGOs and research institutes has established a chain of conservation sites in the Western and Eastern Ghats across the states of Kerala, Tamilnadu, Karnataka, Andhra Pradesh and Maharashtra. The network is called the 'Medicinal Plant Conservation Network' (MPCN). It is a major step towards the conservation of wild genetic resources – the first of its kind in India. The MPCN is today conserving about 1400 species of medicinal plants including 70 red-list species.

The MPCN has adopted a two-pronged strategy. On one hand, there are forest reserves where wild populations of medicinal plants are conserved in their natural habitats so that they can freely breed, evolve and multiply. This ensures their long-term survival. About 50 Medicinal Plant Conservation Areas (MPCAs) have been set up with the cooperation of the State Forest Departments to conserve the medicinal plant diversity in a range of vegetation types and ecosystems.

On the other hand, medicinal plants, especially the threatened species are being conserved in ethnomedicinal gardens. Fifteen ethnomedicinal conservation parks have been established in collaboration with NGOs and research institutes to conserve plants known and used by various ethnic communities of southern India.

In the MPCN, local communities are being motivated to form management and protection committees to secure long term conservation of forest reserves. Training programmes and material have been developed on conservation and utilisation of medicinal plants.

Bamboo and rattans are relied upon by millions of people for their livelihood, in addition to being used as raw material in the pulp and paper industry. At ATREE, attempts have been made to examine the patterns of genetic variation amongst some of these important plant species. Contour maps indicating bamboo and rattan species richness have highlighted regions of high-diversity that could serve as sites for in-situ conservation of these species. These results are meant to be useful to forest managers in arriving at

informed decisions on the management and conservation of rattans and bamboos in the Western Ghats.

A similar study has been undertaken by ATREE on sandal populations in peninsular India. It has emerged that the Deccan Plateau is the hot spot of sandal genetic resources in peninsular India. Results that emerge from the studies undertaken by NGOs and individuals outside the government machinery should be taken into consideration by the government departments, especially the Forest Departments, for conservation planning in the Western Ghats.

The need to identify research objectives that support management of biodiversity in the Western Ghats has to be stressed. This becomes most pertinent within the existing system of Protected Areas wherein a majority of the scientific studies (MSc, Mphil, PhD Dissertations and aided projects) are being carried out. Scientific research within the system of PA need to be designed in consultation with the concerned forest department. Such a process might lessen the procedural delays in obtaining research/collection permits and enable meaningful consultation and use of the outcome (reports/results/publications) of such scientific research.

The French Institute of Pondicherry has developed a strategy to integrate scientific results into management and action plans. A good example of this is the collaborative project between the Institute and the Karnataka Forest Department (Ramesh and Swaminath, 1999). Using satellite imageries, supplemented with ground level verification, it has been estimated that the overall loss of forest cover in the state over the time period 1977 to 1997 was 12%. The loss within the Reserved Forest areas was 9% and in other areas was 19%. Ownership patterns revealed that in the state, while 55% of the forests are under the jurisdiction of the Forest Department, the remaining 45% are under the Revenue department or private owners. By superimposing four sets of layers on the imageries, viz. basal area, richness, Shannon index and levels of endemism, conservation maps have been generated. These maps reveal that nearly 28% of the high conservation areas are outside the Reserve Forests or the Protected Area Network and this is a significant gap in conservation planning in India.

By using the same procedure, the following areas have been identified as 'high conservation areas ' for the Western Ghats.

- Agasthyamalai, Anaimalais and Palnis
- Nilgiris and Wynaad plateau
- Brahmagiri - Pushpagiri
- Kodachadri
- Aganashini
- Kalinadi

Note: The Kalinadi High Conservation Area is amongst those delineated as SESA (see Section 7.2).

7.5 A centralised repository of information

During the early 1980s, the Ministry of Environment and Forests, Government of India identified the Centre for Ecological Sciences, Indian Institute of Science, Bangalore as the first Environmental Information Service (ENVIS) centres dedicated to the Western Ghats. The Centre for Ecological Sciences (CES) had the mandate of collecting and disseminating all available information on the Western Ghats and complement the existing information with primary research and training. Despite the nearly 20 years of research in the Western Ghats undertaken by CES and the many students who have worked for their doctoral degrees on aspects ranging from flora to large mammal ecology in the Western Ghats, its role as a nodal agency has neither been fully realised nor publicised. It may be most appropriate to strengthen CES further as a repository of information for the Western Ghats by

- Providing infrastructure and manpower support to maintain the existing herbarium and museum of plants and insects collected from the Western Ghats
- Enlarging the existing repository of literature on the Nilgiri Biosphere Reserve
- Enlarging the database and maps/satellite imageries available at the centre and making it more widely available
- Update and upgrade the electronic database available with the centre

The second possible agency that could be entrusted with the responsibility of developing and managing a database on the Western Ghats is the French Institute of Pondicherry. This international institution has during the past 30 years has provided immense service in preparing maps of vegetation, climate, soil and land use for the Western Ghats. The institute's rich experience in surveying vegetation and preparing GIS based conservation

strategies for the Western Ghats could be made widely available in an electronic form. Since the French Institute of Pondicherry and the Centre for Ecological Sciences have worked together for preparing vegetation maps especially of the Nilgiri Biosphere Reserve, it may be practical for both the institutions to jointly host the database for the Western Ghats.

Networks as an approach for biodiversity conservation is being endorsed by the NBSAP - Western Ghats Ecoregion. The SAP also recognises that management of networks is a challenge, and requires proven managerial expertise. The incubation period of a network to achieve its mandate is also rather long. Websites for 'shared-data' could be an incentive for networks. This website could be a means to pool and share data, with facilities for online sharing. During the peer review workshop at Coimbatore it was suggested that the Zoo Outreach Organisation and SACON jointly hosted such as website.

7.6 Action research to understand and develop workable models for integrating human concerns in biodiversity conservation, especially wildlife conservation

The loss of biodiversity in and around farming systems has adversely affected several ecosystem functions for example, moisture retention, nutrient turnover, pollination services, natural enemies of insect pests and diseases, etc. Doubts are now being raised about the productivity, stability and sustainability of such input-intensive diversity poor agriculture. In order to understand the implications of declining biodiversity for the sustainability and productivity of agroecosystems, ATREE has initiated a long-term programme to investigate

a) role of biological and genetic diversity in and around agroecosystems in affecting productivity and sustainability of farming systems
b) the role of biological diversity in shaping the pattern of resource use and the intensity of external inputs used in farming systems and
c) the spatial and temporal patterns of exchange of biological resources in the inter-phase zone between agro and natural ecosystems.

ATREE has conducted studies on agrobiodiversity in and around the Biligiri Rangaswamy temple Wildlife Sanctuary in Chamrajnagar district of Karnataka. The study area represents a wide spectrum of farming systems ranging from input intensive,

low diversity farming in the periphery of the sanctuary to zero input traditional farming in the core of the sanctuary.

Elsewhere in Wyanad (Kerala), the M.S.Swaminathan Research Foundation has mobilised 17 women self help groups (SHGSs) from several villages. These SHGs are involved in biodiversity based enterprises such as mushroom-cultivation and sale of medicinal plants, etc. These groups have also been trained to collect the seeds and propogules of threatened food and vegetable crops for cultivation. Two of the SHGs have successfully cultivated legumes, spices, yams, banana cultivars and rice.

Box 7.1 - **Kodai Hills Women Development Centre**

The Kodai Hills Women for Sustainable Development was initiated by the Service Club (Regd), Pannaikadu during the late 1990s . The Service Club has been working in the Kodai Hills since 1975 in the areas of child, youth, women, tribal, socioeconomics, health and environmental development.

The Kodai Hills have a total human population of 125,000 of which males comprise 52% and females 48%. Scheduled castes are 12%, Scheduled Tribes 1.5% and other unclassified 'primitive' people 3.3%. 60% of the women are illiterate and work as agricultural labour earning for 5-6 months a year.

Due to degeneration of natural resources in the Kodai Hills, these women were driven to hardship. Women representatives of 17 villages approached the Service Club for assistance in regenerating the natural resources such as water, firewood, etc. As a result the project 'Kodai Hills Women for Sustainable Development' was launched with the following objectives:

- To create greater awareness among the hill women of their total environment and its current problems
- To establish Village Eco-women's Sanghams in all the Kodai Hills villages in order to promote their active involvement in environmental improvement, protection and conservation
- To provide trainings for hill women in order to improve their political, social and economic awareness and participation
- To provide training in new form of economic development, consistent with the protection of their environment and start eco-friendly income generation and
- To establish new linkages between other women's organisation, NGOs and government departments so that the women can take full advantages of various schemes or training options.

Amongst the various initiatives of the Village Eco-women's Sanghams are bee-keeping, reusing waste water, organic farming, solid waste management, growing fuelwood and fruit trees, etc. The result of training 50 women in each village in nursery techniques is that 15,000 saplings of fuelwood and fruit trees have been planted in the villages. There is also a 'women's development and empowerment micro-finance' scheme established in one of the villages. Seven villages have involved themselves in Joint Forest Management Programmes of the Forest Department.

Source: Kodai Hills Women Development Centre, Service Club, Pannaikadu, Kodai 624 210 and Institute for Environmental Education, M-329, Row Type, Ellis Nagar, Madurai 625 010.

SEVA, an NGO in Madurai (Tamilnadu) has launched a council for the protection of traditional animal husbandry and the natural wealth of the Western Ghats in the districts of Virudhunagar, Madurai and Theni in Tamilnadu. This council, besides promoting awareness on vaccination and control of epidemic outbreaks of cattle diseases amongst the endemic breed of hill cattle viz., *malai maadu*, is also making effort to preserve the

breed from extermination. It has been estimated that this breed of cattle has declined in numbers to the tune of 90% from what was there 20 years ago. To encourage the breeding and survival of the cattle, SEVA organises cattle shows and prizes for the best milking cows and the best maintained bulls, etc. SEVA is also facilitating the grazing of these cattle in forests through public meetings and discussions with the concerned forest department.

The Soligas of Biligiri Rangaswamy Temple Wildlife Sanctuary in Karnataka derive almost half their income from non-timber forest produces (NTFP). Of the various products harvested by the Soligas, the most important are *Phyllanthus emblica* and *P. indofischeri* and honey from *Apis dorsata*. A fairly large number of Soligas have participated in the participatory resource management (PRM) activities organised for their benefit by ATREE, University of Agricultural Sciences, Bangalore. In three years 128 pre-harvest and 74 post-harvest group discussions were conducted. Total attendance over this period was 5958 including men, women and children. The Soligas now have a three year record of productivity, extraction and regeneration in the form of resource maps. Based on these maps, they can track temporal changes in productivity and can vary the amount harvested accordingly. The Soligas have also started to practise better harvesting techniques. The continuing success of participatory monitoring will be dependent upon the incentives the Soligas receive and the eventual role they will play in mangement of resources. Although the Soligas have started to receive better prices for the raw products they harvest, profits from the enterprise unit set up to process NTFPs have declined. The Soligas have also shown disinclination to monitor in the absence of better control over the resources they harvest and in the absence of clear economic benefits for monitoring (R Siddappa Setty, K.S.Bawa and J. Bommaiah: in Ganeshaiah et al, 2001a pp 85-88).

Box 7.2

Sharing the benefits of Biodiversity: the Kani-TBGRI deal in Kerala, India

A team of scientists from the All India Coordinated Research Project on Ethnobiology formed part of a botanical expedition into the forests of the Western Ghats of southern Kerala in December 1987. They were accompanied by some men from the *Kani* tribe as guides. During their arduous treks into the forests the scientists observed the tribals eating certain fruits which seemed to keep them energetic and agile. Indeed, when the exhausted sceintists were offered them they too felt a "sudden flush of energy and strength". When questioned, the *Kanis* were reluctant to reveal the nature and source of the fruit saying the information was sacred, a tribal secret not to be revealed to outsiders. It was only after considerable persuasion tha they showed the scientists the plant from which the fruit (which they called *Aarogyappacha*) was obtained. Specimens of the plant were subsequently collected to study its properties.

Detailed scientific investigation of the plant was carried out by the Tropical Botanical Gardens and Research Institute (TBGRI). Leaves contain certain glycolipids and non-steroidal compounds which contained anti-stress, anti-hepatotoxic and immunodulatory/immunoretorative properties. Eventually the drug *Jeevani* was formulated with *Trichopus zeylanichus*. Thereafter, a licence to manufacture *Jeevani* was given to a private company, Arya Vaidya Pharmacy (Coimbatore) Ltd (AVP), for a period of seven years for a fee of one million rupees (approximately US $ 25,000). It was also decided that the *Kani* tribals would receive 50% of the licence fee, as well as 50% of the royalty obtained by the TBGRI on the sale of the drug.

- Concerns about the arrangement have subsequently been voiced by various governmental and non-governmental institutions and individuals, based on the fact that there is no uniformity in the Kani's perception of benefit-sharing as proposed by TBGRI. The *Kanis* are no longer a single cohesive unit or community; the TBGRI has primarily been interacting with *Kanis* only from one village panchayat area that has been supportive of the institute's role.
- The *Kanis* in other areas expressed misgivings about the arrangement, especially as the TBGRI did not even consult them. The TBGRI, meanwhile, believes that there was no legal requirement to do so, and that it was unaware of the need to seek permission from medicinal practitioners among *Kanis* before making the use of the plant.
- As regards the appropriation of tribal medical knowledge, the TBGRI points out that tribal knowledge, systems have always influenced other systems; that this particular instance of using *Kanis'* knowledge to manufacture *Jeevani* does not necessarily imply an obstruction of traditional tribal practice. Also, the institute emphasises, *Aarogyappacha* was never used by tribals for medicinal purposes; they consumed only the fruit of the plant as an energy-provider. Whereas the medicinal properties of the plant's leaves were identified through research conducted by the TBGRI.
- Objections to the benefit sharing arrangement have also been raised by the KIRTADS (Kerala Institute for Research, Training and Development of Scheduled Castes and Scheduled Tribes) which feels that the only way tribal medicine can survive is by preserving its original form and premises. Otherwise, KIRTADS believes, it is open to misuse as a convenient resource base for other systems of medicine.
- There is also the issue of the *Kanis'* rights over the land they inhabit. Most of the area in and around the *Kanis'* homelands have been declared Reserved Forests under the Indian Forest Act of 1927. Tribals are denied permission to enter such forests and harvest *Trichopus zeylanicus*.

(Source: Anuradha, 2000)

7.7 Inter-state mechanisms to counter smuggling and poaching

Inter-state cooperation in the sustainable management of the Western Ghats ecoregion is crucial. Project Tiger, Project Elephant, the Nilgiri Biosphere Reserve and the case of

sandalwood have provided opportunities for inter-state cooperation in countering smuggling and poaching across the three southern states (Karnataka, Kerala and Tamilnadu). It is also likely that the SESA, if declared, would further our experience in inter-state cooperation. The concept of 'Peace Parks' as that in Africa that ensure transfrontier cooperation in conservation may be extended to the Western Ghats. States may cooperate in conservation of watersheds and the biodiversity therein through the establishment of Peace Parks.

7.8 Relief mechanisms

Studies in the Wynaad WLS has shown that 92% of the damage by wildlife has been on agricultural crops. There have been very few instances of human injury (1.1%) and death (0.6%) due to wildlife (Bashir, 2000). The government of Kerala has the following scheme of paying compensations which are Rs.10,000/- for human death due to wildlife, Rs.5000/- for permanent incapacitation, Rs.1,000/- for injury and for crop damage or livestock loss, a maximum of 75% of the total value or Rs.5,000/- which ever is highest (Bashir, 2000). In Tamilnadu, especially in the Indira Gandhi WLS, compensation for wildlife damage of agricultural crops has been to the tune of Rs.5,000/- per instance. The highest amount paid as compensation is however in the state of Karnataka - Rs.45,000/- for loss of human life in the Bhadra WLS (Anon,1997).

During the brainstorming meeting at the Zoological Survey of India, Chennai a senior Forest Offcial of Tamilnadu said the following: "human-animal conflicts although are much rarer than casualities caused by road accidents, isolated incidents of an elephant or tiger attacking a villager or his crops get magnified interfering with conservation efforts. A speedy district level relief mechanism must be constituted to redress the grievances of people living in the vicinities of forests. Such a mechanism should be devised in the lines of 'Red Cross'".

7.9 Land tenure : The issue of land tenure and diversion of forest lands to non forest purposes, especially those related to development is a critical issue in the Western Ghats. That no part of the remaining forests or grasslands in the Western Ghats be diverted for any other purpose is a key endorsement of the NBSAP- Western Ghats Ecoregion. While plantations that have been carved out of forests could not be addressed, further expansion of plantations in the hills should not be allowed. There is also the vital need for strict control of unplanned urbanisation of the hills and any plan for expansion of human

settlements should be based on natural carrying capacities of the landscape. On the basis of carrying capacities, tourism development plans should be prepared laying down strict guidelines of quantitative and qualitative limitations of tourism in the hill areas. There is also the need to curb luxury tourism and its associated infrastructure, which does not benefit the local people, while imposing an intolerable burden upon them in the form of enivornmental, social and moral degradation. There is a need to favour nature and adventure based tourism with simple pensione-type accomodation which will serve to enhance the natural integrity of the hill areas while providing its people with economic benefits (Palni Hills Conservation Council, 1988).

In addition, conversion of agricultural lands to non agriculture use within the ecoregion should be strictly limited to the reasonable requirements of the resident population of the hill dwellers and appropriate regulations should be notified for the purpose.

Box 7.3 - Tourism and Urbanization Impact on the Wildlife Corridors in the Western Ghats: A case from village landscape around Mumbai

Not much is understood about biodiversity distribution & management at the landscape level. We attempted to explore this dimension at a village landscape in the Mumbai-Pune belt, which is highly urbanised. The study landscape- Tamhini ($18^0$27'N $73^0$25'E) village- adjoins Khandala- a biodiversity hotspot in the northern sector of Western Ghats- both due to high diversity, endemicity & high threat. The elevation ranges from 850-1260 m ASL & average annual rainfall ranges between 3500-5500 mm. Over half the study area, especially near the village, is under private ownership, including few pockets of disturbed or regenerating forests, amidst a past shifting cultivation area.

Our partial checklists over the past few years indicate admirable species richness across organismic groups- trees 260; birds 100; butterflies 62; fish 32; frogs 16; mammals 30; ants 25; etc. The distribution of this biodiversity across the landscape is heterogeneous & non-congruent across groups. Ants for instance, abound in degraded forests while tree diversity & endemicity is concentrated in pristine forests.

Tourism and other urban impacts have more than doubled during the last decade. Resultant large scale land transformations have bulldozed the lateritic plateaus for conversion into roads, resorts, farm houses, etc. These plateaus that house concentrations of endemic & endangered organisms such as ephemeral herbs, herpetofauna, etc., has been encroached upon by tourist resorts, farm houses, roads, etc. Important driver of landscape changes has recently been urbanisation e.g. Ambi Valley tourist resort project by Sahara India Co., Mumbai - Pune Express high-way, ever-increasing farm houses & defense infrastructure (INS Shivaji), growing rail & electricity network etc. The number of tourists visiting Khandala & adjoining areas is nearly doubling every year or two, especially on holidays. Besides multiplied consumption of water, fuelwood, etc., enormous waste i.e. plastic, broken bottles, tin cans, paper and clothes are polluting water and soil. Major landscape changes due to construction of artificial lakes, buildings, roads, improper excavation and dumping, etc. have destroyed the habitats of many endemic species. Besides, the vehicular air and noise pollution wards off sensitive organisms like forest mammals, secretive birds, etc. The deforestation and habitat fragmentation has particularly isolated & shrunk populations of the habitat specialists with poor dispersers (e.g. giant squirrel, tree frogs, etc) that cannot overcome the habitat barrier. The encroachments on the hilly grasslands and scrub may have threatened few reptilian species besides destroying breeding habitats of frogs including *Ramanella montana, Rana malabarica, Polypedates maculatus, etc.* Butterflies such as blue mormon, common nawab may be declining. Poaching, hunting and heavy harvesting of forest products by the locals and urban hunters is another threat. State government

Contd….
has sought to protect parts of this area by declaring it as a wildlife sanctuary, goes the news, for last few years. However, this has not reduced ongoing threats, but caused anxiety amidst local people of losing natural resource rights. Feasible management options include declaring this area as an Ecologically Sensitive Area so as to retain local people's rights while prohibiting major land-use changes & excessive urbanisation. Protecting biodiversity on private lands- both owned i.e. `*malki*' forests and the traditional farming- will need awareness programs & socioeconomic incentives, besides alternative practices. An attempt is this direction has been made by the state forest department & NGOs (Rural Communes and Kalpavriksh), through Medicinal plants Conservation Area (MPCA) & Local Management Committee (LMC) and compilation of People's Biodiversity Registers (PBR).

Source: RANWA, Pune.

On the issue of fuelwood consumption by the plantation sector, fuelwood plantations are a viable option. However, the existing fuelwood plantations of industries are not effective due to the procedural impediments of the Forest Department. Agroforestry could be a major endorsement of the SAP for the Western Ghats to decrease fuelwood demands from forests.

7.10 Assessment of tribal lands

Illegal ganja cultivation is one major problem in the forests of southern Western Ghats. Grazing by cattle supposedly owned by tribals (who are in fact paid labourers of absentee landlords) in the Nilgiri Biosphere Reserve, is another major problem. However, examples from northern Western Ghats and Central India show that low intensity grazing is good for herbs.

Data on human use and misuse of forests, especially on issues like fodder, green manure (for example, in arecanut plantations of Karnataka, Banana and Paddy cultivation in Tamil Nadu), etc is deficient. This has to be in the context of vanishing common and grazing lands, as well as governmental programmes that award ownership rights to tribals (pattas) as part of the tribal development programmes.

Rehabilitation in the Bhadra Tiger Reserve is linked to providing incentives such as dairy farming and small trade in timber. People do not state that tigers have been sighted primarily because it strengthens the stand of the State that it is a Tiger Reserve.

The issue of rehabilitation in Nagarhole is complex. While some of the people want to be rehabilitated, there is a sizeable population which does not want to move out of the sanctuary. The Malaikudiyar tribals when specifically interviewed (as part of the KBSAP) categorically stated that they do not wish to relocate.

Area specific solutions have to be sought for relocation. People can be relocated to habitats similar to their original landscapes, and such an approach can be envisaged only by those who have an insight into wildlife management. Instead of providing a one-time payment, the idea of 'Fixed Deposits' can be considered as incentives for relocation and rehabilitation.

7.11 Commerical/ Contract farming

Most of the current plantations in the Western Ghats have been carved out of forests. Precision farming in plantations should be a major endorsement of the NBSAP - Western Ghats Ecoregion. This would not only cut costs of cultivation, but would also effectively address issues of Integrated Pest Management, Integrated Fertiliser Management and organic farming. This would also effectively address the issue of remunerative prices for coffee and tea. The possibility of leasing wastelands for 'precision' tea and coffee cultivation could also be explored.

7.12 Mining and threats of river development

Open cast mining in the Western Ghats is widespread and has had a long history. While its impact is not so severe in some parts, the states of Karnataka, Goa and Maharashtra have really suffered the onslaught. Of greatest concern is the state government run Kudremukh Iron Ore Company Limited (KIOCL) and its operation aorund the Kudremukh National Park. The August 2001 issue of Protected Area Update reports that 3703 ha initially notified as part of the Kudremukh National Park has been excluded to accommodate KIOCL.

Box 7. 4 Nethravathi River Development

In the shadow of the towering Pushpagiri mountain ranges, in some remote corner of the Western Ghats the Kumaradhara-Nethravathy river valleys are under threat. Nethravathi and Kumaradhara rivers, are home to some of the most spectacular rainforests in the entire Western Ghats, probably amongst the best in India. Two major projects have been planned to tame these wild flowing rivers. While the first one is an 18 MW Hydro-electric project at Doddahalla near Sakleshpur, the second one is the most ecologically and environmentally devastating project ever to be mooted in the history of Karnataka. While the former plans to build a dam, the latter envisages the diversion of all the west flowing streams from Lingadahole in northern Kodagu till Samse the edge of

Kudremukh National Park, in Chikmagalur district. The plan is to build 37 small dams and two canals 300 km long known as "Garland Canals", along the western face of the Western Ghats.

The idea of diverting Nethravathi towards east has been played up regularly by a few politicians of Tumkur district for quite some time. Encouraged by this, two project feasibility reports have been submitted to the Chief Minister of Karnataka by a committee of 9 engineers; most of them retired Superintending and Chief Engineers. This committee is headed by one Mr.G.S.Paramasivaiya, himself a Retired Superintending Engineer.

The first report estimates to divert 90.73 TMC of Nethravathi waters eastwards to 40 taluks of 7 districts of Chikmagalur, Hassan, Mandya, Tumkur, Kolar, Bangalore Rural, Bangalore Urban districts, including Bangalore city. The second report estimates to divert 51.73 TMC of Nethravathi waters to north and northeast to 22 taluks of 6 districts of Chikmagalur, Chitradurga, Bellary, Davanagere, Kolar and Tumkur districts. The reports contend that "the west flowing Netravathi river waters have been draining into the sea as a waste" and this water should be diverted to the dry districts of eastern Karnataka. By doing so, claim the reports, whatever the cost: economical or ecological, there will be no shortage of food and water for the populations in these districts "for generations to come". They acknowledge that this scheme is "totally new" but should be given the go ahead even if it receives criticisms comparing it to other big projects which have come up despite criticisms. They claim it as a "novel scheme" and "the concept of garland canal is a new thought". The name is so chosen because the alignment of the proposed canal is below the peak line or ridge of the Western Ghats "which is meant to collect rain waters that precipitates on the western slopes of the Western Ghats". The water so collected, is proposed to be diverted to fill all the existing tanks in the command area and also many proposed new tanks so that water is present even in summer. By this the ground water will be recharged, claim the reports.

Without even considering the consequences, the Government of Karnataka has accepted the feasibility reports and on the same day announced the sanctioning of a sum of Rs. Five Crores for the preparation of Detailed Project Report (DPR).

In states like Rajasthan, much of whose areas fall under arid and semi-arid zones, people are shunning mega-projects and returning to traditional water harvesting practices. Villagers led by enterprising groups like Tarun Bharat Sangh have started repairing and

rebuilding traditional water harvesting structures like check dams, anicuts and gully plugs at important places where rainwater earlier flowed unhindered. Thousands of such structures have sprung up in the catchment areas of rivers like Aravari and Ruparel reincarnating them from dead rivers to ones, which provide water even during summer. Without hindering nature in any way, this has recharged hundreds of wells and improved the living conditions of thousands of villagers dependent on them. Ecofriendly examples like these are increasingly seen in the states of Maharashtra and Gujarat.

In Karnataka, the Bharatiya Agro Industries Foundation (BAIF) now the BAIF foundation, has achieved remarkable success in watershed management in the dry areas of Tumkur district. Says Dr. G.N.S.Reddy of BAIF, Tiptur, *" Let it be known that we have failed in developing sustainable farming systems in the eastern plains by enabling farmers to harness the rain water to the fullest possible extent. 600 to 700 mm of rain is not meagre by any measure. Harnessing this rainfall and developing suitable rain-fed farming is the need of the hour. Ground water table can be improved even without bringing Nethravathi into these areas. What is required is systematic and decentralised water harvesting measures coupled with green cover of the barren lands without unduly disturbing the cropping pattern. This will open up new possibilities of profiting from dry lands, at least cost to the farmers. This will have great ecological advantages as well.*

There is no proof that the paddy/cotton growers of irrigated tracts are well off than the rain-fed farmers who have successfully adopted well balanced farming systems without need for high input-oriented irrigated agriculture. There are ample evidences to show that the most unscientific high input agriculture as practised in areas such as Gangavathi and Manvi in Raichur district have created more hardship to farmers than solving any of their problems. Look at what happened to the vast tracts of fertile rain-fed tracts such as Hunasgi area in Gulbarga district. In ten years time our irrigation experts have succeeded in achieving 100% water logging of the area in addition to the attendant health problems. Probably the engineers are imagining that they can increase the area under coconut and arecanut in the area by bringing Nethravathi. This will be the ultimate ecological disaster that this region can sustain which is already reeling under the impact of monoculture of coconut.

Those who are trying to flow the Nethravathi in Tumkur should think a little. For whom is this project? When we do not have the will to stop the rainwater from running off waste

every year, why should we bring the Nethravathi, which is hundreds of kilometres away. Can the destruction caused to thousands of villagers by Hemavathi canal by water logging be imagined? Why do only those projects worth crores of rupees attract our eyes?"

The totally new concept of "garland canal" is in itself a big question. Noted environmentalist and retired senior Forest Officer, Dr. A.N.Yellappa Reddy says, *"The topography and geo-morphology of the Western Ghats is highly dissected i.e. each hill is separated from the other by valleys which are thousands of feet deep. If the entire hills are cut open and a parallel river system is created against the natural landscape, this will be an attempt to override the matrix system of stability of these hills, which has evolved over millions of years. These hills are not just rocks and water but have been in their place after evolving for hundreds and thousands of years. When such a wide canal is constructed on slopes that are thousands of feet steep, how can the resultant land slides be prevented? Even if retaining walls are constructed to prevent the landslides throughout the length of the canals, the ever probing root system of the trees, particularly the ficus, will penetrate into the retaining walls, whatever their thickness might be, and the canals will give way. When rock crevices can be forced open by the root system, how can concrete be prevented from being done so?*

Deep probing animals like moles, rats which reside in their hundreds and thousands in these hills will create crevices. When water seeps in, due to the absence of root system the entire soil matrix will be loosened. The landscape is not homogenous and changes at the interval of every ten kilometres at least, like the composition of soil, rocks, etc. Also the large-scale use of explosives will loosen the stability of the entire matrix. Even if single hill under these huge canals gives way the entire network will break down with devastating consequences."

According to the National policy, India is supposed to have 33% of its total landmass under forest cover: 60% for hilly tracts. But the actual figure is only 22% at present. In Karnataka the picture is even gloomier, with just 17% of the total area under forest cover. Even this forest cover is decreasing at an alarming rate particularly in the very region that has the highest forest cover i.e. the Western Ghats. According to official figures, more than 3 lakh 15 thousand hectares of prime forests have been lost in Karnataka till date most of them in Western Ghats (Table 7.1).

Table 7.1: Forest (in hectares) lost from 1956 till 1999 for various purposes in Karnataka (Does not include the forests owned by the Revenue department and private owners)

1. Forests submerged	35,840
2. Forests released for rehabilitation of expatriated ryots	25,820
3. Forests affected by power lines	1,688
4. Forests lost to cultivation	67,217
5. Forests lost to mining	42,678
6. Forests lost to townships	1,791
7. Forests lost to non-agricultural purposes	6,297
8. Forests lost for Kalinadi project	12,500
9. Forests lost for Chakra Project	2,600
10. Forests lost for Varahi Project	15,634
11. Forests lost for Gangavathi Project	10,039
12. Forests lost for Colony and roads	333
13. Forests lost for Bedathi Project I phase	290
14. Forests lost for Kadra and Kodasalli Power projects	3500
15. Forests lost for Sharavathi Tail race project	1068
16. Forests lost for Tunga Dam (Gajanur), 2001	449
17. Forest encroached between 27-04-1978 to 30-04-1988	45,777
18. Forest encroached between 1-05-1988 to 05-05-1997	38,814
19. Forest encroached between 05-05-1997 to 31-07-1998	1,662
TOTAL	3,15,000*

*The total excludes forests lost after 1983 to projects such as Kaiga nuclear reactor, power transmission lines, Kudremukh Iron Ore Company Limited (KIOCL), Mangalore-Bangalore Petroleum Pipeline Project (MBPL) and others, almost all of which are in the Western Ghats

Source: Contributed by Dr.Ameen Ahmed**:** 1 - 13 *The Karnataka Forest Annual Report 1983-84;* 14 *Deccan Herald, Bangalore, 13 April 2000 ('CM to dedicate Kadra, Kodasalli projects to nation on April 15');* 15 *Detailed Project Report of Sharavathi tail race Project;* 16 *Deccan Herald, Bangalore, Spectrum, 29 June 2001;*17- 19 *Karnataka Forest Department Statistics, 1999*

7.13 Providing incremental costs to ongoing initiatives

To address the immediate and long-term problems of availability of plant based raw material used in Ayurveda, concrete ex situ measures need to planned and implemented. Such a measure would also effectively address the unsustainable harvest of medicinal plants from natural forests. It is well known that more than 80% of raw material is currently collected from the wild. While *in situ* conservation through a) reintroduction of certain species into their natural habitats, and b) strict restrictions on collections, can

ensure some level of protection, this effort needs to be augmented by *ex situ* conservation measures.

Based on the above premise, the Arya Vaidya Sala proposes to initiate the cultivation of medicinal plants in four districts of Kerala viz. Malapuram, Kozhikode, Palakkad and Thrissur. Forty farmers as identified by local NGOs and NABARD from each of the four districts will be trained in the identification, and cultivation of medicinal plants. Training on related aspects such as harvesting procedures, semi-processing, storage, marketing etc. The farmers will also be given a brief orientation to Ayurvedic formulations. The Vaidya Sala will provide the seedlings of select medicinal plants to the farmers. These would be from the nurseries of the Vaidya Sala in the four districts. Parallel demonstration sessions on land preparation, manuring, etc., will be conducted. The procedures for the sale of the plants will be worked out with the farmers on a mutual basis (see Section 8.1.2).

7.14 Inventorying of land races, wild relatives of crop plants and establishment of gene sanctuaries

The Western Ghats ecoregion has the highest diversity of wild relatives of crop plants. One hundred and forty five species have been enumerated from the ecoregion; 132 from the Northeast and 125 from the western Himalayas (K N Ganeshaiah, unpublished data). The Western Ghats have also been identified as a centre of diversity for rice and black pepper.

A recently published study of genetic resources and populations of some wild relatives of pulses in the Palni Hills by P Saravanakumar and S J Ignacimuthu (in Ganeshaiah *et al,* 2001b pp65-69) has identified twenty five putative progenators of present day pulses including *Cajanus albicans, C. rugosus, C. scarabaeoides, Canavalia gladiata, Centrosema pubescens, Dolichos trilobus, Dumasia villosa, Dunbaria ferruginea, Flemingia wightiana, Lablab purpureus, Mucuna atropurpurea, M. pruriens, Neonotonia wightii, paracalyx scriosa, Rhyncjosia cana, R. filipes, R. minima, R. rufescens, R. suaveolens, Teramnus mollis, Vigna bourneae, V. dalzelliana, V. grahamiana, V. radiata var. sublobata* and *V. weightii*. The wild pulses showed considerable variation in heights. Variation between different genotypes for plant height was highly significant. For each genotype significant difference was observed among populations of *Rhynchosia rufescens*. High genotypic coefficient of variation with high heritability percentage and high genetic advance were observed in *Lablab purpureus* and *Dunbaria ferruginea*. The

two latter species also showed high genotypic coefficient of variation coupled with high heritability percentage and gentic advance for seeds per plant. Saravanakumar and Ignacimuthu have suggested that due consideration be given to such plants while breeding programmes are undertaken.

In a study of wild relatives of crop plants in Uttara Kannada it was found that such species of plants come from a wide variety of habitats. These species show a whole gradation from belonging to the same species and differing little from cultivated forms, to differing a great deal from a cultivated species in the same genus. They include a whole range of growth forms: herbs (*Oryza* species), creepers (*Ipomoea pes-caprae*), climbers (*Dioscorea* species), lianas (*Acacia sinuata*), shrubs (*Carissa congesta*) and trees (*Artocarpus hirsutus*) as shown below (Gadgil *et al*, 1996a: Table 7.2).

Table 7.2 Wild relatives of crop plants in Uttara Kannada district

Crop species	**Wild relatives in Uttara Kannada**
Abelmoscus esculentus	*Abelmoschus angulosus*
Acacia siuata	*Acacia sinuata*
Amorphophallus campanulatus	*Amorphophallus paeoniifolius*
Artocarpus heterophyllus	*Artocarpus heterophyllus* *Artocarpus hirsutus*
Carissa congesta	*Carissa congesta*
Cinnamomum wightii	*Cinnamomum malabathrum*
Dioscorea alata	*Dioscorea oppositifolia, Dioscorea pentaphylla*
Emblica officinalis	*Emblica officinalis*
Garcinia indica	*Garcinia morella, Garcinia gummi-guttata*
Ipomoea batatas	*Ipomoea pes-caprae*
Mangifera indica	*Mangifera indica*
Murraya koenigii	*Murraya koenigii, Murraya paniculata*
Myristica fragrans	*Myristica dactyloides, Myristica malabarica* *Myristica fatua*
Oryza sativa	*Oryza nivara, Oryza rufipogon, Porteresia coarctata*
Piper nigrum	*Piper nigrum, Piper hookeri*
Sapindus laurifolius	*Sapindus laurifolius*
Sesamum orientale	*Sesamum orientale*
Solanum melongena	*Solanum anguivi*
Terminalia chebula	*Terminalia chebula*
Vigna mungo	*Vigna khandalensis*
Zinziber officinale	*Zingiber purpureum, Zingiber montanum*
Ziziphus jujuba	*Ziziphus oenoplia*

Source: Gadgil *et al*, 1996a.

The above study highlights the need to conserve a greater range of plant biodiversity and appropriate habitats when agrobiodiversity conservation is being contemplated.

Box 7.5 - *Ex situ* Conservation through field gene banks: how sustainable?

Sustainability of *ex situ* conservation efforts has been questioned not only on ecological grounds (inability to maintain evolution possible in natural populations) but also on economic grounds (excessive direct costs), as shown by this case from the Western Ghats which raises questions about its social viability.

While *ex situ* conservation seems to bypass the apparently unchecked habitat destruction in the Western Ghats, it appears unviable in laboratory conditions, due to intensive finance & sophisticated infrastructurerequirement. A progressive group of industrial nature lovers from Pune- Four Eyes Foundation- attempted a compromise by promoting semi-natural conditions i.e. field gene-banks but away from natural population- by tens or hundreds of kilometers, while maintaining similar, if not the same climatic conditions, notwithstanding different soil regime.

Elite environmentalists running the Foundation set out an ambitious target of cultivating at one place about 2000 flowering plant species naturally occurring in various localities of the Western Ghats of Maharashtra state. The cultivation garden was chosen to be an island named Susala (5 sq km) lying between the cities of Pune & Mumbai. The project aimed at collecting seeds/ propagation material of all the 2000 species to raise saplings so that tissue culture, etc., could mutiply the species in future, even if it goes extinct in its natural localities.

Susala island was formed decades ago when the Mulshi Dam, owned by the Tata Electric Companies, was built along the eastern foothills of the Western Ghats. The Tata group gladly hosted the concept of such a `Noah's Ark**'.** Out of 1200 acres, about 300 acres were taken up for plantation. Over 500 species of flowering plants were recorded from Susala, of which trees species constituted about a third- over 150. In addition, about 150 tree species alien to this island but naturally found elsewhere in western Maharashtra were raised in the island nursery.

Despite unparalleled taxonomic expertise of Dr. Vartak, younger colleagues found it very difficulty to locate, collect, preserve & transport propagules & also to raise saplings of most herbaceous species. The project scope was thus narrowed during 1994-5 to about 400 tree species recorded from western Maharashtra.

The villagers employed for the field work & nursery raising were later disappointed with the low wages, as against alternative employment options in nearby cities. Before the Foundation could locate substantial finances, villagers backed out of the project, bringing it nearly to halt. However, it is not too late for other institutions to use & develop the available Foundation further.

Source: Ankur Patwardhan, Fore-Eyes Foundation, Pune.

8.0 Strategy and Action Plan: summary of recommendations

The following strategy and action plan for conservation and sustainable use (including incentives and rewards) of biodiversity in the Western Ghats has been outlined after nearly one year's research/discussion/brainstorming efforts wherein the inputs of around 200 managers/scientists/activists/naturalists/citizens have been synthesised (see Annexures).

The Strategy and Action Plan has been drafted under two broad categories of biodiversity viz. 1) Natural terrestrial and aquatic ecosystems and wild biodiversity and 2) Agrobiodiversity: crops and domesticated animals. It is being suggested that the natural terrestrial and aquatic ecosystems and wild biodiversity be managed using two approaches; the system of Protected Areas (as has been during the past) and a system that includes particpation of multiple users (particularly focussing on a wide range of habitats/ecosystems outside PA).

8.1 Natural terrestrial and aquatic ecosystems and wild biodiversity:

Biodiversity conservation (and utilisation) strategies in the Western Ghats ecoregion should begin with the realisation that the Western Ghats are amongst the 25 biodiversity hot-spots globally recognised. Considering the high levels of ecosystem, vegetation and endemic organismic diversity, there can be *no compromise* whatsoever in the efforts directed on the conservation and sustainable use of this natural wealth. It is also to be recognised that this biodiversity wealth is not uniformly distributed over the ecoregion. In general, the most ancient, complex and unique forms of biodiversity that the ecoregion boasts are largely confined to the hills south of Goa, rendering the states of Karnataka, Tamilnadu and Kerala the three most important stake-holders in the Strategy and Action Plan that is being outlined. The Western Ghats comprise only 2% of the land area of Gujarat. Further, the state of Gujarat has during the year 2001 drafted a 'State Environmental Action Plan' - the first of its kind in India. The Strategy and Action Plan for the Western Ghats ecoregion therefore has not paid special attention to the state of Gujarat. Experts treat Goa and Maharashtra together as 'Sahyadri Range'. Throughout the

Strategy and Action Plan, it is proposed that this geographical/political differentiation be retained.

8.1.1 Protected Areas:

The less than 9% of the Western Ghats which are covered within the existing system of Protected Areas should continue as such. There is not only scope for increasing the area under this system of biodiversity conservation but also for enhancing the representativeness of the Western Ghats' ecosystems within the PA (Rodgers and Panwar, 1988).

The infrastructure and manpower available for the management of the PA in the Western Ghats are not quite uniform. Wheareas they may be on the better side for PA that have received additional grants from the Central Government (see Section 7.1), most Wildlife Sanctuaries and National Parks in the Western Ghats need additional infrastructure and manpower for effective management such that the conservation goals of each PA is met.

With a few exceptions, PA in the Western Ghats are the last safe abodes of most of our large and endangered animals such as elephant, tiger, leopard, gaur and other ungulates, wild dog, endemic primates, giant squirrels, hornbills, birds of prey, crocodile, pythons and large-sized freshwater fishes (popularly called widlife). Managing these animals outside PA system is a major challenge during the years to come. This implies the need for a greater availability of habitat, greater co-operation of people and more vigilance by the managers so that human animal conflicts are both minimised and fairly mitigated (see Section 7.8). If PA management has to be simultaneously sensitive to the wildlife and local people, locality-specific strategies have to be outlined over the years to come.

The Wildlife (Protection) Act 1972 (with the 1991 Amendment) and the Forest Conservation Act 1980 are adequate for wildlife and PA management. There is presently no need for an over-riding general policy or act as that of the National Biodiversity Bill to regulate the management of wildlife and PA.

Scientific research by personnel other than the Forest Department needs streamlining. All research undertaken within PA need to primarily feed into the management of the concerned PA. Research should also provide broader insights for overall PA and wildlife management. For research to complement PA management, research projects must be prepared in consultation with the Forest Department. Such a process could minimize the procedural constraints in obtaining research/trapping/collection permits which frequently

frustrate students and scientists by the undue delays. Further, researchers are to be encouraged not to concentrate on a few PA or species of wildlife, but reach out to the many other less researched PA and species of wildlife.

The National Wildlife Action Plan 1993 has provided for scientific management of PA and research and monitoring (see Section 6.3). While these are being given due consideration, the Forest Department should provide greater opportunities, wherever appropriate, to students and scientists from NGOs and academic institutions to carry out research within PA thereby ensuring better involvement/participation of researchers in the management, research and monitoring of PA and wildlife.

Wildlife research should address issues of genetic bottlenecks and population viability of endangered animals within the PA system. It is essential that conservation strategies are based on genetic-evolutionary principles (Khoshoo, 1997). Non-invasive methods of genetic study has not yet become popular. Extraction of genetic material from faecal matter should be popularised (Khoshoo, 1998).

8.1.2 Outside Protected Areas:

'No park is an island'. As areas of pristine forests are reduced in size they are increasingly susceptible to immigration of animals and plants from nearby anthropogenic secondary successional habitats (Janzen, 1983). No Protected Area in the Western Ghats would survive in the long run if the surrounding 'unprotected' areas are not managed soundly.

Protected Areas in India have historically been established on an *ad hoc* basis with little attention to the conservation value of an area (Ramesh *et al*, 1997). Ramesh *et al* (1997) have suggested that conservation strategies in the Western Ghats should revisit the rationale for establishment of Protected Areas. The potential of various areas as conservation areas needs to be carefully assessed. In the Agasthyamalai region, specifically, the Reserve Forests deserve much higher levels of protection that currently provided. This recommendation is based on a landscape approach that takes into consideration rates and extent of deforestation, the distribution of vegetation types, patchiness of the distribution, tree species richness, uniqueness of habitats and distribution of floral and faunal endemic species and/or their habitats. The Reserved Forests of Ponmudi Hills (100 sqkm) can serve as a link between Shendurni and Peppara-Neyyar Wildlife Sanctuaries. Upper Kodayar (50 sqkm) in Tamilnadu should serve as an extension to the southern border of Kalakad Wildlife Sanctuary.

The need for identifying alternate systems of *in situ* conservation - other than the existing system of Protected Areas, has to be given due consideration. As a first step, the proposal to declare parts of the Sahyadris as 'Sahyadri Ecologically Sensitive Area' should be considered. A detailed plan has been drawn up by the National Committee for Protection of Natural Resources (see Section 7.2). The Ministry of Environment and Forests may consider the immediate notification of the landscape including northern Karnataka, eastern Goa and southwestern Maharashtra, as SESA.

Models proposing to integrate people's livelihoods in the sustainable utilisation of biodiversity in the Western Ghats need to be given high priority. In this regard, the following proposal submitted by the Arya Vaidya Sala, Kottakkal could be considered for it is well in tune with the recommendations for eco-development of the Western Ghats by Prof Madhav Gadgil viz., 'encourage forest based industries to collaborate with the farmers and rural cooperatives to produce the industrial raw material on their own land' (Ecodevelopment of Western Ghats in Karnataka - Karnataka: State of the Environment Report, 1983-84).

The project that has been proposed recommends that medicinal plants be cultivated in selected districts of Kerala. It has been estimated that 80% of the raw material collected for ayurvedic drug manufacture are from natural forests. The proposed area of operation of the project will be in four districts of Kerala viz., Malappuram, Kozhikode, Palakkad and Thrissur. Forty farmers interested in the cultivation of medicinal plants will be identified in each district (160 in all) with the help of district panchayat, voluntray organisations and NABARD. Training will be organised for the benefit of these farmers in nursery practices, cultural operations, harvesting procedures, semi-processing, value-addition methods, storage and marketing of medicinal plants. It is proposed that four lakh seedlings of medicinal plants will be raised in the Vaidya Sala's gardens of Kottakkal, Kottapuram, Kanhirapuzha and Kanjicode (one lakh for use in each district). These nursery raised seedlings will be distributed to the trained farmers for planting in their fields. Appropriate marketing strategies will also be worked out in consultation with the farmers. The project is being proposed for a period of three years with a total cost of Rs 50,21,500 under the following heads: salaries Rs 22,72,500, cost of 2 vehicles Rs 8,50,000, fuel costs Rs 4,50,000, maintenance cost Rs 24,000, travel allowances for the staff Rs 3,00,000, consumables Rs 1,50,000, equipments Rs 5,00,000, nursery costs

4,00,000 and miscellaneous Rs 75,000. Further details may be obtained from the Managing Trustee and Chief Physician, Arya Vaidya Sala, Kottakkal, Kerala 676 503.

The seminar on 'Conservation and Ecological Management of the Western Ghats Through Land Use Planning' organised by the Palni Hills Conservation Council in 1988 (PHCC - Seminar, 1988) recommended that an ecodevelopment plan be drawn for the Western Ghats based on the concept of watershed management and should provide for

- The minimum needs of the hill people, such as protected drinking water, fuel and fodder, and village sanitation
- A process of ecorestoration, emphasing the rebuilding of the resource base of soil, water and vegetation cover while generating large-scale employment
- A realistic family planning programme and
- Ecologically appropriate development programme.

As a first step, 40-50 villages may be selected covering all the Western Ghats' districts. Such a process may ensure the participation of the village panchayats and the adoption of conservation planning tools such as the People's Biodiversity Registers.

The Seminar also recommended that social forestry and afforestation should focus on multi-species plantations and not monocultures, and should not be the exclusive concern of the Forest Departments. Departments of rural development, animal husbandry and horticulture should be involved in the process.

There should be an ecologically appropriate industrial policy for hill areas, authorising only those industries that are not only non-polluting and do not impose a non-sustaining burden on the natural resources of the area, but also lead to the general well-being of the local inhabitants providing employment opportunities (PHCC-Seminar, 1988).

Conservation of watersheds outside the PA system should lay emphasis on improving the indigenous fish resources on which the local humans subsist. Systems for monitoring fertiliser enrichment of aquatic habitats and pesticidal residues in water as well as animal tissues in watersheds need to be developed. Local people (schools and colleges) may be trained and involved in the monitoring process.

8.2 Agrobiodiversity

8.2.1 Domesticated Animals

Inventory of domesticated animal resources in the Western Ghats is a high priority. At present only farm bred animals are documented and catalogued. Inventories in respect of

animals in their breeding tracts and with farming communities do not exist. The periodic censuses of livestock have hitherto been carried out without proper identification of breed and their population. In the absence of precise information, it is difficult to ascertain the exact status of a breed that needs conservation. Population dynamics of various breeds over time is essential to develop and study the impact of strategies for improvement and conservation. Department of Animal Husbandry and Dairying, GOI is being advised to take up the generation of breedwise information in the census reports (Source: Undated report of the National Bureau of Animal genetic Resourced and National Institute of Animal Genetics "Conservation of Domesticated Animal Genetic Resources - Status Report" marked 'For Official Use Only').

8.2.2 Wild relatives of cultivated plants

Wild relatives of cultivated plants (WRCP) range over an entire spectrum of ecological habitats, natural, semi-natural as well as highly human-impacted. Conserving multiple populations of a multitude of such species calls for ecologically wise management of the entire landscape. It goes beyond the traditional approach of conservation of a few pockets of natural habitats through a system of Protected Areas.

A programme of conservation of WRCPs may either take a species centred or a region centred approach. Such an approach calls for establishment of conservation priorities at the habitat level. For any region, these may be arrived at through a series of steps:

- Inventory of WRCPs as congenerics of cultivated plant species on the basis of published literature (see Section 7.14).
- Mapping the distribution of habitat types in the region as types of landscape elements (LSE) with the help of satellite imagery along with field surveys. Based on the mapping, the main LSE and sample areas could be identified.
- Association of groups of WRCPs with different types of LSEs on the basis of field surveys. For this, a representative sample of the different types of LSEs and an all-out-search of WRCPs in each selected LSE should be undertaken in the field.
- Assessment of rates of transformations of LSE types with the help of satellite imagery of earlier years, offcial records and oral histories. Putting all this information together would provide a broad picture of the major forms of the on-going landscape and waterscape transformations, and the socio-economic processes underlying these transformations.
- Assessment of threats to different WRCPs as a result of ongoing landscape changes, and other causes such as unsustainable harvests and low levels of populations of WRCPs.
- Assignment of conservation priorities to WRCPs on the basis of likely threats to their populations, rarity, endemicity, economic use, and taxonomic distinctiveness. For

example, the WRCP endemic species with narrow habitat preference and more distinctive taxonomically are assigned the highest priority.

- Assignment of conservation priorities to different types of habitats or landscape elements on the basis of richness and conservation significance of the WRCP species they harbour.

The Protected Area systems of the region should then be assessed in terms of their coverage of habitats significant for conservation of WRCPs and appropriately strengthened.

It is equally important to wisely manage habitats valuable from the perspective of WRCP conservation outside the Protected Area systems by providing appropriate inputs to the process of development planning. Recent years have witnessed a promising initiative in the form of the programme of joint forest planning and management which is favourable to WRCP populations. A rigid guards and guns approach may turn out to be counter productive.

The conservation effort should include a continual monitoring of ongoing ecological changes and appropriate adjustment of the regime of management of habitats of WRCPs both within and outside the Protected Area systems.

It is essential to create institutions and systems of positive incentives to involve local communities as active partners in the efforts to conserve WRCPs both within and outside Protected Areas (Gadgil, et al 1996a).

9.0 Follow up

9.1 Coordination mechanism to oversee implementation of the action plan

As early as 1988, the recommendations of the seminar on 'Conservation and ecological management of the Western Ghats through land use planning' suggested that all the state governments within whose jurisdiction the Western Ghats lie, should be urged to set up statutorily constituted 'Western Ghats Conservation, Planning and Development Boards' with full administrative and financial responsibility as early as possible, preferably within 1988, invoking if need be, the power to issue ordinances on the subject (Palni Hills Conservation Council, 1988).

However, currently what exist, at the level of individual states are the Kerala Biodiversity Board and the Gujarat Ecological Commission; bodies that were constituted to coordinate biodiversity conservation initiatives in their respective states. These state level bodies are concerned with issues pertaining to the entire state and are not exclusive to the Western Ghats. It is therefore important, that a regional board viz., '**Western Ghats Conservation, Planning and Development Board**', which is a non-political body of members drawn from the various state level biodiversity boards/commissions, state departments of forests, tribal welfare, agriculture, animal husbandry and fisheries, institutions such as the Bombay Natural History Society, Salim Ali Centre for Ornithology and Natural History, Kerala Forest Research Institute, Tropical Botanical Garden and Research Institute, Centre for Ecological Sciences (Indian Institute of Science), and NGOs working in the Western Ghats.

The Board may ideally adopt the following structure and functions:

- The Board is to be constituted with members derived through formal invitations or nominations
- The members may resolve to elect a set of office bearers such as Chairman/President and Secretary for effective functioning. The tenure of the office members will be rotational and decided by mutual consent
- The Board should be vested with the authority to examine and approve/modify/reject any proposal or activity including 'Impact Assessements', undertaken by any sector

viz. private, governmental or others, which has a bearing on biodiversity conservation, planning and development in the Western Ghats.

- For this purpose, the Board should ideally adopt an open and participatory process, drawing upon the wisdom and expertise of not only the members, but also other individuals and institutions of repute and expertise.
- It is recommended that this Board will coordinate and also oversee the effective implementation of the Strategy and Action Plan for the Western Ghats.

9.2 Monitoring mechanism, including periodic evaluation and review

The Western Ghats Conservation, Planning and Development Board will assume overall responsibility for monitoring the implementation of the strategy and action plan for the Western Ghats, within the framework of the national process that was adopted in the formulation of the National Biodiversity Strategy and Action Plan. For this purpose, and in view of the large mandate and spread of the ecoregion, and also to be effective, the Board may invite individuals and institutions of proven expertise, integrity and commitment to undertake the evaluation at local, state and regional scales.

Subject to the availability of resources and manpower, these assessments could be undertaken annually or once in three years. The assesments will be compiled as reports and reviewed by the Board for action. These reports, as appropriate, should be transparent and accessible to researchers, administrators and development workers.

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