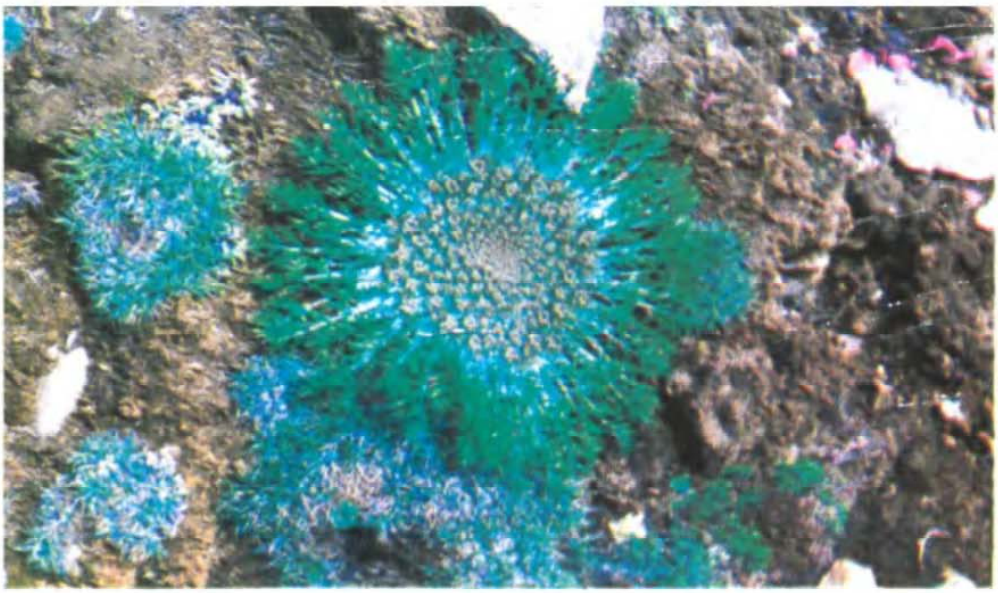
PLANT DIVERSITY HOTSPOTS IN INDIA

AN OVERVIEW



BOTANICAL SURVEY OF INDIA

MINISTRY OF ENVIRONMENT & FORESTS

Tropical forest : Lower storey in open places along the streams.
(Courtesy : H.J. Chowdhery)

Cortiella hookeri (C.B. Clarke) Norman-North
Sikkim, Sebula, alt. 5000 m.
(Courtesy : G.P. Sinha)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PLANT DIVERSITY HOTSPOTS IN INDIA - AN OVERVIEW

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Editors
P.K. Hajra
V. Mudgal

भारतीय वनस्पति सर्वेक्षण
BOTANICAL SURVEY OF INDIA

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MINISTRY OF ENVIRONMENT & FORESTS

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Foreword

Many small and large books have appeared on biodiversity in India in the last one decade.

This book deals with `Hotspots' of one major component of biodiversity, the plant resources in selected and critical areas in India. The work is authored by scientists who are researchers by profession and are well trained taxonomists of Botanical Survey of India, which is the main official agency of the Government for study of plant resources of the country.

Howsoever, one may wish to conserve the bioresource of a region, but needs of growing population and development limit the prospects. Prioritisation and selection of `Hotspots' is, therefore, necessary.

The data is based on life-time work and experience of the authors, and the contents can, therefore, be taken to be quite authentic and exhaustive.

The book covers various groups of the plant kingdom. At some places useful references are made to diversity in major animal groups also. The information in various chapters often covers economic aspects, ethnobotany, rare, endangered or endemic species, and biotic factors. The data in the book should provide ample material for utilisation and conservation of these bioresources, and also for further critical research, such as taxonomy, phytogeography, endemism, genetics, breeding, tissue culture, forestry, control of fungal or other diseases, etc.

This work will also help in the assessment of major gaps in our knowledge on any group of the plant kingdom in these critical geographic regions of the country.

The book will be a useful reference work and should be welcomed by researchers particularly in agriculture, forestry and botany.

The book is so profusely illustrated that it can be a collectors item even for photographers.

January 25, 1997 **S.K. Jain**

Preface

The convention on biological diversity has given momentum in realising the importance of biological resources as base materials for any country's economic growth and development. Speedy surveys and early inventorisation of these objects present an advantage in managing these resources. India with its varied geographical regions, changing topography, distinct seasons and an array of environmental situations supports diverse flora and fauna. Ths diversity is further compounded by the joining of three major biogeographic realms namely Indo-Malayan (the richest in the world), the Indo-Arctic (Eurasian) and the Afro-tropical. Appropriately, India is recognised as one of the 12 megadiversity centres of the world. Out of all the biogeographic regions, the Eastern Himalaya and the Western Ghats are comparatively botanically richer and not surprisingly, these are two of the 18 'Hotspot' areas recognised in the world. Hotspots generally refer to the areas rich in general diversity, high degree of endemism and higher incidence of rare and endangered species of the flora and fauna.

Survey and inventorisation are essentially the tasks of the Botanical Survey of India. It is undoubtedly a difficult task to explore the diversified plant wealth of such a vast country as India, but on the same hand, the significance of the inventorization and conservation of diversity cannot be overlooked for a longer time. In such a situation priorities are to be decided with regard to areas for exploration and inventorisation. The natural option under such circumstances is to work on botanically rich areas as this inventorisation follows evolving scientific methods of management for their conservation, thus safeguarding areas of rich diversity on priority basis.

The present publication is an earnest attempt to analyse the flora of five areas known for thier vast plant diversity. These areas are taken incidentaly from the two Hotspots the Eastern Himalaya (Sikkim, Namdapha and Dibang valley) and the Western Ghats (Agastyamalai and

Nilgiris). It is worth noting that the Nilgiris is the declared biosphere reserve while others represent identified sanctuaries or national parks partially or in total. The material presented focusses on general diversity levels, diversity in specific groups, percentage of endemism in the flora and threatened species. Specific ecological issues that are further related to sustainability of species and ecosystems in these areas, are also discusssed. The editors strongly feel the need of this publication as the information provided therein will serve as a baseline data in scheming methods for management and conservation of these biologically rich areas.

P.K. Hajra
V. Mudgal

Acknowledgements

The preparation of this publication is made possible by the prompt cooperation and involvement of the scientists of the Botanical Survey of India who had been actively engaged in exploration and survey in different hotspot areas of the country.

The editors thank Drs. V. J. Nair and D. K. Singh for processing this material in the computer centres at Southern circle and Northern circle of the Botanical Survey of India respectively. They also acknowledge the assistance rendered by Dr. Venu, Dr. J.R. Sharma and Shri M.K. Pathak, Dr. S. Kumar and Shri B.P. Uniyal in various ways in the final stages of compilation. The assistance from Shri Sanjay Uniyal and Srimati Geetalakshmi, data entry operators of the Botanical Survey of India is also acknowledged.

Thanks are also due to Shri I.J. Gupta, Zoological Survey of India for many constructive suggestions. The editors are also thankful to Shri Utpal Chatterjee, R.G. Bakkta, S.K. Sur, S. Roy and H.M. Mukherjee of publication section and staff and Research scholars of Pharmacognosy unit for their untiring help.

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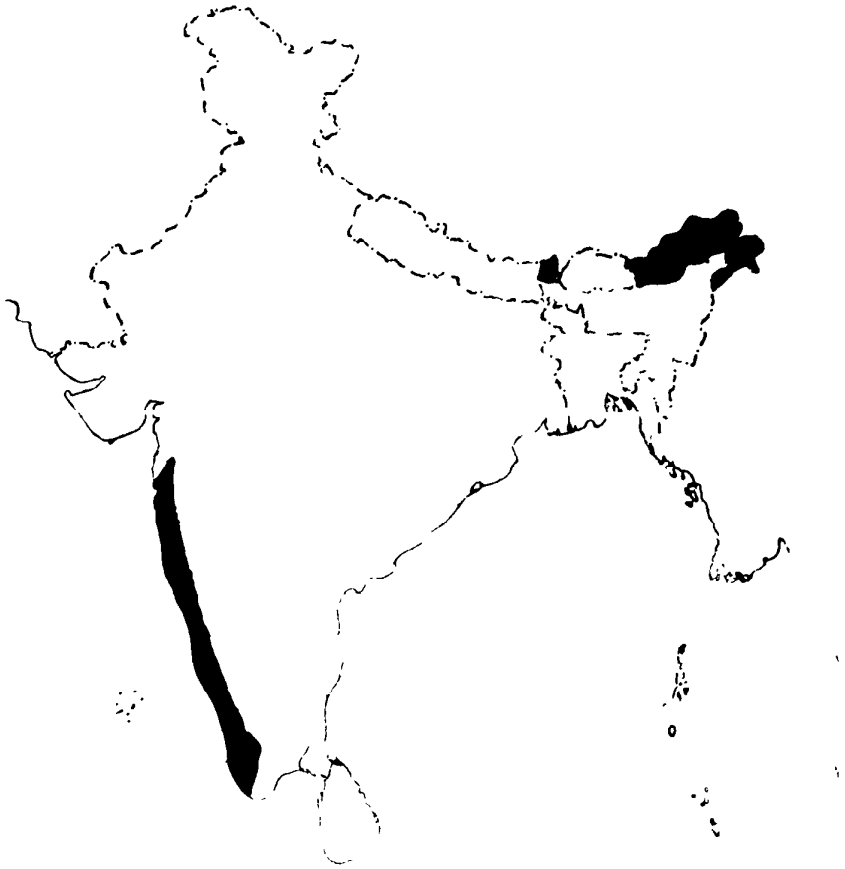

1
INTRODUCTION

Introduction

India with a geographical area of 329 million hectares exhibits a wide array of environmental conditions by virtue of its tropical location, varied physical features and climatic types. The widest variety of biomes exhibited by the country is owing to the confluence of three different biogeographic realms and a variety of environmental conditions. Considering the vastness of the country and variation pattern in different areas, the country is divided into ten botanical regions with distinct bioclimatic conditions. These include 1. Coromandel coast 2. Malabar 3. Indus plain(Indian desert) 4. Gangetic plain 5. Assam 6. Eastern Himalaya 7. Central Himalaya 8. Western Himalaya 9. Andaman and Nicobar Islands 10. Laccadive and Minicoy group of islands.

The flora of India is made up of well over ca 17000 species of flowering plants under ca 320 families. The ten dominant families in Indian flora include Orchidaceae, Fabaceae, Poaceae, Rubiaceae, Euphorbiaceae, Acanthaceae, Asteraceae, Cyperaceae, Lamiaceae and Urticaceae. Besides 17000 flowering plants, the floral diversity includes 64 Gymnosperms, 1200 Pterodophytes, 2850 Bryophytes, 13000 Fungi and 12500 Algae. Similarly, the faunal species comprise 372 mammals, 1228 birds, 428 reptiles, 204 amphibians, 2546 fishes, 5000 molluscs and about 57000 insects. At an aggregate level, India has about 48000 floral and 80000 faunal species.

Although India is connected by land with a number of other countries, it has a large proportion of endemic flora. In fact India harbours more endemic species of plants than any other region of the world except Australia. About 33% of flowering plants are endemic to this country. The reason for the presence of such a high percentage of endemic plants in India is the presence of lofty Himalayan mountain ranges on the north-east and north-west of the mainland and sea on three sides in the peninsular region. Further, the natural attributes coupled with diversity of cultures and lifestyles of the different population groups account for an equally rich

array of crop plants and domestic animals evolved through several centuries of selection and breeding, thus making both our natural and domesticated sectors rich and diverse. The country is also one of the 12 identified centres of origin of cultivated plants. The germplasm resources of India constitute 166 species of agri-horticultural crop plants and about 320 species of their wild relatives. Similarly, India has 27 breeds of cattle, 8 of camel, 6 of horses, 2 of donkeys, 40 of sheep, 22 of goats, 18 buffaloes and 18 types of poultry breed in addition to a variety of Yak, Mithun, Ducks and Geese.

Among different biogeographical zones, the Eastern Himalaya and the Western ghats are botanically rich areas of world significance. The humid tropical conditions met within these regions not only support an exceptionally rich vegetation, both in luxuriance and species diversity, but have also resulted in speciation in several genera, thus adding to the high endemicity of the flora (Nayar 1996).

Eastern Himalaya covering the states of Arunachal Pradesh, Sikkim and Darjeeling district of West Bengal is the richest of the phytogeographic regions of India affording the highest plant/animal diversity (Rao, 1993). The high rainfall, moist and cold climate coupled with factors like altitude, latitude and longitude have added to the multiplicity of habitats and thus provide varied microclimates and ecological niches both for plants and animals. The region supports different vegetational types from the cultivated plants to grasslands and meadows, marshes, swamps, scrub forests, temperate and alpine forests. About 8,000 species of flowering plants, out of which *ca* 3,500 are endemic, find representation in this region. Besides affording a high degree of diversity in orchids, rhododendrons, hedychiums, oaks and bamboos, the region also abounds in large number of plants of medicinal and ethnobotanical values. It is estimated that out of a total of 800 edible plants in India, more than 300 are found in this region. The region is also recognised as a centre of origin of several cultivated plants like Musa, Citrus, jackfruits and many others. The Eastern Himalaya, together with the north-eastern region, have about 200 wild relatives of cultivated plant species. Tables 1 indicates the general richness of some dominant families in north-eastern region in comparison to India and the rest of the

world while Table 2 shows the richness of wild relatives of crop plants in different phytogeographic zones of India.

Table 1. Approximate number of Genera and Species in some Dominant Families of Higher Plants. (R.R. Rao, 1993)

Name of family	North-eastern region	India	World
1. Poaceae	160/500	240/1100	620/10000
2. Orchidaceae	104/700	200/1500	735/20000
3. Fabaceae	50/200	100/750	482/12000
4. Caesalpiniaceae	11/42	23/80	152/2800
5. Mimosaceae	10/35	15/75	56/2800
6. Asteraceae	25/70	135/710	900/1300
7. Cyperaceae	14/175	21/350	90/4000
8. Lamiaceae	30/95	65/380	180/3500
9. Scrophulariaceae	15/35	60/350	220/3000
10. Acanthaceae	25/125	70/340	250/2500
11. Euphorbiaceae	55/160	65/340	300/5000
12. Rubiaceae	50/170	80/280	500/6000
13. Urticaceae	15/45	25/114	45/550
14. Zingiberaceae	18/73	20/115	46/850

Table 2. Wild Relative of Crop Plants in different Phytogeographical Zones of India

Phytogeographical Zone	Species of wild relatives of crop plants
1. Eastern Himalaya (including NE region)	190
2. Western Himalaya	113
3. North-Western plains	49
4. Gangetic plains	73
5. Deccan	96
6. Malabar	142

The Western Ghats is a narrow stretch running approximately for about 1500 km along the west coast of India, projecting a considerable gradient of climatic conditions. Also known as the Malabar province, it is one of the major tropical evergreen forested regions in India and exhibits enormous plant/animal diversity. Further, the climatic and altitudinal gradient has resulted in a variety of forest types ranging from evergreen to semievergreen, from moist deciduous to dry deciduous formations with sometimes stunted montane communities developing in higher hills. As many as 4000 species of flowering plants, of which more than 1600 are endemic, have already been recorded from this region. The narrow and closed valleys are also responsible for this high level of endemism. The region besides affording a high degree of diversity in valuable timber species of families like Clusiaceae, Dipterocarpaceae, Fabaceae, Bombacaceae and Lauraceae, the area is a major centre of diversity for bamboos, legumes and a variety of medicinal plants, spices and condiments. The Western Ghats is also a rich germplasm centre for a number of wild relatives of cultivated plants, having about 145 species of cereals, millets, pulses, vegetables, fruits, etc.

The rich biological diversity in these regions, however, is threatened largely due to various anthropogenic activities. In view of the richness of the biological and habitat diversity, high endemism and comparatively higher incidence of rare and threatened taxa in these two biogeographical areas, the International Union for the Conservation of Nature and Natural Resources (IUCN) has recognised these two regions as "Hotspots" amongst the 18 identified the world over.

Efforts are needed to conserve and maintain gene, species and ecosystems for the sustainable use and management of the biological resources. While the National Conservation Strategy, the National Forest Policy and the National Wildlife Action Plan lay down the policy framework and priorities in the area of biological diversity conservation, *in situ* protection of ecosystems and *ex situ* conservation of biological and genetic resources can help in using biological resources sustainably. A detailed floristic analysis of these 'Hotspot' areas will help in drawing practically feasible action oriented programmes keeping in view the potential benefits that the selected species/populations/ecosystems could provide to mankind in general and to the inhabitants of the area in particular.

In the present publication an attempt has been made to highlight the diverse floral resources, distribution of vegetation types and the enormous floristic diversity in the few selected primary target areas like Agastyamalai hills, Nilgiri Biosphere Reserve including Silent valley and Amarabalan reserve in the Western Ghats and Namdapha, Dibang valley and Sikkim in the Eastern Himalaya.

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2
AGASTYAMALAI HILLS

Plant Diversity in Agastyamalai Hills, Southern Western Ghats

R. GOPALAN

Agastyamalai, a towering range with a peak of 1868 m height is situated at the southern end of the Western Ghats. The area lying between 77°5' and 77°40' E longitude and 8°50' N latitude, falls within the hilly tracts of the Tirunelveli-Kattabomman and Kanniyakumari districts of Tamil Nadu, and Thiruvananthpuram district of Kerala. It has a forest cover of about 2,000 sq. km. with altitudes ranging from 67 to 1868 m. It harbours *ca* 2000 species of flowering plants which include 100 endemic and 50 rare and endangered species (Henry *et al.*, 1984). The inhospitable terrain of this region is still left with some of the pristine ecosystems and having evolved in the course of millions of years, still remains largely undisturbed. The floristic diversity and complexity make it a rich gene-pool region.

The area represents diverse ecosystems with almost all types of vegetation known to occur such as the southern tropical thorn forests, southern tropical moist deciduous forests, tropical semi-evergreen forests (this type corresponds to "Tirunelveli semi-evergreen forests" Champion & Seth, 1968), southern tropical wet evergreen (rain) forests, subtropical montane forests and grassy swards at high altitudes. A detailed account of the vegetation was provided by Henry and Subramanyam (1981), Henry *et al.*(1984) and, Mohanan and Henry (1994). As the tropical rain forests are a precious natural resource, these are confined to the developing countries and vanishing fast mostly due to over-exploitation. The Agastyamalai needs to be regarded as a prime example of this ecosystem in southern India requiring urgent conservational measures.

PLANT DIVERSITY

Agastyamalai and its environs are rich in floristic diversity so much so these represent the biota of the Western Ghats, particularly the

southern part. Its geographcal position is so unique that it has a profound effect which has been rightly considered as "an epitome of the whole Madras State" (Mudaliar & Sundararaj, 1954). Out of about 5,000 vascular plant species reported to occur in peninsular India, this region harbours about 2,000 species (Henry *et al.*, 1984; Nair & Daniel, 1986). The area being located at the southern end of peninsular India, the Indian Ocean, the Arabian sea and the Bay of Bengal act as barriers in south against migration of species from other countries. The natural barriers, varied altitudes, habitat, climate and rainfall resulted in the development of a rich and diverse flora. About 100 endemics occur which include tree species such as *Aglaia elaegnoidea* (Juss.) Benth. var. *bourdillonii* (Gamble) K.K.N. Nair, *Bentinckia condapanna* Berry ex Roxb., *Diospyros barberi* Ramas., *Elaeocarpus venustus* Bedd., *Eugenia floccosa* Bedd., *Nageia wallichiana* (Presl.) Kuntze, *Phyllanthus singampattiana* (Sebastine & A.N. Henry) Kumari & Chandrabose, *Pinanga dicksonii* (Roxb.) Blume, *Symplocos barberi* Gamble, *S. oligandra* Beddome and *Syzygium microphyllum* Gamble. Among the large number of endemic herbs, shrubs and climbers important are *Crotalaria scabra* Gamble, *Desmodium dolabriforme* Benth., *Exacum travancoricum* Bedd., *Grewia pandaica* Drumm., *Hedyotis villosostipulata* (Gamble) R. Rao & Hemadri, *Hetaeria ovalifolia* (Wight) Benth. *ex* Hook., *Malleola gracile* (Lindl.) Schltr., *Ochlandra wightii* C. Fischer, *Impatiens travancorica* Bedd., *Murdannia glauca* (Thw. ex C.B. Clarke) Bruckner, *Sonerila clarkei* Cogn., *Tainia bicornis* Benth., *Vernonia gossypina* Gamble and *Zenkeria sebastinei* A.N. Henry & Chandrabose.

Species such as *Hedyotis travancorica* Bedd., *H. barberi* (Gamble) A.N. Henry & Subram., *H. villosostipulata* (Gamble) R. Rao & Hemadri, *Euphorbia santapaui* A.N. Henry, *Knoxia linearis* Gamble, *Paphiopedilum druryi* (Bedd.) Stein, *Popowia beddomeana* Hook.f. & Thoms., *Piper barberi* Gamble and *Thottea barberi* (Gamble) Ding Hou are considered under rare and endangered.

As the area is floristically rich with genetically diverse populations, more than 30 new taxa have been discovered from here in recent years. These include *Amorphophallus smithsonianus* Sivadasan, *Bulbop-*

hyllum agastyamalayanum Gopalan & A.N. Henry, *Dendrobium diodon* Reichb.f. subsp. *kodayarensis* Gopalan & A.N. Henry, *D. panduratum* Lindl. subsp. *villosum* Gopalan & A.N. Henry, *Euphorbia santapaui* A.N. Henry, *Homalium jainii* A.N. Henry & Swamin., *Indotristicha tirunelveliana* B. Sharma *et al.*, *Ixora agastyamalayana* Sivad. & N. Mohanan, *Marsdenia tirunelvelica* A.N. Henry & Subram., *Memecylon subramanii* A.N. Henry, *Oberonia agastyamalayana* Sathish Kumar, *Peucedanum josephianum* Wadhwa & H. Chowdhery, *Phyllanthus singampattiana* (Sebastine & A.N. Henry) Kumari & Chandrabose, *Pothos crassipedunculata* Sivadasan *et al.*, *Premna balakrishnanii* Rajendran & P. Daniel, *P. mundanthuraiensis* Rajendran & P. Daniel, *Rhynchosia jacobii* Chandrabose & Shetty, *Sonerila kanniyakumariana* Gopalan & A.N. Henry, *Syzygium parameswaranii* M. Mohanan & A.N. Henry, *Tylophora subramanii* A.N. Henry, *Vernonia peninsularis* C.B. Clarke ex Hook.*f.* var. *kodayarensis* Henry & Gopalan. *Aenhenrya agastyamalayana* Gopalan and *Janakia arayalpathra* J. Joseph & V. Chandras. are the two new genera discovered here. Agastyamalai hills are, therefore, very important not only for the conservation of "the finest remaining example of tropical wet evergreen forests (rain forests) on the Western Ghats" (Henry *et al.*, 1984), but also for their varied and unique flora of biogeographical interest. Undoubtedly, the floristic diversity of this region is of an ancient lineage (Subramanyam & Nayar, 1974; Nair & Daniel, 1986; Nair, 1991). Out of the 179 families dealt with for the then Madras state as many as 157 families are represented. The details of the genera and species represented are given in Table 1. The predominant families with the largest number of species are arranged in Table 2.

The striking peculiarity of this area lies in the preponderance of several Sri Lankan species such as *Abarema subcoriacea* (Thw.) Kosterm., *Biophytum nudum* (Arn.) Wight, *Chrysoglossum maculatum* (Thw.) Airy-Shaw, *Pavetta zeylanica* (Hook.f.) Gamble and *Rubus micropetalus* Gardn. Besides, *Andrographis zeylanica* Nees, *Antidesma walkeri* (Tul.) Pax and Hoffm., *Eugenia mabaeoides* Wight and *Neanotis nummularia* (Arn.) Lewis, which were so far considered endemic to Sri Lanka, have also been collected in these forests.

Table 1 : Comparative Account of Genera and Species.

	Madras District	Tirunelveli
Total number of species	4516	2105
Total number of genera	1305	872
Percentage of species represented		47.9
Percentage of genera represented		69.4

Table 2 : Analysis of Predominent Families

	Number of species in Fl. Pres. Madras	Number of species in Tirunelveli Dist.
Leguminosae	433	201
Gramineae	386	145
Rubiaceae	214	128
Euphorbiaceae	194	115
Acanthaceae	200	87
Compositae	186	82
Cyperaceae	171	50
Orchidaceae	194	47

(Mudaliar & Sundararaj, 1954)

Agastyamalai abounds in some economically and medicinally important plants. The area is associated with the ancient sage, Agastya who is said to have lived here on leaves, tubers, fruits and sap of local

wild plants. The region is known for its rare plants that are still widely used in ayurvedic medicines. These include species of *Aristolochia, Cardiospermum, Ceropegia, Dioscorea, Ficus, Gloriosa, Gymnema, Janakia, Knema, Leucas, Naregamia, Rauvolfia, Smilax, Solanum, Stephania, Strychnos, Trichopus, Tylophora*, etc. The more important non-conventional timber species include *Canarium strictum* Roxb., *Cullenia exarillata* Robyns, *Elaeocarpus* spp., *Gluta travancorica* Bedd., *Hydnocarpus* spp., *Litsea* spp., *Mesua nagassarium* (Burm.f.) Kosterm., *Myristica* spp., etc. A number of edible fruit-yielding species occurring are : *Antidesma* spp., *Baccaurea courtallensis* Muell.-Arg., *Calamus rotang* L., *Canthium travancoricum* (Beddome) Hook.f., *Carissa carandas* L., *Emblica officinalis* Gaertn., *Ficus* spp., *Mangifera indica* L., *Solanum* spp. and *Syzygium* spp.

The occurrence of a large number of wild relatives of cultivated plants such as species of *Amomum, Amorphophallus, Atylosia, Canavalia, Cinnamomum, Coffea, Dioscorea, Elettaria, Garcinia, Mangifera, Musa, Myristica, Oryza, Piper* and *Rauvolfia* indicates this area to be a genetic reservoir of wild species.

ECONOMIC ASSESSMENT

The current value of resources and services which the area provides to the national economy on a sustainable basis are yet to be fully assessed. Besides valuable timber trees, revenue is being collected from the sale of minor forest produce like *Acacia concinna* DC., *Alpinia galanga* (L.) Sw., *Anamirta cocculus* Wight & Arn., *Aphanamixis polystachya* (Wall.) Parker, *Bambusa arundinacea* (Retz.) Willd., *Dendrocalamus strictus* (Roxb.) Nees, *Dioscorea* spp., *Diospyros* spp., *Garcinia* spp., *Ochlandra travancorica* (Bedd.) Benth. ex Gamble *Calamus rotang* L., etc. In these forests some of the trees which yield resins and gums are Kanis, the hill tribe inhabiting these forests, mainly collect honey, cinnamomum bark, resin of white dammer, black dammer, bark for red dye from *Morinda tinctoria* Roxb. and fruits of *Garcinia* spp. On the hill slopes commercial cash crops such as coffee, tea, rubber, pepper and cardamom are grown on a large scale.

HUMAN ACTIVITIES AND THEIR IMPACT

The various factors affecting the loss of biodiversity of the area are yet to be fully studied. Several settlements in the existing hydel and irrigation projects (Upper Thambraparani, Servalar, Papanasam Lower, Manimuthar, Kodayar and Neyyar) have caused much ecological disturbance. These hydel/irrigation projects have been instrumental in bringing about changes in the forest types, particularly in the Mundanthurai plateau, from moist deciduous to dry-deciduous indicating a shift in soil hydrology. The tropical wet evergreen forests interspersed by grassy swards at Muthukuzhivayal which was once a botanists' paradise has since been cleared for the construction of the Kodayar Hydroelectric Project.

The Singampatti Reserve Forest has been considerably disturbed due to cultivation of tea and other plantation crops. The increase in the number of pilgrims to the "Pothigaimudi" or "Agastyakudam" the highest peak in the range, has brought about in its wake undesirable developments such as widening of the foot/bridle paths. Accidental as well as intentional fire to the seasonal dry forests by the visitors has had disastrous effects on the habitats of rare and endangered plant species.

The area is well protected by natural barriers both by land and sea. The core region is remotely located and completely free from human activities. The western slope in Kerala has an area of 180 sq km with two wildlife sanctuaries, *viz.*, Neyyar Wildlife Sanctuary (128 sq. km) and Peppara Wildlife Sanctuary (53 sq. km). The animal populations also constitute a complexity of fauna in this region. Among the number of rare and threatened plants and amimals tiger is the apex of the complex biotype. The threatened animal species include Tiger, Lion-tailed macaque, Great pied hornbill, Malabar pied hornbill other more prominent animal species found here are Bison, Black-faced langur, Bonnet macaque, Chamaleon, Chital, Cobra, Crocodile, Elephant, Indian Giat squirrel, Indian monitor lizard, Indian rock python, Indian porcupine, Jackal, King cobra, Leopard, Russells viper, Saw-scaled

viper, Slender lorris, Sloth bear, Wipe snake, Wild boar, Wild dog, and wood pecker. Hunters and poachers who kill the animals for their skins, horns, etc. are the threat to the fauna. However, a number of human activities go on unhindered in the buffer zone. The sanctuaries also attract tourists not only to witness the wildlife but also to experience life in wilderness. The tourists are also enchanted by the scenic beauty provided by several cascades and other water courses, *viz.*, Banathirtham, Agastyar falls and Tiger falls. The 'Pothigaimudi' or 'Agastyakudam' is not only a place of pilgrimage to the numerous devotees of Agastya Maharishi but also offers a spectacular scenery to scale the summit trail. Caused by a large number of tourists/piligrims are required to be assessed properly. About 1000 forest coverage is protected by the existing sanctuaries and tiger reserve.

There are settlements of 'Kanis' of 'Kanikar' the local tribes, on the hills. They live partly on leaves, tubers and fruits of wild plants and wild herbivores. In recent years some of them are employed in hydroeletric projects, private estates and the Forest Department.

Several river valley projects of this area provide economic benefits to the local people. These also offer enormous opportunity for various impact studies in environmental as well as restorative research designed to study ways of rehabilitating degraded ecosystems. The social and environmental values as well as the current value of resources and services, the area provides to the local people/national economy on sustainable basis are yet to be fully assessed.

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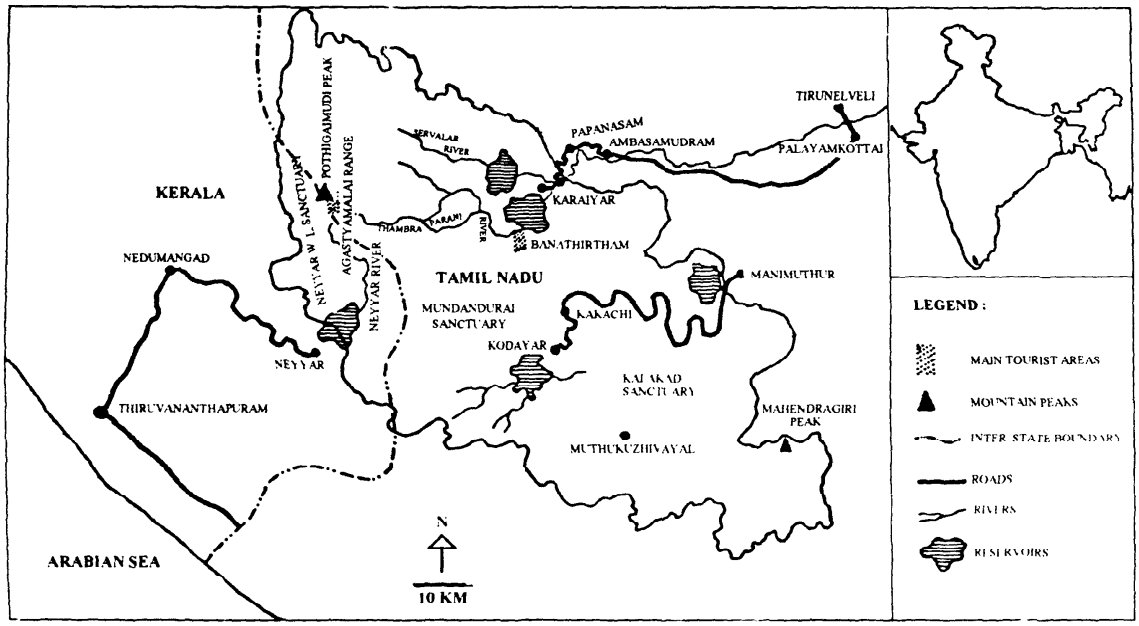
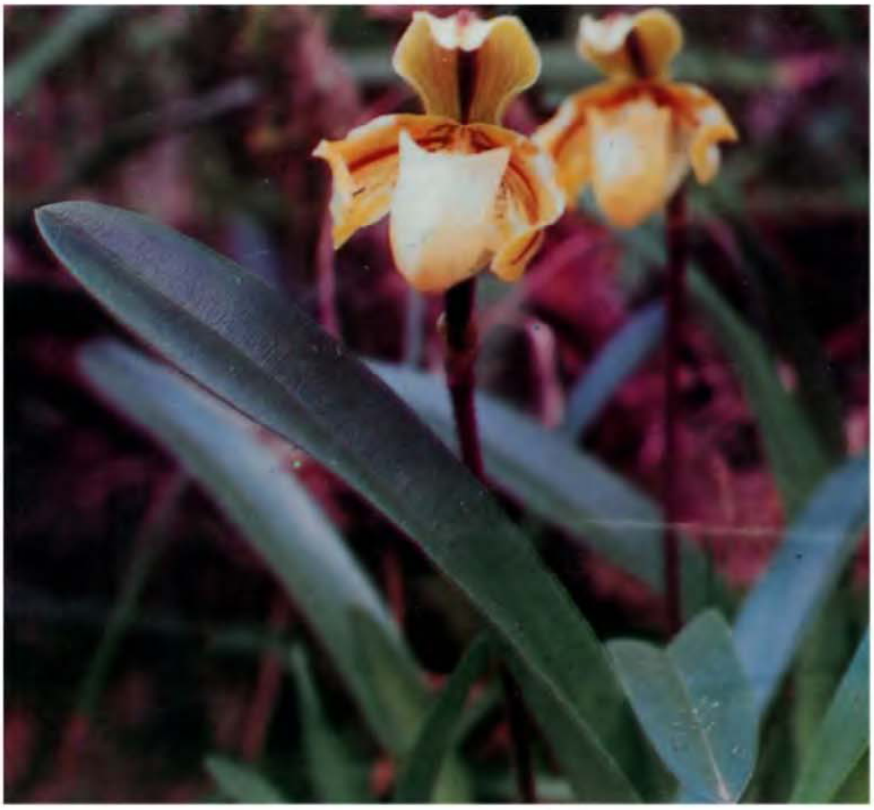


AGASTYAMALAI HILLS, SOUTHERN WESTERN GHATS; INSET SHOWING LOCATION OF AGASTYAMALAI HILLS IN INDIA

A view of Ainthuthalaipothigai from Agastyarpeedam showing sholas and grassland.
(Courtesy : Southern Circle, Botanical Survey of India)

Canopy of an evergreen forest - Agastyamalai.
(Courtesy : Southern Circle, Botanical Survey of India)

Musa acuminata Colla - a rare wild banana.
(Courtesy : Southern Circle, Botanical Survey of India)



Paphiopedilum druryi (Bedd.) Pfitz. - the only lady's slipper orchid of the Western Ghats.
(Courtesy : R. Gopalan)

The rare and endemic *Piper barberi* Gamble.
(Courtesy : Southern Circle, Botanical Survey of India)

3
NILGIRI BIOSPHERE RESERVE

Plant Diversity in Nilgiri Biosphere Reserve

K. VIVEKANANTHAN
P. DANIEL
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India lies at the junction of the 3 major biogeographic realms, namely, the Indo-Malayan, the Eurasian and the Afro-tropical. As a result, it has a rich biological heritage that qualifies it as one of the 12 megadiversity nations in the world. Three richest areas, *viz.*, the north-eastern Himalaya, the Western Ghats and the Andaman and Nicobar islands, have been marked for the overall national strategy of protecting the representative primary benchmark ecosystems and safeguarding the genetic diversity. The Western and Eastern Ghats are the two potential areas in Peninsular India for biodiversity conservation. The Western Ghats to a large extent preside over the biogeography, ecology and biodiversity of Peninsular India as the Himalaya in the north. Their geographical history adds new dimensions to their richness. They form the backbone of the economy of the states of Gujarat, Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu and support a population of over 35 million people. Blanford (1901), and Udvardy (1975) classified this zone as the most significant biogeographical zone in Peninsular India. On the basus of Flora Phytogeographers like Hooker and Thomson (1855), Clarke (1898), Hooker (1904), Chatterjee (1939, 1962), Razi (1955), and Puri (1960) considered "Malabar" as the richest wet tropical forests harbouring a large number of species and ecosystems. In the strategy for the preservation of the biological diversity of the Western Ghats, the Nilgiris and Agastyamalai would form the backbone.

As the Western Ghats or the Malabar rainforests are one of the richest biogeographic provinces of the Indian subcontinent, the Nilgiri tract was the first choice for the constitution of a biosphere reserve in India. It embraces the sanctuary complex of Wynad, Nagarhole, Bandipur and Mudumalai, the entire forested hill slopes of Nilambur

and Nilgiris, the upper Nilgiri Plateau, the Silent Valley and the Siruvani hills. The total area of the biosphere reserve is around 5670 sq km of which 2020 sq km is the core zone, 2290 sq km the manipulation zone (forestry) and it has around 1330 sq km as manipulation zone (agriculture) and 30 km^2 as restoration zone. It includes substantial unspoilt areas of natural vegetation types with several dry scrub, dry and moist deciduous, semievergreen and wet evergreen forests, evergreen sholas, grassy downs and swamps. The Attapadi Plateau, Moyar Valley and parts of Wynad would provide the entire diversity of cultivated plants covering the spectrum from millets of very dry tracts to rice and plantation crops of very humid tracts. The region includes the largest known population of two endangered animal species, namely, the Nilgiri tahr and the lion-tailed macaque, and probably the largest south Indian population of elephant, tiger, gaur, sambar and chital as well as many less known groups of plants including a good number of endemic and endangered speces of plants. It is the habitat of a number of tribal groups remarkable for their traditional modes of harmonious use of the environment (Anonymous., 1980).

This picturesque mountain range is situated in southern India mainly in the north-western corner of Tamil Nadu. It is bounded in the north by the state of Karnataka and in the west and south-west by Kerala and lies between 11°15'-12°15' N and 7°60' 76°45' E. It is the meeting ground or nexus of three mountain systems of Peninsular India, the Sahyadri joining opposite the Makurti peak, the Southern Ghats across the Palghat gap in the south, and the Eastern Ghats in the north-eastern corner (Chatterjee, 1965). The abrupt rise of the Nilgiris from the surrounding areas is very striking. Doddabetta (2,637 m) is the second highest peak in India south of the Himalayas while Makurti, Nilgiri peak, Pichal Betta and Devar Betta, Naraidu Betta, Kundikadu Betta, Kalari Betta are over 2,500 m. Udhagamandalam (Ootacamund), the most popular hill station in south India, is situated in a broad undulating valley at the foot of Doddabetta. Doddabetta is the culminating point of a range of hills running north-south dividing the Nilgiri Plateau into two climatically dissimilar halves, situated in the east and west of it. The south-western part of the Nilgiri Plateau is formed by a high range of hills called the Kundhas or the Upper Nilgiri Plateau. This range rises steeply from the Silent Valley, the Nilambur Valley and the

Ouchterlony Valley forming a continuous hill range broken only by the Sispara Pass. The Nilgiri-Wynad Plateau situated in the north-west has an average elevation of 1000 m. This undulating plateau is characterized by the prevalence of swampy low-lying areas (Wyals or hadlus). The well-known Mudumalai wildlife sanctuary is situated here. The Sigur Plateau, situated in the north with an average elevation of 900 m is the land lying between the foot of the Nilgiris and the Moyar river. The south-eastern and eastern slopes of the Nilgiris confronting the plains of the Coimbatore District are less precipitous showing altitudinal zonation. The panorama of landscapes at different places in the Nilgiris and their scenic grandeur outstrip every other part in south India. The Nilgiris are drained by several small perennial streams which join to form six major river systems, viz., Pykara (called Moyar from Gudalur), Billithada Hall, Kundah, Coonoor river, Sigur river and Kedar Halla.

The verdant Silent Valley covering an area of about 8,952 ha is situated at the south-western corner of the Nilgiris (on the lower side of the Nilgiri Plateau) in the Palghat District of Kerala. It has high and continuous ridges all over 2,000 m altitude along the entire northern, north-eastern and eastern borders and somewhat lower ridges over 1,200 m altitude along the entire western and southern borders. Due to the presence of high ridges all around, the whole plateau is shielded from extremes of climate and has developed its own special microclimate (Manilal, 1988). It is protected on all sides by high hills and, therefore, the vegetation of the area is relatively not exposed to external influences (Nair, 1981). Kunthipuzha, a perennial river and a tributary of Bharathapuzha, originating at an altitude of 1,861 m near the Kozhipara Peak in the north, flows down the entire length of the valley. The main stream is relatively gentle flowing compared to other rivers in the Western Ghats. The western slopes of the Nilgiris are drained by Punnapuzha, Talipuzha, Karimpuzha and Cherupuzha all the tributaries of the Chaliyar constitute a huge, deeply dissected valley and sharp westerly ridges. The slope-forests are the New Amarambalam Reserve Forest (26,572 ha) and a part of the valley is the Karimpuzha Reserve Forest. All the the Nilgiri-Wynad Plateau and Kerala-Wynad meeting there is a high north-south ridge known as the Nilambur vested forest. The extensive forests in Karnataka, north of river Kabini and east of Brahmagiri hill, constitute the Nagarhole Wildlife Sanctuary

and it is also known as Coorg-Wynad. The Mysore Plateau (north) is a flat plateau whereas the South Mysore Plateau is about 800 m high. Bandipur Tiger Reserve lies south of the Mysore Plateau. The Ataapadi Plateau and Siruvani hills in Coimbatore district, Tamil Nadu in the southern (lower) side are considered as spurs of the Nilgiris.

ECOSYSTEM DIVERSITY

A good amount of biodiversity occurs here. This may be attributed to the significant geographical location (trijunction of the Western Ghats), the proximity of the triseas (the Arabian sea, the Bay of Bengal and the Indian Ocean) to these hills as compared to other hills of India, wide range of topographic features having altitudes varying from 300 to 2,637 m, the marked difference in rainfall received from the south-west as well as the northeast monsoons ranging from 700 to 7,629 mm, the high intensity of solar radiation with significant diurnal range of temperature with tropical montane climate, and the presence of a large number of perennial streams and tributaries of river systems.

All the important forest types in southern India from scrub jungles to wet evergreen forests as well as others that are peculiar to the area occur here. Tropical thorn forests, Tropical dry deciduous forests, Tropical moist deciduous forests, Tropical semievergreen forests, Subtropical broad-leaved forests, Tropical wet evergreen forests, Southern montane wet temperate forests popularly known as "sholas" interspersed with Southern montane wet grasslands (savannas), Subtropical hill savannas and fresh water swamps (low and high level) are encountered on these hills. These include their seral and edaphic modifications having variations in floristic composition. The finest remaining examples of tropical evergreen forests or tropical rain forests known as `Malabar rainforest' of the Western Ghats and the original climax formation of the Western Ghats locally known as `sholas' are some of the non-renewable natural resources that occur here. These have developed in course of million years of evolution. In representativeness, ecosystem diversity, naturalness and effectiveness as a conservation unit this tract surpasses any other tract in the country and hence it was declared as the first biosphere reserve.

UNIQUE ECOSYSTEMS AND COMMUNITIES

Southern montane wet temperate forests (locally known as sholas) interspersed with large tracts of southern montane wet grasslands (Shrub-savannas) are the main vegetation type in the high plateaux of the Nilgiris above 1,600 m. The sholas are compact, sharply well-defined small woods confined to sheltered valleys, glens, hollows and depressions where there is adequate moisture and good drainage. They occur all over the range but their composition and size and height of trees vary according to altitude and velocity of wind. Though the sholas show fundamental affinity to the various types of tropical rain forests to the category they belong, but they, however, show marked differences in detail from the main group in structure and floristic composition. The tree species inhabiting the sholas are all predominantly of tropical stock and evergreen represented mostly by members of the families Celastraceae, Claeocarpaceae, Myrtaceae, Symplocaceae and Ternstroemiaceae. However, the total absence of representation of families like Anacardiaceae, Annonaceae, Bixaceae, Connaraceae, Datiscaceae, Dipterocarpaceae, Ebenaceae, Mimosaceae, Sterculiaceae etc. which are characteristic of the tropical rain forests of the adjacent regions is striking. The undergrowth consists of a large number of species of the Acanthaceae (*Strobilanthes* spp. *s.l.*) and Rubiaceae. The ground floor consists of a great wealth of ferns, mosses and fungi. The epiphytic flora is abundant and consists of orchids, ferns, lichens and bryophytes.

'Shola' forests are the most interesting ecosystem and remnants of the original climax formations of the Western Ghats and the montane variation of the wet evergreen forests. According to Bor (1938) the shola forest is a relict of an evergreen climax forest which has been pushed back to its last stronghold by fire and grazing. Theagarajan (1964-74) remarked, "The helpless shola vegetation is indeed an anachronism in this tract having a precarious existence. It is therefore a relict vegetation" This non-regenerating and fast-receding forest is almost a dying community and deserves to be more appropriately called a 'living fossil community' (Vishnu Mittre & Gupta, 1968). Hence, sholas are relicts of extinct vegetation and are now confined to a few pockets in the world (Figs. 1-4).

The Silent Valley harbours the only comparatively undisturbed patch of tropical evergreen forests with a rich flora and a valuable gene pool. Tropical wet evergreen forests, the most magnificent among forests, are still plentiful here making it the best remaining evergreen forests in the southern Western Ghats (Figs. 5-8-Silent Valley; 9, 10 Siruvani hills). The impenetrable New Amarambalam and the Silent Valley still retain some of the original forests in magnitude and grandeur. Another unique feature in the Kunthipuzha, Karimpuzha and Tekkamalayar in the New Amarambalam forests is the presence of a well-preserved riparian vegetation (Anonymous, 1982). Studies Plant diversity in the Silent Valley indicate that the mesic upland forests are comparable to extremely species-rich rain forests. Species-richness in the riparian forests is also high. The high alpha and beta diversities in species composition may indicate that this valley possesses virgin forests (Singh *et al.*, 1983).

High rainfall savannas (Southern montane wet grasslands) are encountered in the southern and western parts of the Nilgiris in places like the western catchment area, Upper Bhavani and Sispara (Kundah Range) which are extremely windy and rainy during the south-western monsoon. The altitude here is about 2,400 m and in places like Upper Bhavani and Arikayampuzha the mean annual rainfall exceeds 5,000 mm. Monsoonal rainfall of 2,000 to 4,000 mm in the month of July or August is not rare, here. In these places the 'monsoon flora' is very interesting with a number of ephemerals and a great profusion of *Impatiens* spp. Swamps and marshes in grasslands filled with peat deposits are noteworthy features in the Kundah Range. The curious plant *Pleiocraterium verticillare* L. (Rubiaceae) appears to be a characteristic of these bogs. The surface of these bogs is covered by herbaceous vegetation with species of *Carex, Eriocaulon, Juncus, Isachne, Utricularia* and *Xyris*. The grass *Eriochrysis rangacharii* C. Fischer is an indicator of the peaty undrained soils of the Nilgiris (Chinnamani, 1983). That it is an extinct grass of a unique but extinct ecosystem may not be an exaggeration. Hooker (1904) pointed out the occurrence of peat bogs on the Nilgiris as a rare instance in India. The Wynad tract with low level swamps is another biogeographically valuable area extensively forested till recently. Another rare ecosystem which is very characteristic of the Sigur Plateau of the Nilgiri is the open sandal bearing scrub.

FLOWERING PLANT WEALTH

The diversity of the vegetation of the Nilgiri Biosphere Reserve has resulted in teaming of plant life in all its variety and complexity. Floristically, the southern Western Ghats are one of the richest areas in the country harbouring not less than 3,500 species representing 27% of the flowering plants of India. There is an equal, if not more, proportion of lower plants (Nair, 1991). Western Ghats cover about 5% of the total land area of the country but they harbour an estimated 4000 species of flowering plants (Sastry & Sharma, 1991). About 80% of the flowering plants reported from the Western Ghats appear to occur in the Nilgiri Biosphere Reserve (Table 1). An analysis of the eight dominant families of flowering plants may indicate the floristic diversity of the biosphere reserve (Table 2). The area contains a relatively large number of species (Table 3) as compared to other adjoining areas. Intensive surveys in New Amarambalam reserve forest and Nilambur vested forests which still remain unexplored would certainly increase the number of known species in the areas concerned.

Table 1: Number of genera and species of flowering plants in the Nilgiri Biosphere Reserve and Certain areas therein

Name of group	No. of species in the Nilgiri Biosphere Reserve	No. of genera and species in Nilgiri Dist., Tamil Nadu	No. of species in the Western Ghats
(1)	(2)	(3)	(4)
1. Angiosperms	3187 spp. (Balakrishnan & Ansari, 1990)	942 genera and 2611 spp. (163 families) (Sharma *et al.*, 1977)	4000 spp. (Sastry & Sharma,1991) Southern Western Ghats-3500 (Nair, 1991)
	Boluvampatty forest, Siruvani, Coimbatore Dist., Tamil Nadu	Pakasura Hills, Hulichal Drug R.F. Nilgiri Dt., Tamil Nadu	

205 genera & 248 species (Subramanyam, 1959) 152 genera & 194 species (Subramanian, 1966)	123 genera & 154 species (Sebastine, 1960)
Boluvampatty R.F., Coimbatore Dist. 357 genera & 549 species (Sreemadhavan, 1965); 435 genera & 702 species (Viswanathan, 1972) Vellingiri and Maruthamalai, Coimbatore Dist. 247 genera & 373 species (Sebastine, 1959)	Mudumalai Wildlife Sanctuary, Nilgiri Dist. 539 genera & 1015 species (Stephen, 1994)
Bandipur R.F., Mysore Karnataka 309 genera & 439 species (Naithani, 1966)	

Table 2: Analysis of the flora of dominant families

Family	No. of genera & species in India	No. of species in Nilgiri Biosphere Reserve	No. of genera & species in Nilgiri Dist.	No. of genera & species in Silent Valley
(1)	(2)	(3)	(4)	(5)
Fabaceae	123/775	333	90/325	26/55
Poaceae	255/1225	243	98/192	32/56

(1)	(2)	(3)	(4)	(5)
Orchidaceae	145/990	175	46/113	49/108
Asteraceae	161/754	154	61/145	25/45
Rubiaceae	90/495	144	39/116	276/49
Acanthaceae	84 /379	134	34/104	18/31
Euphorbiaeae	74/419	122	37/93	23/38
Cyperaceae	24/449	108	11/87	10/22
	(Jain, 1983)	(Balakrishnan & Ansari, 1990)	(Sharma *et al.* 1977	(Manilal, 1987)

Table 3: Number of species reported from different regions

Area	No. of species of flowering plants	No. of genera	Families	Reference
(1)	(2)	(3)	(4)	(5)
Madras Presidency	4,516*	1,305	179	Gamble & Fischer, 1915-1936
Tamil Nadu	5,640* (incl. cult. plants)	---	---	Nair & Henry, 1983; Henry *et al.*, 1987, 1989
Karnataka	3,294	1,323	189	Sharma *et al.*, 1984
Tamil Nadu Carnatic	2,037	990	180	Matthew, 1983
Nilgiri Biosphere Reserve	3,187 (incl. cult. plants)	---	---	Balakrishnan & Ansari, 1990

*incl. gymnosperms

(1)	(2)	(3)	(4)	(5)
Areas in W. Ghats Nilgiri Dist., Tamil Nadu	2,611 (excl. cult. plants)	942	163	Sharma *et al.*, 1977
Tirunelveli Dist., Tamil Nadu	2,105	872	157	Mudaliar & Sundararaj, 1954
Palghat Dist., Kerala	1,270	710	163	Vajravelu, 1990
Thiruvananthapuram Dist., Kerala	1,325	751	195	Mohanan & Henry, 1994
Cannanore Dist., Kerala	1,132	658	157	Ramachandran & Nair, 1988
Hassan Dist., Karnataka	1,700	—	—	Saldanha & Nicolson, 1976
Chikmaglur Dist., Karnataka	616	—	—	Yoganarasimhan *et al.*, 1981
Coorg (Kodagu) Karnataka	1,332	717	160	Keshava Murthy Yoganarasimhan, 1990

ENDEMIC GENERA/SPECIES

The genus *Baeolepis* Decne. ex Moq. (Periplocaceae) is exclusively endemic to the Nilgiris whereas *Ascopholis* C. Fischer (Cyperaceae) is endemic to the Nilgiris and Hassan (Karnataka). *Silentvalleya* V.J. Nair *et al.* is the other genus endemic to the Silent Valley, an integral part of the biosphere reserve. All are unispecific. The following endemic genera of the Western Ghats also occur in the biosphere reserve.

Campbellia	(Orobanchaceae)	unispecific
Helicanthes	(Loranthaceae)	"
Indobanalia	(Amaranthaceae)	"
Jerdonia	(Gesneriaceae)	"
Kanjaram	(Acanthaceae)	"
Meteoromyrtus	(Myrtaceae)	"
Nilgirianthus	(Acanthaceae)	
Phlebophyllum	(")	
Pleocaulus	(")	
Poeciloneuron	(Bonnetiaceae)	
Taeniandra	(Acanthaceae)	
Xenacanthus	(")	

Blasco's (1971) enumeration of the dicotyledonous endemic taxa that occur in the southern Western Ghats may indicate that the Nilgiris is an important centre of speciation and 82 endemic species are exclusively confined to the Nilgiris. Out of the 1932 taxa of flowering plants endemic to Peninsular India (Ahmedullah & Nayar, 1987) about 818 are found in the Nilgiris and adjoining areas which account for about 25% (Mohanan & Balakrishnan, 1991). A recent analysis (Balakrishnan & Ansari, 1990) shows that there are about 135 species endemic to the Nilgiris and the adjoining areas alone. The endemic species of the biosphere reserve (Table 4) may throw light on the biogeography, centres of speciation, areas of extinction, variance and adaptive evolution.

Table 4: Endemic plants of the Nilgiri Biosphere Reserve

1. *Acacia hohenackeri* Craib Mimosaceae
2. *Agrostis schmidtii* (Hook. *f.*) Bor Poaceae
3. *Alchemilla harae* Purohit & Panigr. Rosaceae
4. *A. parijae* Panigr. & Purohit Rosaceae
5. *Anaphalis notoniana* DC. Asteraceae
6. *Andrographis lobeloides* Wt. Acanthaceae

7. *Arisaema translucens* C. Fischer Araceae
8. *A. tuberculatum* C. Fischer Araceae
9. *A. tylophorum* C. Fischer Araceae
10. *Arundinaria wightiana* Nees var. *hispida* Gamble Poaceae
11. *Arundinella setosa* Trin. var. *nilagiriana* Subba Rao & Kumari Poaceae
12. *Baeolepis nervosa* (Wight & Arn.) Decne. ex Moq.- Periplocaceae
13. *Berberis nilghiriensis* Ahrendt Berberidaceae
14. *Biophytum polyphyllum* Munro Oxalidaceae
15. *Bulbophyllum acutiflorum* A. Rich. Orchidaceae
16. *B. elegantulum* (Rolfe) J.J. Smith Orchidaceae
17. *Capparis nilagiriensis* Subba Rao *et al.* Capparaceae
18. *Caralluma nilagiriana* Kumari & Subba Rao Asclepiadacea
19. *Carex pseudo-aperta* Boeck. Cyperaceae
20. *Cayratia pedata* (Lam.) Juss. ex Gagnepain var. *glabra* Gamble Vitaceae
21 *Cinnamomum perrottetii* Meissn Lauraceae
22. *Coelogyne odoratissima* Lindl var. *angustifolia* Lindley Orchidaceae
23. *Crotalaria barbata* Graham Fabaceae
24. *C. candicans* Wight & Arn. Fabaceae
25. *C. formosa* J. Graham ex Wight & Arn. Fabaceae
26. *Cucumella silentvalleyii* Manilal *et al.* Cucurbitaceae
27. *Dalbergia gardneriana* Benth. Fabaceae
28. *Dichanthium pallidum* (Hook. *f.*) Stapf ex C. Fischer Poaceae
29. *Embelia gardneriana* Wight Myrsinaceae
*30. *Eria tiagii* Manilal *et al.* Orchidaceae
31. *Eriochrysis rangacharii* C. Fischer Poaceae

32. *Eriocaulon pectinatum* Ruhl. Eriocaulaceae
33. *E. robustum* Steud. Eriocaulaceae
34. *Fimbristylis latinucifera* Govindar. Cyperaceae
35. *Garnotia schmidii* Hook. *f.* Poaceae
*36. *G. puchiparensis* Bor Poaceae
37. *Glochidion sisparense* Gamble Euphorbiaceae
38. *Habenaria denticulata* Reichb. *f.* Orchidaceae
39. *Habenaria polyodon* Hook. *f.*
40. *Hedyotis hirsutissima* Bedd.- Rubiaceae
*41. *H. silent-valleyensis* Vajravelu *et al.* Rubiaceae
42. *H. sisparensis* Gage Rubiaceae
43. *Helichrysum wightii* C.B. Clarke *ex* Hook. *f.* Asteraceae
44. *Helictotrichon polyneurum* (Hook. *f.*) Henrard Poaceae
45. *Heracleum hookerianum* Wight & Arn. Apiaceae
*46. *Hydnocarpus pendulus* Manilal *et al.* Bixaceae
47. *Ilex gardneriana* Wight Aquifoliaceae
48. *Impatiens clavicornu* Turcz. Balsaminaceae
49. *I. cuspidata* Wight Balsaminaceae
50. *I. debilis* Turcz. Balsaminaceae
51. *I. denisonii* Bedd.- Balsaminaceae
52. *I. gardneriana* Wight Balsaminaceae
53. *I. laticornis* C. E.C. Fisch.- Balsaminaceae
54. *I. lawsonii* Hook. *f.* Balsaminaceae
55. *I. lenta* Hook. *f.* Balsaminaceae
56. *I. levingei* Gamble ex Hook. *f.* Balsaminaceae
57. *I. munronii* Wight Balsaminaceae
58. *I. neo-barnesii* C. E.C. Fischer Balsaminaceae

59. *I. nilgirica* C. E.C. Fischer Balsaminaceae
60. *I. orchioides* Bedd. Balsaminaceae
61. *I. trichocarpa* Hook. *f.* Balsaminaceae
62. *Isachne deccanensis* Bor Poaceae
63. *I. oreades* (Domin) Bor Poaceae
*64. *Ipsea malabarica* (Reichb. *f.*) Hook. *f.* Orchidaceae
65. *Lasianthus ciliatus* Wight Rubiaceae
66. *Leucas rosmarinifolia* Benth. Lamiaceae
67. *Liparis biloba* Wight Orchidaceae
*68. *L. indiraii* Manilal *et al.* Orchidaceae
69. *Mackenziea violacea* (Beddome) Bremek. Acanthaceae
70. *Microtropis densiflora* Wight Celastraceae
71. *M. microcarpa* Wight Celastraceae
72. *Memecylon flavescens* Gamble Melastomataceae
73. *M. sisparense* Gamble Melastomataceae
74. *Myriactis wightii* DC. var. *bellidioides* Hook. *f.* Acanthaceae
75. *Nilgirianthus papillosus* (T. Anderson) Bremek. Acanthaceae
76. *Oberonia bisaccata* Manilal *et al.* Orchidaceae
77. *O. wightiana* Lindley var. *arnottiana* (Wight) R. Ansari *et al.* Orchidaceae
78. *O. wightiana* Lindley var. *nilgirensis* R. Ansari *et al.* Orchidaceae
79. *Ophiorrhiza incarnata* C. Fischer Rubiaceae
80. *O. pykarensis* Gamble Rubiaceae
81. *Orthosiphon rubicundus* Benth. var. *hohenackeri* Hook. *f.* Lamiaceae
82. *Pavetta breviflora* DC. var. *ciliolata* Gamble ex Bremek. Rubiaceae
83. *P. hohenackeri* Bremek. Rubiaceae

84. *Piper nigrum* L. var. *hirtellosum* Ravindran *et al.* Piperaceae
85. *P. ootacamundense* C. DC. Piperaceae
86. *P. pykarahense* C. DC. Piperaceae
87. *P. silentvalleyensis* Ravindran *et al.* Piperaceae
88. *Poa gamblei* Bor Poaceae
89. *Pogostemon nilagiricus* Gamble Lamiaceae
90. *P. paludosus* Benth. Lamiaceae
91. *Phlebophyllum lanatum* (Nees) Bremek. Acanthaceae
92. *Photinia serratifolia* (Desf.) Kalkman var. *tomentosa* (Gamble) Shetty & Vivek. Rosaceae
93. *Pleocanthus sessiles* (Nees) Bremek. Acanthaceae
94. *Reidia fimbriata* Wight Euphorbiaceae
95. *R. megacarpa* Gamble Euphorbiaceae
*96. *Robiquetia josephiana* Manilal & Satish Kumar Orchidaceae
*97. *Sauropus saksenianus* Manilal *et al.* Euphorbiaceae
98. *Senecio kundaicus* C. Fischer Asteraceae
99. *S. lawsonii* Gamble Asteraceae
100. *S. lessingianus* Clarke Asteraceae
101. *S. polycephalus* (DC.) C.B. Clarke Asteraceae
*102. *Silentvalleya nairii* V.J. Nair *et al.* Poaceae
103. *Sonerila wynaadensis* Nayar Melastomataceae
104. *Symplocos microphylla* Wight Symplocaceae
105. *Teucrium wightii* Hook.*f.* Lamiaceae
106. *Thrixspermum muscaeflorum* A.S. Rao & Joseph var. *nilagiricum* Joseph & Vajr. Orchidaceae
107. *Thunbergia wightiana* T. Anderson Acanthaceae
*108. *Toxocarpus palghatensis* Gamble Asclepiadaceae
109. *Youngia nilgiriensis* Babc. Asteraceae

110. *Vanda wightii* Reichb.f. Orchidaceae

**111. *Vateria macrocarpa* B.L. Gupta Dipterocarpaceae

112. *Viburnum hebanthum* Wight & Arn. Caprifoliaceae

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*Silent valley **Siruvani, the rest from the Nilgiris

SPECIES DIVERSITY

An analysis of the distribution of dominant families/genera occurring in India may indicate that they attain the best distribution and development in the Nilgiri Biosphere Reserve. Orchids are fascinating and highly evolved members of the Angiosperms and the Orchidaceae is the second largest family in India 1,141 species in 166 genera are known to occur (Satish Kumar & Manilal, 1994). The Western Ghats harbour 267 species, 3 subspecies and 2 varieties in 72 genera (Satish Kumar, 1991). Mohanan and Balakrishnan (1991) recorded 175 species of orchids in 60 genera for the Nilgiri Biosphere Reserve while 49 genera and 120 species of orchids were reported for the Nilgiri district alone (Joseph, 1982). In the Nilgiri Biosphere Reserve, out of the 175 species 8 are confined exclusively to the Nilgiri Biosphere Reserve, 24 are endemic to the Western Ghats and 6 are endemic to peninsular India. *Bulbophyllum acutiflorum* A.Rich., *B. nodosum* (Rolfe) J.J.S., *Liparis biloba* Wight, *Spiranthes sinensis* var. *wightiana*, *Thrixspermum muscaeflorum* var. *nilagiricum* Joseph & Vajr. and *Vanda wightii* are the endemic and endangered orchids of the Nilgiri Biosphere Reserve (Mohanan & Balakrishnan, 1991). These figures may show that the true orchid flora of peninsular India is found on the Western Ghats in areas like the Nilgiri Biosphere Reserve. The genus *Impatiens* (Balsaminaceae), a non- endemic genus, is one of the largest among the angiosperms. In India there are about 240 species making the genus the largest in the country. Among the 430 species of the genus in the world more than half occur in India. Nair (1991) recorded 17 and 20 species of endemic *Impatiens* L. respectively for Nilgiris and neighbourhood and Anaimudi and High Range. These two areas are the centres of speciation for this genus. Apart from this; species belonging to widely distributed genera like *Glochidion*

(Euphorbiaceae), *Heracleum* (Apiaceae), *Kyllinga*. (Cyperaceae), *Laurembergia* (Haloragaceae), *Ligustrum* (Oleaceae), *Lobelia* (Campanulaceae), *Oldenlandia* (Rubiaceae), *Osbeckia*. (Melastomataceae), *Sonerila* (Melastomataceae), *Sophora* (Fabaceae), *Strobilanthes* (Acanthaceae), *Vernonia* and *Youngia* (Asteraceae) may have at least a section or few species which might have evolved in the Nilgiris. *Carex*, (Cyperaceae), *Crotalaria* (Fabaceae), *Cyperus* (Cyperaceae), *Desmodium* (Fabaceae), *Eugenia* (Myrtaceae), *Euphorbia* (Euphorbiaceae), *Ficus* (Moraceae), *Fimbristylis* (Cyperaceae), *Grewia* (Tiliaceae), *Indigofera* (Fabaceae), *Habenaria* (Orchidaceae), *Leucas* (Lamiaceae), *Oldenlandia* (Rubiaceae), *Piper* (Piperaceae), *Polygonum* (Polygonaceae), *Senecio* (Asteraceae) and *Syzygium* (Myrtaceae) are the other genera well represented in Nilgiri Biosphere Reserve.

The varied topography and climate of the Nilgiris encouraged early European settlers and many generations of farmers, gardeners and foresters to introduce and establish useful and ornamental plants from other parts of the world. Introduced plants like *Ageratina adenophora*, *Ageratum houstonianum* Mill, *Erigeron karvinskianus* DC., *Helichrysum bracteatum* (Vent.) Andr., *Lantana camara* var. *aculeata* (L.), Moldenke, *Oxalis* spp., *Plantago* spp., *Sarothamnus scoparius*. Koch., *Solanum sisymbrifolium* Lam., *Ulex europaeus* L. and *Zantedeschia aethiopica* have now become naturalized here.

A good number of populations of wild relatives of cultivated species also occur here. These include species of *Amomum*, *Alpinia*, *Cinnamomum*, *Coffea*, *Curcuma*, *Garcinia*, *Hedychium*, *Myristica*, *Zingiber* etc. *Piper* has its major development here and 9 species occur on the Nilgiris and 5 in the Silent Valley. Several wild relatives of pulses and grapes are common in this area. There are many principal timber trees like *Anogeissus latifolia* Wall., *Dalbergia latifolia*, *Hopea parviflora* Bedd., *Pterocarpus marsupium*, *Tectona grandis*L. *f.*, *Terminalia* spp., *Toona ciliata* and *Xylia xylocarpa*. Tree species computed for the Silent Valley alone are 118 vascular plants of 84 species in 0.4 hectares. The alpha diversity index was 4.8. It is same as that of the tropical rain forests in the Barro Colorado Island in Panama

Canal (Singh & Ramakrishnan, 1981). A large number of medicinal plants also occur here. The Coorg district, which lies in the north-western portion of the biosphere, harbours 1,332 species. Of which 747 taxa are found to be medicinal, 315 are used in Ayurveda and 272 in Siddha system of medicine (Keshava Murthy & Yoganarasimhan, 1990). It may be emphasized at this point that the richest source of solasodine has been estimated in plants of a population of *Solanum viarum* Dun collected on the Nilgiris. The occurrence of 10 species of *Dioscorea* in the area may indicate their importance in the drug industry particularly in making antifertility drugs.

HUMAN POPULATION/ACTIVITIES

The availability of good land, water, power and forest resources and a salubrious climate have made the Nilgiris and the surrounding regions more attractive to settlers. A direct consequence of such a growth with influx of pupulation is deforestation and consequent habitat destruction. Deforestation and resultant habitat destruction of species has been the multifaceted major threat leading to degradation, depletion and disappearance of the biological diversity (Nair & Daniel, 1986). The Nilgiris are no exception to this.

Since 1950 there has been a spurt in human population in the area. The census of pupulation growth between 1971 and 1981 which records an average growth of 17.2% for the whole of Tamil Nadu, while 27.2% for the Nilgiris alone is a clear pointer. While in Kerala the coastal region having reached the saturation point the population growth is now in the region of the ghats (Pascal, 1988). The Wynad tract attracted droves of refugees and settlers who cleared large areas in the evergreen forests to establish homes and small farm plots. There is a significant influx of the agricultural community in the Nilgiris in recent years.

The major cause of transformation of most of the landscapes has been the expansion of agriculture (cultivation of rice in Wynad, potato and other vegetables on higher elevations around Nanjanad and Ootacamund, conversion of forests for tea and coffee plantations around Coonnor, Kotagiri and Gudalur and conversion of natural

grasslands for monoculture of *Eucalyptus* and wattle around Doddabetta and Kundah Range). The extensive plantations of *Eucalyptus* and wattle have transformed the vegetation of the plateau greatly. In the upper Nilgiri Plateau only about 10% of the natural vegetation is now conserved (Anonynous., 1990-91).

Many multipurpose river valley projects like the Upper Bhavani, Kundah, Pykara and Moyar have not only fluctuated the flow in the rivers and strems but also submerged vast stretches of forests. Recently more human habitations have sprung up and roads have been made to connect remote forest area. The increase in human population and settlement has led to an unplanned and unprecedented growth of urban centres and plantations putting a severe strain on the natural resources of the area. The Nilgiris, the "queen of hill station" is one of the most important tourist centres of South India, which attracts a large number of tourists every year. Too many boarding and lodging houses, clubs, picnic spots, gardens, roads, etc. that have come up as a result of tourism have shrunk the natural vegetation. In addition, over-exploitation for commercial, scientific and educational puposes (material for studies, research and herbaria for students of botany) has also affected the natural vegetation.

The history of the Nilgiri tract indicates that the major tribe, the Badagas, being an agriculture community came as a study wave to colonize these hills and settled. Intensification of agriculture, shifting cultivation, terrace cultivation on slopes, and cultivation in swamps and along perennial streams by these people have had an undue adverse impact on the natural vegetation. The other tribal group, the Todas, is a pastoral community. The southwest portion of the Nilgiri Plateau is still the seasonal grazing ground for them. Their buffaloes are remarkably adapted to the monsoonal fury and the coarse grass of these areas. Their history reveals that pastoralism and livestock rearing have been the principal mode of sustenance for a very long time. Since the year 1970 with the advent of diary development the number of milk collection centres in places around the Sigur Plateau and Mudumalai Wildlife Sanctuary has considerably increased. This has led to overgrazing and degradation of low and high level grasslands

which harbour a number of endemic species. The annual fire during summer months for a better pasture in the ensuing monsoon is another man-made threat to the biological diversity here.

STATUS OF BIODIVERSITY IN THE AREA

Due to developmental activities extensive areas of forest tracts have been cleared in all localities and areas under the various zones of the Nilgiri Biosphere Reserve. New Amarambalam, Silent Valley and Nilambur vested forests to a certain extent are exception to this. The Nilgiris and the surrounding regions are the most badly degraded areas. Once considered as the botanical paradise this area is no more a paradise. Now the non-regenerating and fast receding shola forests of higher elevations of the Nilgiris are almost a dying community. Swamps and marshes in grasslands with peat deposits are another noteworthy ecosystem of the western slopes of the Nilgiri hills at about 2000 m which have almost disappeared and only the remnants and indicators now exist. The Nilgiris, Kerala and Coorg-Wynad and most part of the Nilgiris have become a land of cultivation for commercial crops. Hence, the natural ecosystems have mostly disappeared and the man-made ecosystems have taken over.

In the cleared sholas and subtropical hill forest sites a seral stage is found in large patches. The components of this type of scrub are *Berberis tinctoria* Lesch., *Dodonaea viscosa, Gaultheria fragrantissima* Wall., *Hypericum mysurense, Mahonia leschenaultii, Osyris wightiana* Wall., *Rhodomyrtus tomentosa* Wt., *Rubus* spp. *Strobilanthes* spp., *Wendlandia notoniana,* etc. Stray plants of *Rhododendron arboreum* Sm. subsp. *nilagiricum, Syzygium densiflorum* and *Vaccinium neilgherrense* are also met with in this seral stage. In the cleared sites various kind of formations from pure *Pteridium aquilinum* or *Hypericum mysorense* Heyne to more mixed formations with small specimens of shola species are also found.

There is an uneven competition between introduced, useful and ornamental plants from other parts of the world and the native plants of the Nilgiris. The exotics with beautiful, large, coloured flowers ar

found to be highly attractive to butterflies and other insects and this has created an uneven competition for the native plants in their bid for pollinators. Besides, the feeble dispersal mechanism and production of less number of seeds in native plants have made them threat and extinct-prone.

Recent studies on the rare and threatened plants indicate that more than 500 species of flowering plants of the Western Ghats belong to this cagegory. The 3 volumes of *Red Data Book of Indian Plants* (Nayar & Sastry, 1987, 1988, 1990) recorded 185 taxa of flowering plants from the southern Western Ghats under various categories. Those reported from the Nilgiri Biosphere Reserve are provided in Table 5.

Table 5: Rare and threatened plants reported from Nilgiri Biospher Reserve

1.	*Actinodaphne lanata* Meissner Lauraceae	E
2.	*A. lawsonii* Gamble Lauraceae	R
3.	*Amomum microstephanum* Baker Zingiberaceae	R
4.	*Begonia aliciae* C. Fischer Begoniaceae	E
5.	*Bulbophyllum elegantulum* (Rolfe) J.J. Smith Orchidaceae	V
6.	*B. kaitiense* (Wight) Reichb.f. Orchidaceae	V
7.	*Bunium nothum* (C.B. Clarke) P.K. Mukherjee Apiaceae	Possibly extinct in India
8.	*Carex christii* Boeck. Cyperaceae	I or possibly extinct
9.	*C. vicinalis* Boott Cyperaceae	Indeterminate
10.	*Cayratia pedata* (Lam.) Juss. ex Gagnepain var. *glabra* Gamble Vitaceae	R
11.	*Ceropegia barnesii* Bruce & Chatterjee Asclepiadaceae	R

12.	*C. decaisneana* Wight	Asclepiadaceae	R
13.	*C. pusilla* Wight & Arn.	Asclepiadaceae	R
14.	*Clematis theobromina* Dunn	Ranunculaceae	R
15.	*Coelogyne mossiae* Rolfe	Orchidaceae	V
16.	*Commelina wightii* R. Rao	Commelinaceae	V
17.	*Crotalaria globosa* Wight & Arn.	Fabaceae	R
18.	*C. longipes* Wight & Arn.	Fabaceae	E
19.	*C. peduncularis* Grah. ex Wight & Arn.	Fabaceae	R
20.	*C. priestleyoides* Benth.	Fabaceae	R
21.	*Cynometra beddomei* Prain	Fabaceae	I
22.	*Eria albiflora* Rolfe	Orchidaceae	R
23.	*Eugenia argentea* Bedd.	Myrtaceae	E
24.	*Euonymus angulatus* Wight	Celastraceae	E
25.	*E. serratifolius* Bedd.	Celastraceae	E
26.	*Hedyotis beddomei* Hook. *f.*	Rubiaceae	E
27.	*H. hirsutissima* Beddome	Rubiaceae	Possibly extinct
28.	*Ilex gardneriana* Wight	Aquifoliaceae	Possibly extinct
29.	*Impatiens neo-barnesii* C. E.C. Fisch.	Balsaminaceae	E
30.	*I. nilagirica* C. E.C. Fisch.-	Balsaminaceae	E
31.	*Ipsea malabarica* (Reichb. *f.*) Hook. *f.*	Orchidaceae	E
32.	*Kingiodendron pinnatum* (Roxb. *ex* DC.) Harms	Fabaceae	R
33.	*Liparis biloba* Wight	Orchidaceae	V
34.	*Melicope indicae* Wight	Rutaceae	V
35.	*Memecylon flavescens* Gamble	Melastomataceae	E

36.	*M. sisparense* Gamble	Melastomataceae	I
37.	*Miliusa nilagirica* Beddome	Annonaceae	V
38.	*Meteoromyrtus wynaadensis* (Beddome) Gamble	Myrtaceae	E
39.	*Ophiorrhiza pykarensis* Gamble	Rubiaceae	Possibly extinct
40.	*Pavetta hohenackeri* Bremek.	Rubiaceae	V
41.	*P. wightii* Hook. *f.*	Rubiaceae	Possibly extinct
42.	*Peucedanum anamallayense* C.B. Clarke	Apiaceae	R
43.	*Phaeanthus malabaricus* Bedd.	Annonaceae	V
44.	*Plectranthus bourneae* Gamble	Lamiaceae	I
45.	*Pogostemon nilagiricus* Gamble	Lamiaceae	E
46.	*P. paludosus* Benth.	Lamiaceae	E
47.	*Salacia beddomei* Gamble	Celastraceae	R
48.	*Senecio kundaicus* C. Fischer	Asteraceae	E
49.	*Syzygium palghatense* Gamble	Myrtaceae	E or Possibly extinct
50.	*Tephrosia wynaadensis* J.R. Drumm.	Fabaceae	V
51.	*Toxocarpus palghatensis* Gamble	Asclepiadaceae	V
52.	*Vanda wightii* Reichb.f.	Orchidaceae	Possibly extinct
53.	*Youngia nilagiriensis* Babc.	Asteraceae	E

E = Endangered, I = Indeterminate, R = Rare, V = Vulnerable

CONCLUSIONS

The Nilgiri Biosphere Reserve should not only aim at preserving the biological diversity but also catalyse ecologically sound development of the entire region. The biodiversity that provides man with food, fodder, medicine, shelter and clothing is, however rapidly

getting eroded due to his own growing numbers and activities Hence, we have to be deeply committed to living resource conservation for sustainable development. Without a proper scientific background conservation efforts would be futile. Floristic and taxonomic studies which are basic for all conservation activities are to be intensified as they are absolutely necessary. Biodiversity of a given region in a conservation-conscious context should be projected as a developing futuristic economic resource of the region.

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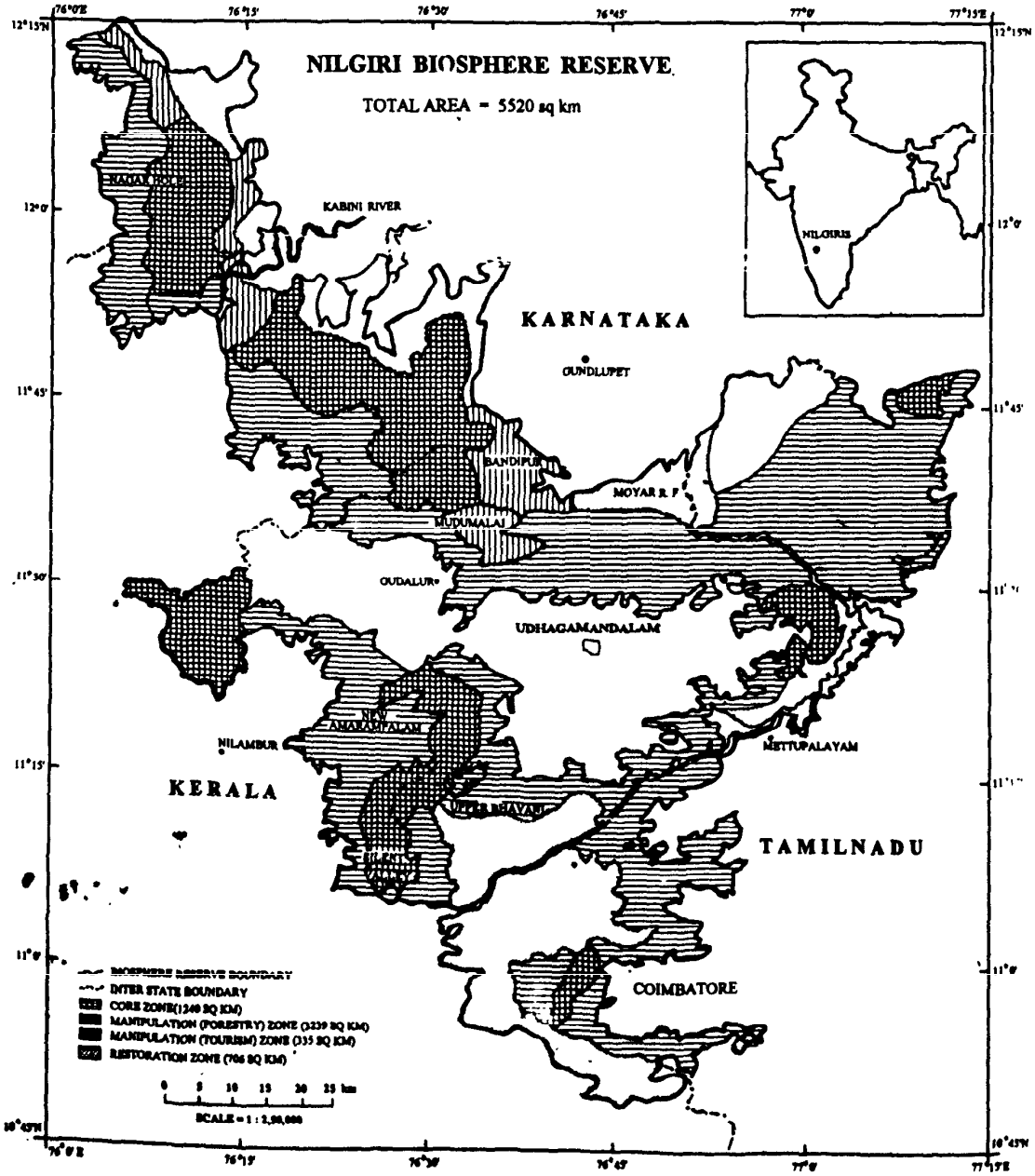
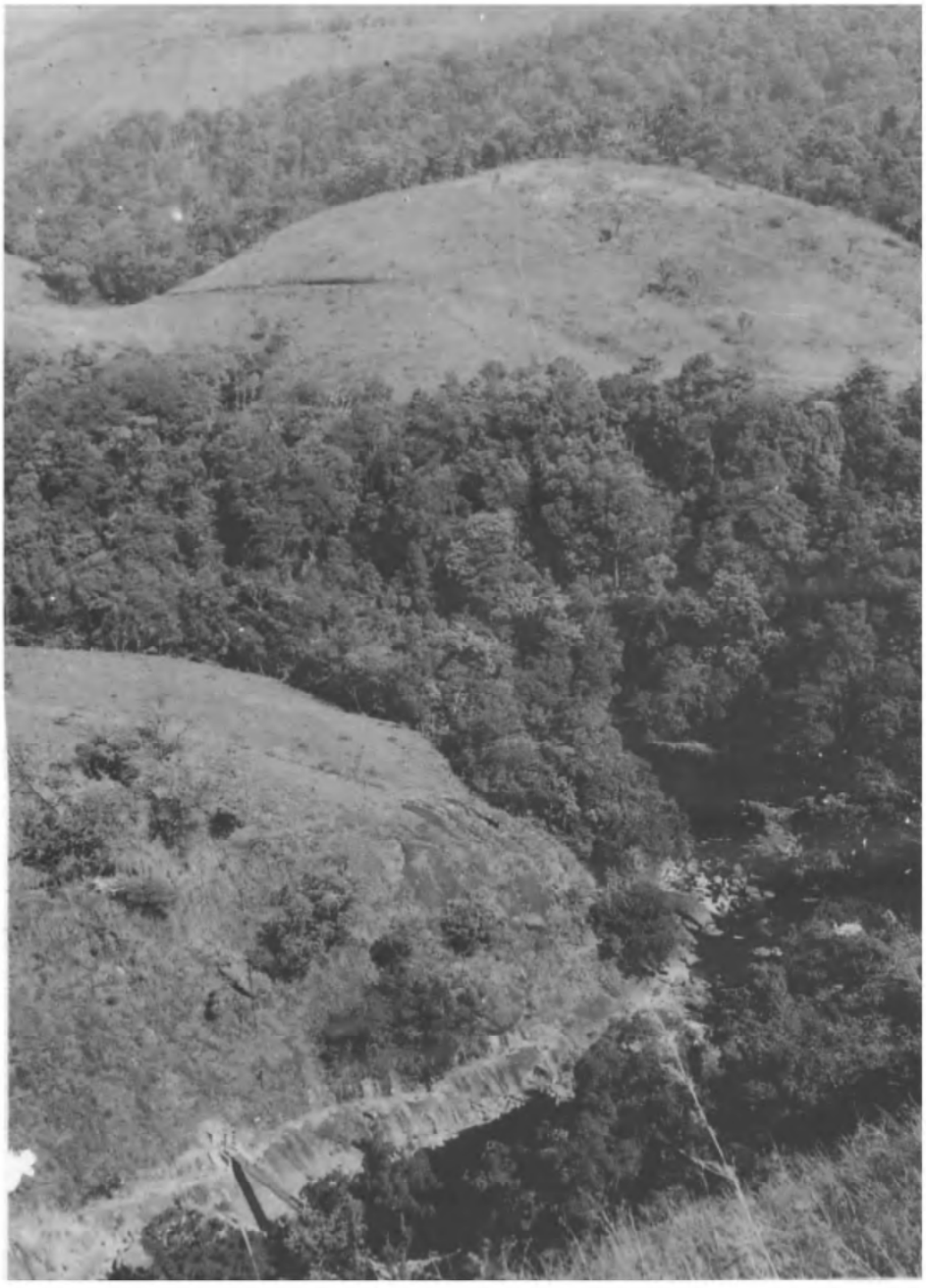


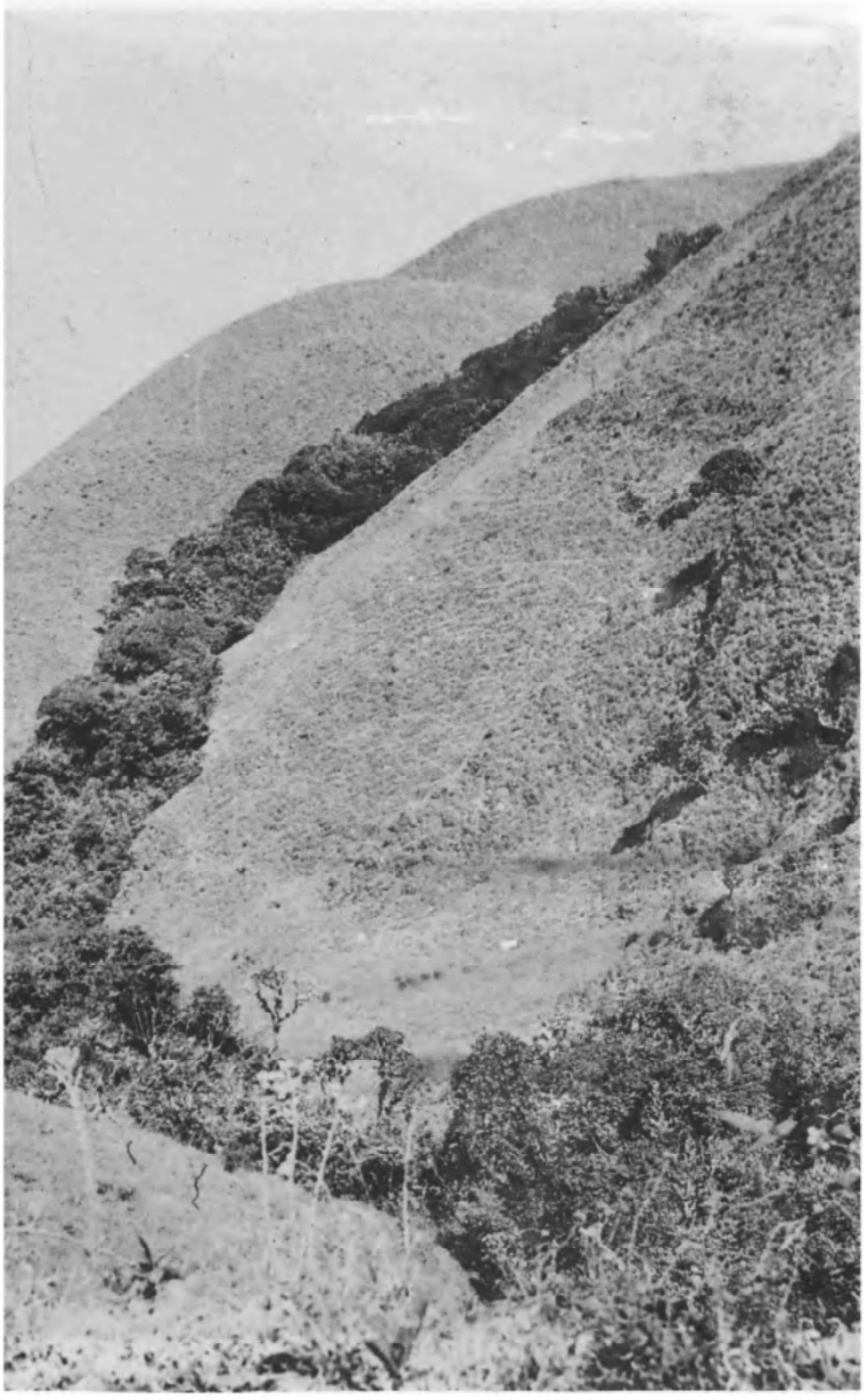
Nilgiri Biosphere Reserve



A view of the Kunthipuzha river flowing through dense forests.
(Courtesy : Southern Circle, Botanical Survey of India)

Southern montane wet temperate forests (Sholas) interspersed with large tracts of Southern wet grasslands (savannas) in the high plateau of the Nilgiri.
(Courtesy : Southern Circle, Botanical Survey of India)

Sholas at Avalanche - Upper Nilgiri Plateau.
(Courtesy : Southern Circle, Botanical Survey of India)



Sholas at Sispara - Upper Nilgiri Plateau.
(Courtesy : Southern Circle, Botanical Survey of India)

Tropical wet evergreen forests in the Silent Valley R.F.
(Courtesy : Southern Circle, Botanical Survey of India)

Tropical wet evergreen forests with savannas in the Silent Valley R.F.
(Courtesy : Southern Circle, Botanical Survey of India)

Sholas at Upper Bhavani - Upper Nilgiri Plateau
(Courtesy : Southern Circle, Botanical Survey of India)

Kunthipuzha river.
(Courtesy : Southern Circle, Botanical Survey of India)

Tropical wet evergreen forests on the Siruvani hills.
(Courtesy : Southern Circle, Botanical Survey of India)

Savannas and evergreen forests at Siruvani - a spur of the Nilgiris.
(Courtesy : Southern Circle, Botanical Survey of India)

4

NAMDAPHA

Plant Diversity in Namdapha Biosphere Reserve (Proposed), Arunachal Pradesh

A. S. CHAUHAN

The Proposed Namdapha Biosphere Reserve extends over ca 2500 sq km of uninhabited land spread over in Changlang and Lohit districts of Arunachal Pradesh. The reserve area lies between 27 ° - 28° 51' N latitude and 95° 45' - 97° 30 'E longitude at the junction of the out spurs of Eastern Himalaya and the Patkoi ranges of Myanmar. The reserve is bounded in the north by the Mishmee hills, on the east by Homakharan Bum (with extensive table- land and high peaks over 4000 m, the highest being Dapha Bum *ca* 4571 m); on the west by Dibrugarh district of Assam and its southern limit extend to Patkoi hills. The area is endowed with a conglomeration of different climatological regimes, and this has adequately manifested in remarkable diversity - both in plants and animals. The area is covered with virgin lush evergreen dense vegetation extending over 4000 sq km from tropical and subtropical to even alpine, with rich gene pool of wild and cultivated plants. The progenitors of many cultivated and other economic plants viz., *Amomum, Citrus, Dioscorea, Musa, Piper, Zingiber* and orchids grow profusely. Besides, several species of primitive angiospermic families such as Magnoliaceae, Lardizabalaceae, Hamamelidaceae and Chloranthaceae are found in this reserve. The tropical humid climate coupled with heavy rainfall facilitates dense plant growth. The natural virgin forests are so complex, delicate and fragile that a minor imbalance could be determental. These bioresources are under threat due to indiscriminate felling of trees, shifting cultivation, over exploitation as well as natural calamities, etc.

Topography

The Namdapha Biosphere Reserve is a highly rugged area with deep valleys and hill ranges running in different directions. The great Himalaya at its eastern end take a mighty sweep around the peak of Namdapha Barwa (7,765 m) in Tibet and swings forward the North and South Chinese

Szechwan mountains lie towards the east. The Eastern Himalaya trials off towards the south in a narrow ridge which is slightly forward to the east meeting the eastern end of the Patkoi mountains at Chaukam pass. The eastern sides of the mountains are drained in the Irrawady basin while the western slopes are drained in the Brahmaputra basin. Parallel to but north of Patkoi there is a higher ridge, stretching from east to west called the Dapha Bum ridge which has many high peaks of over 4500 m. This ridge separates the Noa-Dihing drainage basin from the northern Lohit river basin.

Geology

Geologically the area is of recent origin and owes its formation to the upheavel of the Himalayas in pleiocene period of the Tertiary age. The geological information of this area dates back to 1886 when La Touche (1886), during his reconnaissance traverse of the Noa- Dihing valley up to the Chaukam pass, visited Miao Bum and referred to this coal reams exposed on the hill slopes at a distance of 2.4 km from Dihing at an elevation of 433 m above Dihing. The information so far has led to the deciphering of various geological aspects, structural, tectonic and geomorphic in broad patterns and has helped to some extent in establishing the mineral resources of the park.

Soil

Soil is characterised by a surface layer of considerable depth having loamy texture with colour varying from yellow to reddish. It is acidic in nature. Deep layer of sandy loam soil, rich in vegetative matter is also found in the lower gentle slopes of the hills which support the best fully stocked *Dipterocarpus* forests. On the ridges and precipitative slopes, the soil depth becomes shallow while on the areas near the river banks liable to be frequent inundation, the soil tends to be sandy on the sloping grounds and loamy on the plains.

Climate

The area falls within the sub-tropical zone, and enjoys sub-tropical climate with a distinct, though short, cold weather from November to February in the lower reaches. This is the pleasant period when humidity in the air is

least, cold season is far longer period at higher altitudes as in other Himalayan regions. With the onset of south-west monsoon, the humidity starts rising in the month of May. This coupled with the rise of temperature makes the weather oppressive especially during the months of June, July and August.

Rainfall

Heavy rainfall during the monsoon is an important feature of this territory. Narrow peripheral strip of land below the elevation of 1000 m surrounding the Brahmaputra valley is the rainiest part of the territory, receiving more than 250 cm of rain annually. In this region, the rainfall increases up to 400 cm towards east. The number of rainy days with more than 2 .5 mm of rain averages between 125 and 150 annually.

Temperature

December and January are generally the coldest months, when the mean maximum temperature in the plains (below 900 m) is about 20° C while the mean minimum is about 5°C. Much lower temperatures are experienced at higher elevations above 3000 m and the mean is below freezing point. The months of July and August are normally the warmest when the mean daily temperature is 27 ° C at places below 900 m. At the elevation of 3000 m, the mean daily temperature is about 25°C.

Relative Humidity

Relative humidity is always high except in the winter months. Clear or lightly cleared skies are common during the post - monsoon. During the summer the relative humidity is between 60 - 70 per cent.

VEGETATION

The Namdapha supports a luxuriant tropical, temperate and alpine vegetation in pristine and virgin form. Its unique geographical position, varied topography, high annual precipitation spread throughout the year and

minimum biotic interference due to inaccessibility and remoteness makes the area one of the richest botanical treasure house of the country. The tropical and subtropical evergreen forests predominate mostly in lower reaches and alpine vegetation is met within upper reaches. The low land tropical evergreen forests are perhaps the largest remaining *Dipterocarpus* forests in the whole of India. The floral diversity is such that no single species can be said as the dominant species of this reserve. The forests are further remarkable in the lack of clear cut storey formation of vegetation, perhaps due to vigorous natural regeneration continuously throughout the year owing to conducive climatic and edaphic factors. The best of *Dipterocarpus retusus* Blume (Hollung) sometimes reach a height of over 50 m, with large buttresses and are covered with the epiphytic growth of Lichens, Mosses, Ferns, Piperomias, Aroids and Orchids.

The dominant trees are *Albizia julibrissin* Durazz var. *mollis* (Wallich) Benth., *A. procera* (Roxb.) Benth., *Alnus nepalensis* D. Don, *Anthocephalus chinensis* (Lam.) A. Rich. ex Walp., *Artocarpus chama* Buch.- Ham., *A. heterophyllus* Lam., *Canarium strictum* Roxb., *Castanopsis echinocarpa* Miq., *C. kurzii* (Hance) S.N. Biswas, *C. tribuloides* (Sm.) DC., *Celtis tetrandra* Roxb., *Dipterocarpus retusus* Blume, *Duabanga grandiflora* (Roxb. ex DC.) Walp., *Elaeocarpus aristatus* Roxb., *E. sphaericus* (Gaertn.) K. Schum., *Exbucklandia populnea* (R. Br. ex Griff.) R.W. Br., *Ficus altissima* Blume, *F. elastica* Roxb. ex Hornem, *F. drupacea* Thunb., *F. nervosa, F. rigida* Jack., *Mangifera sylvatica* Roxb., *Nauclea griffithii* Hav., *Quercus lamellosa* Sm., *Q. semiserrata* Roxb., *Shorea assamica* Dyer, *Terminalia myriocarpa* Heurck. & Muell. - Arg. and *Toona ciliata* Roem. The middle storey, which is almost obscure comprises *Altingia excelsa* Noronha, *Bruinsmia polysperma* (C.B. Clarke) van Steenis, *Castanopsis indica* (Roxb.) A. DC., *Dalbergia assamica* Benth., *Dillenia indica* L., *D. pentagyna* Roxb., *Docynia indica* (Wallich) Decne., *Dysoxylum binectariferum* (Roxb.) Hook. *f.* & Bedd., *D. gobara* (Buch.-Ham.) Merr., *Elaeocarpus tectarius* (Lour.) Poir., *Syzygium kurzii* (Duthie) Balakr., *Euodia trichotoma* (Lour.) Planch., *Kydia calycina* Roxb. var. *glabrescens* (Mast.) Deb, *Magnolia griffithii* Hook. *f.*, *Schima wallichii* (DC.) Korth., *Terminalia chebula* Retz., *T. citrina* (Roxb.) Flem., and *Turpinia pomifera* DC., etc. *Actephila excelsa* (Dalz.) Muell., *Actino-*

daphne obovata (Nees) Blume, *Alangium chinense* (Lour.) Harms., *Beilschmiedia roxburghiana* Nees, *Cinnamomum bejolghota* (Buch. Ham.) Sweet, *C. tamala* (Spr.) Nees & Eberm., *Drypetes assamica* (Hook. f.) Pax. ex Hoffm., *Ficus semicordata* J.E. Sm., *Garcinia cowa* Roxb. ex DC., *Griffithianthus fuscus* Merr., *Gynocardia odorata* R. Br., *Litsea cubeba* (Lour.) Pers., *L. monopetaia* (Roxb.) Pers., *L. salicifolia* (Roxb. *ex* Nees) Hook. *f.*, *Macropanax undulatus* (Wallich *ex* G. Don) Seem., *Magnolia hodgsonii* (Hook. *f.* & Th.) Keng and *Styrax serrulaltum* Roxb. form third storey of the canopy.

Some common large shrubs or small trees are *Aralia armata* (G. Don) Seem., *Ardisia virens* Kurz, *Brassaiopsis glomerulata* (Blume) Regel., *Pseudobrassaiopsis hispida* (Seem.) R.N. Ban., *Camellia caudata* Wall., *Coffea khasiana* Hook. *f.*, *Debregeasia longifolia* (Burm.*f.*) Wedd., *Maesa indica* (Roxb.) Wall., *Micromelum integerrimum* (Roxb.) Wight & Arn. ex. Roem., *Morinda angustifolia* Roxb., *Murraya paniculata* (L.) Jack., *Myrsine semiserrata* Wall., *Saurauia armata* Kurz, *S. macrotricha* Kurz, *S. napaulensis* DC., *S. punduana* Wall., *S. roxburghii* Wall., *Vernonia volkameriaefolia* DC. and *Oreocnide rubescens* (Blume) Miq. These forests have also entangling web of thick lianas, wiry climbers, creepers and weak stragglers viz., *Adenia trilobata* (Roxb.) Engl., *Argyreia argentea* Choisy, *A. nervosa* (Burm. f.) Boj., *Cayratia japonica* (Thunb.) Gegnep., *Cissus assamica* (Laws.) Craib, *Combretum flagrocarpum* C.B. Clarke, *C. punctatum* Blume, *Crawfurdia campanulacea* Wall. ex Griffith, *Dioscorea alata* L., *D. pentaphylla* L., *Entada pursaetha* ssp. *sinohimalensis* Grierson & Long, *Erythropalum scandens* Blume, *E. vagum* (Griff.) Mast., *Mastersia assamica* Benth., *Paederia scandens* (Lour.) Merr., *Tetrastigma bracteolatum* (Wall.) Planch., *T. leucostaphylum* (Dennst.) Alston., *T. obovatum* (M.A. Lawson) Gagnep., *T. rumicispermum* (M.A.Lawson) Planch., *Poikilospermum suaveolens* (Blume) Merr., *Thladiantha hookeri* C.B. Clarke, etc. The ground in these forests are dark and moist due to lofty trees with thick canopy and has a thick layer of undisturbed humus, supporting many fleshy fungi and saprophytic flowering plants. The common herbs are *Andrographis paniculata* (Burm. *f.*) Nees, *Blumea fistulosa* (Roxb.) Kurz, *Begonia aborensis* Dunn, *B. barbata* Wall. ex DC., *B. palmata* D. Don, *B. roxburghii* (Miq.) DC., *Cardamine*

hirsuta L., *Chirita macrophylla* Wall., *Euphorbia hirta* L., *Hedyotis verticillata* (L.) Lam., *Hygrophila salicifolia* (Vahl) Nees, *Impatiens porrecta* Wall. *ex* Hook. *f.* & Th., *Knoxia mollis* R.Br., *Limnophila chinensis* (Osb.) Merr., *Lobelia angulata* Forst., *L. montana* Reinw. & Blume, *Mosla dianthera* (Buch.-Ham. ex Roxb.) Maxim., *Oenanthe thomsonii* C.B. Clarke, *Oxalis corymbosa* DC., *Plantago erosa* Wall., *Phyllanthus urinaria* L., *Polygonum posumbu* D. Don, *P. strigosum* R. Br., *P. tenellum* Blume, *Ranunculus cantoniensis* DC., *Spilanthes acmella* (L.) Merr., *Torenia diffusa* D. Don and *Viola diffusa* Ging. Some of the common grasses and sedges are *Arundinella decampedalis* (O.Ktze.) Jan., *A. nepalensis* Trin., *Arundo donax* L., *Carex caricina* (D. Don) Ghildyal & Bhattacharya var. *caricina, Coix lacryma-jobi, Cyperus brevifolius* (Roxb.) Hassk. *Fimbristylis dichotoma* (L.) Vahl, *Garnotia acutigluma* (Steud.) Ohwi, *Imperata cylindrica* (L.) Raeusch., *Isachne albens* Trin., *Oplismenus compositus* (L.) P. Beauv., *Phragmites karka* (Retz.) Trin. *ex* Steud. var. *karka, Saccharum griffithii* Munro *ex* Aitchis., *Themeda villosa* (Poir.) *A. camus, Pogonatherum crinitum* (Thunb.) Kunth and *Setaria palmifolia* (Koen.) Stapf

Epiphytes and other climbers are very common on the tree trunks and common ones are *Aeschynanthus acuminata* Wall., *A. hookeri* C.B. Clarke, *A. superba* C.B. Clarke, *Agapetes variegata* D. Don, *Piper clarkii* DC., *P. hymenophyllum* Miq., *P. mannii* DC., *P. sylvaticum* Roxb., *P. thomsonii* (DC.) Hook.*f., Pothos cathcartii* Schott, *P. scandens* L., *Procris laevigata* Blume, *Rhaphidophora grandis* Schott., *R. hookeri* Schott. and *Schefflera venulosa* (Wight & Arn.) Harms. Besides, more than 120 species of orchids, which include some highly ornamental species were also collected from the reserve area.

Some of the taxa viz., *Cinnamomum glaucescens* (Nees) Meissn., *Dipterocarpus retusus* Blume, *Shorea assamica* Dyer and *Terminalia myriocarpa* Heurck. & Muell. Arg. which grow profusely at lower elevations from Miao to 65th mile forests, are totally absent near Gandhigram towards Myanmar border. Other interesting taxa e.g. *Rhopalocnemis phalloides* Jungh, *Sapria himalayana* Griff. are found near 40th mile

and Kumon Bum forest areas, while *Balanophora dioica* R.Br. shows its maximum population density towards Kumon Bum at 1800 m altitude. *Betula, Quercus, Peliosanthes, Primula* and *Rhododendron* spp. are found at higher elevations. Besides, *Pinus merkusii* Jung & De Vries, a Burmese pine is also found in the Kulung and Lati valley. A number of palms like *Calamus* spp., *Caryota urens* L., *Didymosperma nana* Wendl. & Drude, *Livistona jenkinsiana* Griff., *Phoenix rupicola* T Anderson, *Pinanga gracilis* (Roxb.) Blume, *Wallichia densiflora* Mart., *W. triandra* (Joseph) S.K. Basu, *Zalacca secunda* Griff., etc. grow profusely in this area.

FLORISTIC DIVERSITY

The flora of Namdapha biosphere is rich and dense as well as diverse in species composition. It supports several endemics that have evolved locally or have survived only due to protective natural barriers.

As far as the phytogeographical relationship and affinities of the flora of Namdapha are concerned, these show greater affinity with Indo-Malayan flora. Besides, it also harbours the plants of other region of India, adjacent as well as far off countries, According to Good (1947), India along with the continental South east Asian region, falls under the palaeotropical kingdom and Indo Malaysian sub- kingdom. Chatterjee (1962) found Good's treatment of the provinces of India unsatisfactory and differed with him in putting together the moist area of eastern Assam and dry area of Upper Myanmar under one province. On the basis of distribution of Flora, the Indian sub-continent was sub-divided into various botanical or floristic provinces by Clarke (1898), Hooker (1906), Chatterjee (1939) and Razi (1955). It is evident from their treatment that these floristic limits are subjective and not very precise, and correspond fairly well with the limits of vegetation types.

More phytogeographical accounts of Indian subcontinent and its different regions are discussed by several other authors (Meher-Homji and Mishra, 1973; Mani, 1974; Rao, 1974) and majority are of the opinion

that the flora of Arunachal Pradesh shows great affinities with the flora of Indo-China, apart from its rich endemicity.

The present studies reveal that there are ca 73 species of Lichens, 59 species of Hepaticae (Bryophytes), 112 species of Pteriodophytes, 5 species of Gymnosperms and ca 870 species of Angiosperms in this reserve. The statistical analysis is given in Table - 1.

Table- 1: The Floristic Analysis of Namdapha Biosphere Reserve.

	Dicots	%	Mono-cots	%	Lichens	Hepat-icae	Pterido-phytes	Gymno-sperms
Families (215)	119	86.1	19	13.9	17	21	36	3
Genera (639)	403	78.4	111	21.6	34	33	54	4
Species (1119)	674	77.6	196	22.4	73	59	112	5

The of monocots to dicots is 1: 3.5 and genera to species is 1 : 1.66. Only *ca* 70 % of the total area of the Biosphere reserve could be explored so far and the floral elements of temperate and alpine regions could not be worked out due to several reasons.

An analysis of major 10 families of angiosperms with their respective genera and species is given in descending order in the Table - 2 to show the richness and diversity of the flora of Namdapha Biosphere Reserve. Families like Orchidaceae, Rubiaceae, Leguminosae and Poaceae are almost equally represented. Besides, a comparison of this sequence (Table 3) with those given by Hooker (1906) for Flora of British India has revealed that the family Orchidaceae occupies the first position in both, while the position of other families show considerable variation. Besides, the replacement of Lamiaceae by Acanthaceae shows the rich gene pool of *Phlogacanthus, Boeica* and their allied species in the Biosphere.

Table - 2: The Ten Dominant Families in Namdapha Biosphere Reserve.

Families	Genera	Species
Orchidaceae	35	81
Rubiaceae *	31	59
Leguminosae *	22	49
Urticaceae *	13	39
Poaceae *	27	33
Euphorbiaceae	22	32
Asteraceae	19	24
Cyperaceae	7	20
Acanthaceae	11	18
Gesneriaceae	8	15

Table -3: The Ten Dominant Families in India and Namdapha Biosphere Reserve.

Namdapha Biosphere Reserve	Flora of British India (Hook.*f.*, 1904)
Orchidaceae	Orchidaceae
Rubiaceae	Leguminosae
Leguminosae	Poaceae
Urticaceae	Rubiaceae
Poaceae	Euphorbiaceae
Euphorbiaceae	Acanthaceae
Asteraceae	Asteraceae
Cyperaceae	Cyperaceae
Acanthaceae	Lamiaceae
Gesneriaceae	Urticaceae

*The families Fabaceae, Ceasalpiniaceae, Mimosaceae, Moraceae, Urticaceae, Bambusaceae and Poaceae though treated seperately are kept here under the families Leguminosae, Urticaceae and Poaceae for comparison.

The floristic analysis of Lichens, Hepaticeae (Bryophytes) were shown in Table 4 & 5 respectively. Pteridophytes and Gymnosperms grouped in terms of families, genera,species and their status are shown in Table- 6.

Table - 4: Floristic Analysis of Lichens.

Family	Genera	Species
Arthoniaceae	1	1
Opergraphaceae	2	3
Strigulaceae	3	3
Clathroporinaceae	1	6
Peltigeraceae	1	2
Collemataceae	2	5
Coccocarpiaceae	1	2
Bacidiaceae	1	3
Eectolechiaceae	3	5
Gomphillaceae	2	3
Asterothyriaceae	1	2
Pilocarpaceae	3	6
Parmeliaceae	6	13
Usneaceae	1	3
Ramalinaceae	1	1
Cladoniaceae	1	5
Physciaceae	4	8
Total : 17	34	73

Table 5: Floristic Analysis of Bryophytes (Hepaticae).

Family	Genera	Species
Lepidoziaceae	1	5
Calypogeiaceae	1	2
Caphaloziaceae	1	1

Family	Genera	Species
Jackiellaceae	1	1 (1+2 var.)
Lophoziaceae	1	1
Jungermanniaceae	2	5
Geocalycaceae	2	3
Radulaceae	1	2
Porellaceae	1	3 (+1 var.)
Jubulaceae	1	3
Lejeuneaceae	7	10
Fossombroniaceae	1	2
Pelliaceae	1	1
Pallaviciniaceae	1	1
Aneuraceae	2	5
Targioniaceae	1	1
Conocephalaceae	1	1
Rebouliaceae	2	2
Marchantiaceae	2	3
Ricciaceae	1	1
Anthocerotaceae	2	2 (+ 1 spp.)
Total: 21	33	55 (+3 var.& 1 spp)

It is relevant to mention here that a number of rare, endangered and threatened taxa; two new genera; four new species were described from here, thus placing the region as one of the most important and biologically rich areas.

Table - 6: Floristic Analysis of Pteridophytes and Gymnosperms.

Families	Genera	Species	Rare/Banned
Huperziaceae	2	3	B
Lycopodiaceae	1	1	B

Families	Genera	Species	Rare/Banned
Selaginellaceae	1	5	
Equisetaceae	1	2	
Psilotaceae	1	1	B
Angiopteridaceae	1	1	B
Polypodiaceae	12	26	
Dipteridaceae	1	1	R
Drynariaceae	1	1	R
Lygodiaceae	1	2	
Cheilanthaceae	2	2	-
Marattaceae	1	1	
Cryptogrammaceae	1	1	
Pteridaceae	1	10	
Adiantaceae	1	3	
Hemionitidaceae	2	2	
Antrophyaceae	1	3	
Vittariaceae	1	4	
Hymenophyllaceae	2	3	
Dicksoniaceae	1	1	R
Cyatheaceae	1	3	B
Dennstaedtiaceae	1	2	
Pteridiaceae	1	1	
Lindsaeaceae	1	2	R
Aspleniaceae	1	9	
Athyriaceae	2	5	
Aspidiaceae	1	2	
Dryopteridaceae	2	5	
Lomariopsidaceae	1	1	R
Bolbitidaceae	1	1	
Nephrolepidaceae	1	1	R
Oleandraceae	1	1	
Davalliaceae	1	2	
Blechnaceae	2	2	
Salviniaceae	1	1	R
Pinaceae	2	2	R
Cephalotaxaceae	1	1	
Gnetaceae	1	2	R/B
Total: 39	58	117	

So far as the richness and genetic diversity of the Flora of Namdapha Biosphere Reserve is concerned, it may be mentioned here that many taxa hitherto reported rare and endemic to Assam, Manipur, Meghalaya and Nagaland could also be collected from Namdapha and few of them are growing profusely. They include *Aeschynanthus superba* C.B. Clarke, *Angiopeteris evecta* Hoffm. *Bruinsmia polysperma* (C.B. Clarke) V. Steenis, *Cheirostylis pusilla* Lindl., *Christensenia aesculifolia* (Blume) Maxon, *Cyathea gigantea* (Wallich ex Hook.) Holt., *Arundina graminifolia* (D. Don) Hochr., *Diplomeris pulchella* D. Don, *Gnetum ula* Brongn., *Glycosmis cymosa* (Kurz) Narayanswamy, *Impatiens porrecta* Wall. *ex* Hook.*f.* & Th., *Iodes hookeriana* Baill., *Phlegmariurus phlegmaria* (L.) Sen & Sen, *Magnolia griffithii* Hook. *f.* & Th., *M. pterocarpa* Roxb., *Oxyspora cernua* Beauv., *Pteracanthus nobilis* (C.B. Clarke) Brem., *Pseudobrassaiopsis hispida* (Seem.) R.N. Ban. and *Tetrastigma obovatum* (Laws.) Gagnep., etc. It also hosts several rare and endangered taxa which are being depleted or on the verge of extinction due to many developmental projects and 'Jhum' cultivation in other parts of north- eastern region.

Many primitive flowering plants viz., *Exbucklandia, Houttuynia, Kadsura, Magnolia* and *Talauma* and many species of the *Annonaceae, Lauraceae, Myrsinaceae* and *Piperaceae* are found here. Apart, many taxa of nearby Sino-Himalayan, Bhutanese, Burmese, Malaysian and to a lesser extent with peninsular Indian affinity could be seen in this area. (Mani, 1974). These affinities are best illustrated by an enumeration of some of the common elements. The Chinese, Bhutanese and Himalayan genera found in the Namdapha Biosphere are: *Actinidia, Anthocephalus, Bruinsmia, Bulbophyllum, Camellia, Cymbidium, Epigeneium,* and *Kadsura.* Of the Malayan elements occurring in Namdapha are genera like : *Balanophora, Engelhardtia, Exbucklandia, Miliusa, Talauma, Vaccinium,* etc.

The flora exhibits affinities with peninsular India with common elements like *Butea parviflora* Roxb., *Cissampelos pareira* L., *Dillenia indica* L., *D. pentagyna* Roxb., *Eurya japonica* DC., *Elatostema platyphylla* Wedd., *Entada pursaetha* DC., *Garcinia cowa* Roxb. ex DC., *Hydrocotyle javanica* Thunb., *Kadsura heteroclita, Leea edgeworthii*

Santapau, *Mesua ferrea* L., *Meliosma simplicifolia* (Roxb.) Walp., *Pavetta indica* L. and *Trichosanthes tricuspidata* Lour.

HUMAN ACTIVITIES

Many tribes of Arunachal Pradesh viz., Wanchoo, Tangsa, Singhpho, Khamtis, Nocte and Mishmis are inhabiting Buffer - II area of the reserve in Miao, Jairampur & Nampong, Kalai, Jehun, Glao lake village and in Kulung & Lati valley as such there is no threat to core area of Namdapha. But the settlement of Chakma and Hazang refugees (about 25,000 population) on the western side of Deban river in the buffer zone with proximity to the core area will create major threat to this reserve in future. Their livelyhood is mainly on 'Jhum cultivation' and their activities expand unchecked in reserve forests and unclassified state forest alike. Similarly, the settlement of Lamas from Bhutan (about 450 population, basically Jhumias) on the north bank of the Noa-Dihing river are also in close vicinity to the core area. In this context, mention may be made here that the State Forest Department of Arunachal Pradesh and the Field Director, Project Tiger, Namdapha has already sent a proposal for the resettlement of these refugees to some other suitable areas and the case is pending with the Arunachal Pradesh Government. Almost similar problem is also prevailing in the Gandhigram and Vijoynagar area on the south-eastern flanks of the reserve, where the settlements of Lisu's (*ca* 2000 population) and 200 families of ex- servicemen (Assam Riffles) exist. Shifting cultivation, cutting of trees for shelter, fuel, fodder and poaching of wild life are the main activities around these habitations.

ETHNOBOTANICALLY IMPORANT PLANTS

Food Plants

The Namdapha Biosphere is diverse and rich ethnobotanically. The tribals of various ethnic groups inhabiting this area practice 'Jhum' cultivation. Land holdings are small and subsistence agriculture prevails. The natives still gather many wild food plants from nature sites. Tubers, rhizomes, shoots, berries, etc. of wild plants are eaten raw or boiled or even cooked as vegetables. Similarly, the ripe fruits of many wild plants which are pulpy

and sweet are either eaten raw, roasted or pickled and also used as vegetables. 'Lisus' are mainly dependant on the wild plants for their survival. A list of species used by them is appended here.

Name of the plant	Family	Plant parts used
1. *Abroma augusta* L. *f.*	Sterculiaceae	Bark used for fibres
2. *Aconitum lethale* Griff.	Ranunculaceae	Rhizome used for arrow poisoning
3. *Actephila excelsa* (Dalz.) Muell.	Euphorbiaceae	Beverage
4. *Aesculus assamica* Griff.	Hippocastanaceae	Leaves for fish poisoning
5. *Agapetes variegata* D. Don	Ericaceae	Flowers as vegetable
6. *Albizia julibrissin* Durazz	Mimosaceae	Dried leaves as substitute for tea
7. *Alpinia malaccensis* (Burm.*f.*) Rosc.	Zingiberaceae	Rhizome and fruits are eaten
8. *Amomum dealbatum* Roxb.	Zingiberaceae	Seeds as Condiment
9. *Aquilaria malaccensis* Lam.	Thymelaeaceae	Fungal infected wood forms the source of agar
10. *Arundo donax* L.	Poaceae	Young shoots as vegetable
11. *Begonia barbata* Wall. ex DC.	Begoniaceae	Leaves & stems as vegetable
12. *Beilschmiedia roxburghiana* Nees	Lauraceae	Fruits very sweet in taste
13. *Calamus floribundus* Griff.	Arecaceae	Young shoots are eaten as vegetables & ripe fruits are also eaten; stem used for furniture
14. *Callicarpa arborea* Roxb.	Verbenaceae	Bark chewed with pan
15. *Castanopsis indica* (Roxb.) A. DC.	Fagaceae	Rosted seeds eaten
16. *Chloranthus elatior* R. Br.	Chloranthaceae	Leaves as vegetables
17. *Clerodendrum colebrookianum* Walp.	Verbenaceae	Leaves as vegetables
18. *Coffea khasiana* Hook. *f.*	Rubiaceae	Seeds as substitute of coffee
19. *Cyperus haspan* L.	Cyperaceae	Plant ash as a substitute of salt
20. *Dioscorea glabra* Roxb.	Dioscoreaceae	Tubef and bulbs eaten
21. *Garcinia cowa* Roxb.	Clusiaceae	Leaves & fruits eaten raw or cooked
22. *Hedychium coronarium* Koen.	Zingiberaceae	Rhizome as condiment
23. *Hodgsonia macrocarpa* (Blume) Congdon.	Cucurbitaceae	Fruits & Seeds for its oil
24. *Houttuynia cordata* Thunb.	Saurauiaceae	Roots & leaves as vegetable

Name of the plant	Family	Plant parts used
25. *Jasminum sambac* (L.) Aiton	Oleaceae	Flowers as tea flavour
26. *Macrosolen cochinchinensis* (Lour.) V. Tiegh	Loranthaceae	Leaves as tea
27. *Piper sylvaticum* Roxb.	Piperaceae	Fruits as condiment
28. *Setaria pumila* (Poir.) R. & S.	Poaceae	Seeds as cereals
29. *Solanum spirale* Roxb.	Solanaceae	Leaves & fruits as curry
30. *Zanthoxylum alatum* Roxb.	Rutaceae	Leaves & young shoots as vegetable

Medicinal plants

Namdapha Biosphere Reserve harbours numbers of medicinal plants, which are being used by the tribals of Changlang and Lohit districts of Arunachal Pradesh. Some of the medicinal plants are listed below with their uses:-

Name of Plant & Family	Habit	Uses
Achyranthes aspera L. (Amaranthaceae)	Herb	Roots used in urinary disorders; stem and leaves in boils, wet piles, skin disease & seeds in hydrophobia
Alpinia allughas (Retz.) Rosc. (Zingiberaceae)	Tall herb	Rhizome used in fever and rheumatism
Anthocephalus chinensis (Lam.) A. Rich ex Walp. (Rubiaceae)	Tree	Leaves used in case ophthalmia and stomatitis
Barleria cristata L. (Acanthaceae)	Shrub	Roots and leaves used in cough and swellings
Buddleja asiatica Lour. (Buddlejaceae)	Shrub	Plants are used as abortifacient and skin diseases
Cannabis sativa L. (Cannabinaceae)	Shrub	Plants used in stomach disorders and as appetite stimulants
Chirita vestitum A. DC. (Gesneriaceae)	Herb	Leaves used in itching

Name of Plant & Family	Habit	Uses
Cissampelos pareira L. (Menispermaceae)	Twining	Tuber acts as diuretic, shrubs generally taken after delivery; leaves for itching roots are also used in case of snake bite
C. divaricatum Jack. (Verbenaceae)	Shrub	Roots and leaves are taken in dysentery and fever and also useful in cephalalgia
Costus speciosus (Koen.) Smith (Zingiberaceae)	Tall herb	Rhizomes used in respiratory troubles
Croton caudatus Geiseler (Euphorbiaceae)	Shrub	Fruits used in vomiting
Cyathea gigantea (Wall. ex Hook. *f.*) Holttum (Cyatheaceae)	Woody shrubs or herb	Leaves used in swelling
Dillenia indica L. (Dilleniaceae)	Tree	Fruits used in cough, fever and weakness
Elaeocarpus sphaericus (Gaertner) Schumann (Elaeocarpaceae)	Tree	Flowers and fruits used in cardiac disorders
Equisetum diffusum D. Don (Equisetaceae)	Herb	Plant used in joining broken bones of cattle
Garcinia acuminata Planch. & Triana (Clusiaceae)	Tree	Fruits used in stomach disorder
G. cowa Roxb. ex. DC. (Clusiaceae)	Tree	Fruits used in gastrointestinal problems
Houttuynia cordata Thunb. (Saurauiaceae)		Rhizomes taken in cough and leaves in cholera
Mastersia assamica Benth. (Fabaceae)	Woody Climber	Leaves used in wounds
Musa velutina Wendl. & Drude. (Musaceae)	Tall perennial herb or shrub	Pseudostem used in dysentery, check the bleeding
Persicaria hydropiper (L.) Spach (Polygonaceae)	Herb	Stems and leaves used in urinary disorders
Piper thomsoni (DC.) Hook. *f.* (Piperaceae)	Climber	Roots promote the discharge of urine
Pothos scandens L. (Araceae)	Climbing shrub	Leaves used to cure small pox

Name of Plant & Family	Habit	Uses
Spilanthes paniculata DC. (Asteraceae)	Herb	Flowers used in toothache
Tacca integrifolia Ker.-Gawl. (Taccaceae)	Herb	Leaves used in dysentery
Toddalia asiatica (L.) Lam. (Rutaceae)	Shrub	Roots used in diarrhoea and fever
Trema orientalis (Blume) Blume (Ulmaceae)	Tree	Plants used in diseases of nervous system
Xanthium strumarium L. (Asteraceae)	Shrub	Plants used in inflamation of the thyroid glands and ulcers
Zanthoxylum aramatum DC. (Rutaceae)	Small tree	Leaves used in indigestion twigs in toothache

Wild relatives of cultivated plants:

The forests explored so far are rich in wild species of cultivated plants. Some of the important plants are given below:

Artocarpus chama Buch. Ham. *ex* Roxb. (Wild Jackfruit) A tall tree with edible fruits.

Citrus medica L. A wild citrus allied to cultivated common lime, distributed at lower altitudes in the Biosphere.

Camellia caudata Wall. (Wild Tea) - A small tree which grows under the dense canopy of tall trees.

Coffea benghalensis Heyne ex Roem. & Schult. (Wild Coffee) A shrub with white flowers.

C. khasiana Hook. f. (Wild Coffee) A common shrub with orange red flowers.

Coix gigantea Roxb. Plants are grown in the kitchen- garden for seeds.

Coix lacryma-jobi L. Plants are cultivated in the kitchen gardens for its seeds.

Ensete glaucum (Roxb.) Cheesman Wild banana found growing on the road side before Deban.

Mangifera sylvatica Roxb. Wild mango plant collected near 36th mile and 40th mile with long pendulous bunches of beaked fruits. Mature fruits are pinkish - red with leathery thick edible skin and very thin non fibrous covering over the nut.

Musa glauca Roxb. - A tall wild banana, common in moist and open places on forest edges.

Musa rosacea Jacq. - A common wild banana on road sides and forest edges.

Musa velutina Wendl. & Drude - A common gregarious dwarf banana with attractive erect, bright - red spadix.

It is interesting to note that in spite of terrestrial contiguity with surrounding area, this area shows considerable endemicity e.g. *Aconitum lethale* Griff., *Begonia aborensis* Dunn, *B. iridescens* Dunn, *Ceratostylis subulata* Blume, *Chirita mishmiensis* Debb., *Cymbidium eburneum* Lindl. var. *parishii* (Rechb. *f.*) Hook. *f.*, *Euonymus glaber* Roxb., *Phaius rubra* Lindl., *Piper clarkii* C. DC., *Rubus burkillii* Rolf, *Symplocos pealii* King & Das and *Wallichia triandra* (Joseph) S.K. Basu Besides, Namdapha hosts a rich gene pool of several rare and endangered taxa viz., *Aeschynanthus superba* C.B. Clarke, *Angiopteris evecta* Hoffm., *Aquilaria malaccensis* Lam., *A. khasiana* Wall., *Esmeralda cathcartii* Rechb. *f.*, *E. clarkei* Rechb.*f.*, *Balanophora dioica* R. Br., *Bruinsmia polysperma* (C.B. Clarke) van Steenis, *Cheirostylis pusilla* Lindl., *Christensenia aesculifolia* (Blume) Maxon, *Cyathea gigantea* (Wall. *ex* Hook.) Holtt., *Cymbidium eburneum* Lindl. var. *parishii* (Rechb.*f.*) Hook. *f.*, *Diplomeris pulchella* D. Don, *Galeola altissima* (Blume) Rechb. *f.*, *Glycosmis cymosa* (Kurz) Narayan., *Gnetum gnemon* L., *G. ula* Brongn., *Impatiens porrecta* Wall. ex Hook. *f.* & Th., *Iodes*

hookeriana Baill., *Liparis distans* C.B. Clarke, *Livistona jenkinsiana* Griff., *Magnolia griffithii* Hook. *f.* & Th., *M. pterocarpa* Roxb., *Oxyspora cernua* (Roxb.) Triana, *Pentasacme wallichii* Wight, *Phlegmariurus phlegmaria* (L.) Sen & Sen, *Pseudobrassaiopsis hispida* (Seem.) R.N. Ban., *Psilotum nudum* (L.) P. Beauv., *Pteracanthus nobilis* (C.B. Clarke) Brem., *Tetrastigma obovatum* (Laws.) Gagnep. etc. Some of these plants are getting rare in North-Eastern region due to several biotic influences. The genetic diversity met with in crop plants and plants of horticultural value is also remarkable.

The selective felling of *Aquilaria malaccensis* Lam., for 'Agar' extraction, *Canarium strictum* Roxb. for 'Dhoop' and *Cinnamomum glanduliferum* (Nees) Meiss. may pose serious threat to their population. 'Attar' trees are often wounded for its resin These trees may also face threat in due course.

Besides, the natural factors such as floods, earth-quakes, land slides, natural competition between species, and forest fires affected a change in the native flora of this region. Population pressure, coupled with increased demand on natural forest areas for cultivation, grazing and fuel has brought about the destruction of natural forests at greater pace year after year. The jhum fallows abandoned by jhumias gradually transformed into barren rocky places or grassland. This has also facilitated the invasion by alien species, particularly exotic weeds like *Chromolaena, Eupatorium, Lantana, Mikania,* etc. About 700 taxa of N.E. region are now recognised under different categories of threat. Some species namely *Acer oblongum* var. *microcarpum* Hiern, *Adinandra griffithii* Dyer. *Agrostemma khasiana, Begonia aborensis* Dunn, *B. burkillii, Clematis apiculata, Meliosma henryi* ssp. *mannii, Morinda villosa,* Hook. *f., Premna punduana* Wall. *Pternopetalum senii,* etc. appear to have vanished totally from the area.

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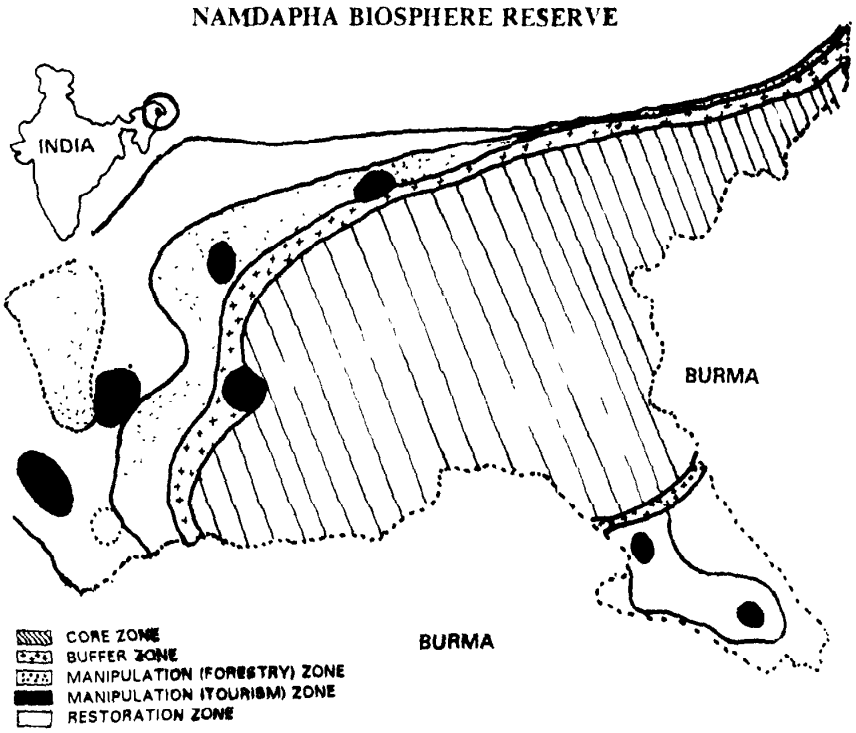

Namdapha Biosphere Reserve.

A view of Biosphere reserve.
(Courtesy : Eastern Circle, Botanical Survey of India)

Dipterocarpus retusus Bl. after 27th mile. M.V. Road.
(Courtesy : Eastern Circle, Botanical Survey of India)

Disturbed tropical forest at 15th mile point.
(Courtesy : Eastern Circle, Botanical Survey of India)

Forest view of Kumon Bum in the back of Ramnagar.
(Courtesy : Eastern Circle, Botanical Survey of India)

Dendrobium nobile Lindl. - A showy orchid.
(Courtesy : Eastern Circle, Botanical Survey of India)

Dendrobium wardianum Warner - A showy and rare orchid.
(Courtesy : Eastern Circle, Botanical Survey of India)

Confluence of rivers Noa - Dihing and Deban near Deban.
(Courtesy : Eastern Circle, Botanical Survey of India)

Bamboo forest destroyed for Jhum.
(Courtesy : Eastern Circle, Botanical Survey of India)

Alpinia nigra Gaertn.
(Courtesy : Eastern Circle, Botanical Survey of India)

Rhopalocnemis phalloides Jung - An interesting root parasite of the family Balanophoraceae.
(Courtesy : Eastern Circle, Botanical Survey of India)

Rhaphidophora decursiva Schott.
(Courtesy : A. S. Chauhan)

Balanophora dioica R. Br. - A rare and interesting root parasite.
(Courtesy : Eastern Circle, Botanical Survey of India)

Arachnis cathcarstii (Lindl.) J.J. Smith.
(Courtesy : Eastern Circle, Botanical Survey of India)

Aeginetia indica Roxb.
(Courtesy : A.S. Chauhan)

5
DIBANG VALLEY

Plant Diversity in Dibang Valley District, Arunachal Pradesh

H.J. CHOWDHERY

Arunachal Pradesh lies within the Eastern Himalaya and is characterised by varying altitudes, ranging from foothills to 8500 metres, diverse topography, high degree of precipitation and rain. The flora is extremely rich and diverse with rare, endemic, primitive and curious plant species. Takhtajan (1969) has rightly denoted this region as the "Cradle of Flowering Plants" Being located at the junction of Paleoarctic, Indo-Chinese and Indo-Malayan biogeographic regions, Eastern Himalaya as a whole acts as an entry point for the floral elements from the adjascent countries like China, Myanmar and Bhutan. The knowledge of its flora: wealth is not fully known and approximately 50% of the flora of this region still remains to be investigated (Rao, 1993).

Arunachal Pradesh has been divided into 13 administrative districts namely - Tawang, East Kameng, West Kameng, Lower Subansiri, Papum pare, Upper Subansiri, West Siang, Upper Siang, East Siang, Dibang valley, Lohit, Changlang and Tirap. Dibang valley is the remotest and inaccessible region and for this reason, it is the least explored district with regard to its flora. It lies between 27°-29° 30' North latitude and 95° 15' 97° 50' East longitude and situated in the north- eastern corner of Arunachal Pradesh. It is bounded in the north by China; Lohit in the east; Assam in the south and East Siang in the west. The district Dibang valley was carved out from Lohit district in 1980 with its headquarter at Anini. This is the largest district of the state, having a geographical area of 13029 sq km and 66.62% of its geographical area is under forest cover (8160 sq km). As per Census of India 1981, the population of this district was 30978 with a density of 2 per sq. km, however 1991 Census indicated an increase in population by 39.02 percent with present figures stand close to 40278.

The district derives its name from its principal river Dibang which is also called 'Talon' by 'Idus' a local tribe of this region. This river

originates from the southern flank of the Himalayan ranges and flows from north to south through the district cutting deep gorges and difficult terrain in its upper course and finally meets Lohit river near Sadiya. 'Dri' and 'Ithun' are its main tributaries. The river changes its course very often eroding its banks.

THE TRIBES AND ECONOMY

The main tribes inhabiting this district are the Idus, Mishmis, Padams, Khamptis. The staple food of the people is rice, millet and meat. Apart from this, a variety of wild leafy vegetables, roots, tubers, fruits as well as pumpkin, potato, brinjal, ginger, onion, mustard leaves, chillies and flowers of banana, bamboo shoots, mushrooms are included in their diet. Fish is a delicacy. Normally the food is boiled and flavoured with chillies and salt. Spices are also used but not very frequently. A beer called 'Yu' or 'Apong' is the common drink and is fermented from 'rice' or 'millets'

Agriculture is the mainstay of the economy and the traditional shifting cultivation of 'Jhum' is the most popular method practiced by the people. The crops grown are rice, maize, finger millet and fox-tail millet, sweet potato, yams, buckwheat and aroides. These tribes possess the knowledge of many medicinal plants to care and heal their diseases and wounds. For the construction of the houses, they use plant material available in these forests, viz., leaves, thatching grass, bamboos, timber etc. Their houses are generally built on bamboo or wooden piles. The floor and walls are made of split-bamboos. Hunting and fishing is their way of life. Each tribe/village has forests and streams over which it claims hunting and fishing rights.

BIODIVERSITY

The state has a very rich and diverse flora and fauna. It abounds in rich evergreen forests and according to one estimate by the Botanical Survey of India, the state harbours approximately 5000 species of angiosperms of which the most dominant group-orchids account for more than 525 species. Although the forests in majority of the districts of

Arunachal now bear the scars of wide ranging destruction due to various human activities, Dibang valley by virtue of its remote and inaccessible terrain has escaped such impacts to a considerable extent. Encroachment for human habitation and clearing of the forests for traditional agriculture 'Jhum' are the identified ecological issues in this district.

The area is rich in faunal resources and a large number of animals like tiger, panther/leopard, clouded leopard, golden cat, fishing cat, Himalayan bear, sloth bear, jackal, fox, civets (large and small Indian civet, palm civet and masked palm civet), mongoose, otters, elephant, wild buffalo, goral, serrow, samber, barking deer, musk deer, hog deer, pangolin, wild bore, Indian hare, percupines, rats, moles and shrews, giant flying squirrel, striped squirrel, particoloured flying squirrel etc. and several species of bats occur in this district.

The avian fauna comprises of about. 500 species. 'White Winged Wood Duck' is the most threatened bird and among others a variety of owls, eagles, partridges, tragopans, monal pheasant, pheasant, water hen, pigeons, dores, red jungle parakeet, swallon, swifts, cuckoos, rollers, braodbills, magpie, bee eaters, kingfishers, hornbills, bulbul, flower-peckers, flycatchers, robins, spotted munia, rosefinches are common.

Reptiles are represented by a variety of lizards and snakes viz., black krait, cobra, king cobra, pit viper, python and many others. A wide variety of fresh water fishes like mahaseer and other carps are quite common in perennial streams and ponds.

A number of insects, earthworms, scorpions, centipedes and millipedes also occur and among them beautifully coloured attractive butterflies are worth mentioning.

The rich biodiversity has prompted the establishment of 2 Wildlife Sanctuaries in this valley.

1. **Mehao Wildlife Sanctuary** covers 281.50 sq km area for the

major animals like-hoolock gibbon, tiger, leopard, red panda, elephant etc.

2. **Dibang Wildlife Sanctuary** covers 4149 sq. km area and harbours musk deer, serow, takin, goral, black bear, red panda, leopard, monal, tragopan, kalij and other pheasants and many other rare birds.

Recently a Biosphere named Dihang-Dibang Biosphere has also been proposed which will cover areas of Dibang valley, East and West Siang districts.

It was Kingdon Ward who for the first time botanically explored Lohit and Mishmi Hills (1929, 1931 and 1953). The Eastern Circle of the Botanical Survey at Shillong subsequently conducted some plant explorations in this region. With the inception of Arunachal Field station by the Botanical Survey at Itanagar in the year 1976, two plant exploration tours were undertaken in the foothill regions of Dibang valley. Besides, the scientists of State Forest Research Institute, and Forest Research Institute, Dehra Dun have also carried out few plant explorations in this area. But so far no proper assessment of its floristic wealth could be made.

In the absence of extensive floristic survey and assessment, it is not possible to give an exhaustive account of the flora of this remote district. However, an attempt has been made to enumerate the plant diversity in Dibang valley. The write up in following pages in essentially based on the published literature, limited surveys and discussion with scientists working in the region.

VEGETATION

The vegetation of Dibang valley can be broadly categorised based on the altitude and species composition into following main forest types:

1. Tropical forests : up to 900 m.
2. Subtropical forests : between 900-1800 m.
   i). Subtropical broad leaved forests.

ii). Subtropical/Temperate Pine forests.

3. Temperate forests : between 1800-3500 m.

4. Sub-alpine/Alpine forests : between 3500-5500 m.

1. **TROPICAL FORESTS** : These forests occur throughout the district along the foothills, river valleys and are characterised by broad leaved evergreen or semi-evergreen tree species. The region experiences heavy rainfall, high summer temperature and mild cold during winter months. The forests have well marked tiered arrangement of species according to height. The top canopy composed of tall trees which shed their leaves for a short period during February-March. However, the under storeys remain evergreen. *Terminalia myriocarpa* Heurck. & Muell. is the most dominant species that occurs in pure stands near the river banks. The other prominent species of the top canopy are *Ailanthus grandis*, *Phoebe cooperiana* U.N. Kanjilal Das, *Duabanga grandiflora*, *Terminalia citrina* Roxb. ex Flem., *Terminalia belerica* Roxb., *Magnolia* spp., *Elaeocarpus aristatus* Roxb., *Pterospermum acerifolium*, Willd., *Gmelina arborea* L., *Acrocarpus fraxinifolius* Wight, *Sapindus mukorossi* Gaertn., *Artocarpus chaplasa* Roxb., *Morus laevigata* Wall., *Bischofia javanica* Blume, *Dillenia indica*, *Sterculia villosa* Roxb., *Sapium baccatum* Roxb., *Castanopsis indica* (Roxb.) A. DC., *Bombax ceiba* Burm. *Albizia procera* (Roxb.) Benth., *Firmiana colorata*, etc.

The middle storey is dominated by *Castanopsis indica*, *Chukrasia tabularis* A. Juss., *Bischofia javanica*, *Syzygium cumini*, (L.) Skeels. *Kydia calycina* Roxb., *Magnolia hodgsonii*, (Hook. *f.* & Th.) Keng, *Garcinia pedunculata* Roxb., *Litsea panamonja*, Hook *f.*, *Quercus lanceaefolia* Roxb., *Macaranga denticulata*, (Blume) Muell., *Stereospermum chelonoides* DC., *Dysoxylum procerum* Hiren, *Vatica lanceaefolia* (Roxb.) Blume, *Albizia lucida* (Roxb.) Benth., *Premna latifolia* Roxb., *Saurauja cerea*, Griff., *Gynocardia odorata*, Br., etc.

In the shrubby and herbaceous layers *Clerodendrum*, *Mussaenda*, *Boehmeria*, *Maesa*, *Anplectrum*, *Osbeckia*, *Impatiens*, *Phlogacanthus*,

Eupatorium, Alpinia, Laportea, Casearia, Leea, Calamus, Phrynium are quite common. *Livistona jenkinsiana* Griff. is seen occasionally.

These forests support a variety of climbers namely *Acacia, Vitis, Porana paniculata* Roxb., *Mucuna macrocarpa* Wall., *Thunbergia grandiflora* Roxb., *Entada pursaetha* DC., *Conocephalus cochinchinensis, Smithia, Callicarpa, Hodgsonia macrocarpa* (Blume) Cong., *Tinospora, Gnetum* sp., *Bauhinia vahlii* Wight & Arn., *Spatholobus roxburghii,* (Blume) Cogn., *Ficus scandens* Roxb., *Mikania micrantha* Kunth.

The tall trees with their dense close canopy enhances humidity in the atmosphere thus provide excellent conditions for the luxurient growth epiphytic orchids namely, *Aerides, Pholidota, Dendrobium, Bulbophyllum, Cymbidium, Eria, Phalaenopsis* etc. and various types of ferns.

In certain places, low hill plain and semi-evergreen riverine forests are also found which occur in areas affected by floods and occasional inundations by large rivers. Such forests to a certain extent differ in species composition. In certain cases, the middle storey is absent and its place is taken over by shrubby layer. The top storey or canopy is dominated by *Terminalia myriocarpa* Heurck. & Muell., *Albizia lucida* (Roxb.) Benth., *Bombax ceiba* Burm, *Sterculia villosa* Roxb., *Dillenia indica* L., *Bischofia javanica, Pterospermum acerifolium* Willd., *Aglaia hiernii* Visw. & Ramach., *Stereospermum chelonoides* DC., *Magnolia* spp., *Ailanthus grandis* whereas, *Litsea monopetala* Pers., *Ficus elmeri* Merr., *Micromelum integerrimum* (Roxb.) Wight & Arn. *ex* Roem., *Meyna laxiflora, Maesa* species are some of the common elements of the middle storey. Species of *Musa* , *Alpinia, Phrynium, Calamus, Hedychium, Costus, Phragmites, Maranta* are encountered in marshy places. Amongst the orchids, *Dendrobium, Papilionanthe, Aerides, Rhynchostylis, Eria, Bulbophyllum* are most common.

2. **SUBTROPICAL FORESTS :** These can be divided into 2 subtypes.

(i) **Subtropical broad leaved evergreen Forests :** This region receives lesser rainfall but is characteristically cooler with humid climate. The vegetation is dense, broad leaved evergreen type generally dominated by the members of the Fagaceae. Such forests have distinct storeyed nature. The top storey or canopy is dominated by species namely *Quercus lamellosa* Smith, *Q. elegans* Blume, *Q. spicata* Smith, *Acer niveum* Blume, *Engelhardtia spicata* Blume, *Michelia oblonga* Wall., *Schima wallichii* Chois, *Albizia arunachalensis* Sahni & Naithani, *Castanopsis* spp., *Ficus* spp., *Photinia* sp., *Manglietia insignis* Blume, *Ulmus lancifolia* Roxb. whereas, species of *Cinnamomum, Rhododendron, Myrsine, Eurya, Symplocos. Wendlandia, Schefflera* are the main constituent of the middle storey.

The shrubby and herbaceous layer is much more pronounced and is composed of *Mahonia nepalensis* DC., *Eurya acuminata* DC., *Plectranthus ternifolius* D.Don, *P. undulata* L., *Viburnum foetidum* Wall., *Camellia caduca* Brandis, *Sophora acuminata* Benth., *Vernonia saligna* DC., *Rosa indica L., Ardisia, Oxyspora, Boehmeria, Astilbe, Symplocos, Rubus, Gaultheria, Anaphalis* spp., *Anemone vitifolia* Ham., *Inula, Justicia khasiana* C.B. Clarke, *Leucas ciliata* Benth., *Osbeckia stellata* Wall., *Plantago major* L., *Oxalis, Polygonum, Potentilla* sp., etc. Among the climbers *Clematis, Thunbergia, Holboellia, Clitoria, Dioscorea, Jasminum, Lagenaria, Lygodium, Senecio scandens* D.Don, *Codonopsis javanica* Hook.f. & Th., *Crawfurdia speciosa* Wall., etc. are common.

These forests offer congenial climate for the epiphytic forms which include a large number of orchids, ferns, bryophytes, lichens, etc. *Arachnis, Bulbophyllum, Cleisostoma, Coelogyne, Eria, Liparis, Cymbidium, Dendrobium, Vanda* species are common. On moss covered tree trunks *Peperomia reflexa* A.Dietr. can be seen growing as an epiphyte alongwith *Chirita, Aeschynanthus, Vaccinium, Agapetes* species. The moist, humus rich forest floor harbours a variety of ground orchids, like species of *Anthogonium. Calanthe, Phaius. Malaxis. Oberonia. Nervilia, Chrysoglossum*, etc.

(ii) **Subtropical/Temperate Pine Forests :** These forests extend both in subtropical and temperate zones and normally occur in rain shadow areas. Such forests are represented mainly by Species of *Pinus* and are generally associated with *Alnus nepalensis* D.Don, *Rhododendron arboreum* Smith, *Lyonia ovalifolia* (Wall.) Drude, *Rhus javanica* L., *Gaultheria* sp., *Corylopsis himalayana* Griff., *Spiraea callosa* Thunb., *Artemisia nilagirica* (C.B. Clarke) Pamp., *Osbeckia stellata, Ajuga, Coriaria, Indigofera, Photinia, Desmodium, Rubia, Rubus* spp. These forests lack epiphytic forms, however, orchids like *Otochilus, Coelogyne, Dendrobium* species can still be seen. In moist shady places of such mixed forests few terrestrial orchids viz., *Calanthe, Habenaria, Phaius, Pleione, Satyrium nepalense* D.Don are seen.

3. **TEMPERATE FORESTS:** This group can be divided into 2 subtypes depending upon the moisture availablility.

(i) **Temperate broad leaved forests :** This type is found between 1800 and 2800 m in cold climatic regions with severe winter coupled with moderately high rainfall. They exhibit complex structure. The top canopy is represented by tall trees, like *Betula, Magnolia campbellii* Hook. *f.* & Th., *Alnus nepalensis* D. Don,, *Quercus lamellosa* Smith, *Exbucklandia populnea* (R. Br. ex Griff.) R.W. Br., *Castanopsis indica* (Roxb.) Miq., *Acer oblongum* Wall., *A. pectinatum* Wall., *A. leavigatum* Wall., *Symplocos spicata* A. DC., *Michelia* sp., *Rhododendron* sp., *Sorbus* sp., *Euoynymus* sp. etc. The lower storeys are occupied by small trees and shrubs like- *Lyonia ovalifolia* (Wall.) Drude, *Vaccinium doniannum* Wight, *Myrsine semiserrata* Wall., *Corylopsis himalayana* Griff., *Illicium griffithii* Hook *f.* & Th., *Ribes* sp., *Benthamidia* sp., Gregarious patches of *Chimonobambusa* are also seen. The ground flora consists of species of *Fragaria, Begonia, Geranium, Corydalis, Polygonum. Thalictrum. Anaphalis, Valeriana* and *Coptis teeta* Wall. in some places. Climbers like *Holboellia, Rubus, Codonopsis* species etc are of rare occurrence. Various kinds of

epiphytes such as *Rhododendron*, *Agapetes*, *Vaccinium*, *Aeschynanthus* alongwith orchid species of *Eria*, *Vanda*, *Cymbidium*, *Otochilus*, *Coelogyne*, *Bulbophyllum*, are of common occurrence alongwith many types of ferns and fern allies like species of *Lycopodium*, *Selaginella*., etc.

(ii) **Temperate coniferous forests :** These forest types are confined to hill tops between 2800 and 3500 metres which experience regular snowfall during winter months. These are dominated by top canopy species like *Abies densa* Griff., *Tsuga dumosa* (D.Don) Eichler, *Cupressus torulosa* D. Don, *Taxus baccata* sub sp. *wallichiana*, *Larix* sp., etc. Sometimes, broad leaved tree species of *Rhododendron*, *Sorbus*, *Photinia*, *Betula*, *Schefflera*, *Quercus*, *Ilex*. etc. are seen associated with these conifers. The lower layers are mainly dominated by shrubs and herbs of which *Hypericum*, *Rheum*, *Berberis*, *Plectranthus*, *Polygonum*, *Rumex*, *Mahonia*, *Rubus*, *Rosa*, *Pedicularis*, *Podophyllum*, *Silene*, *Drymaria*, *Sambucus*, *Agapetes* are prominent. The climbers are very rare and are represented by species of *Lonicera*, *Crawfurdia*, *Rubus*, etc. Lichens, Bryophytes, fungi and ferns dominate the epiphytic flora in these forests.

4. **SUB-ALPINE AND ALPINE FORESTS :** These forests occupy the highest altitude (3500-5500 m) and generally lack tree species. Being covered by snow for a major period of the year, the vegetation is faced with adverse and extremes of the climatic conditions not favourable for its growth and survival. The plants of this zone exhibit amazing survival strategies (Chowdhery & Rao, 1992). Influenced by the severe climatic conditions, these plants have evolved to complete life cycle in short span before the short and favourable growing season is over. They produce spectacular, attractive, flamboyant red, yellow, blue and violet flowers to attract insect pollinators.

In the lower altitudes of this zone between 3500-4000 m, tree species like *Cupressus torulosa*, shrubby or bushy *Rhododendron* spp., *Tsuga dumosa* are seen with few epiphytic orchid species like *Bulbophyllum*,

Pleione hookeriana (Lindley) Moore and terrestrials like *Gymnadenia orchidis* Lindl., *Spathoglottis ixioides* Lindl., *Habenaria cumminsiana* King & Pantl., *Herminium lngilobatum* Hegde & Rao which are found associated with other plants viz., *Aconitum*, *Primula*, *Gentiana*, *Rhodiola*, *Saussurea*, *Saxifraga*, *Sedum*, etc.

The alpine zone that occurs between 4000 5500 m, is also referred as alpine meadow. The plants here are gregarious and mostly herbaceous viz., *Rhododendron*, *Gaultheria*, *Ribes*, *Vaccinium*, *Anaphalis*, *Pedicularis*, *Aster*, *Silene*, *Swertia*, *Stellaria*, *Sedum*, *Saxifraga*, *Arenaria*, etc.

Besides the above types of forest, there are other recognisable habitats such as Jhum lands, degraded forests, grasslands and bamboo forests. Among these, the former two are the results of human activities, causing heavy damage to primary forests.

Jhum Lands : 'Jhum' lands are generally abandoned after 2-3 years. These fallowlands are invaded by *Trema orientalis* Blume as a weed associated with *Macaranga peltata* Muell., *Mallotus albus* Muell., *Calamus erectus* Roxb., *Pseudostachyum polymorphum* Munro, species of *Mikania*, *Eupatorium*, etc.

Degraded Forests : These forests have a very low species diversity and are generally dominated by inferior quality of trees and shrubs. The commonly encountered species are *Mallotus tetracoccus* (Roxb.) Kurz, *Macaranga denticulata* (Blume) Muell., *Callicarpa arborea* Roxb., *Bauhinia*, *Glochidion*, *Saurauja nepalensis* DC., *S. roxburghii* Wall., *Maesa indica* Wall., *Zanthoxylum*, *Sambucus*, *Capparis*, *Clerodendrum*, *Croton*, *Eurya*, *Randia*, *Rubus* species and weeds like *Mikania*, *Eupatorium*, *Ageratum*, etc.

Bamboo Forests : Such forests normally develop in abandoned Jhum' lands. The common bamboo species are *Arundinaria* spp., *Chimonobambusa callosa* Nakai., *Dendrocalamus hamiltonii* Nees. & Arn., *Pseudostachyum polymorphum* Munro *Cephalostachyum fuchsianum* Gambel, *Schizostachyum helferi* (Munro) Majumdar etc.

Grass Lands : These are formed due to 'Jhum' cultivation and occassional fires at high altitudes or overgrazing. A variety of grasses invade such areas intermingled with trees namely *Bombax ceiba* Burm., *Duabanga grandiflora* (Roxb. ex DC.) Walp., *Macaranga denticulata* (Blume) Muell. etc.

Some of the most common plants available in the area are presented in Table - 1 along with local names.

GYMNOSPERMS

Arunachal Pradesh harbours a rich Gymnospermous flora as compared to other states of India. Conifers are economically the most valuable amongst the Gymnosperms as they are used as fuel wood, timber for house construction and resin. Out of 33 species of Gymnosperms known from Arunachal Pradesh (Beniwal & Haridasan, 1992) 12 of them occur in Dibang valley.

Abies densa Griff.
A. spectabilis Spach.
Amentotaxus assamica Ferguson
Cephalotaxus griffithii Hook. f.
Gnetum montanum Mgf.
Juniperus recurva Buch.-Ham.
Larix griffithiana Hort. ex Carr.
Pinus armandi Franchet
P. merkusii Jung
P. spinulosa Henry
Taxus baccata L. Subsp. *wallichiana* (Zucc.) Pilger
Tsuga dumosa (D. Don) Eichler

ECONOMICALLY IMPORTANT PLANTS

The rich and diverse flora of Dibang Valley contains a large number of economically important plants such as medicinal, aromatic, ornamental, horticultural, wild edible, timber and fodder species. Some important plants under various heads are given below.

A. **Medicinal Plants:** Dibang valley abounds in a variety of medicinal plants. Some of the commercially exploited medicinal plants found here are *Aconitum* spp., *Rheum emodi* Wall., *Podophyllum hexandrum* Royle, *Berberis* spp., *Halenia* sp., *Taxus baccata* L. subsp. *wallichiana, Coptis teeta, Gaultheria fragrantissima, Panax* spp., *Picrorhiza kurrooa* Royle ex Benth., *Nardostachys jatamansii* DC., *Aquilaria malaccensis* Lam., *Piper brachystachyum* Benth., *Paederia foetida* Benth, *Cissus quadrangularis* L., *Litsea cubeba* (Lour.) Pers., *Plectranthus japonica* (Burm. *f.*) Koidz., *Zanthoxylum* spp. etc. Detailed explorations, surveys and collection of ethnobotanical information from the locals with simultaneous scientific screening of the indigenous medicinal plants will yield data on plants which can be exploited on commercial basis. Local farmers here grow *Coptis teeta* for sale in Assam and Calcutta (W. Bengal). According to an estimate (Forest Department, Arunachal Pradesh, 1981), during 1972-1978, 7691.57 kg, dried rhizomes of *Coptis teeta* were sold for Rs. 2,89,139.50.

B. **Timber Yielding Plants:** Many valuable timber yielding species occur in these forests. Some such important ones which are being commercially exploited are given under :

Ailanthus grandis, Albizia lucida, (Roxb.) Benth. L. *A. lstonia scholaris* (L.) R. Br., *Anthocephalus chinensis* (Lam.) A. Rich. *ex* Walp., *Artocarpus chaplasha* Roxb., *Altingia excelsa* Nor, *Aglaia hiernii* Visw. & Ramac. *Artocarpus lakoocha* Roxb., *Bombax ceiba, Bischofia javanica, Bauhinia variegata* L., *Betula alnoides* Ham., *Canarium bengalensis* Roxb., *Canarium resiniferum* Brace & King., *Chukrasia tabularis* A. Juss., *Castanopsis indica, Dysoxylum procerum* Hiern., *Dysoxylum hamiltonii Hiren., Dysoxylum binectariferum* (Roxb.) Hook. *f.* & Bedd., *Dillenia indica, Duabanga grandiflora, Echinocarpus assamicus* Benth., *Eurya acuminata* DC., *Gmelina arborea, Gynocardia odorata, Mesua assamica* (King & Prain) Kosterm., *Kydia calycina* Roxb., *Michelia champaca, L., Mesua ferrea,* L., *Morus laevigata,* Wall., *Macaranga denticulata* (Blume) Muell., *Magnolia pterocarpa* Roxb., *Pterospermum acerifolium* Willd, *Phoebe goalparensis, Phoebe paniculata.* Nees, *Pinus roxburghii, Pinus*

wallichiana A.B. Jackson, *Picea* sp., *Sterculia villosa* Roxb., *Sterculia* sp., *Schima wallichii* Chois., *Terminalia myriocarpa* Heurck & Muell., *Tetrameles nudiflora* R..Br. *Magnolia hodgsonii*, (Hook. f. & Th.) Keng, *Michelia baillonii* (Pierre) Finet & Gagnepain, *Tsuga dumosa* etc.

C. **Ornamental Plants**: A wide range of attractive wild ornamental plants occur in the flora of Dibang valley.

i) **Orchids :** Orchids are among the most beautiful creation of nature and are well known for their attractive, colourful flowers which need no introduction. Out of 525 species of orchids, which occur in Arunachal, about 200 are expected to form the part of the local flora. This includes many rare, endangered and endemic species. A large number of ornamental species of *Coelogyne, Cymbidium, Dendrobium, Vanda, Phalaenopsis, Phaius, Pleione, Aerides, Calanthe,* etc. are found growing in these forests and have a great potential for exploitation as horticultural species. A highly ornamental and endemic species of Lady's slipper orchid, *Paphiopedilum wardii* Summerh., known only from Lohit and Dibang valley districts of Arunachal Pradesh is now considered to be extinct.

ii) **Rhododendrons :** Rhododendrons are evergreen highly ornamental, flowering plants and many species have been successfully introduced in cultivation. Several species that occur in Dibang Valley have attractive flowers and can be grown in the gardens in cooler regions.

iii) **Hedychiums :** These are most beautiful, fragrant floweing plants of the Ginger family (Zingiberaceae) and can be easily grown through rhizomes in the gardens.

iv) **Others :** Apart from the above well known ornamental groups of plants, there are several other wild species available in these forests which have showy flowers and are easily cultivable. Some of such selected plants are the species of genera like-

Begonia	flowers and foliage.
Impatiens	flowers
Tacca	flowers and foliage
Lagerstroemia	flowers
Erythrina	flowers
Agapetes	flowers
Phlogacanthus	flowers
Melastoma	flowers and foliage
Clerodendrum	flowers and foliage
Ixora	lowers
Jasminum	flowers
Hypericum	flowers
Aster	flowers
Magnolia	flowers and foliage
Camellia	flowers and foliage
Michelia	flowers

Apart from these trees, shrubs and herbs certain climbers like species of *Aristolochia, Clematis, Combretum, Hedera, Thunbergia, Rhaphidophora* can easily be trained as ornamental climbers.

A large variety of ferns and fern allies, *Pothos,* Bamboos, *Ficus,* Palms, Canes, *Philodendron* and many kinds of aroides can be successfully exploited for their beautiful foliage for indoor and outdoor.

D. Wild Relatives of Crop Plants

A variety of legumes, cucurbits, chillies, colocasia, ginger, cereals, etc. are under cultivation by the locals of Dibang valley. These have been selected after years of trial and selection from among the locally growing wild relatives. Apart from these a wide range of wild relatives of many medicinal, crop plants occur in these forests like, *Camellia, Musa, Citrus,* Cucurbits, *Capsicum, Vitis, Dioscorea, Curcuma, Zinger, Colocasia,* wild mango, many legumes and millets etc. A very interesting small sized tree - *Edgeworthia gardeneri* C.F. W. Meissn.is found in this district whose bark is very much similar to currency note paper in quality.

E. Rare, Interesting and Endemic Plants:

The rich diversity of this region is in great danger at present due to ever increasing human pressure on the forests and natural resources. Some species have become rare/threatened or even extinct like the Lady's Slipper Orchid *Paphiopedilum wardii* Summerh. Species of *Aconitum, Rhododendron,* orchids, *Coptis teeta, Panax* spp, *Taxus baccata.* subsp. *wallichina, Dioscorea* spp., *Aquilaria malaccensis, Podophyllum hexandrum, Balanophora dioica* Br., *Sapria himalayana* Griff., *Rheum* sp. are some of the known plants which fall under the rare, threatened or endangered category. Certain ferns like *Angiopteris evecta* Hoffm., *Polystichum lentum, Dipteris wallichii* (B. Br.) Moore and the species of *Cyathea* (tree fern) are also rare or threatened.

Leycesteria dibangvalliensis Das & Giri, *Albizia arunachalensis,* Giri, *Maesa nayarii* Giri, *Sonerila arunachalensis, Begonia aborensis* Dunn, *Coptis teeta, Agapetes refracta* Airy-Shaw, *Capparis pachyphylla* Jacobs, *Lysimachia congestiflora* forma *santapaui* (Subba Rao & Holim) Deb, *Polystichum lentum, Rhynchotechum calycinum* C.B. Clarke etc. are some of the endemic species to Dibang valley (Arunachal Pradesh).

F. Primitive Plants:

The presence of many primitive plant species like *Exbucklandia populnea* (R. Br. *ex.* Griff.) R.W. Brown *Altingia excelsa* Nor., *Alnus nepalensis* D.Don, *Betula alnoides, Myrica esculenta, Magnolia hodgsoni* (Hook.*f* & Th.) Keog, *Haematocarpus Validus* (Miers) Bakh. *f. ex* Forman, *Euptelea pleiosperma* Hook.*f.* & Th., *Houttuynia cordata* Thunb. and species of *Magnolia* L. indicates that the flroa of this region is primitive lending support to Takhtajan's view.

Although the rich diversity of the flora of Dibang valley is well acknowledged but the comprehensive account on the flora and plant resources is still lacking. Vast areas of the district are still unexplored or underexplored. It is felt that proper inventorisation of the flora and plant resources of Dibang valley is essential for its monitoring and management schemes.

CONSERVATION MEASURES

Like other parts of the state, the forests in Dibang Valley are the only source of livelihood for the local population. The 'Jhum' cultivation practiced by these tribes has been under controversy as it causes destruction of forests and soil erosion. Now, attempts are being made to encourage wet cultivation in villages which increases the yield; terracing and contour bunding for hill slopes under cultivation in order to check the soil erosion/land slides; to grow vegetables, fruits and other cash crops to earn extra income. *Coptis teeta,* coffee etc. are now being grown by the locals. Apart from this, various minor forest products like leaves, thatch, ballies, polls, dhuna resin, simul cotton and medicinal herbs are also collected for sale.

In order to protect these forests from further degradation and to afforest vast tracts of abandoned 'Jhum' cultivation lands, the Government (State & Central) has initiated several conservation measures. These include:

Constituting Reserve Forests.

Scientific Management and protection of forests.

Apna Van Programme: This scheme involves afforestation of waste land, abandoned Jhum land and degraded forests by individual or community with subsidy from State Government @ Rs. 2500/- per hectare for 5 years with a ceiling of 5 hectare for an individual and 20 hactare for a village community. The beneficiary will have the absolute right on the plantation produce including timber. The scheme is now very popular and successful.

Minimum Need Programme: The scheme has been launched to meet the ever increasing fuel wood demand of the local propulation. Here the plantation is raised in abandoned Jhum/Wasteland and degraded forests in the vicinity of the villages with participation from the villagers. These plantations will meet the fuel requirement of the population thus relieving pressure on the forests for fuel wood and will also help in improving the ecological balance in the area.

Decentralised Peoples Nursery: In this scheme a farmer/student can raise a nursery of economically important plants and the seedlings thus raised will be purchased by the Government @ 70 paisa per seedling.

Integrated Wasteland Development Project & National Wasteland Development Project for Rainfed Area.

Area Oriented Fodder, Fuelwood Plantation Project: An interesting Non-Governmental Afforestation programme has been launched by the local tribal people in Dibang valley where plantations are being raised on their own land with the finances from the industrialists. The mature plantation products and timber etc. from these plantations will be supplied to the sponsoring wood based industries. Fast growing species like Kadam, Khokan are being grown which mature in 10-15 years.

Protected Areas for the in-situ conservation of natural resources: Three protected areas have been designated in Dibang valley district:

1- Mehao Wildlife Sanctuary : Area 281.50 sq. km.

2- Dibang Wildlife Sanctuary : Area 4149 sq. km.

3- Dihang Dibang Biosphere Reserve : Area about 8400 sq. km (Proposed).

DIHANG-DIBANG BIOSPHERE RESERVE

Conducive climate coupled with other favourable ecological factors and the unique geographical location of Dibang valley has evoked enough attention of the conservationists and Governmental agencies to establish a Biosphere Reserve in this area. Consequently a Biosphere Reserve called Dihang Biosphere Reserve has been proposed to setup carving out areas mainly from Dibang valley and certain areas from Upper Siang and

West Siang districts. The proposed Biosphere Reserve foster a vegetation which is luxurious in its density and most varied in its species contents. Spreading over an area of about 83400 sq. km, Dihang-Dibang Biosphere Reserve has virgin forests. The abandoned jhum lands have scrub jungles of secondary vegetation. The core zone of the proposed Biosphere Reserve covers 80% of the total area and includes Mouling National Park(483 sq km), Dibang Wildlife Sanctuary (4149 sq km) and some other areas. There are a few villages within the buffer zone and in the immediate vicinity of the reserve.

Table-1: Common Plants of Dibang Valley

1. TREES

Botanical name	Local name
Lagerstroemia reginae Roxb.	Ajhar
Mangifera indica L.	Am
Aglaia hiernii Visw & Ramch.	King Amari
Spondias pinnata Kurz	Amora
Myristica kingii Hook. *f.*	Amul
Beilschmiedia assamica Meissn.	Amsoi
Emblica officinalis Gaertn.	Amloki
Dysoxylum binectariferum Hook. *f.*	Banderdima
Magnolia hodgsonii (Hook.f. & Th.) Keng	Baramthuri
Crataeva religiosa Ham.	Barun
Aesculus assamica Griff.	Bhishgach
A. punduana Hiern	Bikhsopa
Litsea panamonja Buch.-Ham.	Bhuisopa
Terminalia belerica Roxb.	Bohera
Chukrasia tabularis A. Juss.	Bogipoma
Eugenia praecoxum Roxb.	Bogijamuk
Morus laevigata Wall.	Bola
Elaeocarpus varunua Ham. ex Mast.	Bonjalpai
Ailanthus integrifolia Lamk.	Borpat
Ehretia acuminata R. Br.	Bual
Mangifera sylvatica Roxb.	Bon Am

Botanical name	Local name
Pterospermum acerifolium Willd.	Bon Baguri, Hatipoila
Clematis cadmia Ham.	Banjalkia
Hydnocarpus kurzii (King) Warb.	Chalmugra
Gynocardia odorata R. Br.	Dalmugra
Artocarpus lakoocha Roxb.	Dewachali
Heritiera papilio Bedd.	Dhaman
Canarium strictum Roxb.	Dhuna
Ficus lamponga Miq.	Dimaru
Ficus bengalensis L.	Bor
Magnolia griffithii Hook. *f.* & Th.	Gahorisopa
Dysoxylum hamiltonii Hiern	Gendhelipoma
Premna bengalensis Clarke	Gohora
Gmelina arborea Roxb.	Gomari
Cinnamomum glaucescens (Nees) Meisn.	Gonsorai
Crypteronia paniculata Blume	Gorumara
Adina cordifolia (Roxb.) Hook. *ex.* Brandis.	Haldu
Castanopsis indica DC.	Hingori
Laportea crenulata Gaud.	Hatisurat
Terminalia myriocarpa Heurck & Muell.	Hollock
Terminalia citrina (Gaertn.) Flem.	Hilka
Elaeocarpus floribundus Blume	Jalpai
Syzygium cumini (L.) Skeels	Jamuk
Lannea coromandelica (Houtt.) Merr.	Jiapoma
Echinocarpus assamicus Benth.	Jabahingori
Altingia excelsa Nor.	Jutuli
Anthocephalus chinensis (Lamk.) A. Rich ex Walp.	Kadam
Bauhinia spp.	Kachnar
Duabanga grandiflora (Roxb. ex DC.) Walp.	Khokan
Talauma phellocarpa King	Khorikasopa
Albizia procera (Roxb.) Benth.	Koroi
Drypetes assamica (Hook. *f.*) Pax. & Hoffm.	Koliori
Leea indica (Burm. *f.*) Merr.	Kukura thengia
Beilshmiedia brandisii Hook. *f.*	Leluk

Botanical name	Local name
Baccaurea sapida (Roxb.) Muell.	Le teku
Erythrina suberosa Roxb.	Madar
Schima wallichii Chois.	Ma riasal
Phoebe cooperiana U.N. Kanjilal & Das	Mekahi
Albizia lucida (Roxb.) Benth.	Moj
Mallotus tetracoccus (Roxb.) Kurz	Morolia
Vatica lanceaefolia Blume	Morhal
Pterospermum lanceaefolium Roxb.	Mota Nahor
Mesua ferrea L.	Nahor
Dillenia indica L.	Owtenga
Stereospermum chelonoides DC.	Paroli
Trema orientalis Blume	Phakdima
Michelia oblonga Wall.	Phul sopa
Kydia calycina Roxb.	Pichola
Endospermum diadenum (Miq.) Airy Shaw	Phulgamari
Endospermum chinense Benth.	Phulgamari
Toona ciliata Roem.	Pom
Olea dioica Roxb.	Poreng
Sapindus mukorossi Gaertn.	Ritha
Elaeocarpus ganitrus Roxb.	Rudrakshya
Artocarpus chaplasha Roxb.	Sam
Alstonia scholaris (L.) R. Br.	Satiana
Sapium baccatum Roxb.	Selleng
Mesua assamica (King & Prain) Kosterm.	Nahor
Lagerstroemia parviflora Roxb.	Sida
Bombax ceiba Burm.	Simul
Albizia procera (Roxb.) Benth.	Siris
Magnolia or *Manglietia* spp.	Sopa
Cinnamomum tamala Nees	Tejpat
Knema linifolia (Roxb.) Warb.	Tejranga
Garcinia spp.	Thekera
Michelia oblonga Wall.	Titasopa
Sterculia villosa Roxb.	Udal
Bischofia javanica Blume	Urium

Botanical name	Local name
2. SHRUBS	
Pteris quadriaurita Retz.	Bihlongoni
Randia dumetorum (Retz.) Lamk.	Bihmona
Clerodendrum viscosum Vent.	Bhat,Dhopat tita
Saurauja punduana Wall.	Bonposola
Eupatorium odoratum L.	Garmau lota
Solanum subtruncatum Wall.	Hatibhekuri
Citrus spp.	Kol gach
Lantana camara var. *aculeata* (L.) Moldenke	Lantana
Melastoma malabathricum Linn.	Phutukg
Coffea bengalensis Roxb.	Kothnaphul
Phlogacanthus thrysiflorus (Roxb.) Nees	Tita
Rubus ellipticus Sm.	Jetelupoka
3. GRASSES	
Saccharum ravennae Murr.	Murr. Ikra
Saccharum spontaneum L.	Khagri
Phragmites karka Steud.	Nal
Imperata cylindrica (L.) Raeusch.	Thatch
4. CANES AND PALMS	
Pinanga gracilis Blume	Garuga tamul
Calamus latifolius Roxb.	Hauka bet
Calamus tenuis Roxb.	Jati bet
Calamus erectus Roxb.	Jengu
Calamus floribundus Griff.	Lejai bet
Calamus flagellum Griff.	Raidang bet
Livistona jenkinsiana Griff.	Tokopatta
5. BAMBOOS	
Schizostachyum polymorphum (Munro) R. Majumdar	Bojal bans

Botanical name	Local name
Bambusa tulda Roxb.	Jati bans
Dendrocalamus hamiltonii Munro	Kabo bans Kako bambu or
6. CLIMBERS	
Stenochlaena palustre L.	Dhekia lota
Heptapleurum venulosum Seem.	Dhobai lota
Bauhinia vahlii Wight & Arn.	Ghila lota
Vitis latifolia Roxb.	Gowalia lota
Tinospora cordifolia Miers	Miers Hogum
Spatholobus roxburghii Benth.	Hati lota
Acacia pennata Willd.	Kuchai
Ficus scandens Roxb.	Dimoru lota
Roydsia suaveolens Roxb.	Madhumalti
Gnetum scandens Roxb.	Mermeri lota
Mikania micrantha Kunth	Mikania
Vitis planicaulis Hook. *f.*	Pani lota

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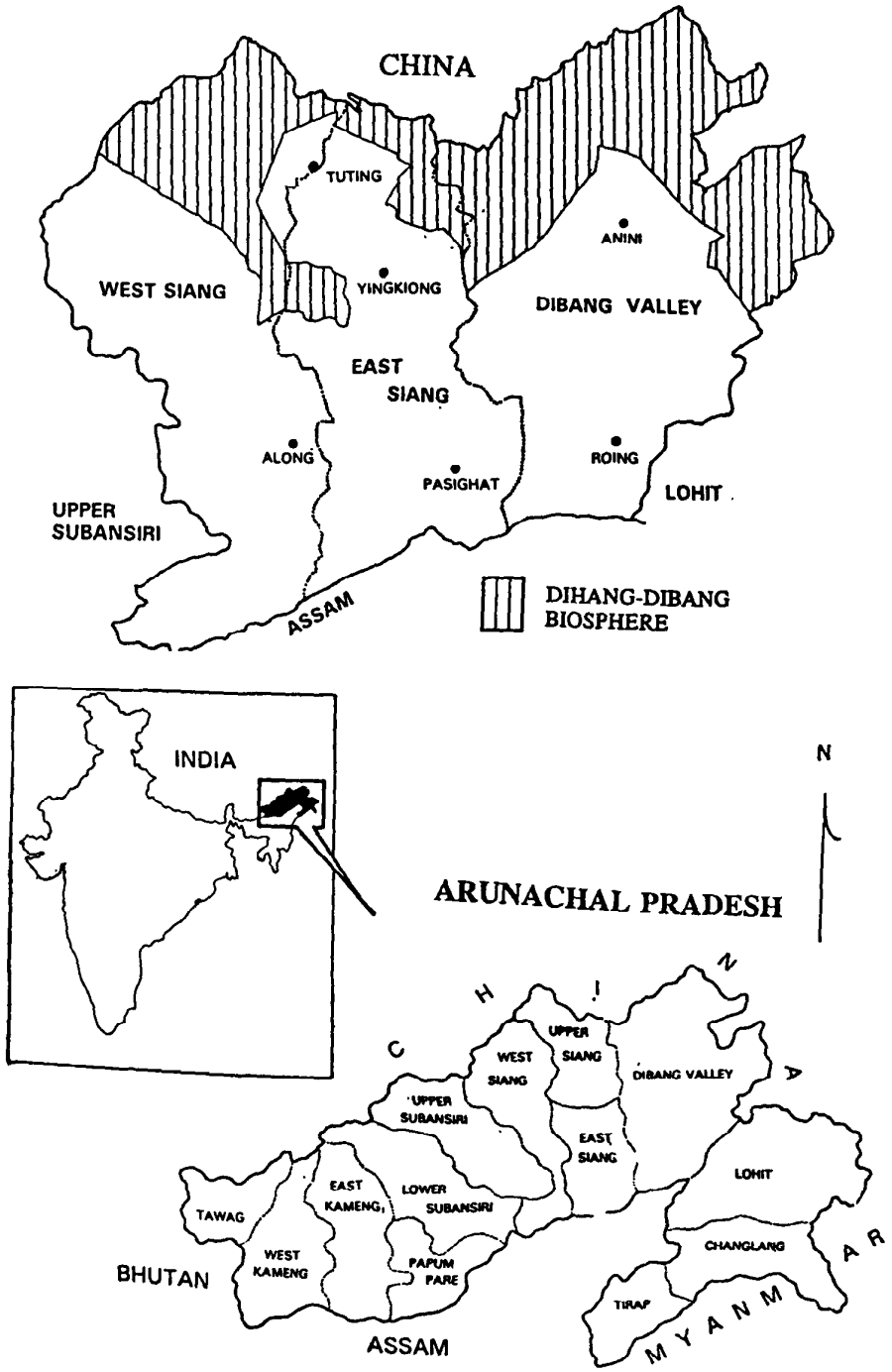


Dibang Valley.

Aquilaria malaccensis Lamk.
A medicinal plant. The plant is rare and threatened due to its excessive and indiscriminate exploitation.
(Courtesy : K. Haridasan)

Mithun - The semi domesticated cow is the state animal of Arunachal Pradesh
(Courtesy : H.J. Chowdhery)

Gmelina arborea Roxb. - A useful timber tree.
(Courtesy : H.J. Chowdhery)

Dipteris wallichii (R. Br.) Moore - A rare fern.
(Courtesy : H.J. Chowdhery)

Musa balbisiana Colla - Wild banana.
(Courtesy : H.J. Chowdhery)

Melastoma normale D. Don - A shrub with large attractive flowers.
(Courtesy : H.J. Chowdhery)

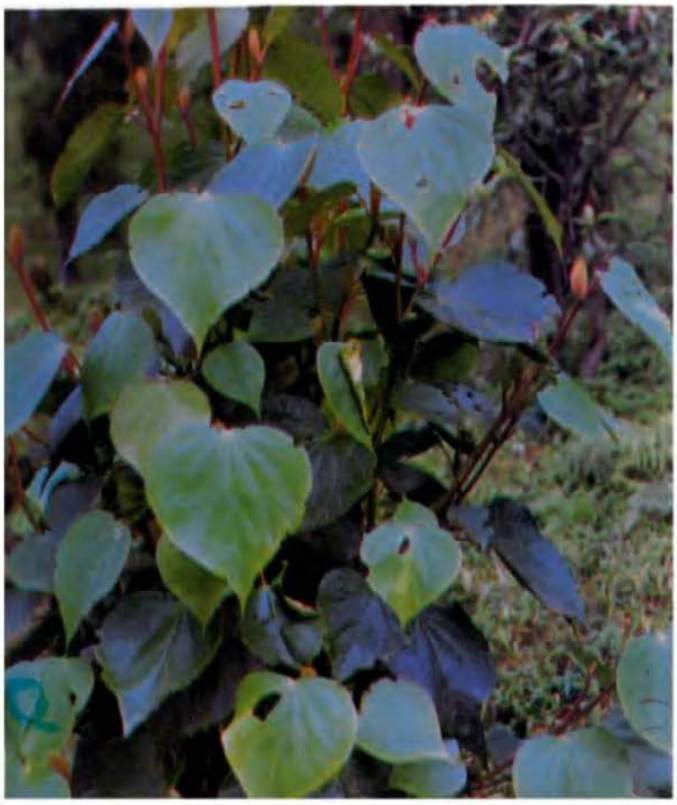
Impatiens latifolia Hook. *f.* & Th. - An ornamental herb.
(Courtesy : H.J. Chowdhery)

Cyathea gigantea (Wall. *ex* Hook.) Holt. (Tree fern) - A threatened species.
(Courtesy : H.J. Chowdhery)

Dibang Valley - A typical hanging bridge made of canes, bamboos and liana on a river.
(Courtesy : Manas Bhaumik & M.K. Pathak)

Tropical forest : Lower storey in open places along the streams.
(Courtesy : H.J. Chowdhery)

Anini (Dibang Valley) - Barren looking slopes and hillock which are covered with grasses upto 1.5 m tall.
(Courtesy : Manas Bhaumik & M.K. Pathak)



Exbucklandia populnea (R. Br. *ex* Griff.) R. W. Br. : A primitive angiosperm.
(Courtesy : H.J Chowdhery)

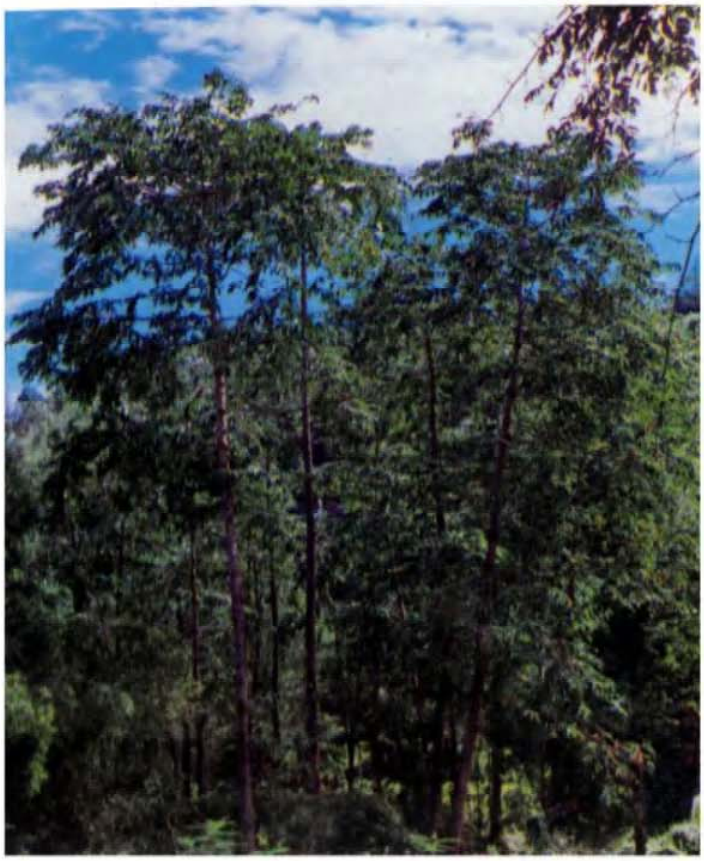
Dibang Valley - Grassy slopes with coniferous forests in the pockets.
(Courtesy : Manas Bhaumik & M.K. Pathak)

Amomum subulatum Roxb. : Wild large cardamon in flower.
(Courtesy : H.J. Chowdhery)

Amomum subulatum Roxb. : Wild large cardamon-mature fruits.
(Courtesy : H.J. Chowdhery)

Vanda stangeana Reichb. *f.* - A rare, ornamental orchid.
(Courtesy : H.J. Chowdhery)

Cymbidium iridioides D. Don
(Courtesy : H.J. Chowdhery)

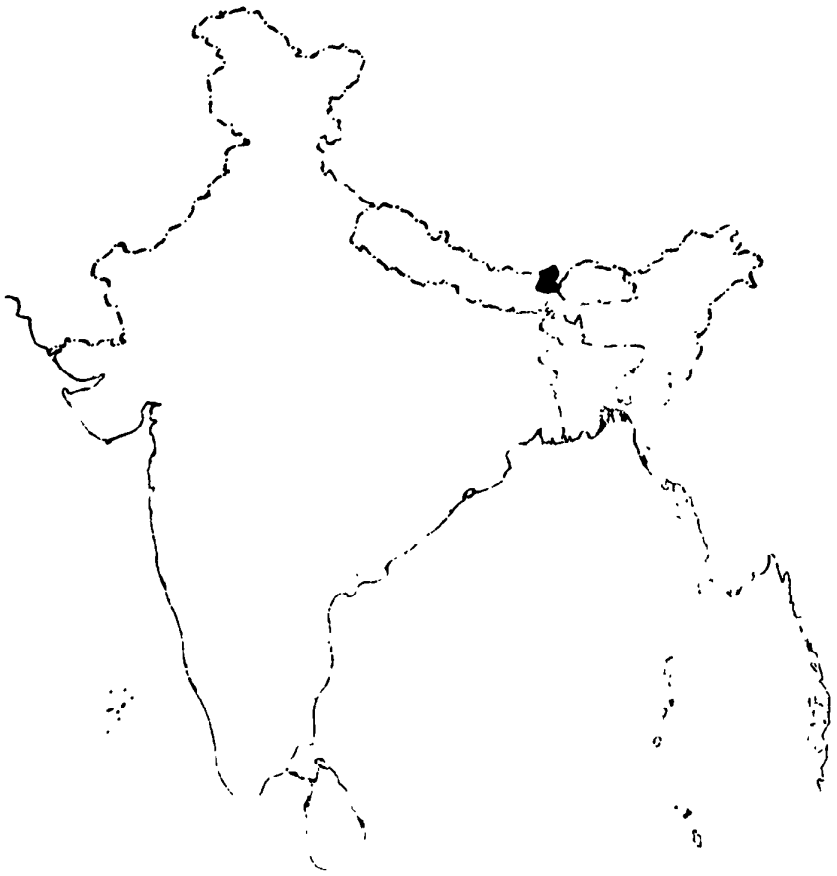


Duabanga grandiflora (Roxb. ex DC.) Walp.
(Courtesy : H.J. Chowdhery)

Piper peepuloides Roxb. : The plant has high medicinal value.
(Courtesy : K. Haridasan)

Arundina graminifolia (D. Don) Hochr.
(Courtesy : H.J. Chowdhery)

Edgeworthia gardneri Meissn. : The bark of this plant can be used for currency note paper.
(Courtesy : K. Haridasan)



6
SIKKIM

Plant Diversity in Sikkim Himalaya

P. SINGH
A.S. CHAUHAN

Eastern Himalaya is the richest phytogeographical region of India showing a great deal of diversity in both animal as well as plant life-forms. The high rainfall coupled with moist and cold climate and factors like altitude, project variety of habitats and provide a variety of unique ecological niches for different plant and animal species. The region together with eastern India is recognised as "refugium" of flowering plants and centre of active speciation. It is a centre of origin of several cultivated plants like Musa, Citrus, Jack fruits and has been the source of species of genera *Pyrus, Prunus, Rubus, Sorbus, Ribes, Hordeum.* In addition, wild progenitors of a number of ornamentals are found in Eastern Himalaya of which special mention may be made of Orchids, Rhododendrons, Primulas and Hedychiums. The region is the source of several species of cereals, pulses, fruits, oil yielding plants, spices, tuberous vegetables, and a whole range of medicinal and aromatic plants.

Lying on the western flank of the Eastern Himalaya, Sikkim, one of the smallest states of India, is phytogeographically interesting, and was first botanically explored by Joseph Dalton Hooker. The total area of the state is 7096 sq. km., of which 2656 sq. km (36. 3%) is under forest (Anonymous, 1992). It harbours relatively unspoilt pockets of natural vegetation ranging from Tropical pine forests, Tropical broad leaved forests, Subtropical forests, Temperate broad leaved and coniferous forests, Sub - alpine scrubs, Alpine meadows and swamps- generally related to the high mountain flora of the north temperate zone. The state is the habitat of a number of endangered animal species like Snow Leopard, Clouded Leopard, Red Panda, Musk Deer, Great Tibetan Sheep, Tibetan Antelope, Tibetan fox, Wild Ass etc. As many as 690 species of butterflies have been reported from Sikkim Himalaya (Harbal, 1992).

GEOGRAPHICAL LOCATION AND PHYSIOGRAPHY

Sikkim is located between 27°5' to 28°9' North latitude and 87° 59' to 88° 56' East and the state lies on the western flank of Eastern Himalaya bounded by Nepal in the west, Bhutan in the south-east, Tibet in the north and north-east and the district of Darjeeling (West Bengal) in the south. The mountain chains which run southwards from the main Himalayan ranges form the natural boundaries of Sikkim; the snow clad peaks of Chola range with altitudes above 4000 m dividing it from Tibet in North -east and Bhutan in the south-east; Singalela range likewise separating it from Nepal in the west, with the east-west axis of the Great Himalaya forming the barrier between Sikkim and Tibet in the north. Mountain passes along these ranges over the years facilitated two way traffic of traders, pilgrims and adventurers from Nepal, Tibet and Central Asia. The most renowned of these passes are Nathula (4392 m), Jelep La (4388 m), Donkia La (5520 m), Kongra La (4809 m). The topography of Sikkim is quite varied with altitude ranging from 250 to 8598 m, and almost with no flat piece of land anywhere. Mt. Khanchendzonga (8598 m)in north-east border of the state is the third highest mountain in the world, and is sacred to the people of Sikkim. The picturesque landscapes and mountain ranges in Sikkim and their scenic beauty, along with cultural richness of the state allures nature lovers and tourists from near and distant lands.

The state of Sikkim is drained by numerous small perennial streams which join to form two major river systems, viz., Teesta and Rangeet which ultimately join to form Teesta near Melli and enter Darjeeling district of West Bengal.

Geologically, Sikkim encompasses the lesser Himalaya, Central Himalaya and the Tethys Himalaya (Raina & Srivastava, 1981). Major portion of Sikkim is covered by precambrian rocks and is much younger in age, the geological position is known as 'younger units of paleozoic age' The southern area has sedimentary and metasedimentary rocks. The physical configuration of Sikkim is partly due to its geographical structure. The north-eastern and western portions of the state are constituted of hard massive gneiss rock capable of resisting denudation. The south and central region is

chiefly formed of comparatively soft thin slates and half schistern rock which denudes very easily. The trends of the mountain system as a whole is east- west direction. The boundary ridges, however, run in a more or less north- south direction, i.e. Singalila and Chola ridges, and another north - south ridge in the central portion, viz., Tendong ridge, divides the Rangeet from the Teesta valley.

Sikkim is the most humid region in the whole range of the Himalaya due to its proximity to the Bay of Bengal, direct exposure to the south-west monsoon and its physical features. The rainfall varies from 200 - 500 cm in most of its inner valleys except for its northern most region, viz., Llonakh valley and Cholamau plains which receive scanty rainfall. From June to September, monsoon brings heavy rainfall to exposed slopes and valleys throughout the state. Lower hills and valleys enjoy a subtropical climate, warm in winter; hot and extremly humid in summer. Towards the interior and with rise in altitude, the climate becomes gradually more temperate with cool winters, hot summers and often heavy rainfall. In the northern part of the state, summers are short and cool, and the winters cold with considerable snowfall and frost.

Climate and natural features of Llonakh valley situated in northern part of the state is quite different (Smith & Cave, 1911). Llonakh valley constitutes flats and screes along the streams of Lungma chu and Naku chu, which join together to form Llonakh chu. Llonakh flats form a wonderful expanse of gently undulating ground in the midst of the highest peaks in the Himalayas. They are the level floor formed by the action of some huge glaciers or set of converging glaciers that have long ago disappeared or are now represented by comparatively small glaciers at the heads of all the valleys. On the flanks of this flat valley are huge moraines - accumulations of mighty boulders with a very limited plant life. Small lakes in the shallow basins are found regularly below the foot of each glacier.

ECOSYSTEM DIVERSITY

Its unique geographical position (trijunction of eastern Himalaya, central Himalaya and Tibet), high annual precipitation varying from 200 - 500 cm, wide range of topography having altitudes varying from 250 - 8598 m and

presence of large number of perennial streams makes the state of Sikkim one of the richest treasure house of biodiversity in the country.

All the important forest types of eastern Himalaya like sub-Himalayan wet mixed forests, sub-tropical hill forests, Himalayan sub-tropical pine forests, wet temperate forests, mixed coniferous forests, eastern Oak-Hemlock forests, Oak-Fir forests, moist alpine scrubs and dry alpine scrubs are found in Sikkim (Champion, 1936). Sal forests are restricted up to around 900 m altitude along the valleys of Rangeet and Teesta. Pure chirpine forests are the dominating feature in small pockets in dry valleys of south Sikkim.

Tropical forests range up to 900 m above msl and mainly consist of tropical moist deciduous to semi evergreen elements with Sal (*Shorea robusta* Gaertn.) as a dominant species. They occur along Teesta and Rangeet valleys at low altitudes. At some places in dry valleys e.g. near Chitam pure chir pine forests can also be seen in their pristine glory. Along the river banks *Saccharum* sp., *Oroxylum indicum* (L.) Vent. and *Meizotropis buteiformis* Voigt are the common species.

Subtropical forests are confined between 900 - 1500 m above msl. These are mainly mixed forests comprising *Adina cordifolia* (Roxb.) Hook. *f.* ex Brandis, *Alangium chinense* (Lour.) Harms, *Bischofia javanica* Blume, *Callicarpa arborea* Roxb., *Castanopsis indica* (Roxb.) Miq., *Eurya cerasifolia* (D. Don) Kobuski, *Fraxinus floribunda* Wall., *Ficus* spp., *Gynocardia odorata* R. Br., *Helicia nilagirica* Bedd., *Macaranga denticulata* (Blume) Muell. -Arg., *Magnolia hodgsonii* (Hook. *f.* & Thoms.) Koenig., *Michelia velutina* DC., *Mangifera sylvatica* Roxb., *Saurauia nepaulensis* DC., *Schima wallichii* (DC) Korth., *Vernonia volkameriaefolia* DC. Predominant shrubs in these forests are *Buddleja asiatica* Lour., *Clerodendrum*, *Embelia floribunda* Wall., *Mussaenda roxburghii* Hook. *f.*, *Melastoma malabathricum* L. and *Vitex negundo* L. etc. Climbing species of *Piper*, *Smilax*, *Tetrastigma*, *Cissus*, *Pothos*, *Rhaphidophora* are common in the area and ferns and fern allies along with species of orchids constitute rich epiphytic flora of this region. Species of *Musa* and *Pandanus* form dense patches in humid and exposed areas. Tree fern *Cyathea* is found here and there in moist shady places. Exotic

weeds like *Eupatorium* sp. and *Mikania micrantha* Kunth got naturalized in many parts of subtropical region.

Temperate forests are prevalent between 1500 3500 m altitude. These forests can be mainly distinguished as broad leaved temperate forests and coniferous forests. Main components of broad leaved type in Sikkim are *Alnus nepalensis* D. Don, *Acer campbellii* Hook. *f.* & Th., *Betula utilis* D. Don, *Engelhardtia spicata* Blume, *Exbucklandia populnea* (R. Br. ex Griff.) R.W. Brown, *Ilex dipyrena* Wall., *Juglans regia* L., *Populus ciliata* Royle, *Prunus nepalensis* Koch., *Malus sikkimensis* (Wenz.) Koehne, *Quercus lineata* Blume, *Q. lanata* Smith, *Q. lamellosa* Smith, *Q. oxyodon* Miq., *Q. glauca* Thunb., *Lithocarpus pachyphylla* (Kurz) Rehder, *L. elegans* (Blume) Hatus ex Soep.

Shrubby vegetation is quite dense and diverse in temperate forests and comprises *Berberis umbellata* Wall., *B. wallichiana* DC., *Elaeagnus umbellata* Thunb., *Gaultheria fragrantissima* Wall., *Piptanthus nepalensis* D. Don, *Prinsepia utilis* Royle, *Rhododendron* spp., *Hippophae salicifolia* D. Don, *Maddenia himalaica* Hook. *f.* & Th., *Pieris formosa* D. Don, *Rubus macilentus* Jacq., *Viburnum erubescens* Wall., *Zanthoxylum oxyphyllum* Edgew. etc.

Alpine vegetation occurs between 3500 - 5000 m. The lower altitudes of this zone support shrubby species of *Rhododendron, Berberis, Cotoneaster, Diapensia, Euonymus, Gaultheria, Salix* and *Vaccinium*, while *Rhododendron anthopogon* D. Don and *R. setosum* D. Don form dense tussocks in upper alpine regions.

At higher elevations of alpine zone as in areas like Thangu in Lachen Valley and Yome-Samdong in Lachung valley, the vegetation is typical alpine moorland type where tree growth is completely arrested and the stunted bushy growth forms dense clumps.

UNIQUE ECOSYSTEMS/COMMUNITIES

Llonakh valley has unique ecosystems of rare kind. The species inhabiting the high altitudes are predominantly of Tibetan affinity. Ranunculaceae

are moderately represented. Among the few shrubby plants of the higher regions are the species of *Berberis* which persist far into the upper Llonakh valley where they are much dwarfed and generally prostrate. *Corydalis* is well represented and rich in species. The Cruciferae are well represented by *Draba. Lychnis, Stellaria* and *Arenaria* are strongly represented in species and number, while the tufted Arenarias form one of the most characteristic features of the Llonakh. Legumes are moderately represented by the species of *Astragalus* and *Oxytropis*. Rosaceae are conspicuous feature of the vegetation with many species of *Potentilla Sibbaldia, Spiraea* and *Cotoneaster Saxifraga* is another dominant genus in upper reaches. Umbelliferae are represented by prostrate *Cortia, Pleurospermum* and *Trachydium* on open wind-swept areas of Llonakh. With the exception of *Galium,* Rubiaceae are absent from the higher altitudes. Compositae are well distributed with abundance of species of *Saussurea* in the valley. *Anaphalis* and *Artemisia* are common towards the dry Tibetan region. *Pedicularis* is another dominant genus of this valley, their bright colours are a conspicuous feature in sparse Llonakh vegetation. Prostrate species of *Salix* are prevalent right up to the melting snow. Species of *Habenaria* and *Cypripedium* sparingly represent the Orchidaceae. Juncaceae, Cyperaceae and Graminae are less prevalent. *Ephedra* and dwarf Junipers ascend to over 5000 m altitude. The dominant genera of the area are *Arenaria* (14 sp.), *Potentilla* (17 sp.), *Saxifraga* (34 sp.), *Saussurea* (21 sp.), *Rhododendron* (15 sp.), *Primula* (24 sp.), *Pedicularis* (31 sp.), *Corydalis* (16 sp.) (Smith & Cave, 1911).

A part of this valley comes under Khanchendzonga National park - the only national park of the state. The park has the highest ranges of elevations (1820 - 8598 m) in the country. The flora of this important park has not been documented so far. The park covers an area of 850 sq. km and most of the area falls under north district and around 30 % comes under south and west districts of Sikkim. There is proposal by the state forest department to increase the area under Khanchendzonga National park.

FLOWERING PLANT WEALTH AND PHYTOGEOGRAPHICAL RELATIONSHIPS

The floral diversity is fascinating and approximately 4500 species of flowering plants have been reported to occur in this region. As many as

362 species of ferns and fern allies have been reported from Sikkim and Darjeeling (Mehra & Bir, 1964). An analysis of dominant families of Monocotyledons and Dicotyledons clearly indicate the floristic richness of this state. Intensive surveys in Khanchendzonga National Park, Pangolakha range (East Dist.), Dombyong valley, Tankara La, Sakyong valley, Tolung, Zemu and Llonakh valley, (North Dist.), Karchi, Hilley R.F., (West Dist.) Tendong, Melli, Chitam R.F., Mainam R.F., (South Dist.) would further increase the knowledge about the flora of Sikkim.

Hooker (1904) attributed the floristic diversity of the Indian subcontinent " to the immigration of plants from different bordering countries, notably Chinese and Malayan on the east and south, of oriental, European and African on the west, and of Tibetan and Siberian on the north" In Sikkim, many such influences can be easily noticed. Some interesting phytogeographic elements of the flora of Sikkim are discussed below.

1. **South East Asian Malesian Elements**

These elements (representing species of many parts of tropical SE Asia, including South Myanmar, Thailand, Indo- China, Malaya, Malaysia and Indonesia) are the dominant elements in the Tropical and Subtropical forests.

2. **Sino - Himalayan - Japanese Elements**

The close links among temperate floras of the Himalaya, China and Japan have been recognised since long. Each of these regions has numerous endemic taxa, and many other taxa which extend two or three of the regions. The Himalayan region is typical in having both endemic taxa and other taxa showing range upto China and Japan.

3. **Deccan Elements**

These elements are mainly represented in tropical belt and are relatively few in number.

4. **Tibetan Elements**

The Tibetan vegetation is mainly Xerophytic and very different from that of Himalayan mainly because of low rainfall and high altitude. Some of the Tibetan elements extend into north Sikkim.

5. **Euro- Siberian Elements**

Quite a number of temperate and alpine zone species of Sikkim are of European and Siberian origin.

6. **Arctic - Alpine Elements**

These elements consist of taxa widespread in arctic regions and also found at high altitudes on some of the high mountain ranges of Europe and Asia, showing disjunct distribution.

FLORISTIC ANALYSIS

Sikkim, which accounts for only 0.2 % of the geographical area of the country is custodian of more than 26 % of the flowering plants of India. An analysis of dominant families/ genera occurring in India indicates that they show high concentration and development in Sikkim. Singh *et al.* (1995) reported 12 genera and 16 species of gymnosperms occurring wild in Sikkim. Table-1 represents the diversity of gymnosperms in Sikkim. Orchidaceae, Cyperaceae, Juncaceae, Ericaceae, Rosaceae, Saxifragaceae are also well represented in the state of Sikkim(Tables-2 and 3). Apart from this, species belonging to genera like *Astragalus* (Leguminosae), *Bulbophyllum* (Orchidaceae), *Carex* (Cyperaceae), *Calanthe* (Orchidaceae), *Coelogyne* (Orchidaceae), *Corydalis* (Fumariaceae), *Cymbidium* (Orchidaceae), *Dendrobium* (Orchidaceae), *Desmodium* (Leguminosae), *Eria* (Orchidaceae), *Ficus* (Moraceae), *Gentiana* (Gentianaceae), *Juncus* (Juncaceae), *Oberonia* Lindl. (Orchidaceae), *Pedicularis* (Scrophulariaceae), *Primula* (Primulaceae), *Rhododendron* (Ericaceae), *Rubus* (Rosaceae), *Saxifraga* (Saxifragaceae) show overwhelming presence in Sikkim.(Table-4).

Varied topography and climate of this state encouraged gardners, foresters and farmers to introduce and establish a number of useful and ornamental plants from other parts of the world. Many introduced plants have become naturalized here viz., species of *Ageratum*, *Calceolaria*, *Chromolaena* *Eupatorium*, *Lantana*, *Mikania*, *Zephyranthes*, etc.

The forests of Sikkim are also rich in wild relatives of cultivated plants such as species of *Amomum*, *Cinnamomum*, *Curcuma*, *Elymus*, *Hordeum*, *Mangifera*, *Musa*, *Piper*, *Prunus*, *Saccharum*, *Vitis* and *Zingiber*. Added to it is a whole range of medicinal and ornamental plants, some of which have gone into commerce. Among the important ones are *Abies densa* Griff., *Artemisia nilagirica* (C.B.Clarke) Pamp., *Begonia laciniata* Roxb., *Berberis aristata* DC., *Bergenia purpurascens* (Hook. *f.* & Th.) Engl., *Cissampelos pareira* L., *Costus speciosus* Smith, *Curculigo orchioides* Gaertn., *Dicentra thalictrifolia* Hook. f. & Th., *Dichroa febrifuga* Lour., *Drymaria cordata* Willd., *Ephedra gerardiana* Stapf var. *sikkimensis* Stapf, *Heracleum nepalense* D. Don, *Iris decora* Wall., *Juniperus recurva* Buch.-Ham., *Nardostachys grandiflora* DC., *Picrorhiza scrophulariflora* Pennell, *Podophyllum hexandrum* Royle, *Potentilla fulgens* Wall., *Pratia begonifolia* Lindl., *Przwalskia tangutica* Maxim., *Rheum australe* D. Don, *Rhus insignis* Hook. *f.*, *Rumex nepalensis* Spreng, *Skimmia laureola* Hook. *f.*, *Swertia chirayita* Ham., *Taxus baccata* L. subsp. *wallichiana*(Zucc.) Pilger, *Valeriana hardwickii* Wall., *V. jatamansii* DC., *Zanthoxylum alatum* Roxb.

The region abounds in a number of primitive taxa viz. *Exbucklandia*, *Houttuynia*, *Magnolia*, *Michelia* and several species of Annonaceae, Myrsinaceae, Piperaceae, Lauraceae etc. It also harbours botanical curiosities like *Aeginetia indica* L., *Balanophora involucrata* Hook. *f.*, *Rhopalocnemis phalloides* Jungh., *Pinguicula alpina* L., *Drosera peltata* Sm., *Ephedra gerardiana* Stapf var. *sikkimensis* Stapf and species of *Utricularia*

Table 1: Number of genera and species of gymnospherms in Sikkim and India

S.N	Genera	No. of spp. in India.	No. of spp. in Sikkim	Percentage (%)
1.	*Abies*	4	2	50
2.	*Cupressus*	3	1	33
3.	*Cycas*	4	1	25
4.	*Ephedra*	8	1	13
5.	*Gnetum*	5	1	20
6.	*Juniperus*	5	3	60
7.	*Larix*	1	1	100
8.	*Picea*	3	1	33
9.	*Pinus*	7	2	28
10.	*Podocarpus*	2	1	50
11.	*Tsuga*	1	1	100
12.	*Taxus*	1	1	100

Tabl-2: Dominant families of Dicots of Sikkim

S.N.	Family	No of spp. in India	No. of spp. in Sikkim	Percentage (%)
1.	Compositae	1069	280	26
2.	Leguminosae	1011	201	20
3.	Rosaceae	492	138	28
4.	Scrophulariaceae	423	112	26
5.	Rubiaceae	659	110	17
6.	Labiatae	452	95	21
7.	Euphorbiaceae	528	94	18
8.	Ranunculaceae	286	69	24
9.	Gentianaceae	212	68	32
10.	Saxifragaceae	172	66	38

Table-3: Dominant Families of Monocots of Sikkim

S.N.	Family	No. of spp. in India	No. of spp. in Sikkim.	Percentage (%)
1.	Orchidaceae	1087	448	41
2.	Gramineae	1259	271	22
3.	Cyperaceae	533	143	27
4.	Liliaceae	216	71	33
5.	Araceae	153	42	27
6.	Juncaceae	53	38	72
7.	Zingiberaceae	167	31	19
8.	Commelinaceae	89	21	24
9.	Arecaceae	95	17	18
10.	Dioscoreaceae	35	12	34

Table-4: Genera Predominantly Represented in Sikkim

S.N.	Genera	No. of spp. in India	No. of spp. in Sikkim.	Percentage (%)
1.	*Bulbophyllum*	90	43	48
2.	*Calanthe*	23	17	74
3.	*Coelogyne*	39	17	44
4.	*Cymbidium*	23	10	43
5.	*Dendrobium*	90	36	40
6.	*Gentiana*	54	33	61
7.	*Juncus*	44	36	82
8.	*Pedicularis*	100	43	43
9.	*Polygonatum*	16	12	75
10.	*Primula*	102	56	55
11.	*Saussurea*	65	30	46
12.	*Swertia*	35	19	54

Endemic Taxa

The genus *Brachycaulos* (Rosaceae) is exclusively endemic to Sikkim and genus *Cyathopus* (Poaceae) is endemic to Sikkim and Western Bhutan whereas the following endemic genera of the Eastern Himalaya also occur in Sikkim.

Aucuba (Cornaceae)
Bryocarpum (Primulaceae)
Gamblea (Araliaceae)
Lepidostemon (Cruciferae)
Parajaeschkaea (Gentianaceae)
Paroxygraphis (Ranunculaceae)
Pleurospermopsis (Umbelliferae)
Risleya (Orchidaceae)
Sphaerosacme (Meliaceae)
Treutlera (Asclepiadaceae)

Chatterjee (1939) made detailed studies on the endemism in the Indian flora He observed that Himalaya exhibit 3165 endemic while the entire country is in possession of 6850 endemics. In other words, Himalaya has a very high percentage of Indian endemics (about 50 %). Several species which were described from Sikkim, have been collected from other parts of Himalaya later on. The number of species growing exclusively in Sikkim has yet to be determined. Full assessment of endemic taxa can be made only after studies on distribution of all the taxa of Sikkim are worked out and analysed.

Table-5 : Endemic Plants of Sikkim

A. Plants strictly endemic to Sikkim: -

1. *Acronema pseudotenera* P.K. Mukherjee (Apiaceae)
2. *Anaphalis cavei* Chatterjee (Compositae)
3. *Anaphalis hookeri* Cl (Compositae)
4. *Anaphalis subumbellata* Clarke (Compositae)
5. *Anemone demissa* Hook. *f.* & Th. var. *monantha* Bruehl (Ranunculaceae)

6. *Angelica nubigena* (C. B. Clarke) P.K. Mukherjee (Apiaceae)
7. *Arenaria thangoensis* Smith (Caryophyllaceae)
8. *Astragalus zemuensis* W. W. Simth. (Leguminosae)
9. *Berberis umbellata* G. Don var. *branii* Ahrendt. (Berberidaceae)
10. *Blumea sikkimensis* Hook. *f.* (Compositae)
11. *Cacalis chola* (W.W. Smith) R. Mathur (Compositae)
12. *Calamus inermis* T. Anders. (Arecaceae)
13. *Caragana spinifera* Komarov (Leguminose)
14. *Carex kingiana* C.B. Clarke (Cyperaceae)
15. *Codonopsis affinis* Hook. *f.* Th. (Campanulaceae)
16. *Coelogyne treutleri* Hook. *f.* (Orchidaceae)
17. *Cremanthodium palmatum* Benth. subsp. *benthamii* R. Good (Compositae)
18. *Crepis atropappa* Babcock (Compositae)
19. *Inula macrosperma* Hook. *f.* (Compositae)
20. *Juncus sikkimensis* Hook. *f.* (Juncaceae)
21. *Saussurea yakla* C.B. Clarke (Compositae)
22. *Lactuca cooperi* Anthony (Compositae)
23. *Ligularia kingiana* (W.W. Smith) R. Mathur (Compositae)
24. *Ligularia pachycarpa* (C.B. Clarke ex Hook. *f.*)Kitamura (Compositae)
25. *Ligularia yakla* (C.B. Clarke) V. Singh & P. Singh (Compositae)
26. *Mahonia sikkimensis* Takeda (Berberidaceae)
27. *Podophyllum sikkimensis* Chatterjee & Mukherjee (Berberidaceae)
28. *Ranunculus sikkimensis* Hand. (Ranunculaceae)
29. *Rhododendron sikkimensis* Pradhan & Lachungpa (Ericaceae)
30. *Uvaria lurida* Hook. *f.* & Th. var. *sikkimensis* King (Annonaceae)

B. Eastern Himalayan endemics in Sikkim

1. *Abies densa* Griff. (Pinaceae)
2. *Agapetes incurvata* (Griff.) Sleum. (Ericaceae)
3. *Agapetes sikkimensis* Airyshaw (Ericaceae)
4. *Betula utilis* D. Don (Betulaceae)
5. *Dipsacus atratus* Hook. *f.* & Th. (Thoms.) ex C.B. Clarke (Dipsacaceae)

6. *Eriobotrya hookeriana* Decne. (Rosaceae)
7. *Geum macrosepalum* Ludlow (Rosaceae)
8. *Larix griffithii* Hook. *f.* & Th. (Pinaceae)
9. *Lindera heterophylla* Meissn. (Lauraceae)
10. *Liparis perpusilla* Hook. *f.* (Orchidaceae)
11. *Lloydia flavonutans* Hara (Liliaceae)
12. *Maddenia himalaica* Hook. *f.* & Th. (Rosaceae)
13. *Meconopsis grandis* Prain (Papaveraceae)
14. *Meconopsis superba* Prain (Papaveraceae)
15. *Meconopsis villosa* (Hook.f.) G. Taylor (Papaveraceae)
16. *Myricaria albiflora* Grierson & Long (Tamaricaceae)
17. *Primula whitei* W. W. Smith (Primulaceae)
18. *Rhododendron baileyi* Balf. (Ericaceae)
19. *Rhododendron camelliaeflorum* Hook. *f.* (Ericaceae)
20. *Rhododendron ciliatum* Hook. *f.* (Ericaceae)
21. *Rhododendron glaucophyllum* Rehder (Ericaceae)
22. *Rhododendron grande* Wight (Ericaceae)
23. *Rhododendron lanatum* Hook. *f.* (Ericaceae)
24. *Rhododendron lindleyi* Moore (Ericaceae)
25. *Rhododendron wallichii* Hook. *f.* (Ericaceae)
26. *Rhododendron wightii* Hook. *f.* (Ericaceae)
27. *Rubus fragarioides* Bertol. (Rosaceae)
28. *Saussurea conica* C.B. Clarke (Compositae)

HUMAN ACTIVITIES AND STATUS OF PLANT DIVERSITY

History of Sikkim indicates that 'Lepchas" the orginal inhabitants of this region, were forest dwellers and lived in harmony with nature. Earlier workers remarked with astonishment on the knowledge of these people about plants and animals. For most of the plant species they have a different local name. Since early part of this century agriculture communities came as a study wave to colonize these hills and settled. Population increase at a rate of 28.47 % between 1981 and 1991 has put a lot of pressure on forest areas. More human habitations have come up throughout the state and network of roads has been created to connect even remote hamlets in the forest areas. The increase in population is leading to unplanned and unprecedented growth of town centres and plantations putting a strain on

the natural resources of the area. Too much emphasis on tourism is also adversly affecting the natural vegetation. In addition over exploitation for commercial purposes has caused the depletion of some species of natural vegetation. For instance during 1990-91, 1000 kg of *Nardostachys grandiflora*, 10720 kg of *Aconitum* sp. and 6200 kg of *Picrorhiza* were collected from the wild habitats in north Sikkim.

Besides, uneven competition with exotic weeds, sensitive dispersal mechanism and inability to sustain critical level of population due to production of less number of seeds have made native plants extremely prone to various degrees of threats. Red Data Book of Indian Plants Vol.I III (Nayar & Sastry, 1987, 1988, 1990) have recorded following species from Sikkim, which need immediate attention for conservation (Table-6).

Table-6 : Endangered plants in the Sikkim Himalaya

1. *Acer hookeri* Miq. var. *majus* Pax. (Aceraceae) Endangered
2. *Acer osmastoni* Gamble (Aceraceae) Endangered
3. *Aconitum ferox* Wall. ex Seringe (Ranunculaceae) Vulnerable
4. *Acronema pseudotenera* P.K. Mukherjee (Apiaceae) Indeterminate
5. *Angelica nubigena* (C.B. Clarke) P.K. Mukherjee Indeterminate (Apiaceae)
6. *Aphyllorchis parviflora* Smith (Orchidaceae) Vulnerable
7. *Arenaria thangoensis* Smith (Caryophyllaceae) Vulnerable
8. *Begonia rubella* Buch.- Ham. *ex* D. Don (Begoniaceae) Rare
9. *Begonia satrapis* C.B. Clarke (Begoniaceae) Rare
10. *Begonia scutata* Wall. *ex* DC (Begoniaceae) Rare
11. *Bulleyia yunnanensis* Schlr. (Orchidaceae) Rare
12. *Calamus inermis* T. Anders.(Arecaceae) Endangered
13. *Calanthe alpina* Hook. *f. ex* Lindl. (Orchidaceae) Rare
14. *Calanthe mannii* Hook. *f.* (Orchidaceae) Rare
15. *Carex kingiana* C.B.Clarke (Cyperaceae) Indeterminate
16. *Ceropegia hookeri* C.B. Clarke *ex* Hook. *f.* Endangered (Asclepiadaceae)
17. *Ceropegia lucida* Wall. (Asclepiadaceae) Endangered

18. *Cissus spectabilis* (Kurz) Planchon Endangered (Vitaceae)
19. *Codonopsis affinis* Hook. *f.* & Th. (Campanulaceae) Rare
20. *Coelogyne treutleri* Hook. *f.* (Orchidaceae) Extinct.
21. *Cotoneaster simonsii* Hort. *ex* Baker Indeterminate
22. *Cymbidium eburneum* Lindl. (Orchidaceae) - Vulnerable
23. *Cymbidium hookerianum* Reichb. *f.* (Orchidaceae) Vulnerable
24. Cymbidium whiteae King & Pantl.(Orchidaceae) - Endangered.
25. *Cypripedium elegans* Reicheb. *f.* (Orchidaceae) Rare
26. *Cypripedium himalaicum* Rolfe (Orchidaceae) Rare
27. *Didiciea cunninghamii* King & Prain *ex* King & Pantl.- (Orchidaceae) Endangered
28. *Dioscorea deltoidea* Wall.ex Kunth (Dioscoreaceae) Vulnerable
29. *Diplomeris hirsuta* (Lindl.) Lindl.- Vulnerable
30. *Juncus sikkimensis* Hook. *f.* (Juncaceae) Rare
31. *Lagerstroemia minuticarpa* Debberm. *ex* P.C. Kanjilal (Lythraceae) Rare
32. *Lactuca cooperi* Anthony (Asteraceae) Endangered.
33. *Livistona jenkinsiana* Griffith (Arecaceae) Endangered
34. *Lloydia himalensis* Royle (Liliaceae) - Vulnerable
35. *Nardostachys grandiflora* DC. (Valerianaceae) Vulnerable
36. *Ophiorrhiza lurida* Hook. *f.* (Rubiaceae) Rare
37. *Paphiopedilum fairieanum* (Lindl.) Stein (Orchidaceae) - Endangered
38. *Paphiopedilum venustum* (Wall. *ex* Sims.) Pfitz. (Orchidaceae) Vulnerable
39. *Panax pseudo-ginseng* Wall. (Araliaceae) Vulnerable
40. *Phoenix rupicola* T. Anderson (Arecaceae) Rare
41. *Picrorhiza kurrooa* Royle *ex* Benth.(Scrophulariaceae) Vulnerable
42. *Pimpinella tongloensis* P.K.Mukherjee (Apiaceae) Endangered
43. *Pimpinella wallichii* C.B. Clarke (Apiaceae) Indeterminate
44. *Pternopetalum radiatum* (W.W. Smith) P.K. Mukherjee (Apiaceae) - Indeterminate
45. *Rhopalocnemis phalloides* Jungh. (Balanophoraceae) Rare

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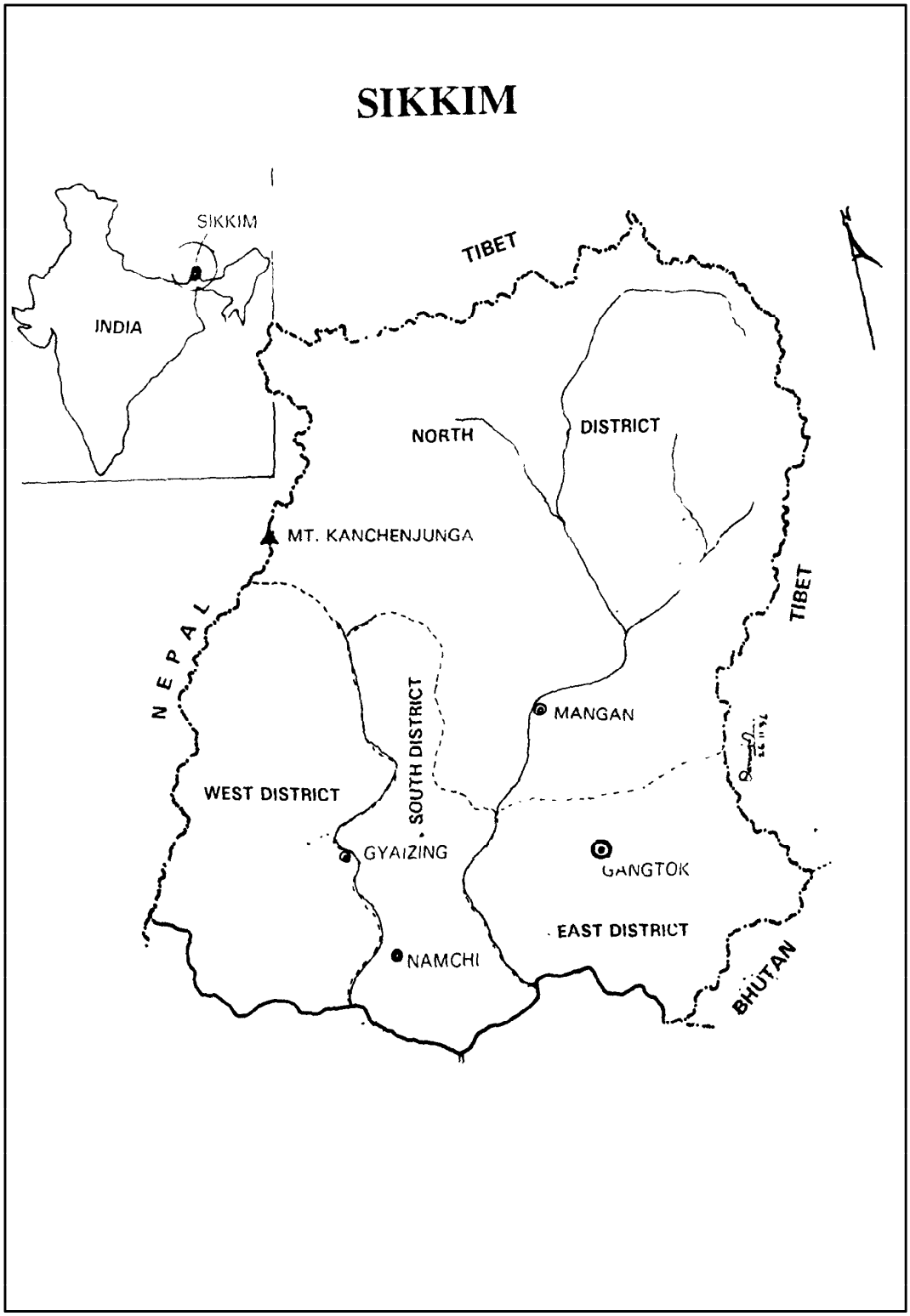
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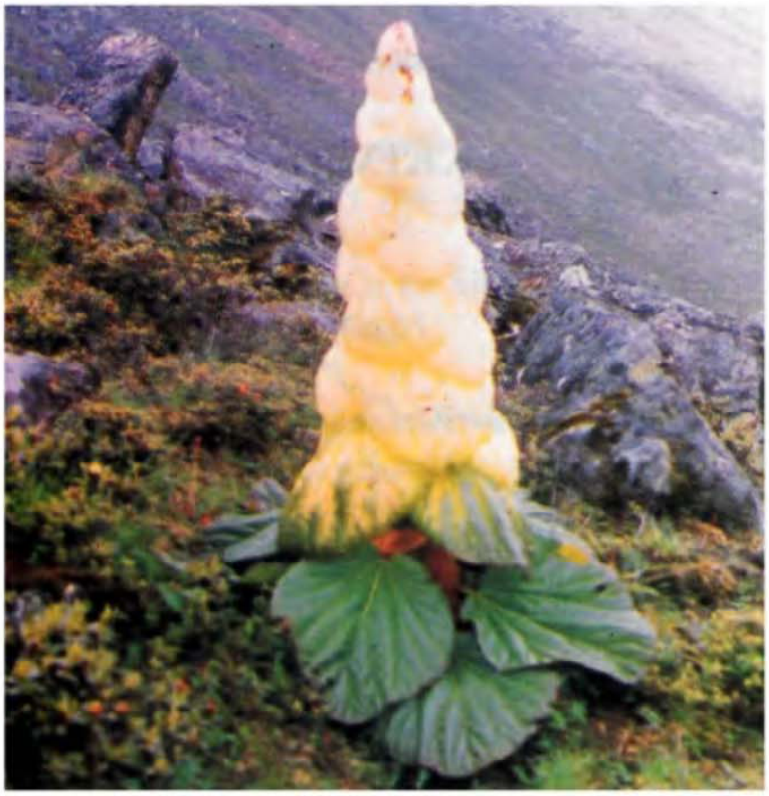
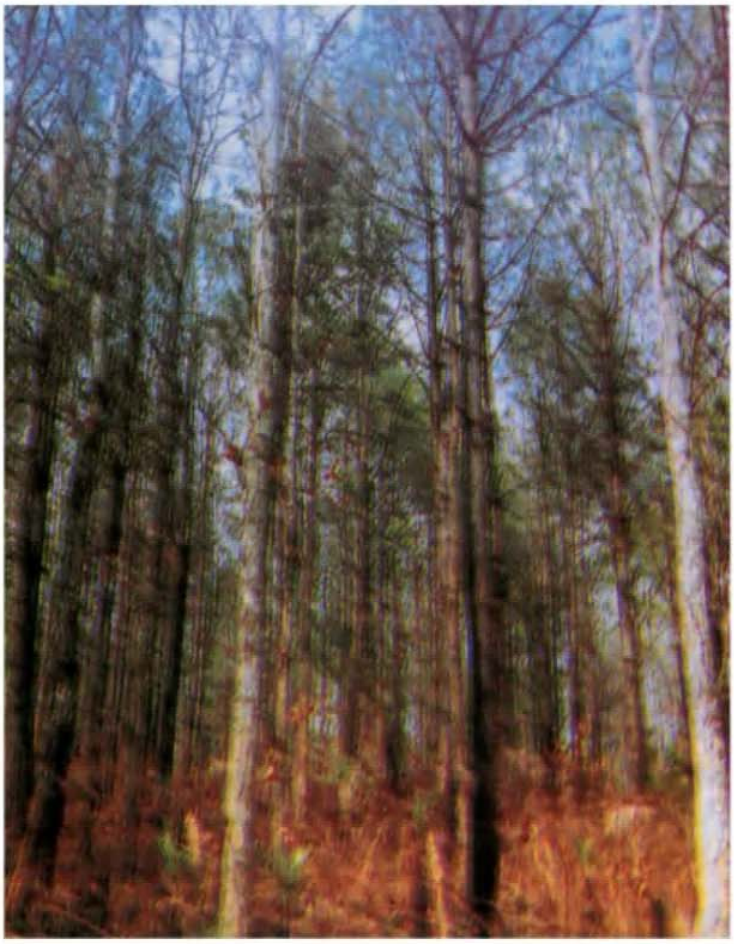


Rheum nobile Hook. *f.* & Th. - Yumthang, alt. ca. 4800 m (North Sikkim)
(Courtesy : G.P. Sinha)

Meconopsis simplicifolia (D. Don) Walp.
(Courtesy : Sikkim Himalayan Circle, Botanical Survey of India)



Chir pine forest-South Sikkim, 500 m, May 1994.
(Courtesy : P. Singh)

Alpine Meadows in North Sikkim
(Courtesy : Sikkim Himalayan Circle, Botanical Survey of India)

Cortiella hookeri (C.B. Clarke) Norman-North Sikkim, Sebula, alt. 5000 m.
(Courtesy : G.P. Sinha)

Meconopsis horridula Hook. *f.* & Th.
(Courtesy : Sikkim Himalayan Circle, Botanical Survey of India)

Soroseris hookeriana (C.B. Clarke) Stebbins - Selu La, western side towards Lashar alt. ca. 5000 m.
(Courtesy : G.P. Sinha)

Dendrobium chrysanthum Wall.
(Courtesy : Sikkim Himalayan Circle, Botanical Survey of India)

Primula sikkimensis Hook. *f.*
(Courtesy : A.S. Chauhan)

Meconopsis paniculata (D. Don) Prain - A rare plant in N. Sikkim.
(Courtesy : B. Ghosh)

Arisaema propinquum Schott.
(Courtesy : Sikkim Himalayan Circle. Botanical Survey of India)

A young tree of *Tsuga dumosa* (D. Don) Eichler.
(Courtesy : Sikkim Himalayan Circle. Botanical Survey of India)

Rhododendron lepidotum Wall. ex G. Don.
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in the high plateau of the Nilgiri.
(Courtesy : Southern Circle, Botanical
Survey of India)


स्वतंत्रता के 50 वर्ष
50
Years
of
Independence
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