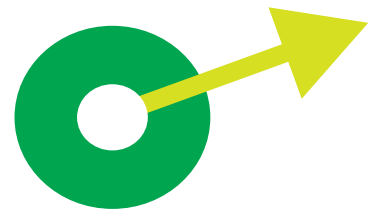


3

BIODIVERSITY  
CONSERVATION  
AND ECOLOGICAL  
SECURITY

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## Biodiversity Conservation and Ecological Security

Indian Council of Forestry Research and Education, Dehradun, has created an independent entity as Biodiversity Conservation Division at Hqs. for developing state-wise biodiversity profile, celebration of International Biodiversity Day, capacity building through trainings, awareness and extension programmes on biodiversity and its conservation, organizing seminars/workshops on biodiversity related issues, publication of biodiversity related books/brochures, etc.

The Division organized a training workshop on “The Significance and Scope of REDD/REDD+ for India's Forests” on 7 and 8 November 2012. Sixteen IFS officers from different states attended the training workshop. Another training programme on Climate Change and Carbon Mitigation for Scientists and Technologists, Government of India, was organised from 19 to 23 November 2012. Nineteen scientists/technologists from different government organizations participated in the training programme.



A training workshop on “The Significance and Scope of REDD/REDD+ for India's Forests” at ICFRE

The Division also organized a training programme on Climate Change, Forest Ecosystems and Biodiversity: Vulnerabilities and Adaptation Strategies for Scientists and Technologists, Government of India, from 17 to 21 December 2012. Twenty two scientists/technologists from different government organizations participated in the training programme.

To provide insight into the unique treasure of India's forest biodiversity, a coffee table book on “**Forest Biodiversity in India**” has been published. The book is first of its kind in India in the field of Forest Biodiversity, depicting various dimensions through photographs and will be of tremendous value to the readers in understanding the unique heritage of our country. The book was released by the Hon'ble Minister of Environment and Forests, Govt. of India during COP-11 at Hyderabad, in November 2012.



Forest Biodiversity in India



## International Biodiversity Day

**The International Day for Biological Diversity, 2012** on "Marine Biodiversity" was celebrated at different regional institutes of ICFRE, namely, Institute of Forest Biodiversity (IFB), Hyderabad; Institute of Forest Genetics and Tree Breeding (IFGTB), Coimbatore; Rain Forest Research Institute (RFRI), Jorhat; Tropical Forest Research Institute (TFRI), Jabalpur; Institute of Forest Productivity (IFP), Ranchi; Institute of Wood Science and Technology (IWST), Bangalore; Arid Forest Research Institute (AFRI), Jodhpur; Himalayan Forest Research Institute (HFRI), Shimla. Many publicity and competition/awareness programme, like painting competition, essay competition, elocution competition and quiz competition, on the subject of marine biodiversity were conducted. During the IBD celebration at Forest Research Institute (FRI), Dehradun, the chief guest was Dr. Aziz Qureshi, Governor of Uttarakhand who stressed upon the importance of the relationship between human life and biodiversity. The Governor distributed prizes to twenty students for winning in the essay and painting competition held on 20 May 2012 by the Uttarakhand Biodiversity Board.

### 3.1 Biodiversity Conservation

#### Establishing germplasm garden of some rare and endangered plants

Locations of five species viz. *Catamixis baccharoides*, *Ulmus wallichiana*, *Rauwolfia serpentina*, *Berberis aristata* and *Mahonia jaunsarensis* were identified and collection of propagation material (seeds/ cuttings/wildlings) was done from Chakrata, Haridwar and Dehradun area for their multiplication and conservation.

Wildlings of *Catamixis baccharoides* have been successfully established in germplasm garden. Propagation of *Mahonia jaunsarensis* and *Berberis aristata* have been done through cuttings. Accessions from CMAP have been received and added to the Garden. Germplasm of *Ulmus wallichiana* has been collected from Chakrata (Uttarakhand) and Kashmir (J & K), and plants have been produced successfully through cutting.

#### Reassignment of forest types

The data on forest compositions of different forest types of UP, Punjab, Haryana, Uttarakhand, Delhi and Chandigarh were collected by the teams of scientists and officers. Data from 375 designated points of different forest types of the states were compiled, analysed and published in the form book "Reassignment of Forest Types".

#### Taxonomic studies on parasitoids belonging to subfamily Braconinae (Hymenoptera: Braconidae) of Uttarakhand

Survey and collection of parasitoids and their hosts was carried out from Gwaldham, Bageshwar, Gairsen, Karanprayag, Gaucher, Herbal garden (Muni ki Reti, Rishikesh) and Thano Forest Division and Kalsi, Karwa Pani, Thano, Barkot forest nurseries of Uttarakhand.

Rearing of hosts samples was carried out for emergence of parasitoids. Similarly, the study of seven species of genus *Bracon* present in NFIC has been done. Study of the morphological characters of *Iphiaulax immsi* Cam., emerged from wood of *Terminalia tomentosa* and *Iphiaulax spilocephalus* Cam., emerged from wood of *Calotropis procera* and identification of three species has been carried out up to genus level which are belonging to the



genus *Ipobracon*. Updating of specimens present in NFIC has been done. These were *Coeloides melanostigma* Strands (*Coeloides stigmaticus* Hellen); *Eurobracon tripligiatus* (Cameron) (syn. *Exobracon maculipennis* Cameron); *Hybogaster xanthopsis* (Cameron) (syn. *Iphiaulax spilocephalus* Cameron); *Pseudovipio castrator* (Fabricius) (syn. *Glyptomorpha castrator* Fabricius); *Stenobracon (Stenobracon) deesae* (Cameron) (syn. *Glyptomorpha deesae* Cameron).

### Studies on taxonomy of the family Eulophidae (Hymenoptera: Chalcidoidea) present in National Forest Insect Collection (NFIC) except Doon Valley

Card mounted specimens of Eulophidae were sorted out from NFIC. A total 380 Eulophids, collection from Arafwala, Terah, Nowshera, Shahdara, Dipalpur (Punjab, Pakistan stored in NFIC), Sitabani, Tanda Range Haldwani, Halduya, Barat Rao (Nainital Distt) and NFIC were identified as *Aprostocetus* sp., *Aprostocetus gala*, *Elasmus brevicornis*, *Euderus* sp., *Euplectrus niblis*, *Neotrichoporoides* sp., *Pediobius agantha*, *Pediobius bethylicidus*, *Pleurotropopsis* sp., *Tetrastichus* spp., *Tetrastichus epilachnae*, *Tetrastichus pantnagensis*, *Tetrastichus tunicus* and *Tetrastichus triozei*. Identified specimens were card mounted and labelled.

### Studies on taxonomy of the Family Encyrtidae (Hymenoptera: Chalcidoidea) present in National Forest Insect Collection (NFIC) except Doon Valley

A total 1584 Encyrtids, collection of NFIC and different locations including Bairangna, Mandal, Kanchula, Anusuiya (Chamoli Distt.), Badshahi Thaul, Munikereti (Distt. Tehri), Pothi Basa (Rudraprayag Distt), Pragatinagar, Dangan

(Uttarkashi Distt), Sitabani, Baratrao, Halduya, Lal Kuan (Nainital Distt.), and Kirsu (Pauri Distt.) were identified as follows:

*Anagyrus* spp., *Anicetus* spp., *Ageniaspis* spp., *Apoleptomastix bicoloricornis*, *Cerapteroceroides similes*, *Cerchysiella* sp., *Copidosoma* spp., *Copidosoma floridanum*, *Copidosoma gracilis*, *Copidosoma indicum*, *Copidosoma oreinos*, *Gyranusoidea* spp., *Homalotylus* spp., *Metaphycus* spp., *Microterys* spp., *Neodusmetia sangwani*, *Ooencyrtus aethes*, *Parablatticida* spp., *Rhopus* spp. *Ruanderoma* sp. and *Trechnites manaliensis*.

The four species of genus *Ooencyrtus* were found to be different from the known species on the basis of detailed morphology.

Three species were micro photographed and measured for their 75 different body parts.

### Studies on thrips of forest and medicinal plants, problems caused by them and their management in Uttarakhand

Survey for the collection of thrips has been carried out from Gwaldham, Bageshwar, Gairsen, Karanprayag, Gaucher, Herbal garden (Muni ki Reti) Rishikesh, Thano Forest Division, NWFP Nursery FRI and Kalsi. Collected thrips species were identified as: *Gynaikothrips uzeli* from *Schefflera actinophylla* plant, *Scirtothrips dorsalis* from *Chilli* plants, *Thrips flavus* from *Albizia lebbeck* and *Citrus* fruits; *Thrips tabaci* from *Plumbago zeylanica* (Chitrak); *Hoplothrips gowdeyi* and *Scirtothrips dorsalis* were associated with *Aloe barbadensis*;



*Hoplothrips gowdeyi*



*Thrips flavus* was associated with *Ocimum sanctum*; *Thrips tabaci* from *Terminalia chebula*; *Mycterothrips ruvidus* was reported from *Eucalyptus* galls.

### **Digitization of the type material (E-typing) present in National Forest Insect Collection, F.R.I., Dehradun using Auto -Montage 3-D imaging system**

A database was developed in windows application for the entry of data of types of NFIC. The various records of type specimens have been entered into the database which includes many relevant information such as name of the species, their accession numbers, collection date, holotype/ paratype, male/ female, taxonomic position, host, collector, identifier etc. which were earlier hand written in various records like accession register, index cards etc.

The information related to type specimens available in the form of hard copy as books, journals, monographs etc. has been scanned and saved in PDF format. About 900 articles of different types of insect species have now been scanned and digitally entered into the database.

### **Study of the reproductive biology of endangered taxa, “*Trachycarpus takil* Becc.(Areaceae), *Mahonia jaunsarensis* Ahrendt (Berberidaceae), *Pittosporum eriocarpum* Royle (Pittosporaceae) and *Eremostachys superba* Royle ex Benth(Labiatae)”**

In this study, life cycle of four RET plant species *Eremostachys superba*, *Mahonia jaunsarensis*, *Trachycarpus takil* and *Cinnamomum glanduliferum* have been critically examined in actual forest locations to find out the cause of their poor regeneration and distribution in nature. With the

beginning of the flowering season, survey was conducted for studying the reproductive biology of the species. Survey was also conducted during the vegetative stages of the species. In the year 2013, with the beginning of the flowering period, survey was conducted in various sites. For *Eremostachys superba* Royle ex Benth. (Lamiaceae), regular visits were made to type locality Mohand, Dehradun to monitor the flowering of the plants. But no flowering was observed in the area this year also. As the species has also been reported from Rajaji National Park, several visits were made to locate the species but the species could not be located. A good population of the species is growing in the garden of Botanical Survey of India, Dehradun.

### **Study on grasses of Uttarakhand and Himachal Pradesh**

Exploration cum collection tours have been organized to Chamoli, Nainital, Jaunsar Bawar, Uttarkashi, Rudraprayag, Haridwar, Rishikesh, Mussoorie, Champawat, Chakrata, Kalsi, Saiya, Chamba, Udham Singh Nagar, Narender Nagar, Almora, Ranikhet, Mohand, Herbertpur, Badkala Range, Pithoragarh and in and around New Forest campus in Uttarakhand and Solan, Paunta Saheb, Nahan (Sirmour), Mandi, Una, Great Himalayan National park (Tirthan valley, Oat, Siang valley, Thari Beat) in Himachal Pradesh. Total 2415 specimens have been collected from which 1739 specimens identified.

### **Inventorization, characterization and conservation strategies of selected rare and endangered plant species of India**

Rare and threatened species such as *Ilex pseudo-odorata*, *Catamixis baccharoides*, *Sophora*



*mollis* and *Pittosporum eriocarpum* were studied. Extensive field survey was carried out in the Mussoorie, Jharipani, Hathipaon, Rishikesh and adjoining area, Rajaji National Park etc. *Pittosporum eriocarpum* was found in the Jhari Pani and Hathipaon area. Population of the species was very less in the area. Seed of the plants were collected. *Ilex pseudo-odorata* was found in the Hathipaon, only 5 trees could be traced in the whole of Mussoorie and adjoining areas. *Sophora mollis* was found in the Sahastradhara area. Population of the species was found very less.

### Butterfly diversity in relation to landscape changes in the Walayar Valley, at Palakkad Gap in the Western Ghats

Enumerated the butterfly species occurring in different vegetation types in the Walayar Valley. About 35 species of butterflies were recorded so far, from teak plantations; 36 species from moist deciduous forests and 27 species from dry deciduous forests. Data were collected on the seasonality of different butterfly species and their nectar and larval host plants. It was noticed that the shrubby undergrowth in plantations and moist deciduous forests provide suitable habitats for many species of butterflies. Occurrence of some butterfly species like *Troides minos* (Southern Birdwing) (Endemic) *Arhopala psuedo-centaurus* (Western centaur oakblue) (Not common) and *Melanitis phemida* (Great evening brown) (Rare) in the study area is interesting.

### Biology and conservation of endemic plants of Kalakad Mundanthurai Tiger Reserve, Tamil Nadu

Intensive field surveys were carried out to locate 5 endemic species and to study their

distributions, association, population and phenology status by repeated perambulation in the Kalakad Mundanthurai Tiger Reserve, Tamil Nadu. Phenological observations, distribution and recording of plant associations for the species *Eugenia singampattiana*, *Phyllanthus singampattianus*, *Palaquium bourdillonii* and *Sonerilla kanyakumariana* are in progress.

The population of *Sonerilla kanyakumariana* is not much and only few individuals are recorded. For the study of vegetation propagation and seed germination, two nurseries were established.



*Phyllanthus singampattinus*- stem cuttings raised in nursery

### Impact of forest plantation on ground flora diversity under soil characteristics including the prescription of management practices

For the study of ground flora diversity and soil properties, *Eucalyptus grandis* and *Acacia mearnsii* (Berijam Range) plantations in Kodaikanal area were selected and enumerated the ground flora diversity. It is found that *Shola species*



like *Neolitsea scorbiculata*, *Rhododendron* etc regenerate sporadically in the plantations. Thirty two species of ground flora were recorded from *Eucalyptus grandis* plantation and 24 species in *Acacia mearnsii* plantation including tree regeneration. Herbarium specimens were made for species which could not be identified in the field. Soil samples were collected from all these plantations for studying soil micro flora and physical and chemical properties. Details on population density of arbuscular mycorrhizal (AM) fungi, PGPR's and other fungi were recorded.

A total of 44 species of Orthoptera, belonging to three different families was recorded from seven different habitat types viz., scrub jungle, deciduous forest, evergreen forest, grassland, plantations, sholas and swamp forests in NBR. Seven habitats namely scrub jungle at Masinagudi; Deciduous forest at Mudumalai; Shola forest at Kothagiri; Grassland at Kodanadu; Teak Plantation at Kargudi and Evergreen forest at Gudalur have been surveyed at regular interval to observe the incidence and seasonality of Orthopteran insects. The species *Xenocatantopshumilis*, *Conocephalus maculatus* and *Phlaeobainfumata* are common in all habitat types surveyed. Studied the host range of *Xenocatantopshumilis*, *Phlaeobainfumata*, *Oxya sp.*, *Acrida sp.*, *Gastrimargus sp.* and *Orthacris maindroni*. Conducted extensive study on orthopteran diversity of high altitude shunted wet evergreen forests, called shola to understand the impact of landscape changes. The upland forests act as refuges for highly mobile polyphagous insects like grasshoppers. *Oxyapus covitata*, *Phlaeobainfumata*, *Oxyanidula* and *Xenocatantopshumilis* species were recorded during the orthopteran population survey conducted in shola forest, grasslands and swamps at Kotagiri and Kodanaad. Diversity of

grasshoppers in Nilgiris shola forests at three different locations each in Nilgiris North and Nilgiris South divisions respectively, based on anthropogenic pressure and climate change have been studied. A total of 15 species including an unknown gryllid and two unidentified Acridid have been recorded from Nilgiris Shola forests and grasslands.

### Investigation on floristic diversity in teak plantation of various age groups in Barnawapara Project Division, Raipur, Chhattisgarh

Plantations promote understory regeneration by shading out grasses and other light-demanding species, changing understory microclimates, improving soil properties and increasing vegetation structural complexity. With this view, the project was started to determine the changing of plant diversity in different years plantations, changing of soil properties in teak plantation and the similarities between plant species in each of teak plantations and plant species in natural forest of teak.

Enumeration of vegetation was carried out in three ranges viz. Rawan Range, Raikera Range and Sirpur Range of Barnawapara Project Division, Raipur (CG). 48 trees, 12 shrubs and 36 herbs species were recorded in different years aged plantations from selected three ranges. The compartment wise, dominant tree species were- Teak, Sinha, Karra, Saja, Char, Bija, Mahua, Tendu, Dhawara, Kasai, Bhilwa, Kusum, Moyan, Baheda, Kumbhi, Amaltas, Dhaman, Ghont and Chinti in 12 compartments of Rawan Range.

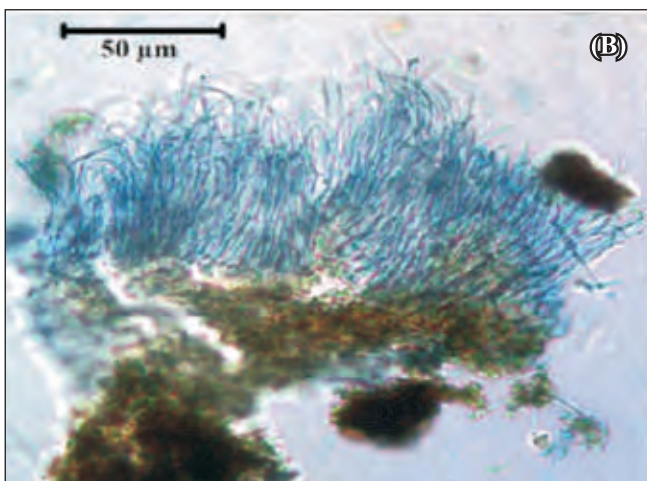
### Taxonomy and documentation of wood decay fungi of Chhattisgarh and Odisha

Survey was conducted in the rainy season of the year 2010, 2011 and 2012, 59 forest areas under





districts were visited in Chhattisgarh (41) and Odisha (18) and from their 727 specimens of wood decaying were collected on thirty five timber tree species. The following species of wood decaying fungi were identified- *Auricularia polytricha*, *Daldinia concentrica*, *Daedalea flavida*, *Ganoderma lucidum*, *Favolus sp.*, *Flavodon flavodon*, *Hymenochaete rubiginosa*, *Polyporus sp.*, *Hypoxylon sp.*, *Mircroporus xanthopus*, *Hexagonia teneuis*, *Ramaria sp.*, *Pycnoporus sanguineus*, *Stereum sp.*, *Corioloopsis sp.*, *Necteria sp.*, *Lenzites elegans*, *Schizophyllum commune*, *Phellinus sp.*, *Boletus sp.*, *Pyrofomes tricolor*, *Trametes*



New species: (A)- *Phlyctaeniella indica*: Symptoms on wood and (B)- Pycnidia with conidiophores and attached conidia

*cingulata*, *Trichaptum bisogenum*, *Xylaria polymorpha*, *Earliella scabrosa*, *Navisporus floccosa*, *Leucocoprinus birnbaumii*, *Mycena rosella*, *Helvella sp.*, *Phlyctaeniella sp.* and *Hapalopilus nidulans*. One new species *Phlyctaeniella indica* and two species namely *Leucocoprinus birnbaumii* and *Mycena rosella* were recorded as new record to India. The occurrence and distribution of wood decaying fungi on different host in forest and wood depots of Chhattisgarh and Odisha was also reported. The maximum number of wood decaying fungi recorded from Chhattisgarh and minimum from Kopriya, Odisha. Three species common to all places viz. *Flavodon flavus* (Kolt) Ryv. *Trametes cingulata* Berk and *Schizophyllum commune* Fr. with 100 per cent occurrence and frequency.

### Documentation of sacred groves of Rajasthan and assessment of biological diversity in some of them for improved management and people livelihoods

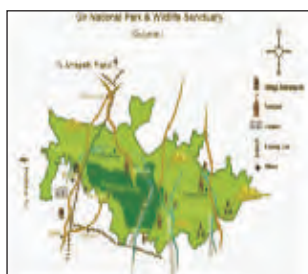
A survey done for 11 sacred groves which showed that high plant and animal diversities were available in these areas.

### Screening, identification and preparation of a comprehensive check- list of the Lepidopteron fauna of Sasan Gir Wildlife Sanctuary of Gujarat state

The survey had been conducted in Gir Wild Life Sanctuary to identify the suitable sites, where the prominent population of butterflies and moths are found had been identified. Periodical visits had been made in selected sites (East & West Gir) in order to collect systematic and random sampling. Detailed record and description of various sampling sites had been maintained and displayed in the map. The record sheet of butterflies and moth had been



maintained along with the photographic documentation. Sixteen species of Nymphalidae, ten species of Pieridae, four species of Papilionidae, two species of Arctiidae, two species of Sphingidae, two species of Noctuidae and two species of Lycaenidae have been identified in sixty eight locations of East and West Gir. The detailed life history of *Danais chrysippus* (Nymphalidae) had been studied.



Map of Gir wild life sanctuary



*Hypolimnas misippus*  
(Nymphalidae) Schedule-II  
Indian wildlife protection  
Act 1972



*Euploea core*  
(Nymphalidae) Schedule-IV  
Indian wildlife protection  
Act 1972



*Castalius rosimon*  
(Lycaenidae) Schedule-I  
Indian wildlife protection  
Act 1972

### Taxonomy and molecular analysis (through RAPD-PCR) of Moths (Lepidoptera) in Cold Deserts (Spiti and Leh) of Indian Himalayas

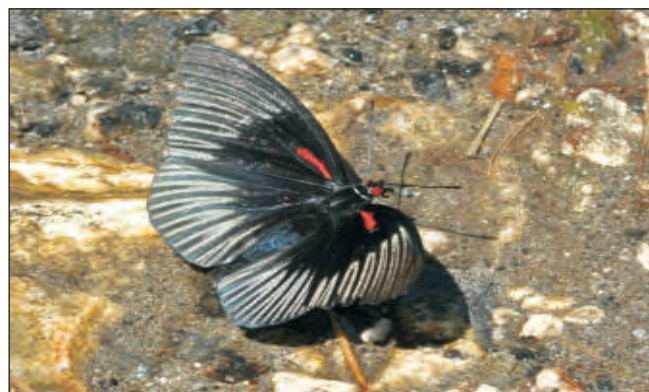
A total of 170 specimens of moth (Lepidoptera) species have been collected from various localities of cold deserts of Leh and Spiti till date. Ten species moths have been identified i.e. *Agrois ypsilon*, *G. operculella*, *Y. rorella*, *S. litura* *Plusia orechalsea*,

Diamond back moth, *Polyphaenis confecta*, *Helicoverpa armigera*, *Xestia C-nigrum* and *Ochropleur avallesioca*.

On the basis of the results obtained from the data collected and analysed till date, it is observed that many species which look similar, when seen from the naked eye but vary in their genetic constitution, which interprets that these may be very closely related to each other morphologically but are entirely different and may not be designated as the same species.

### Ecological studies on the distribution patterns and food plant resources of butterflies along with the altitudinal gradients in different forest ecosystems of the Eastern Himalaya

Surveys were carried out in forest areas of Arunachal Pradesh covering 13 districts from East to West (Changlang, Lohit, Anjaw, Upper and lower Dibang valleys; Upper, West and East Siang, Upper and Lower Subansari, Popumpare, East and West Kameng) from Dec 2011- March 2013, to collect ecological data on butterflies. Data on 300 species of butterflies collected so far, including rare and very rare species, many are yet to be identified, along with their ecological parameters/ correlates i.e. GPS coordinates, altitude, slope, aspect, temp,



The very rare-Empress, *Sasakia funebris* in mixed sub-tropical broadleaf forest of Upper Dibang Valley, Arunachal Pradesh which was rediscovered after 88 years in India



The very rare- Ludlow's Bhutan Glory, *Bhutanitis Ludlowii*, a Papilionidae thought to be endemic to Bhutan was discovered in moist temperate forests in West Kameng district of Arunachal Pradesh

humidity, habits and forest type habitat, some food plants, plant associates, biotic disturbances, canopy cover, etc. The data are being incorporated in a GIS database of Arunachal Pradesh for elevation gradient and forest type, distribution districtwise, etc. Some rare butterfly species include the Empress, *Sasakia funebris*; Ludlow's Bhutan Glory, *Bhutanitis ludlowii*; Manipur Jungle Queen, *Sticopthalma sparta*; Peal's palmfly, *Elymnias pealii*; Yellow Gorgon, *Meandrusa payeni*; Panther, *Neurosigma siva*; Brown Prince, *Rohana parvata*, etc.

### Exploration of diversity and utilization potential of *Sphagnum* species of forestry importance in N.E. India

Eight species of *Sphagnum* species collected from various localities of Meghalaya and from Sikkim viz., *S. pseudocymbifolium* C. Muell, *S. papillosum* Lindt., *S. squarrosum* Crom., *S. khasianum* Mitt., *S. cuspidatum* C. Muell., and *S. subsecundum* Nees, *S. junghuhnianum* Doz. & Molk, and *S. plumulosum* Roell. The taxonomic characterization of all species completed with their habitat etc. The water holding capacity of all collected species analyzed in lab.

The air-layering trials laid down on several commercially important trees of the region viz., *Cinnamomum zeylanicum* (Dalchini), *C. tamala* (Tezpat), *Gmelina arborea* (Gamari) *Elaeocarpus* (Rudraksh), *Aquilaria malaccensis* (Sasi), *Litchi chinensis*, *Heteropanax fragrans* (host plant of Moonga silk-worm), *Guada angustifolia*, *Citrus reticulata*, *C. lemon* and *C. maxima* for air layering experiment. However, two species of Bamboos (*Bambusa balcooa* and *Bambusa vulgaris* 'Wamin'), and two orchids (*Dendrobium* and *Rhynchostylis*) have been selected for substrate media experiment.



Experiments on orchids, *Sphagnum* used as substrate media

Several training-cum -demonstrations were organized to the farmers and the officers of several states of Northeast India including Assam, Meghalaya, Tripura and Manipur. A training programme was organized in Nokahara village of Ri-Bhoi District of Meghalaya to demonstrate farmers' friendly technique of Air-layering.

### 3.2 Forest Botany

#### Establishment of molecular taxonomy facilities and molecular characterization of selected bamboo species

DNA extraction, quantification, and RAPD analysis of Bamboo species collected from FRI Bambusetum, Pant Nagar and Lalkuan were carried out. Bamboo leaf samples of 13 species were



collected from Bambusetum, RFRI Jorhat. Voucher specimens of the samples were prepared. DNA extraction and analysis of samples, collected from different locations were carried out. A number of ISSR primers were used for their suitability. Suitable primers were identified. Species were characterized using RADP and ISSR markers.

### Digitization of Herbarium of Forest Research Institute

The Dehra Dun Herbarium contains approximately 3,30,000 specimens and nearly 1400 valuable Type specimens. The oldest collection dates back to 1807. Besides collections from the Indian region, herbarium contains specimens from all over the world. In addition to the phanerogams, the herbarium has valuable collections of Pteridophytes. It also includes 40 'Types' specimens of newly described taxa. In all 2,973 genera, 17,573 species, 44,693 specimens, more than 1,00,000 scanned photographs and 45,173 nos. edited photographs were digitized.



Dehradun Herbarium, Specimen Sheet (above)

### Revision of Indian Woods-their identification, properties and uses- Volume-II

Writing of book is well underway. This reference book 'Indian Woods- Volume II' is being revised by adding microstructure data of 23 families and upgrading information on properties and uses.

### Study on wood anatomy of Indian shrubs for the purpose of their identification and efficient utilization

Wood anatomical structure of 200 Indian shrubs was studied. The species identification key for these shrubs has been developed. Correct identification of these shrub-woods shall lead to their efficient utilization, both in timber and in pharmaceutical industry. Interesting structural patterns were observed with few families having different anatomy of shrub and trees, reflecting upon homogeneity and heterogeneity in taxonomic classification.

### Pollination Entomology Dynamics and role of insect pollinators in fruit-set of species of Sonneratiaceae and Avicenniaceae in mangroves of Karnataka

The main aim of the study is the determination of insect pollinators in fruit-set of species of family Sonneratiaceae and Avicenniaceae of mangrove plant. Study of floral morphology and flowering season was made, May month is the peak flowering season in Avicenniaceae and July in Sonneratiaceae. Anthesis, Anther dehiscence were studied, stigma receptivity, pollen longevity, and viability of pollen was studied. Pollination biology of all the mangrove plants was studied by Bagging, Emasculation and natural pollination experiment. Insects responsible for fruit-set i.e. visitors and pollinators were collected and identified and preserved in laboratory. Visit frequency of insect has also been recorded.

### Reproductive biology of *Aquilaria malaccensis* Lamk., a critically endangered and economically important species for effective conservation

Studies were carried out on pollination ecology, pollen biology, pollen-pistil interaction; natural



*Aquilaria malaccensis*. a. Flowering branch. b. Fruiting branch. C. Dehiscent fruits, the seed is still hanging in one of them. d, Wasp feeding on the caruncle e. Wasp landing on the seed.

recruitment from soil seed bank and on pollinators across their distributional ranges in NE India.

Studies on seed dispersal were carried out. A rare mode of seed dispersal by a wasp, *Vespa affinis* L. was reported. The present study reports wasp dispersal of seeds, not only in a tropical forest species, but also in a tree species.

### 3.3 Ecology and Environment

#### Development of Biomass Expansion Factor (BEF) for some tree species of Garhwal Himalaya, Uttarakhand

Forests of *Shorea robusta* (sal) and *Pinus roxburghii* (chir) of Garhwal Himalaya were surveyed to note the diameter range of both the species to work out the diameter classes and mean tree diameter of both the species for harvesting as per Stratified Tree Technique method of Art and Marks (1971).

#### Ecological study of watershed in Mussoorie hills of Dehradun

Grasses diversity during all seasons from degraded sites was dominant. Soil moisture percentage within 0-30 cm were observed more during all seasons than 30-60 cm depth under plantation and degraded landscapes whereas it was vice-versa in the case of natural forests. Infiltration rate ( $\text{cm hr}^{-1}$ ) in natural forest was more than plantation and degraded landscape. Microclimatic status under natural forest was more than plantation.

#### Impact of human induced disturbances on regeneration and population structure of *Rhododendron arboreum* and *Myrica esculenta* in mid hills of Garhwal Himalaya

Regeneration of *R. arboreum* and *M. esculenta* was monitored under human induced disturbed and undisturbed condition in the field. Field survey was



also conducted for seed maturity indices. Seed viability test of *R. arboreum* was also monitored in laboratory. A consistence reduction in seed viability of *R. arboreum* was recorded from the beginning to the subsequent months. Seeds were found viable only for two years. Seed germination of *R. arboreum* and *M. esculanta* was recorded higher under open exposed sites than under thick canopy cover.

### Population structure, regeneration status and pollination ecology of *Dalbergia latifolia* and *D. sissoides*

Assessment of populations of *Dalbergia* sp. was made in Coimbatore Forest Division (Tamil Nadu) and Mannarkkad Forest Division (Kerala), Palakkad Forest Division (Kerala) and Vazhachal Forest Division (Kerala). In most of the locations, both *Dalbergia latifolia* and *D. sissoides* were found to occur together, in varying proportions. There was a preponderance of mature trees of higher girth classes in all the locations studied, with very less number of pole stages and saplings. The regeneration was found to be scanty and generally it was seen in the open areas, away from the mother trees. Regeneration through root suckers (i.e. from damaged root) was noticed in one location in Coimbatore Forest Division.

### Tree rich Biobooster: A novel approach to synergise growth and pest management

Mass culture of VAM, *Azospirillum* and *Phosphobacteria* was established under laboratory to test the efficacy of biomixtures. About twelve treatments of tree rich biobooster (FYM, effluent compost, vermicompost, and green manure) along with coir pith and vermiculite as base material were prepared and



Preparation of Tree rich Biobooster



Evaluation on eucalyptus biomass

conducted to examine the effect of bioinoculants with biomanure on *Casuarina* and *Eucalyptus* biomass. *Casuarina* sp., *Eucalyptus* sp, *Tectona grandis*, *Ailanthus excelsa* and *Ailanthus tryphysa* germination studies has been conducted on tree rich biobooster as coir pith and vermiculite base media to evaluate the effect of biobooster on germination. FYM and effluent compost along with coir pith as base material found to enhance the biomass when compared to vermiculite, green manure, all composts and all composts with PGPR as coir pith as base material.



### Development of models for conversion of plantations into secondary forests in Andaman Islands

Conducted the plantation surveys from North to South Andaman and selected sample plots of 5ha each in teak plantations, padauk plantations and mixed plantations located adjacent to moist deciduous forests, semi evergreen forests and evergreen forests. A total of 12 sample plots of 5 ha each have been selected. Each sample plot was further subdivided into 5 plots of 1ha each for various treatments and control. The species diversity present in sample plots of padauk, teak and mixed plantations have been carried out. Similarly, the species diversity, relative density, dominance and frequency have been worked out. Thinning was carried out in the plantations and seeds collected to raise nursery.

### Identification of extent of forest lands in forest fringe villages

Socio economic survey have been completed for Dharmapuri, Villupuram, Namakkal, Salem, Tiruvannamalai and Coimbatore. In Dindugal, 15 villages have been covered. Ecological survey has been completed for Salem, Villupuram and Tiruvannamalai and data entry made. In Kerala, the socioeconomic survey has been initiated in Palakkad and Malapuram. In Andaman, 58 villages have been surveyed for socio-economic study.

### Structure, diversity and regeneration studies in permanent preservation plots in moist deciduous and evergreen forests of Western Ghats in Karnataka

Despite the importance of the forests in Western Ghats, information on their original condition tend to be more descriptive than subjective. Most of the studies undertaken in the field of conservation

biology pertain to the current status of the ecosystems. Information on past vegetation composition and how they have been transformed over a period with respect to species composition, structure etc. is scanty. This study is expected to throw some light on structure, diversity and regeneration studies in permanent preservation plots in tropical wet evergreen forests in Kettlekan, Uttar Kannada District and in moist deciduous forests of Western Ghats in Karnataka in Karka, Bhagavati, and Kuligi in Dharward and Belgaum districts. The study will utilize secondary data in PPP records of these five sites as baseline data and utilizing past data on history and management for which no reports are currently available in public domain.

### Vegetation Carbon Pool Assessment Project in India

The project envisages temporal inventory of the forest and soil carbon stocks as well as measurement and modelling of carbon exchange along the atmosphere-vegetation boundary. Six carbon flux measurement towers using eddy covariance



Collection of herb/shrub biomass, litter collection net and litter decomposition bags



techniques are installed in five major forest types of the country.

### Conservation, Management and Utilization of selected Rattans of Assam

Analyzed 101 soil samples collected from different rattan growing areas for macro and micro nutrients. Nutritional value of the shoots of two commonly used rattan species of North East India, *Calamus flagellum* Griff. and *C. floribundus* Griff. was also studied.



Tribal people selling the rattan shoots in a local market at forest village near Dehing Patkai WLS.

### 3.4 Wetland

#### Ecological study of wetland forest ecosystem of Doon Valley (Uttarakhand)

Jhilmil Jheel wetland is known for conservation of *Cervus duvauceli* (*Barasingha*). The habitat is located at the junction of Bhabar and Terai formations representing a very unique and species rich eco-system which encompasses spectacular landscapes, tall grasslands, secondary shrubs and tropical moist deciduous forests. The present study revealed that 56 plant species belonging to 28 families are present in the area. The floral diversity includes 28 tree species, 16 shrub species and 12

herb species. *Shorea robusta* (IVI 28.3) is the dominant tree species, whereas, *Adhatoda vasica* is recessive.

The study of Asan wetland revealed that the 57 plant species belonging to 27 families were recorded in the study area. Out of this, 10 tree species, 21 shrub species, 26 herb species have been recorded. *Acacia catechu* (IVI 116.19) is the dominant tree species whereas *Morrrya koenzii* (IVI 107.85) and *Ageratum conyzoides* (IVI 48.44) are the dominant shrub and herbs species respectively. The aquatic vegetation of the Asan reservoir mainly comprises of *Typha elephantina*, *Photamogeton pectinatus*, *Ceratophyllum demersum* and *Eichhornia crassipes* of these *Typha elphantia* is dominated community covers the largest area.

### 3.5 Invasive Species

#### Impact of invasive species on plant diversity in selected forest sites of Uttarakhand, Haryana and Punjab

Impact of invasive species using quadrat method in the Jhjhra and Asharodi Range was carried out. The dominant species of the area is the *Shorea robusta*. Other important species of the area were *Mallotus philippensis*, *Syzygium cumini*, *Jasminum pubescens*, *Murraya koenigii*, *Vallisneria spiralis*, *Ardisia solanacea*, *Clerodendron viscosum*, *Milium velutinum*, *Coffea bengalensis*, *Flacourtia indica* etc. Vegetative analysis was carried out in the control, *Lantana* and *Ardisia* infested areas. It was observed that *Lantana camara* was heavily invading the open areas. However, its impact was less inside natural forest. *Ardisia solanacea* was dominant in the shrubby layer. Very few species other than *Ardisia* were observed. Above ground wet and dry biomass of *Lantana camara* was estimated using destructive harvesting.





### Documentation and distribution of Forest Invasive Species (FIS) of Jabalpur, Katni, Mandla and Seoni districts of Madhya Pradesh

Thirty nine invasive species have, so far, been documented and identified from forest area of four districts of M.P.

### Impact of *Prosopis juliflora* on biodiversity, rehabilitation of degraded community lands and as a source of livelihood for people in Rajasthan State

Extensive studies were carried out in Jodhpur, Pali, Jaipur (Sambhar) and Bharatpur districts of Rajasthan state to study the impact of *P. juliflora* on biodiversity, rehabilitation of degraded lands and as a source of livelihood. Recorded 38 species of herbs, shrubs and trees associated with *P. juliflora*. Thirty species of invertebrates and 72 species of vertebrates were also found associated and dependent on *P. juliflora*. *P. juliflora* was recorded as new host for two species of insects belonging to Order Coleoptera (*Mylabris* sp.) for the first time. Twelve faunal species under various conservation status were found associated and dependent on *P. juliflora*.

Studies on utilization aspect revealed that *P. juliflora* is a tree of innumerable uses. The main utilization of *P. juliflora* was as fuel wood and bio-fencing. It is utilized as fodder by the human for cattle. Pods are utilized by herbivores as food. Dry twigs were found to be utilized by 18 species of birds for making nests. The tree provides shade to both humans and animals including wildlife for their dwelling beneath it. Tender leaves are of medicinal value. *P. juliflora* can be utilized for rearing of cantharidin producing beetles *Mylabris* species.

### 3.6 NTFP Resource Development

#### Population dynamics of threatened medicinal plants species growing in buffer and transition zone of Tadoba National Park, Maharashtra

Following species were suggested for the study after discussion with officials of Forest Department

*Chlorophytum borivilianum* Santapau & R.R.Fern, *Dipcadi ursulae* Blatt, *Eulophia nuda* Lindl, *Uraria picta* (Jacq.) DC, *Eulophia ramentacea* Wight, *Rauvolfia serpentina* (L.) Benth.ex Kurz, *Desmodium gangeticum* (L.)DC.

#### Ecological assessment of diversity of medicinal plants in conservation areas of Chhattisgarh and strategies for their protection

Seasonal data for floristic composition were collected from 7 Medicinal Plant Conservation Areas (MPCA) established in Chhattisgarh. Phytosociological studies showed that there was a marked seasonal variation in ground flora of these Conservation Areas. 251 plants were identified and documented from the conservation areas of Chhattisgarh. Herbarium for 132 species of medicinal importance was prepared and submitted to Funding Agency, Chhattisgarh State Medicinal Plant Board, Raipur, Chhattisgarh.



Important medicinal plants growing in MPCA, Chhattisgarh



### **Raising of Model Nursery under the project of A.P. Medicinal and Aromatic Plants Board with Species such as Myrobalans (*Terminalia spp.*), Sandal wood, Red sanders etc.**

A target was set to raise two lakhs seedlings under the model nursery project. Seeds of *Santalum album*, *Pterocarpus santalinus*, *Terminalia bellirica* and *Terminalia chebula* were sown on beds and seedlings were transplanted to polybags. Seedlings of *Santalum album*, *Pterocarpus santalinus*, *Terminalia bellirica*, *Terminalia chebula*, *Aloe vera* and other medicinal species like *Ocimum sanctum*, *Andrographis paniculata*, *Asparagus racemosus*, etc. were raised. ASSO of Myrobalans (*Terminalia*) is raised in four hectare area.

### **3.7 Bioremediation**

#### **Study of bioaccumulation of heavy metals and its impact on different plant species**

Results showed that *Dalbergia sissoo* has potential for their use in phytoremediation and reclamation of heavy metal contaminated sites; other tree species like *Alstonia scholaris*, *Holoptelia integrifolia* have also showed positive response towards accumulation of heavy metals so that they can also be used for the same purpose.

Results also showed that protein, total chlorophyll and amino acid contents were reduced with increased dose of different heavy metals. Proline content showed different response in different doses of different heavy metals (Co, As, Pb, Cu, and Cr). The Bioconcentration Factor (BCF) is an index of the ability of the plant to accumulate a particular metal with respect to its concentration in the soil. The BCF for Cobalt was maximum in *Grevilia robusta* at the concentration of 30mg/l. The BCF for Arsenic was at 30mg/l in *Holoptelia integrifolia*, maximum among all the

tree species. In *Dalbergia sissoo*, results showed that maximum BCF was for lead at 40mg/l.

Translocation Factor is an indication of the ability of the plant to translocate metals from the roots to the aerial parts of the plant. Maximum Translocation Factor was seen for Lead in *Alstonia scholaris* at 40mg/l treatment.

### **Integrated nutrient management for improved growth of trees on overburden dumps**

Study was conducted in Kanhan region of Western Coal Fields Limited, Junnardeo and PENCH area of Western Coal Fields Limited, Shivpuri for selection of coal mine overburden site for laying out experiment. Shivpuri open cast coalmine at Haranbhata was then selected for taking up the experiment.

### **3.8 Seed Science and Technology**

#### **Germination and ecophysiology of two important tropical forest tree species: *Schleichera oleosa* and *Pterocarpus marsupium***

Mature seeds of *Pterocarpus marsupium* and *Schleichera oleosa* were collected from Jabalpur (MP), Chindwara (MP) and Korba (Chattisgarh). Effect of soil type and depth, light and temperature on germination of these two species was evaluated. Sampling for germination showed that both species were orthodox in nature and dormancy of *Schleichera oleosa* overcame after one year of storage. Deterioration of seeds of *Schleichera oleosa* was observed at different temperatures, if stored at high moisture content. Viability of seeds of *Pterocarpus marsupium* was maintained for more than one year at all temperatures and moisture content (as high as 10.5%). Effect of maturation on dormancy and germination of seeds of *Schleichera oleosa* and *Pterocarpus marsupium* seeds was also evaluated. Seeds of *Pterocarpus marsupium*



acquired germination capacity and desiccation tolerance well before shedding.

### Standardization of the techniques for germination, collection and maintenance of maximum viability of four important tropical species: *Bridelia retusa*, *Sterculia urens*, *Boswellia serrata* and *Saraca indica*

Fruits of *Sterculia urens* and *Bridelia retusa* were collected during March-May. Seeds were pretreated to increase the germination of *Sterculia urens* and *Bridelia retusa*. Removal of germination inhibitor in seed coat resulted in the increase in germination of *Sterculia urens*. No treatment was successful to induce germination of *Bridelia retusa*. Maturation studies are continued in *Sterculia urens* and *Bridelia retusa*.

### Optimization of seed germination methods and Clonal Multiplication Area Management of *Ailanthus excelsa* Roxb.

The aim of the project was to optimize seed germination studies and clonal multiplication by establishing vegetative multiplication area. Accordingly, different treatments were given to seeds. The seeds treated with IBA were found to be suitable for high seed germination. Further, macro propagation protocol was standardized using coppice shoots from vegetative multiplication area. The facilities like Mist Chamber, seed germinator, Vermicompost pit, and shade house had been created and are being utilized for other projects too.

### 3.9 Eco-restoration

#### Development of Model Plantation/Eco-restoration in Coal Mine Areas of BCCL, Dhanbad

A total 34 number of plant species including 16 tree species, 7 shrubs, 7 grasses, 3 herbaceous and one Bamboo species were planted by way of

various means, such as, seed broadcasting, seed mixed with soil ball, seedling planting, stem cutting, Bulbils and culm/slip. These species are of multi uses like timber, fodder, medicinal, edible, soil binder, soil enrichment etc.). Among planted species, *Dalbergia sissoo*, *Azadirachta indica*, *Phyllanthus emblica* were recorded to be highly successful species. Similarly, among grasses *Cenchrus ciliaris* and *Cenchrus setigerus* were found to be the promising species. Besides these, a number of horticulture species such as *Mangifera indica* (Aam), *Artocarpus heterophyllus* (Kathal) and *Psidium guava* (Amrud) were also planted in the areas.

### Treatment of heritage trees

Twenty five trees were treated at Ta Prohm temple, Cambodia with training to Cambodian officials. Bodhivriksha at Bodhgaya was examined for its health status and given treatment. Vat vriksha at Jyotisar, Kurukshetra, Haryana was attended and found under stress due to human activities. Suggestions for its conservation and longevity were given.



Conservation of trees at Ta Prohm temple, Cambodia

### Standardization of plantation techniques for major forest plant species in Madhya Pradesh

Project initiated from January, 2013. Jungle / site clearance and staking works were completed.



Seedling preparation / procurement and pit digging work is in progress.

### Development of site specific regeneration augmentation plan for potential degraded areas in Western Ghats

Experimental trials established at four sites in Attapaddy Reserve Forests (Siruvani and Pudur) and Silent Valley National Park buffer zone (Thathengalam and Panthanthodu) with selected pioneer species, such as, *Maesa indica*, *Macaranga peltata*, *Clerodendrum viscosum*, *Olea dioica* and *Syzygium cumini* for wet sites; *Clerodendrum viscosum*, *Holarrhena pubescens*, *Helicteres isora*, *Macaranga peltata* and *Glycosmis mauritiana* for moist sites; *Tarenna asiatica*, *Dodonaea viscosa*, *Glycosmis mauritiana*, *Clausena dentata* and *Mundulea sericea* for dry sites in Pudur area were visited and survival recorded.

Seedlings of canopy species like *Palaquium ellipticum*, *Dimocarpus longan*, *Mesua ferrea*, *Prunus ceylanica*, *Euodia lunu-ankenda* (wet site); *Terminalia bellirica*, *Adina cordifolia* (*Haldina cordifolia*), *Gmelina arborea*, *Xylea xylocarpa*, *Pterocarpus marsupium* (Moist sites); *Holoptelia integrifolia*, *Azadiracta indica*, *Chloroxylon sweitinia* (Dry sites) were planted within the pioneer species in experimental plots with spacing of 3m x 3m.

Better survival of pioneer species, *Syzygium cumini*, *Olea dioica* and *Maesa indica* in wet sites; *Helicteres isora* and *Macaranga peltata* in moist site; *Tarenna asiatica* and *Dodonaea viscosa* in dry site was observed. Among canopy species planted, very few individuals of *Melicope lunu-ankenda* and *Dimocarpus longan* in wet site; *Xylea xylocarpa*, *Terminalia bellirica* and *Gmelina arborea* in moist site; *Chloroxylon sweitenia* in dry site survived.

### Exploitation and utilization of beneficial microflora from the sholas for restoration of degraded shola forests in the Nilgiri Hills, Tamil Nadu

Fruits of shola species namely, *Michelia nilagirica*, *Mappia foetida*, *Viburnum erbuscens*, *Photonia notoniana*, *Michelia champaca*, *Berberis tinctoria*, *Syzygium cumini*, *Syzygium arnottianum*, *Dysoxylon malabaricum*, *Neolitsea zeylanica*, *Meliosma wightii*, *Hydnocarpus alpina*, *Litsea wightiana*, *Euodia Lunu-ankenda*, *Elaeocarpus oblongus* and *Symplocos cochinsinensis* were collected from Naduvattam, Glenmorgan, Kariamandhu, Kodanadu and Kotagiri areas of Nilgiris. Seed extraction and processing methods were standardized. Conducted germination studies and recorded seedling vigour parameters in the germinated seedlings, and transplanted.

### Restoration ecology and species recovery studies in Tsunami impacted mangroves of Andaman Islands

The project is about restoration of the mangrove ecosystem impacted due to Tsunami and to recover mangrove species that are rare, endangered and threatened. A total of 12 sample plots of 2 ha each have been selected in North Andaman, Middle Andaman, Baratang and South Andaman. The vegetation surveys in adjoining mangrove areas have been undertaken. Species composition, abundance and size of mangrove stands, have been documented. Life history traits, such as, patterns of reproduction, propagule distribution and successful seedling establishment are being documented. Mangrove nurseries have been established in all locations. Assisted natural regeneration and artificial regeneration has been carried out in two locations.