

# 2.1 Ecosystem Conservation and Management

## Overview

Systematic and scientific studies in respect of forest ecology have become inescapable in the present scenario when **Climate Change** is impinging upon the dynamics of forest ecosystem. It is important to understand the behaviour of ecosystems in the wake of changing climatic patterns. Climate change has multifaceted implications, accordingly addressing on the related issues in a scientific manner requires good scientific understanding in maintaining the flow of goods and services from existing forests both at National as well as global level. Efforts and the provisions made in the past under United Nation's Framework Convention on Climate Change (UNFCCC) in Kyoto-Protocol are mainly at broader levels and are inadequate to address the challenges and adaptive capacity of communities (human, floral & faunal) at ground level especially in the developing countries. Even as per the prediction by Intergovernmental Panel on Climate Change (IPCC), the GDP of the country like, India can decline up to 9% due to shifting of growing seasons, which will have catastrophic impact on more than 400 million people, largely India's poor.

As far as the Biodiversity is concerned, India being the seventh largest country in the world and Asia's second largest nation has now emerged as the twelfth largest economy in the world. The ever growing economy and the vision 2020 of India, will directly impinge upon the natural resources, particularly the remaining forest ecosystems and is certainly becoming a matter of concern.

Conservation of wildlife and biodiversity in natural heritage sites including sacred groves, protected areas, and other biodiversity '**Hotspots**' is crucial for maintaining the resilience of ecosystems. Specific actions in this programme may include *in-situ* and *ex-situ* conservation of genetic resources, especially of threatened flora and fauna, Creation of biodiversity

registers (at national, district, and local levels) for documenting genetic diversity and the associated traditional knowledge, Effective implementation of the Protected Area System under the Wildlife Conservation Act and Effective implementation of the National Biodiversity Conservation Act, 2001.

Project under the Theme			
Projects	Completed Projects	Ongoing Projects	New Projects Initiated During the Year
Plan	17	15	12
Externally Aided	05	08	06
<b>Total</b>	<b>22</b>	<b>23</b>	<b>18</b>

## 2.1.1 Climate Change

### Carbon Foot-print Mapping of FRI, Dehradun.

A Project on carbon footprint mapping of FRI Dehradun has been envisaged for a period of two years from 2011-13 for an amount of Rs. 7.50 lakhs. An inventory of GHG emitting appliances of FRI will be prepared. The carbon footprint from such sources will be calculated through appropriate statistical modeling by calculating the average working hours of such sources. The carbon footprint mapping of its employees on sampling basis will be undertaken through structured questionnaires. The overall carbon emissions of FRI will be calculated. Once the size of a carbon footprint is known, appropriate strategies and interventions for mitigation of such emissions will be proposed to offset the emissions in a rational manner in Indian context.

### Energy and Mass Exchange in Vegetative System

Agro Meteorological Station has been installed in New Forest Dehradun Campus. One year physiological



data pertaining to photosynthesis, respiration and soil respiration has been measured. Similarly, biophysical parameters such as plant height, DBH, LAI and PAR for about two years have also been recorded. In addition, the other physical parameters such as radiation and energy balance, latent and sensible heat were also recorded for about two years. Further analysis of data is in progress.

There are evidences that (i) The Himalayas are warming more than global average rate, (ii) that the extent of warming increases with altitude, and (iii) is greater during winter than summer. The climate change is going to affect forest ecosystems variously: species migration and extinction, phenological “disturbances” and changes in rates of basic ecosystem processes are some of the most common changes that would affect forests. It is quite likely that new forest communities may be created and old ones may disappear.

The Rhododendrons are an indicator species and important forest element. These species are commonly found in north-western, central and north-eastern parts of Indian Himalaya. It provides an interesting example of phenological variations within time limits along altitudes. To study the effect of climate change on phenology of Himalayan Rhododendron, a project proposal funded by UCOST was implemented by FRI, Dehradun at Chopta-Tung Nath area of Rudraprayag District (UK) during the year 2009-11. The meteorological data and phenological events were regularly recorded from September 2009 to December 2011. Based on the data collected and analyses, following conclusions were drawn.

The Alpine species (*R. anthopogon* & *R. lapidotum*) took minimum time from flower initiation to seed dispersal (June to September), however, the sub alpine species (*R. campanulatum*) took one month more time from flowering to seed dispersal than alpine species. *R. arboreum* and *R. barbatum* which are temperate species take maximum time from flowering to seed dispersal i.e. March to November that means alpine species complete their cycle within 4 months, when the snow melts and weather is convenient for plant growth.

However, the sub alpine species takes 5-6 months and temperate species 8-9 months to complete their life cycle.

The floral and vegetative bud break was noticed 10 to 15 days early in all four species. In *R. arboreum*, 100% flowering was observed in the month of April. At the end of April, flower colour faded and turned into light pink colour. The flowering completed from 5% to 100% in 10 to 35 days in *R. arboreum* and *R. barbatum*. After completion of flowering time, the vegetative bud grew rapidly and broke to leaf flush in May- June, in case of these two species. However, in case of *R. campanulatum* the vegetative bud break was observed 10-15 days later than *R. arboreum* and *R. barbatum*. The alpine species were fast in performing phenological events and just after 20 days of flowering, the vegetative bud break was observed followed by new leaves flushing in mid of June. The capsule mature and seed dispersed in September in alpine species followed by Sub alpine species in October and temperate species in November-December.

The regeneration in all four species was normal. It was found more in open sites than under dense canopy. *R. campanulatum* was observed upwards shifting from sub alpine (3400 mt.) to alpine region (3800 mt.). Therefore altitude has a strong impact on phenology of all four species being studied.

The Comparative study of meteorological data and Phenological events of four Rhododendron species did not lead to any significant conclusion. In some cases,



*R. arboreum*



*R. barbatum*



*R. lapidotum*



*R. campanulatum*



*R. anthopogon*

flowering in *R. arboreum*, *R. barbatum* and *R. campanulatum* was advanced by 5-10 days. However, no significant change noticed in alpine species. The seed dispersal was delayed by 10-15 days in the case of the alpine species in 2011 as compared to 2010.

However, not much difference was observed in opening of capsule and dispersal of seed in case of sub-alpine and temperate species.

#### Effect of Elevated CO<sub>2</sub> on Active Principles of Important Medicinal Plants

Raised the seedlings of *Withania somnifera*, *Ocimum sanctum*, *Coleus forskholii*, *Azadirachta indica*, *Gymnema sylvestre* and *Catharanthus roseus* in the nursery and kept under the different elevated CO<sub>2</sub> levels. Periodical data on growth, total plant, fresh and dry weight, root shoot ratio, no. of leaves, no. of primary and secondary roots etc; were taken. Observations on physiological parameters were taken under different elevated CO<sub>2</sub> levels. Medicinal plants parts were dried for alkaloids estimation. Worked out the chlorophyll 'a', 'b' and total for above medicinal plants under different CO<sub>2</sub> levels. Worked out the morphological parameters like SPA, LAR, etc.

#### Vegetation Carbon Pool Assessment of the North Region of Andhra Pradesh

Vegetation carbon pool assessment was taken up in 21 forest sites and 30 TOF (Trees outside forest) areas in Srikakulam, Vizianagaram and Visakhapatnam districts. Site details, forest type, soils and other relevant data were recorded. All the plant specimens were identified and made into herbarium for further studies. Quadrats were laid to meet sampling requirements and trees, shrubs and herbs were identified in each quadrat. GBH, height, fresh and dry biomass of plant species





were recorded. The quantitative measurements were recorded in the prescribed formats of IIRS for further analysis.

### National Vegetation Carbon Pool Assessment for Six Districts of Andhra Pradesh

A total of 36 plots at pre-assigned geographic coordinates were studied by laying out four quadrats of 0.1 ha each. The data on above ground biomass and locality information were collected. Total forest biomass was estimated in six districts of Andhra Pradesh viz., Medak, Mahabubnagar, Guntur, Nalgonda, Ranga Reddy and Hyderabad districts. Similarly, biomass estimation of trees outside forests has been completed at 30 sites.

### Utilization of Automatic Weather Station/Agrometeorological Station Data for Agriculture, Forestry and Hydrological Applications in Madhya Pradesh.

Conducted grass biomass studies from three national parks viz. Kanha National Park (KNP), Bandhavgarh National Park (BNP) and Madhav National Park (MNP) in Madhya Pradesh in three seasons including March, September and December. The studies were conducted near Automatic Weather Station (AWS) and Agro - Meteorological Station (AMS) installed by Space Applications Centre (SAC), Ahmedabad to quantify grass biomass per unit area. Maximum grass production was found in September (post rainy season) and December (winter season), which gradually decreased in the month of March.

Measured soil moisture profile by volumetric method at an interval of 30 cm and till the depth of 150 cm near AWS and AMS in MNP, BNP and KNP. Soil moisture increased with depth due to vertical seepage and accumulation of water to lower horizons in different seasons. Maximum soil moisture was recorded in September, followed by December and March.

Specific Leaf Area (SLA) of abundantly available tree species in MNP, BNP and KNP was quantified in the selected seasons. No regular trend in different seasons was found.



Conducting Grass Biomass Studies at Supkhar (KNP)



Collecting Meteorological Data from AMS Installed at Raunda (KNP)

Also developed regression equation for quantifying above ground biomass against GBH for *Shorea robusta*.

### Carbon Sink and Fertility Status Relation of Soil under Different Land Use System of Some States of NE India.

Characterized soil under six land uses e.g., plantation forest, tea, coffee, rubber, Jhum land areas and cardamom plantation areas. Surface soil samples were collected from six NE Indian states viz., Assam, Meghalaya, Arunachal Pradesh, Sikkim, Tripura and Nagaland. Carbon sequestration potential and fertility status of soil under six land use systems were assessed. Wide variation of organic carbon content (low to high) in soil was found among the six land use systems. Soil organic carbon (SOC) range under all the land use systems was found: 2.6 - 200.6 t/ha.



Highest amount of organic carbon sink in soil (200.6 t/ha) was found under sub-alpine and alpine plantation forest soil of Arunachal Pradesh state followed by cardamom plantation areas soil of Sikkim State (130.0 t/ha) with respect to the other land use types viz. coffee, tea, jhum land and rubber plantation area. Lowest amount of organic carbon sink in soil (42.4 t/ha) was found under Tea plantation area. Minimum quantity in the range of total soil organic carbon sink, among six different land uses was found below 10 t/ha except that under cardamom plantation area, where it was found 26.0 t/ha. Organic carbon content in soil under all the six land use systems found increased with the increase in altitude of site. Maximum amount of organic carbon sequestration in soil was found under the six land uses such as, plantation forest (200.6 t/ha) > Cardamom plantation (130 t/ha) > Jhum land (73.2 t/ha) > Rubber plantation (52.0 t/ha) > Coffee plantation (47.0 t/ha) > Tea plantation (42.4 t/ha).

Soils, collected from all the Plantation Forest, Cardamom, Jhum land, Rubber, Coffee and Tea plantation areas were acidic. Few exceptions were observed where neutral or alkaline soil was found under some sites of tea plantation areas of Sibsagar, Assam; coffee plantation areas of Haflong, Assam; and jhum land areas of Lumding, Nagaon district; Rongmriden of Karbianglong and Gurbasti of NC Hills district of Assam. Wide variation was found in available nitrogen (N) content in soil sample belonging to six land use systems. Low and medium content of available nitrogen was found under some locations whereas other locations showed high status of soil available nitrogen. Available nitrogen range, under all the six land use systems was found: 194 - 4180 kg/ha. Available phosphorous (P) content was found low in most of the areas under all the six land use cover. High available phosphorus status was found only in two plots of tea garden soil sample, collected from Raidang TE, Tinsukia, Assam. Available phosphorous range under all the six land use systems was found: 0.2 - 105 kg/ha. Low to Medium available potassium (K) content in soil was found under all the six land use systems. In few locations, high available potassium (K) status of soil was

also found. Available potassium range under all the six land use systems was found: 60 - 2640 kg/ha. Soils were found light with loamy and sandy texture under all the six land use systems with few exceptions where clay texture was found.

### Studies on Carbon Sequestration in Different Forest Types of Rajasthan

Project was started with the objectives; (i) to estimate carbon stock in forest soils, (ii) to estimate carbon stock in forest litter, and to estimate carbon stock in above ground and below ground biomass; with broader objective 'to provide an estimate of carbon stock of forests in Rajasthan' for its utilization in planning and execution of afforestation/ reforestation programme in this region. In the year 2011-12, six districts namely; Jhalawar, Bundi, Karauli, Sawai Madhopur, Jodhpur and Kota, covering 239 forest blocks and 466 sampling plots were surveyed growth of trees and shrubs measured and vegetation studied. 680 soil samples, 300 Coarse Woody Debris (CWD) samples and 240 litter samples were collected for carbon analysis. Biomass of 90 plants recorded, 103 trees recorded and carbon estimation carried out. Some important forest types were *Anogeissus pendula* scrub, *Acacia catechu* and *Boswellia serrata* type. In Kota and Bundi Forest Divisions, most of the forests are infested by *P. juliflora*. In the forests of these divisions, soil organic carbon content (0-90 cm soil layer) was highest in Kota (41.46 ton/ha) and lowest in Jhalawar (18.27 ton/ha), whereas, soil inorganic carbon was highest in Karauli (57.72 ton/ha) and lowest in Bundi Forest Division (2.88 ton/ha). Average soil organic carbon was highest (0-30 cm soil layer) in Kota in 30-60 cm soil layer in Sawai madhopur and in 60-90 cm soil layer in Karauli, Jhalawar and Bundi Forest Division.

Data compilations on *P. juliflora* revealed that about 38% of forest blocks are infested by *P. juliflora* in Rajasthan. Above ground biomass of *P. juliflora* was highest (53007.83 Kg/ha) in Jalore, followed by Bhilwara (40415.68 Kg/ha) and Jhunjunu (7167.20 Kg/ha). The lowest above ground biomass (126.38 Kg/ha) was recorded in Sikar District. Below ground





Pit Opening for Soil Carbon in *Anogeisus pendula* Scrub Type Forest in Kota Division



*Acacia catechu* Forest in Kota Division



*Boswellia serrata* Forest in Darra Sanctuary, Kota Division



*Phoenix savannah* Forest type in Chitorgarh

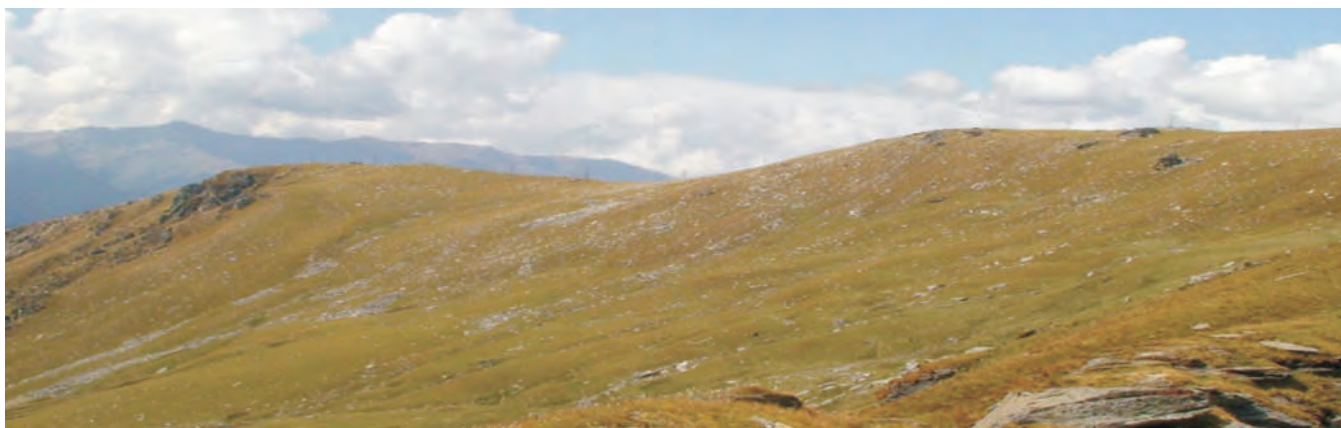
biomass showed similar trend as in the case of above ground, biomass was highest in Jalore (20872.78 Kg/ha) and lowest (94.04 Kg/ha) in Sikar forest area. If all the districts categorized into 3 ecological zone i.e., arid, semi arid and sub-humid, then *P. juliflora* showed highest above ground biomass of 6552.83 Kg/ha and below ground biomass of 2611.10 Kg/ha in sub-humid zone, 2658.65 Kg/ha and 1048.78 Kg/ha in semi-arid zone and 1169.25 Kg/ha and 502.37 Kg/ha in arid zone, respectively.

### Assessment of Carbon Stock in Forest Types of Shimla Forest Circle, Himachal Pradesh

Collected the relevant data for each of the forest types from compartment history files of Shimla, Theog, Chopal and Rohru forest divisions of Shimla forest

circle. The major forest types identified in this circle included; Chirpine, ban oak, deodar, silver fir, spruce, Kharsu oak and alpine pastures.

Detailed field survey was carried out in selected sites of these forest types. The sites for alpine pastures were identified at Chansel (3600-4000m) and Kawar (2800-3000m) of Rohru forest division and Talra (3000-3300m) of Chopal forest division whereas sites for mixed forest of Silver fir and Spruce were selected at Deya (2500-2800m) in Chopal forest division and Larot (3200m) in Rohru Forest Division. The sites for ban oak forest were identified at Taradevi (2000m) and Koti (2100m) in Shimla Forest Division, whereas, for deodar forest sites were identified at Deya (1950-2300m) in Chopal Forest



Alpine Pasture at Chansel (Dodra Kwar)



Deodar Forest, Koti (Shimla Division)



Ban oak Forest, Taradevi (Shimla Division)

Division, Garakufer (2250m) in Theog Forest Division and Koti (2150m) in Shimla Forest Division. Sites for chirpine forest were identified at Dhami (1500m) and Taradevi (1900m) of Shimla Forest Division, whereas, for Kharsu oak site was identified at Chansel (3500m) in Rohru Forest Division. Biomass studies were also conducted in alpine pasture of Chansel, Kwar and Talra. Soil samples were collected for nutrient studies.

#### **Evaluation of the Potentialities to Reduce Green House Gas (GHG) Emission from Municipal Dumping Sites for Effective Solid Waste Management**

The waste fraction data were collected from two dumping sites i.e. - Doiwala and Rishikesh. Degradable Organic Carbon (DOC) percentage of dumped municipal waste at these dumping sites was done for

summer, rainy and winter season. Estimation of Carbon dioxide was also done in Nanurkheda, and Vikas Nagar in addition to the above dumping sites for 2011-12. GHG emission from alternative scenario i.e. from composting/vermi-composting was also estimated.

#### **Soil, Vegetation – Atmosphere Carbon Fluxes Measurement and Modeling (SVF)**

The Indian Institute of Remote Sensing (IIRS) has undertaken a National Carbon Project (NCP) under Geosphere Biosphere Programme (GBP) of the Indian Space Research Organization (ISRO) to estimate the carbon pools and fluxes in different terrestrial ecosystems of India. The project envisages temporal inventory of the forest and soil carbon stocks as well as measurement and modelling of carbon





exchange along atmosphere-vegetation boundary. Six carbon flux measurement towers using eddy covariance techniques are installed in five major forest types of the country. Betul (teak forest) in Madhya Pradesh is one of them. The objectives of the project are to measure the vegetation and soil parameters to support modelling and to collect the data related to silviculture, inventory, management and utilization, to estimate the net ecosystem exchange of carbon carried out inventory of teak forest in experimental site. Collected leaf samples of 9 tree species for Leaf Area Index; Collected soil samples and analyzed soil moisture % and soil carbon%, EC, pH, N, P and K. Litter production and decomposition rate and Herb/Shrub Biomass were recorded. Data for phenophase of 10 species was also recorded.



Litter Trap

### Monitoring the Impact of Climate Variables on Plant Diversity in Bhimashankar Permanent Preservation Plot of Sub Tropical Hill Forest of Maharashtra

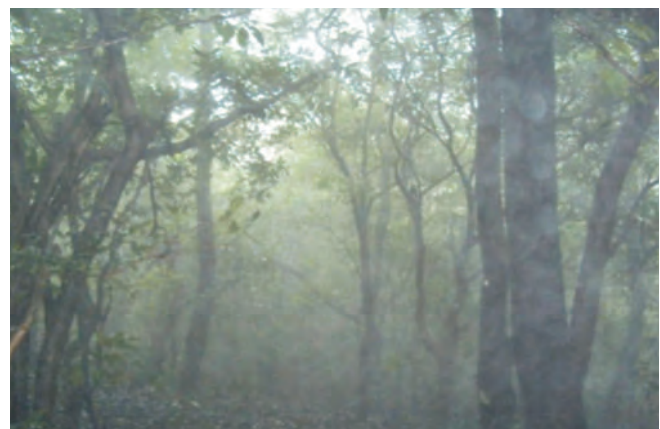
The study is being carried out in Bhimashankar permanent preservation plot of subtropical hill forest (8A/C<sub>2</sub>), one of the 23 preservation plots of Maharashtra state. The Bhimashankar preservation plot is rich in biodiversity and efforts will be made in the present study to monitor the impact of possible climate variables on vegetation dynamics. Previously, plant diversity of this preservation plot was studied by TFRI, Jabalpur in the year 1999. Such types of study which include scientific investigations at ecosystem level have not been undertaken in this region. The data generated through this study will be provided the base for future strategies to be adopted for ecosystem monitoring in relation to climate change on global basis.



Collection of Herb/Shrub Biomass



Litter Decomposition Bags



Subtropical Hill Forest





Secondary information collected from available resources. Collection of climatological data is in progress. Preliminary survey was carried out in comptt. No. 19 for general information pertaining to site, terrain, physical features and vegetation. Floristic identification for inventorization and phenological observations on important species was carried out. Total 16 tree species recorded. Vegetation sampling was done to know the type of plant species present, so that vegetation of the area can be assessed quantitatively and qualitatively. Simple Random Sampling was carried out through laying out quadrats.

### 2.1.2. Ecosystem Services

#### Study on Ecosystem Services Imparted by Reserve Forests of Mussoorie Forest Division

A three year project on ecosystem services imparted by reserved forests has been implemented from 2009-10 to 2011-12. Four distinct ecosystems/ forest types at different altitudes have been selected for the study. Sal Forest area below 1500 m altitude, Chir Forest Area between 1500-1800 m altitude, Oak Forest Area between 1800-2100 m altitude and Deodar Forest Area above 2100 m altitude were identified and selected for the study.



Deodar Forest Area at Devalsari

A total of 58 sample plots were laid for data collection in different locations. Average GBH and height of trees was recorded in different girth classes for each forest type for valuation of carbon sequestration potential, based on biomass. The total biomass in each girth class was calculated to estimate the tree biomass in tonnes per hectare.



Site Selection at Ringalgarh, Mussoorie



Biomass Collection at Ringalgarh

Estimations indicated that biomass in deodar forests was almost twice that of pure Sal forests which was closely followed by Oak and Chir forests. Field data collection through Questionnaire has been done for valuation of other environmental services using Surrogate Market Technique, CVM, WTP and Hedonic Pricing methods. The recreation value was calculated through structured Questionnaires based on Travel Cost Method (TCM).



### 2.1.3. Hydrology

#### Comparison of Hydrological Regime of Degraded and Dense Oak Forest in Mussoorie Area

A five years project on forest hydrology is being implemented from 2007-2012. It is jointly funded by ICFRE and UCOST on 50:50 basis for a total cost of Rs. 31.20 lakh. The purpose of the project is to study the impact of forest cover on the hydrological regime and comparison of the same having dense Oak forest with a degraded micro-watershed to establish the functional relationship between forest cover and various hydrological parameters.

Two micro-watersheds viz (1) Arnigad micro-watershed (dense oak forest – 285 ha) and (2) Bansigad micro-watershed (degraded oak forest – 190 ha) have been selected about 36 km away from Dehradun towards Mussoorie.

Meteorological observatory was set up at both the locations and about 64,800 readings at each micro-watershed were recorded for temperature, rainfall, humidity, wind velocity and evaporation through different instruments. Soil moisture sensors were installed at different elevations and depths in each micro-watershed and 70 readings of soil moisture were recorded. Initial analysis of both meteorological data and soil moisture data has been completed. Two weirs at the exit points of each project site were constructed and about 53851 readings of water discharge were recorded. Both, hydrological and meteorological data were recorded from March 2008 to February 2011 and a data base for first three years developed for analysis.



Dense Micro Watershed at Arnigad, Mussoorie



Meteorological Observatory, Bansigarh, Mussoorie



Degraded Micro Watershed at Bansigarh, Mussoorie



Weir at Site





Soil samples for physio-chemical properties in different locations of each micro-watershed were also collected. About 800 water samples were collected to measure suspended load from each micro-watershed. Infiltration tests at four locations of each micro-watershed were done through double ring infiltrometer and interpretation of infiltration rate completed. About 5000 water and precipitation samples were collected for isotopic and tritium analysis at NIH Roorkee. Annual budgeting of rainfall and runoff for three years has been done to indicate the correlation of hydrology on forest.

#### 2.1.4. Ecology & Environment

##### Development of Biomass Expansion Factor (BEF) for Some Tree Species of Garhwal Himalaya, Uttarakhand

Felling of *Shorea robusta* (sal) and *Pinus roxburghii* (chir) trees was done. Fresh weight of each component viz. leaf, twig, branch, bole, root, bark etc of all felled trees were taken in the field and representative samples of all these components were carried to the laboratory for oven dry weight estimation. Drying of some of tree components completed and calculation for biomass and BEF estimation is in progress. Drying of some thick discs of boles of some big trees is also in progress. Tabulation, computerization of fresh and dry weight of already felled trees of both the species done and biomass of these trees estimated.

##### Study of Bioaccumulation of Heavy Metals and its Impact on Different Plant Species

Heavy metal (Cu, Co, Cr, Pb, As) doses of four different concentrations i.e.- 10mg/l, 20mg/l, 30mg/l and 40mg/l were given to the plant species (*Lagerstroemia* sp., *Holoptelea integrifolia*, *Alstonia scholaris*, *Grevilia robusta*, *Dalbergia sissoo*, *Terminalia arjuna*), which were sown for experimentation in the Central Nursery of FRI for one year. The effect of above heavy metals on plant morphological parameters was noted. The morphological parameters i.e. root length, shoot length, root- shoot ratio, biomass etc. were also

recorded. Sample preparation for heavy metal analysis in laboratory was also started during 2011-2012.

##### Ecological Study of Watershed in Mussoorie Hills of Dehradun

In kairkuli watershed of Mussoorie hills under protected and degraded natural forests, plantation were selected after consultation with forest officials of the Mussoorie Forest Division. Several quadrats of 10 x 10 m, 5x 5 m and 1x1m. were laid out under selected landscapes for phytosociological determination of trees, shrubs, and herbs. *Quercus leucotrichophora* was dominant under natural forest where as *Cupressus torulosa* was dominant under plantation. Under degraded natural and plantation sites *Berberis* spp were dominant in shrubby form. Under growth biomass was determined by harvest method from the selected sites and degraded natural forest shows more biomass followed by protected natural forest. Soil samples were collected from the selected permanent plots from the depth of 0 -30 cm. and 30 - 60 cm. Soil moisture % from protected natural forest was observed more than others. Physico – chemical determination of soils are in progress. Microclimatic data of the selected landscapes were collected in day time when sun shining was in peak. Temperature (°C) and relative humidity (%) recorded from protected and natural forest show more value than plantation, whereas degraded natural forest and plantation did not show any variation.

##### Impact of Human Induced Disturbances on Regeneration and Population Structure of *Rhododendron arboreum* and *Myrica esculenta* in Mid Hills of Garhwal Himalaya

The viability of seeds of *Rhododendron arboreum* was found to be declining from 70-80% to 30-40% over the years from the date of collection of seeds from the forest area. Germination rate was recorded high in undisturbed sites as compared to that in disturbed sites both for *R. arboreum* and *M. esculenta*. Seed germination in the field was recorded higher in undisturbed sites than that in the disturbed sites both for *R. arboreum* and *M. esculenta*.



### Ecological Study of Wetland Forest Ecosystem of Doon Valley, Uttarakhand

#### Asan Barrage

The ecological studies conducted in Asan Barrage in Doon valley revealed that there were 57 plant species belonging to 27 families. Out of this, 10 were tree species, 21 shrub species and 26 herb species. The study of water indicated that water was free of pollution.

#### Jhilmil Area

Similar study was also carried out in Jhilmil Area and data revealed that there were 76 plant species belonging to 30 families. Out of this, 20 were tree species, 26 shrub species and 30 herb species. The study of water indicated that water was free of pollution.

### Impact of Forest Plantations on Ground Flora Diversity and Soil Characteristics

For the study of Ground flora diversity and soil properties, *Eucalyptus grandis* and *Acacia mearnsii* plantations were selected in Pykara and Naduvattam ranges of Nilgiris (TN) and Munnar and Devikulam Ranges of Munnar (Kerala). Enumerated plant species in and around the selected Teak plantations for quantitative assessment of ground flora diversity in different Teak plantations like Aravallikavu (1975 and 1939), and Mayiladi area (1987) in Nilambur Range, Kerala, Sadvayal (1968-1969) and in Kalkothi (1978), Coimbatore Range in Tamilnadu by laying out quadrats (10 each of 100 sq. m) in each plantations. Enumeration was also done in selected *Eucalyptus grandis* (Naduvattam range) and *Acacia mearnsii* (Pykara Range) plantations in Nilgiris. It was found that *Cestrum aurantacum* was the single dominant species on the ground flora in Nilgiris in *Acacia mearnsii* plantations. 32 species of ground flora were recorded from *Eucalyptus grandis* plantation in Naduvattam. 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.

### Structure, Diversity and Regeneration Studies in Permanent Preservation Plots in Moist and Evergreen forest of Western Ghats in Karnataka

Initial survey of Karka, Bhagavathi and Kulgi ppp of Dharwar Circle was carried out in the month of January and data recorded. Survey of Katlekan ppp of Sirsi Division was carried out in the month of February and the data recorded.

#### Seed Biology Studies

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. Parameters such as 100 fruit weight, Fruit moisture content, Seed moisture content, 100 Seed weight, Germination %, Shoot length, Root length, Collar diameter and Seedling vigour were found out. The transplanted seedlings were subjected to study on effect of microbial inoculation. Studies on germination of seeds inoculated with growth promoting microbes are in progress.

### Monitoring of Changes in Flora and Fauna in the Reserved Forest along the Thellavagu Nallah

Data collection on monitoring changes of flora and fauna in the reserved forests along the Thellavagu nallah was done. Data were analyzed for IVI value and plant diversity.

### Study on Impact of Podu Cultivation on Phytodiversity and Soil Factors in the Eastern Ghats of Andhra Pradesh

Surveyed the identified podu areas in Bhadarachalam Forest Division of Khammam District, Maredumilli range of Kakinada forest division and Palakonda Range of Srikakulam Forest Division.





Collected the data of phytodiversity of podu areas and control plots. Collected the soil samples from the respective areas and analyzed them for various prospects.

### 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 has been started to determine the changing of plant diversity in different year old plantations, changing of soil properties in these teak plantations and the similarities between plant species in each of these teak plantations and plant species in natural forests of teak.

Quadrats have been laid out in 25 compartment of teak plantation of various age groups i.e. 1, 4, 7, 10, 13,

16, 19, 22, 25, 28, 31 years. Enumeration of vegetation was also carried out. Eighty four trees, 12 shrubs and 36 herbs species have been recorded other than teak. Soil samples were collected for estimation of soil nutrients.

### Ecological Assessment of Diversity of Medicinal Plants in Conservation Areas of Chhattisgarh and Strategies for their Protection

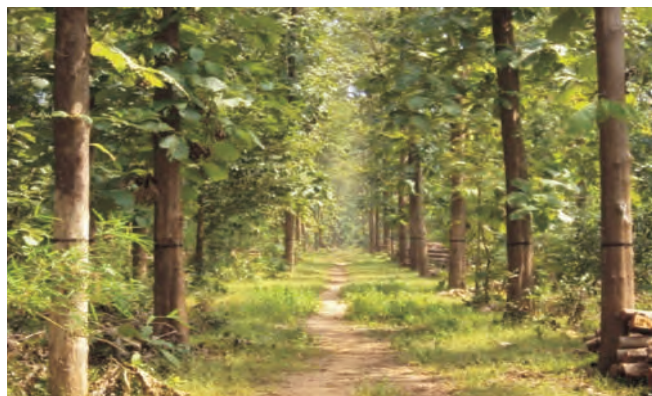
In view of extremely rich bio-cultural diversity in the state and dependence of forest dwellers for their health requirements on medicinal plants, the Government has declared Chhattisgarh as a 'herbal state' in July 2001. Accordingly, the Chhattisgarh Forest Policy has specially provided for evolving a feasible mechanism for *in-situ* / *ex-situ* conservation, domestication, propagation and non-destructive harvest of medicinal plants with the active help and support from local people including traditional healers and vaidyas.

To document floral composition, taxonomic characteristics, listing of endemic and threatened species, regeneration of the important species and traditional uses, associated with medicinal plants being utilized by the local people/tribals; 7 conservation areas of medicinal plants of CGSMPB have been proposed for study in Chhattisgarh state.

Survey, identification and documentation of medicinal plants has been carried out at 7 MPCA i.e. Jabarra at Damtari, Keochi at Marvahi, Bandhatola at Kheragarh, Bhatwa at South Kondagaon, Machkot at



Team at Work With Forest Officials



Teak Plantation



*Curculigo orchioides*



Jagdapur, Ghatpandari at North Sarguja and Patia at Jashpur Forest Division. 152 Plant species having medicinal importance have been identified from this region.



*Gloriosa superba*



*Mitragyna parviflora*



*Uraria lagopoides*



*Thespesia Lampas*



*Ziziphus oenophila*

### **Influence of Forest Canopy Cover on Ground Flora and Micro-climate in Western Ghats (Maharashtra)**

Assessed change in ground flora including herbs and shrubs with change in canopy density in the selected sites of Raigad, Ratnagiri and Sindhudurg districts of western ghats (Maharashtra). Number of species in ground flora increased with decrease in canopy density.

Observed effect of canopy structure and density on natural regeneration and growth of ground flora including native and alien species.

Change in soil parameters was also observed due to change in organic matter, litter fall and decomposition, moisture conservation, light intensity, temperature and humidity which was attributed to varying canopy density.





### Counterbalancing the Detrimental Effect of Sponge Iron Factory-emitted Particulate Matters (SIFPM) with the Protective Effect of Vesicular Arbuscular Mycorrhiza (VAM) on the Growth of Seedlings of Important Tree Species

The project was started to assess the protective effect of Vesicular Arbuscular Mycorrhiza (VAM) on the growth of seedlings of important tree species. The sites selected for the study are industrial areas of Ghugus (Maharashtra), Raigarh, Raipur (Chhattisgarh) and Bhopal (Madhya Pradesh). Innumerable Sponge Iron Factories have been established in Madhya Pradesh, Chhattisgarh and Maharashtra which emit pollutants mainly in the form of  $SO_2$ , NO,  $NO_2$ ,  $N_2O_5$  and Suspended Particulate Matters (SPM). SPM causes a huge loss to the environment on vegetations like closing of stomata in leaves and dispersal of several toxins in the environment. Around these factories, the average growth of the trees found to be stunted and deformed.

Six months old 1200 plants of ten tree species are presently under study of this project namely *Tectona grandis*, *Gmelina arborea*, *Dendrocalamus strictus*, *Dalbergia sissoo*, *Pongamia pinnata*, *Cassia siamea*, *Azadirachta indica*, *Emblica officinalis*, *Peltaforum ferrugineum*, *Schleichera oleosa* and *Butea monosperma* on a critical comparison with control data collected from least polluted areas. Physicochemical estimations in terms of biochemical estimations (Chlorophyll, Sugar, Ascorbic Acid and Phenol) of leaf and soil samples are in progress.

Experiments have been made with two sets at the nursery of TFR I; Soil + FYM (Control) and Soil + FYM + SPM (Experimental); the soil has been treated with the SPM collected from the industrial areas affected with the pollution from sponge iron factories. This is a model experiment which shall mimic the polluted condition and analysis of which along with growth data would tell us the magnitude of the loss or how much the plant is immune to pollution effects.

Soil around the feeder roots and feeder roots were collected from different tree species for VAM culture.

These soil and root samples were inoculated in different pots with maize seeds for VAM culture. For VAM culture, firstly the potting mixture was autoclaved (Soil + Sand + FYM) twice for sterility, and then transferred to earthen pots (10 kg capacity) in field. Then, soil and root samples collected from the affected sites were mixed with this pot-mix in 1:20 ratio, and immediately thereafter, 15 maize (*Zea mays*) seeds were sown at 2.5 inch depth. The maize plants were irrigated with sterile water to avoid any VAM contamination from other sources. The Mycorrhiza grew well in 3 months, and after that, the desired VAM was harvested.

It was observed that application of VAM for a particular species as collected from the affected area, cultured, harvested and when applied in pot-mix (mixed with environmentally toxic particulate matters) of nursery-grown seedlings, significantly confer physiological protection as reflected from general health, growth-data (Height, collar circumference, number of branches and number of leaves) and biochemical assays (soluble protein, phenol, carbohydrate, ascorbic acid, chlorophyll a & b). The same trend of improvement was noticed in all the species as mentioned.



Four Experimental Categories of *Gmelina arborea*

Four Experimental Categories of *Azadirachta indica*

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

Field survey in Gibbon WLS, Karbi Anglong, in forest areas of Karimganj and Hailakandi District, Dibrusaikhowa NP, Jeypore RF, Poba RF and Nambor RF Garampani was carried out and phenological information and population dynamics data recorded. Samples, soil and plant samples for herbarium were



also collected and soil pH, bulk density, C, N, P and K etc determined.

### 2.1.5. Invasive Species

#### Investigations on Ecology of Mimosa Invasion in Kaziranga National Park, Assam

The work done till date under this project can be summarized as follows: Grid map of size '810m X 810m' of the study area was generated. Classification of course resolution satellite images (LISS 3) was completed. Questionnaire based appraisal survey for presence/absence of Mimosa in each range was also carried out. GPS based reconnaissance survey of the study area was carried out for collection of geo-coordinates of Mimosa invaded patches. A 'Potential invasion map' was prepared based on GPS information and the preliminary classified map. Vector layers like drainage, roads, camp locations, compartments and grids were integrated with Potential invasion map in GIS environment and base map prepared. Visual interpretation of higher resolution satellite images has been completed. GPS location (both polygons and points) of Mimosa patches were examined in the image thoroughly. A model was developed to integrate remote sensing, GPS and GIS data/information and weightage of each layer was provided using Analytical Hierarchy Process (AHP) to get the mimosa invasion map of Kaziranga National park.

It was found under the project, *Mimosa invisa* had been coming up in tall grass community, identified as *Erianthus ravanae-Imperata cylindrica-Saccharum spontaneum*, *Erianthus ravanae-Saccharum spontaneum-Imperata cylindrica*, *Veteveria zizanoides-Imperata cylindrica-Saccharum spontaneum*, *Veteveria zizanoides-Saccharum spontaneum-Imperata cylindrica* in Bagoroi and Kohora range, in Kaziranga National Park. 35 other plant species in association of *Mimosa invisa* were also identified viz. *Erianthus ravanae* (Ekora), *Imperata cylindrica* (Borota kher), *Saccharum spontaneum* (Kohua), *Imperata cylindrica* (Kher), *Veteveria*

*zizanoides* (Birina), *Alpinia allughas* (Tora) etc. Seedlings of  $321.6 \pm 56.2$  no seedlings/sq m and  $270.4 \pm 52.6$  no/sq m in *Mimosa invisa* infested site in Bagori and Kohora Range were recorded, respectively. In some sites, maximum 780 no seedlings/ sq m of *Mimosa invisa* were also recorded. It was observed initially that the infested weed was coming up in tall grass community particularly *Erianthus ravanae-Imperata cylindrica-Saccharum spontaneum*, *Erianthus ravanae - Saccharum spontaneum*, since weed required support to climb up. When the tall grass community were destroyed to some extent by wild animal and made space, the weed is able to exist within the tall grass community. Gradually, they grew up and by profuse branching, form a net like cover at the top of the tall grass. It reduces the regeneration and gradually disappear tall grass and ultimately weed gets dominance over to grass. It was observed some shrub species like *Alpinia allughas*, *Desmodium sp.*, *Ageratum conyzoides*, *Eupatorium odoratum*, *Litsaea monopetala*, *Bombax ceiba*, etc. are preserved in Mimosa infested site, which is an indication of transforming the site from grassland to tree dominated land.

Data recording on phenological events of Mimosa was completed and phenograms prepared with all events of life cycle which included Seed germination time, Inflorescence initiation, flowering, pod formation, seed setting and seed maturation periods. Seeds from healthy Mimosa plants identified in invaded areas were collected from Western, Central, Eastern and Burapahar ranges of KNP. Seeds were processed and stored for seed biology and germination studies. Viability and vigour of the seeds were studied following standard ISTA methods. Seed germination trials were laid out in laboratory and nursery conditions. Field trials for seedling emergence from soil seed bank were also completed. The seed burial effect (soil layer to 27 cm soil depth), biomass analysis at different environment gradient and seed soaking in water at different intervals experiments were completed. It showed the range of seed viability in different conditions as 90 – 95%. The control measures experiments showed good results when stem cut up to 12 cm from ground before seed





setting, all the selected stems died after three months. A Questionnaire (in vernacular language) was prepared and questionnaire based appraisal survey for existing Mimosa control measures was carried out.

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

Alien species are non-native or exotic organisms that occur outside of their natural adapted ranges due to their dispersal potential. Many alien species support our farming and forestry systems. Alien species become invasive when they are introduced deliberately or unintentionally outside their natural habitats into new areas, where they express the capability to establish, invade and compete with native species. Many of the plant species intentionally introduced in various countries in the past have become major threat to the forest biodiversity and their control measures consume substantial financial resources. Preliminary survey has therefore been carried out in four districts i.e. Jabalpur, Mandla, Katni and Seoni of M.P.

invasive species so far been documented and identified from forest area of above four districts.

### Ecological Impact Assessment of Invasion of *Lantana*, its Removal and Subsequent Restoration of Habitats in Rajaji National Park of Tropical Moist Deciduous Forest

Distinct changes in the dominance of understorey vegetation such as *Adhatoda zeylanica*, *Murraya koinigii* and *Clerodendrum viscosum* in mixed vegetation communities and *Ehretia laevis* a middle sized tree and *Clerodendrum viscosum* in Sal forest was recorded after removal of *Lantana* from the National Park. Besides, species diversity of herbs and shrubs also recorded higher in *Lantana* removal sites than *Lantana* invaded sites in both Sal and Mixed vegetation communities. Similarly the number of grasses was also recorded higher in *Lantana* removal sites than *Lantana* invaded sites.

### 2.1.6. Phytoremediation

#### Phytoremediation of Soil for Productivity Enhancement During Land Disposal of Effluent

A survey was conducted at Balotra, Salawas and Pali in January, 2011 and in the vicinity of effluent disposal area at Luni, Jojri and Bandi river, respectively studied. Plant and tree species like; *Acacia nilotica*, *Acacia tortilis*, *Prosopis juliflora* (Swartz.), *Aerva pseudotomentosa*, *Sacharum munja*, *Echinops echinatus* were observed at Salawas, whereas, *Prosopis cineraria* (Linn.), *Salvadora persica* Linn., *Aerva pseudotomentosa*, *Argemone mexicana* at Balotra and *Parkinsonia acculeata*, *Blumea oblique*, *Euphorbia hirta*, *Calotropis procera* and *Chenopodium album* were recorded at Pali.



*Hyptis suaveolens* in Mixed Forest



*Lantana camara* in Teak

Three sites at each district have been selected for the study and their details have been recorded. Thirty Nine



*Carissa carandus*



*Hyptis suaveolens* Infestation



*Parkinsonia acculeata* at Bandi River, Pali



*Prosopis juliflora* at CETP Plant, Balotra



Water and soil samples were collected from river basins and parameters like; pH, EC, Dissolved Oxygen, Chloride, Total Dissolved Solids (TDS), Suspended Solids, Soil Organic, Soil Inorganic and Soil Moisture Level etc were analysed in the laboratory. Water samples collected from Balotra showed high pH, very high Electrical Conductivity and Total Dissolved Solids. Water samples collected from river Jojri, Salawas also showed high pH, very high Electrical Conductivity, high Chloride, high Total Dissolved Solids and very low Dissolved Oxygen. Whereas, soil samples when analysed showed low pH and high Electrical Conductivity.



Affluent Water Sample Collected at Jojri River, Salawas

Many sites were considered for the study, but a favorable site for the field experimentation has been identified at Salawas village in vicinity of Salawas Treatment Plant (STP) Jodhpur. The proposal for the land has also been sent to Jodhpur Development Authority, which is under consideration.

### 2.1.7. Biodiversity

#### Grasses of Uttarakhand and Himachal Pradesh

The herbaria of Forest Research Institute and Botanical Survey of India are being scrutinized for collections of grass specimens from Uttarakhand and Himachal Pradesh. Libraries of both these organizations are also being consulted for references on grasses. Some of the books consulted included Grasses of Burma, Ceylon, India and Pakistan, Flora

Simlensis, Flowering Plants of Uttarakhand (A Check list), Herbaceous Flora of Dehradun, Flora of South Indian Grasses, The family Grasses in various Indian Floras, etc.

Exploration cum collection tours were conducted to collect the grass specimens. In Uttarakhand following places were covered – Chakrata, Dehradun, Mohand, Rajaji National Park, Pithoragarh, Lohaghat, Tanakpur, Uttarkashi, Nainital, Champawat, Narendranagar, Vikasnagar, Saiya, Tueni, Mussoorie, Rudraprayag, Chamoli, Gopeshwar, Haridwar, Rishikesh, Jaunsar & Chopta Mandal. Around 1500 specimens have been collected of which 600 specimens have been identified. Some of them are – *Apluda mutica*, *Andropogon monticola*, *Andropogon contortus*, *Arundinella hispida*, *Arundinella nepalensis*, *Cynodon dactylon*, *Typha angustifolia*, *Saccharum spontaneum*, *Sporobolus tremulus*, *Paspalum flavidum*, *Paspalum scorbiculatum*, *Digitaria sanguinalis*, *Panicum flavidum*, *Panicum colonum*, *Panicum ramosum*, *Panicum repens*, *Sporobolus diander*, *Cymbopogon martinii*, *Setaria tomentosa*, *Setaria homonyma*, *Setaria glauca*, *Ischaemum ciliare*, *Pennisetum purpureum*, *Echinochloa crusgalli*, *Erianthus sp.*, *Eriochloa polystachya*, *Poa pratensis*, *Chloris virgata*, *Pogonanthus sacchanoides*, *Bromus unioloides*, *Vetiveria zizanioides*, *Chloris barbata*, *Chloris burnei*. Unidentified specimens are in the process of identification.

Paonta Sahib, Dhaulta Ku-an and adjoining areas, Solan, Una, Hamirpur, Kandhaghat, Kumarhatti, Spathu, Simla highway and Parwanu and adjoining areas and boundaries of district Sirmour, Una, Hamirpur and Mandi have been covered in Himachal Pradesh. Around 500 specimens have been collected of which 300 specimens have been identified and remaining specimens are in the process of identification.

#### Bioecology and Management of the Gall Insect in Eucalyptus

Regular and extensive surveys were conducted and sites : Chidiyapur, Star Paper Mills, Shakumbhari Devi





Range, Roorkee and Kalesar (Yamunanagar) along with roadside plantations (Randomly at three sites during every tour) were finalized for regular collection of data on seasonal abundance, damage percent and bio-ecological aspects of the gall insect. Collection of data is in progress. Rearing of the insect is being carried out in the laboratory as well as in outdoor cages. Collection and procuring of clones of Eucalyptus is in progress from different sources for studying the resistance in eucalyptus.

### **Taxonomic Studies on Parasitoids Belonging to sub family Braconinae (Hymenoptera: Braconidae) of Uttarakhand**

Survey and collection of parasitoids belonging to sub family Braconinae and their hosts / key insect pests have been carried out from Kaleswar, Kalsi, Timli, karwapani and New Forest campus. As a whole 21 parasitoids were collected. Sorting of parasitoids belonging to Braconinae was carried out and slides were prepared.

One Species of genus *Bracon* (4 specimens)  
One Species of genus *Atanycolus* (9 specimens)  
One Species of genus *Ipobracon* (8 specimens)  
Detailed morphological studies of following two species have been carried out:

1. *Iphiaulax immsi* Cameron, emerged from wood borer of *Terminalia tomentosa*  
2. *Iphiaulax spilocephalus* Cameron, emerged from the wood borer of *Calotropis procera*. Updating of the already present genera of NFIC: *Hypogaster xanthopsis* (Cameron, 1905) = *Iphiaulax spilocephalus* Cameron, 1905  
*Stenobracon (Stenobracon) deesae* (Cameron 1902) = *Glyptomorpha deesae* Cameron 1902.

### **Studies on Taxonomy of the Family Eulophidae (Hymenoptera: Chalcidoidea) Present in National Forest Insect Collection (NFIC) Except Doon Valley**

1. Literature on Eulophidae was collected (Hansson 2000, 2006).
2. Sorting and identification: Four hundred card mounted specimens of Eulophidae were sorted out from "Burma Collection", stored in NFIC.

Following species were identified:

- a) *Tetrastichus tunicus* : Four series of specimens collected from Naungkhangyi, Botanical Garden, Wet wan road Myamo, Myanmar; vi-x. 1940; MH Desai, from seeds of *Lantana camara*
  - b) *Euplectrus petiolatus* : Collected from Maymo; 08.vii.1940; MH Desai; undet pyralid on *Diospyros burmanica*.
  - c) *Oomyzus sokolowskii* Collected from Maymo; 28.iv.1940; MH Desai; undet. Host.
- 2) Slide preparation of two species of *Pleurotroppopsis* was done. They were dried and card mounted (HMDS). Species were macrophotographed. Morphometrics of species were also done.
  - 3) A total of 2774 specimens were identified from unidentified Eulophid collection, present in NFIC. All the specimens belong to species *Tetrastichus triozei* which were collected from the location Terah in Punjab.
  - 4) Studied and compared the following holotypes with identified eulophids at ZSI Western Ghat Regional Station, Calicut: 1. *Elachertus adimalicus*, 2. *Tetrastichus abatus*, 3. *Tetrastichus arucicus*, 4. *Tetrastichus chindakicus*, 5. *Tetrastichus cotesiae*, 6. *Tetrastichus dasi*, 7. *Tetrastichus dulciculus*, 8. *Tetrastichus flavilatus*, 9. *Tetrastichus girishi*, 10. *Tetrastichus heydoni*, 11. *Tetrastichus laparus*, 12. *Tetrastichus sumatus*, 13. *Tetrastichus thonicus* and 14. *Tetrastichus tunicus*.

### **Studies on Taxonomy of the Family Encyrtidae (Hymenoptera: Chalcidoidea) Present in National Forest Insect Collection (NFIC) Except Doon Valley**

1. Card mounted specimens of Encyrtidae were sorted out from "Burma Collection" stored in NFIC. Following species were identified:
  - a) *Copidosoma indicum*
  - b) *Copidosoma floridanum*

Both were collected in Myanmar, Maymo; 10-11.v.1940; M.H. Desai; ex unknown host.



2. 1235 specimens stored in two Cabinet boxes and collected from different locations of Punjab during 1930s were identified as *Copidosoma varicorne*. Alcohol preserved encyrtids, collected from canopy fogging of *Vateria indica* Karnataka: Bannadapaare, Makuta near Virajpet (N 12°04' 39.2"; E 75°43'33.6") in the Western Ghat; 26.vi.2003; YB Srinivasa; were identified as: *Bothriothorax* sp. (2 specimens), *Copidosoma varicorne* (1 specimen), *Copidosoma subalbicorne* (4 specimens), *Adelencyrtus* sp. (6 specimens), *Adelencyrtus quadriguttus* (1 specimen), *Adelencyrtus* sp (14 specimens), *Epitetracnemus* sp (1 specimen), *Ooencyrtus agalmatus* (1 specimen) and *Trechnites* sp. (6 specimens).
3. Encyrtid specimens in alcohol were dried and mounted. They were identified as 3 undetermined species of *Ooencyrtus*, three species of *Adelencyrtus* and *Ooencyrtus corbetti*.
4. Alcohol preserved specimens from Karnataka were cleaned and dried with HMDS technique. Following species were identified: 1. *Adelencyrtus* sp1; 2. *A.* sp2; 3. *A.* sp3, 4. *Comperia indica*, 5. *Cheiloneurus zeyai*, 6. *Ooencyrtus uthesiae* and 7. *Copidosoma indicum*. They were card mounted and some of their parts like wings and antennae were mounted in Canada balsam.

*Psyllaephagus* sp. parasitizing *Trioza fletcheri* minor leaf gall former of *Terminalia arjuna* was compared with *Psyllaephagus bengalensis* Hayat. Present species differs from it on the basis of antennal segments, body size and colorations. Morphometry for 75 different measurements each of female and male were taken from the HMDS dried and slide prepared specimens. *Psyllaephagus* sp. was macrophotographed.

Description of the new species *Neastymachus scutopunctilatus* was completed and paper submitted for publication.

### Bioassay of Some Selected Plant Extracts against Major Defoliators of Poplar and Shisham.

Collection of *Clostera cupreata* and *Plecoptera reflexa* was done from the selected sites (Chichhrauli,

Haryana and Thanu, Uttarakhand). Rearing of defoliators was done in chimney as well as in wooden cages in the laboratory to maintain the culture for laying down a series of experiments. Collection of *Adina cordifolia* was done from the field, it was shed dried and ground to powder. Extraction of ground material of *A. cordifolia* was done in different solvents viz. petroleum ether, acetone, methanol and water sequentially in Chemistry Division, FRI. Moisture free yield was calculated which was 4.06, 4.91, 18.42 and 9.21 per cent in petroleum ether, acetone, methanol and water respectively. Different extractives were prepared by diluting in different solvents. Testing trials of different extracts was done at 1% concentration, to find out their



*Cerapteroceroides anustifrons*  
(Head Dorsal View : Female)



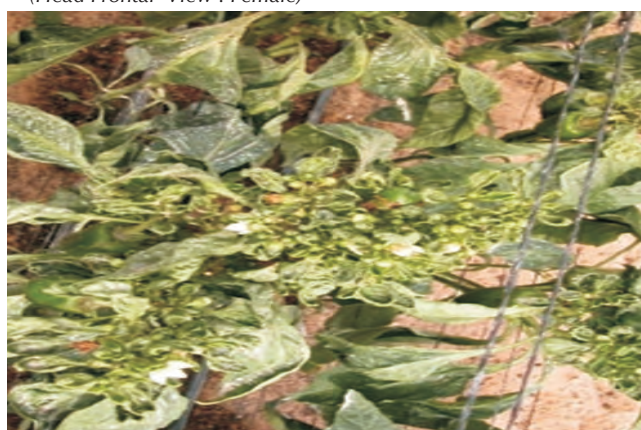
*Cerapteroceroides anustifrons*



*Cerapteroceroides anustifrons*  
(Head Frontal View : Female)



*Scirtothrips dorsalis* Hood



Plant of Solanaceae Family Attacked by *Scirtothrips dorsalis*





effectiveness against poplar and shisham defoliator but due to heavy rains, the breeding of larvae of poplar and shisham defoliators got affected by fungal infection. Laboratory testing work of *A. cordifolia* extract against *C. cupreata* and *P. reflexa* is in progress.

### Orthopteran Diversity of the Nilgiri Biosphere Reserve (NBR)

Inventory of orthoptera in the selected habitats at respective sites has been made with regular interval. A total of 37 species have been observed in NBR. Population pattern of orthoptera in the selected sites has been studied in correlation with abiotic factors. Host preferences of selected orthopteran species namely *Xenoceatantops humilis*, *Conocephalus maculatus* and *Phlaeoba infumata* have been completed, and found most of them are monocot feeders. Scrub jungle, grass land, deciduous forest, ever green forest, and shola forest have been selected to study the impact of anthropogenic disturbance. The upland forests act as refuges for highly mobile polyphagous insects like grasshoppers. Extensive study on orthopteran diversity of high altitude shunted wet evergreen forests called shola is in progress, in order to understand the impact of landscape changes.



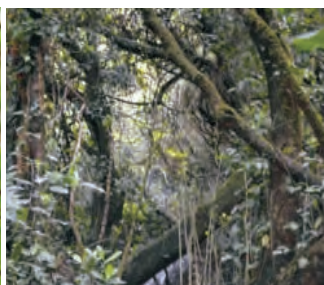
*Orthacris maindroni* Bol.  
Ingrisch & Shishodia



*Mirollia longipinna*



Inventory of Orthoptera in Nilgiri Shola Forest – Avalanche  
*Elimaea (Orthelimaea) securigera* (Brun.)



### Biodiversity of Wood Inhabiting Fungi in the Rainforests of Makutta, Western Ghats

The study started with preliminary identification of site/transects for the sampling work at the LTI plot, Makutta, based on the observation and existence of fungal fruiting bodies. Line transect method was followed for the actual sampling work carried out in the study area. Regular visit to transects for documenting the macrofungi was carried out during all the quarters. Documentation was categorized based on the prevalence of fungi during monsoon, pre and post monsoon. The documentation was carried out through photographs collections and characterization of the macrofungi. A total of 30 species of macrofungi was identified. Substrates of the fungi were also recorded as fallen logs, twigs and snags. A manual is under preparation for field identification of macrofungi for the study area.

### Pollination Entomology – Dynamics and Role of Insect Pollinators in Fruit-set of Species of Sonneratiaceae and Avicenniaceae in Mangroves of Karnataka

The project was started during December 2011. Recruitment of Research Fellows has been completed. The main objective of the project is the identification of insect pollinators responsible for fruit set of mangrove plants of family Sonneratiaceae and Aviceniaceae. The mangrove areas selected for the study are Mangalore, Kundapura, Karwar, Honnawar and Udipi in the West coast of Karnataka. Preliminary surveys were conducted to locate flowering plants of selected families in the study sites. Insects belong to Hymenoptera, Diptera, Lepidoptera were collected from different plants. Studies on pollination biology of plants in Sonneratiaceae and Avicenniaceae has also been initiated.

### Studies on the Species Diversity of white flies (Aleyrodidae: Homoptera) and Their Natural Enemies in Mangrove Habitats of India

The project was started during December 2011. Surveys were conducted in Muthupet (Tamil Nadu) and Vypeen Island (Kerala) mangroves. The collected whiteflies were mounted and preserved. The host plants are identified.



### Achanakmar-Amarkantak Biosphere Reserve

The continuous activities undertaken in the project include updating information on flora and fauna of Achanakmar-Amarkantak biosphere reserve by new additions to the already existing database. Collected references from recent literature on tropical moist/ dry deciduous type of **biosphere reserves** from web site and collated with the conditions of the Achanakmar-Amarkanatak biosphere reserve. Collected meteorological data of the core zone from the manual observatory.

Recorded regeneration status of trees from the permanent plots laid at core and buffer zones of biosphere reserve. Surveyed, collected, identified and preserved 300 specimens which includes 180 species of butterflies, 16 species of moths and two species of bugs among the 198 identified species. Recorded status of selected economically important threatened flora in biosphere reserve. Created web based information centre for Achanakmar-Amarkantak biosphere reserve and linked to the website of TFRI, Jabalpur (<http://tfri.icfre.gov.in/AABR/index.html>).

### Ecological Studies on the Distribution Patterns and Food Plant Resources of Butterflies along Altitudinal Gradients In Different Forest Ecosystems of the Eastern Himalaya (Arunachal Pradesh)

Scientist of RFRI, Jorhat visited different places in Arunachal Pradesh for site selection and sampling were carried out in three selected sites including Namdapha and Pakke Tiger Reserve along with Eaglenest sanctuary in Arunachal Pradesh. Visited Namdapha Tiger Reserve for pilot study, transects laid for study in the visited sites. Data collection was done.

### Exploration and Conservation of Genetic Resources of Selected Rare and Endemic Plants of Northeast India

A study was carried out on four different rare and endemic plant species- *Gnetum gnemon*, *Livistona jenkinsiana*, *Vanda coerulea* and *Renanthera imschootiana* at RFRI, Jorhat.

Socio-economic prospects on endemic gymnosperm- *Gnetum gnemon*, and indigenous and threatened palm- *Livistona jenkinsia* had been carried out. *Gnetum gnemon* is a gymnosperm which is shrubby in nature and endemic to this region. The leaves of this plant are hugely collected and used by different tribes as leafy vegetables. Roasted oily seeds are eaten as fruit.

The leaves of palm –*Livistona jenkinsiana* widely used in roofing of traditional hut. Besides, leaves are used in making of Jhapi- a traditional helmet in the North East India.

Population and regeneration status of *Livistona jenkinsiana*, and *Gnetum gnemon* had been assessed in the region. Multiplication and *ex-situ* conservation methods of *Vanda coerulea* and *Renanthera imschootiana* has also been studied.

### Exploration of Diversity and Utilization Potential of *Sphagnum* species of Forestry Importance in N.E. India

Studies were conducted in Khasi, Jantia and Garo Hills of Meghalaya and Eastern and Western part of Sikkim. Taxonomical characterization of 6 species of *Sphagnum* have been completed viz. *S. khasianum pseudocymbifolium*, *S. cuspidatum*, *S. papillosum*, *S. squarrosum*, and *S. palustre*. The physical and



Collection, Preservation and Documentation of *Sphagnum* species





*Sphagnum pseudocymbifolium*  
West Khasi hills



*Sphagnum squarrosum* Sangmei  
(near forest nursery) East Khasi hills



*Sphagnum cuspidatum*  
Mawreng, East Khasi Hills



*Sphagnum papillosum* Laitlyntok  
near Basti, East Khasi hills

**Taxonomic Diversity among *Sphagnum* species**



Wet Sphagnum



Girdling of Branch



65 Days Old



Detached from Mother Plant



Tag with Filled Sphagnum



40 Days Old



Transfer to Polybag



Detached from Mother Plant

**Air Layering trials on *Cinnamomum zeylanicum* using *Sphagnum* as Substrate**

chemical properties of all identified species of *Sphagnum* are under progress. The Trials on Air layering shows good results and the results have been transferred to end users. Three numbers of trainings were also given to farmers in different villages of Assam and more than 1000 branches air-layered through 2 *Sphagnum* species. More than 80% branches show very good results. The trials with orchids also show very good results in comparisons to control media. The *ex-situ* conservation of three

species of *Sphagnum* done in Low cost shade house in RFRI campus was also done.

**Studies on Species Diversity of *Ganoderma* in Assam with Reference to Utilization and Cultivation of its Selected Species**

Various host range of *Ganoderma* spp. as well the diversity of the fungi in Assam were studied. The estimation of polysaccharide (total soluble sugar), moisture content of different samples of *Ganoderma* spp. was also carried out.





*Ganoderma lucidum*



*Ganoderma Sp.*



*Ganoderma multiplicatum*



*Ganoderma Sp.*

### Impact of *Prosopis juliflora* on Biodiversity, Rehabilitation of Degraded Community Lands and as a Source of Livelihood for People in Rajasthan State

Survey was carried out in and around Jodhpur, Pali and Bharatpur districts of Rajasthan and associated floral and faunal diversity were recorded of the selected sites in grazed and ungrazed areas. *P. juliflora* density was worked out in orans, gochars, protected areas, revenue lands, wastelands, wetlands, saline lands, agriculture fields and urban forestry models. The floral diversity was represented by 29 species of herbs, shrubs and trees belonging to 16 families. The most dominant family recorded was Fabaceae, followed by Salvadoraceae and Poaceae among the associated floral diversity.

Studies on dependant or associated faunal diversity revealed that 22 species were of soil arthropods and entomofaunal invertebrates. 42 species of vertebrates were also found directly or associated with *P. juliflora*. The inflorescence of *P. juliflora* attracts large number of bee species and numbers of bee-hives were also observed. One species of homoptera (*Cicada*) and two species of coleoptera (*Myllocerus*) were reported for the first time from *P. juliflora* from India.

Studies on utilization aspects revealed that *P. juliflora* tree has given a wide spread green cover to the xeric environment of the Indian Desert, besides providing fuel, fodder and food for the human, cattle and wildlife especially during severe summer and winter months. Studies on utilization of other exotic species associated with *P. juliflora* revealed that *Acacia auriculiformis* leaves were extensively used for amelioration of *mehandi* quality for commercial use and its bark for tanning purposes, whereas *Acacia tortilis* was used mainly as fuel wood and *Parkinsonia aculeata* as an ornamental tree.

### Screening, Identification and Preparation of a Comprehensive Check- list of the Lepidopteran Fauna of Sasan Gir National Park of Gujarat State

Aim of the study was to study the Lepidopteron fauna of Sasan Gir Forest. The experimental sites have been selected viz; Chodiya Vistaar, Babulwala Chowk,





Dhadoria, Kamleshwar Dam, Valodra, Adodia, Ratanguna, Didarkri river, Peripite site and Kareli. The butterflies and moth species were collected from the Gir National Park, Junagarh, Gujarat, and identified, preserved and augmented in the insect collection boxes. All the specimens were photographed. The preparation of slides of wings and genitalia were carried out. The butterflies species, collected from the Gir National Park, Junagarh, Gujarat have been identified up to species level. The four species of Nymphalidae, two species of Danaidae, three species of Pieridae, two species of Papilionidae and one species of Sphingidae have been identified.

### Ecological Assessment of Floristic Diversity in Kalatop Khajjiar Wild-life Sanctuary of District Chamba, Himachal Pradesh

The study sites were selected and the phytosociological studies conducted by laying out the quadrats of different sizes for tree, shrub and herbs randomly in different altitudes. In this sanctuary, total number of plant species recorded were 232 belonging to 76 families and 218 genera. In Talai-I beat, total number of plant species was 149 belonging to 55 families and 133 genera. In Khajrot beat, total number of plant species was 105 belonging to 60 families and 95 genera. In Khajjiar beat, total number of plant species was 101 belonging to 54 families and 95 genera. In Kangarrakh beat, total number of plant species was 127 belonging to 65 families and 119 genera. In Ala beat, total number of plant species was 93 belonging to 44 families and 87 genera. Dainkund beat revealed 102 plant species belonging to 54 families and 95 genera. Lakadmandi beat showed that the total number of plant species was 81 belonging to 52 families and 76 genera. Talai-II beat of the sanctuary revealed 109 plant species belonging to 58 families and 102 genera. In Kalatop beat, total number of plant species was 142 belonging to 71 families and 127 genera. Out of 100 medicinal plant species recorded from the Kalatop-Khajjiar wild life sanctuary, 7 species viz; *Cinnamomum tamala*, *Dioscorea deltoidea*, *Paris polyphylla*, *Podophyllum hexandrum*, *Polygonatum verticillatum*, *Taxus wallichiana*, *Zanthoxylum armatum* fall in the category of threatened plants. Conducted the ethnobotanical study in 14 villages and documented 45 plant species used for different purposes.



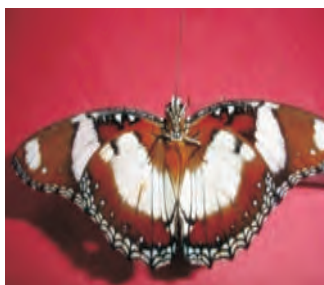
*Junonia lemonias* (L.)  
Nymphalidae



*Junonia orithya* (L.)  
Nymphalidae



*Junonia almana* (L.)  
Nymphalidae



Male (ventral)  
*Hypolimnas missipus* (L.)  
Nymphalidae



*Catopsilia crocale*  
Pieridae



*Ixias pyrene evippe* (Drury)  
Pieridae

Butterfly species of Sasan Gir Forest

The permanent plots were also established in different forests in the Kalatop- Khajjiar wild life sanctuary for recording the time series data. In the plot established in alpine pasture, number of shrub and herb species was 5 and 44 with the dominance of *Viburnum erubescens* and *Geum elatum* respectively. The diversity index for shrub and herb species was 1.12 and 3.39 whereas dominance index was 0.42 and 0.04 respectively. In Ban oak and Rhododendron forest, number of tree, shrub and herb species was 2, 11 and 30



with the dominance of *Quercus leucotrichophora*, *Rhododendron arboretum* and *Trifolium repens* respectively. The diversity index for tree, shrub and herb species was 0.68, 2.02 and 3.06, whereas dominance index was 0.51, 0.16 and 0.06 respectively. In mixed forest of conifer and broad leaved, number of tree, shrub and herb species was 10, 11, 27 with the dominance of *Persea duthiei*, *Sarcococca saligna* and *Ptercanthus urticifolius* respectively. The diversity index for tree, shrub and herb species was 2.10, 1.58 and 2.69, whereas dominance index was 0.14, 0.32 and 0.10 respectively. In mixed conifer forest, number of tree, shrub and herb species was 4, 8 and 30 with the dominance of *Abies pindrow*, *Viburnum erubescens* and *Valeriana jatamansii* respectively. The diversity index for tree, shrub and herb species was 1.14, 1.62 and 2.83, whereas dominance index was 0.35, 0.30

and 0.10 respectively. In pure deodar forest, number of tree, shrub and herb species was 1, 5, 21 with the dominance of *Cedrus deodara*, *Cedrus deodara* sapling and *Valeriana jatamansii* respectively. The diversity index for shrub and herb species was 1.47 and 2.36, whereas dominance index was 0.26 and 0.16 respectively.



Ban oak and Rhododendron Forest



Mixed Conifer Forest

### Taxonomy, Biodiversity and Habitat Association of Noctuid Moths (Lepidoptera: Noctuidae) in Various Conifer Forests of Himachal Pradesh

Total of 2740, 1360 and 1540 specimens of Lepidoptera moths have been collected from different conifer sites during 2009 and 2010 respectively. Out of these 663, 737 and 865 specimens belong to Noctuid moths collected during 2009, 2010 and 2011 respectively out of which 129 species have been identified. All species have been dissected to study wing venation and genitalia for taxonomic update. Data for biodiversity analysis has been recorded for the two years and third year data collection is in progress as per the methodology adopted to study the biodiversity of the Noctuid moths. During the field survey, some insect larvae were collected from the field and reared in the lab. It was also noted whether these species are causing the damage to the host (only selected conifers and associated vegetation) or are simply the host of the particular species. For example, during the present study, the following is the pest status of noctuid species of respective hosts given in parenthesis:



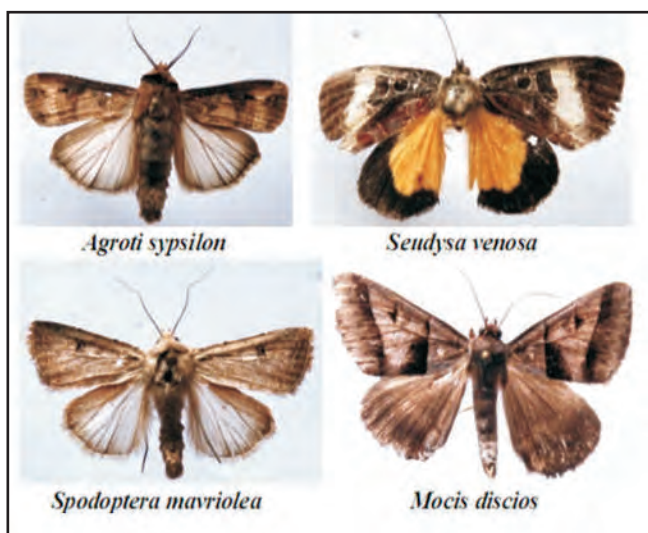
View of Alpine Pasture



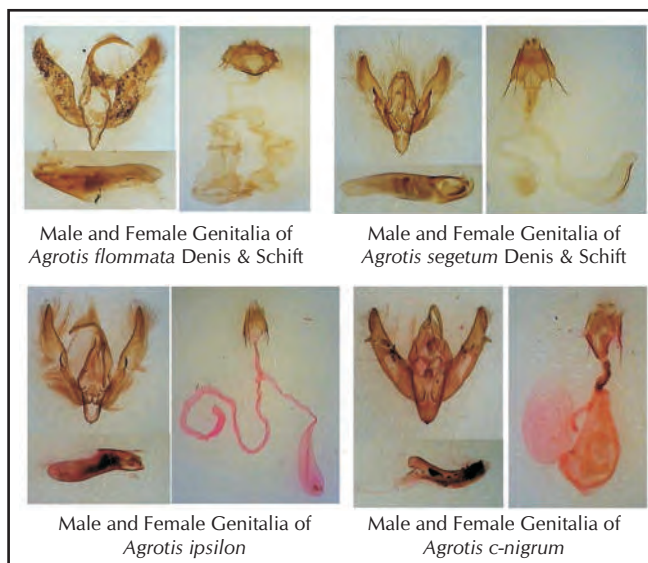


### Major pests:

- *Trichoplusia orichalcea* Fabricius (Polyphagous, Herbs of the Deodar forests)
- *Agrotis segetum*, (cutworm of deodar and other conifers, polyphagous)
- *Agrotis ipsilon*, (cutworm of deodar and other conifers, polyphagous)
- *Spodoptera lituro* Fabricius (Polyphagous)
- *Spodoptera cilium* Guenee (Polyphagous)
- *Plecoptera reflexa* Guen. (Major pest of *Dalbergia sisso* in the zone of Chirpine)



Images of Noctuid Moths



Genitalia of Noctuid Moths

### Ecological Dynamics of Vegetation Structure and Assessment of Morphological Adaptive Variation to Create Base-line Data in Selected Species in Dalma Wildlife Sanctuary”

A total of 68 Sample plots have been laid out in the sanctuary covering all ranges. Plant specimens are collected and herbaria are prepared. 186 nos. of plant species are identified and authenticated. Few species of elephant food like *Mallotus philippensis* is collected for bark and leaf nutrient estimation. Species identified were: *Kydia calycina*, *Mallotus philippensis*. These species were found extensively in the sanctuary and are third most preferred species for elephants. The variation studies revealed good amount of variation in fruit parameters. Morphological features such as leaf structure revealed five major types of leaf shapes. Bark is also preferred by elephants as food and exhibits three main types. The chemistry of bark content is being investigated through aqueous, petroleum ether or chloroform extraction. The leaves and bark have high water content and recalcitrant- it dries out with in 1 hour. Genetic stability of the species is being investigated under stressed and non-stressed conditions.

### Assessment of Phytodiversity Dynamics for Conservation in Jeypore Reserve Forest

Data for phytosociological analysis was recorded from field as per standard methodology. Analysis has been done. Total 185 plant species has been observed. Plant specimens were identified. Herbarium was prepared. Natural regeneration potential of trees was studied. Climatic database, prepared for temperature and rainfall, was collected from different tea estates surrounding the study area, which can be used by researcher in future. Physical and chemical analysis of soil has been done. Training was imparted to target groups. Demonstration of sample plot was done. Targets have been achieved as per action plan of the project. Training on Biodiversity conservation and awareness was imparted to target group and demonstration of sample plots done before ecodevelopment committee members, forest department officials, students and farmers.



### 2.1.8. Forest Botany

#### Revision of Indian Woods – their Identification, Properties and uses- Volume – II

The objective of this project was to revise Indian Woods- Volume II by adding microstructure data and upgrading information on properties and uses.

Microstructure features of 23 families along with their microphotographs was studied. Literature on strength properties, uses, durability etc. collected. All the data collected shall be incorporated in writing the second volume of the reference book on 'Indian Woods – their Identification, Properties and uses'.

The project completion report has been submitted. Writing of book is underway.

#### Study on Wood Anatomy of Indian Shrubs for the Purpose of their Identification and Efficient Utilization.

Due to the ban on tree felling and scarcity of tree wood resources, wood from shrubs is being looked upon as alternate source for many end uses like tool handles, furniture, agriculture implements etc.

Also, stems of many shrubs are being used by pharmaceutical companies for preparation of various drugs. In India, so far, we do not have much information on wood anatomy of Indian shrubs. Thus, for academic purpose also wood anatomical data of Indian shrubs is required.

Since in India, the expertise of xylotomic (wood anatomical) studies is available mainly at FRI, Dehradun, therefore this work can be undertaken here only. Thus, the broad objective of the project is to study the wood anatomical structure of Indian shrubs. The species identification key for Indian shrubs that shall be developed towards the end of the study shall provide an authentic way of wood recognition, thus, leading to their efficient utilization, both in timber and in pharmaceutical industry.

In India, so far, we do not have much information on wood microstructure of Indian shrubs. Thus, the study shall be first of its kind with lot of academic importance. Since in India, the expertise of xylotomy studies is

available mainly at FRI, Dehradun therefore this work can be undertaken here only. The proposed work may bring out some interesting structural patterns present within a family with altogether different anatomy of shrub and trees. This shall reflect upon homogeneity and heterogeneity in taxonomic classification. So far, the studies have been carried out for *Abelia trifolia*, *Leycesteria formosa*, *Pentaphyxis stipulata*, *Solanum erianthum*, *Duboisia myoporoides*, *Ardisia humilis*, *Ardisia involurata*, *Ardisia paniculata*, *Embelia floribunda*, *Embelia ribes*, *Embelia robusta*, *Scleropyrum ridleyi*, *Osyris arborea*, *Melastoma malabathricum*, *Oxypora paniculata*, *Osbeckia crinita*, *Azima tetracantha*, *Salvadora persica*, *Rhodomyrtus tomentosa*, *Psidium guajava*, *Myricaria squamata*, *Woodfordia fruticosa*, *Rosa lechenaultiana*, *R. macrophylla*, *R. moschata*, *R. sericea*, *Rubus ellipticus* and *Rubus lineatus*.

#### Assessment of Wood Properties and Growth of the Progenies of Different Clones of *Populus deltoides* Bartr. ex. Marsh

**The Experimental Site:** Study site was located at Rudrapur (Udhamsingh Nagar), Uttarakhand, India. It is situated at around 28°N latitude; 78°E longitude and at the altitude of 200 M. The annual rainfall is 1200 mm; of which 88% occurs during June-August. The average maximum summer temperature (April-June) is 36.7°C and average minimum temperature (December-February) was 7.5°C (2005-06). The soil of the site is sandy loam.

The growth parameters namely tree height and DBH (diameter at breast height) were measured for each individual before the collection of wood samples. Study material was collected from the 130 progenies of *Populus deltoides* raised by WIMCO Plantations Ltd. at Rudrapur (Udhamsingh Nagar), India at the age of 6 years. The wood samples were collected from three, pith to periphery direction to cover radial variations. Each sample contain two growth rings so that it maintain the uniformity of age of the sample.

Cross, radial and tangential sections (15-20µm thick) were cut on Reichert microtome for microscopic examination. The sections were stained in





Heidenhain's haematoxylin and safranin, and mounted following standard laboratory procedure for making permanent slides. The data on vessel frequency (%), and proportion of tissue were taken from cross section.

Small radial chips were macerated for determination of fibre and vessel-length following Schultz's method (30% Nitric acid and a pinch of Potassium chlorate). Data on fibre-length, vessel-length, fibre-diameter and lumen-diameter were taken from macerated material.

Observation on microscopic features of various cell types (%) such as vessel, parenchyma, rays and fibres and vessel diameter were recorded from cross section. The frequency of vessels was determined from the average of 10 counts per  $\text{mm}^2$  area. Twenty five counts were taken from macerated samples of each species for vessel, fibre-length, vessel and fibre-diameter.

Basic density of wood samples was determined as the ratio of oven dry weight vs. green volume. The green volume was determined by water displacement method.

The DBH (diameter at breast height) and height of each individual were recorded. Wood anatomical data for fiber length, diameter, wall thickness, vessel element length and diameter for and specific gravity for 88 progenies were determined. The fibre length ( $\mu\text{m}$ ) ranged between  $1077.11 \pm 30.17$  (progeny no. 173) to  $1254.22 \pm 47.96$  (B-13); fibre diameter ( $\mu\text{m}$ ) between  $22.56 \pm 0.19$  (progeny no 25) to  $(27.22 \pm 1.58$  (W-80); wall thickness ( $\mu\text{m}$ ) between  $3.55 \pm 0.69$  (B-20) to  $7.54 \pm 6.25$  (progeny no 5); vessel element length ( $\mu\text{m}$ ) between  $461.44 \pm 24.60$  (progeny no. 129) to  $596.22 \pm 19.76$  (progeny no. 102) and vessel element diameter ( $\mu\text{m}$ ) between  $95.56 \pm 2.22$  (progeny 173) to  $121.22 \pm 1.92$  (progeny no. 37). The lowest specific gravity was in progeny B-20 ( $0.33 \pm 0.01$ ) and highest was in 125 ( $0.41 \pm 0.01$ ). The data of 21 progenies were analyzed for multivariate analysis. Variations due to replication were non-significant for all the wood traits. Intra-tree radial variations were significant for all the studied wood traits except for fibre diameter. Interaction between progeny replication was non-

significant for all the wood traits except for wall thickness. Multivariate analysis for 50 progenies in three replications were analysed for tissue proportion and fibril angle. MANOVA showed that inter-clonal (progeny of clones) variation in proportion of tissue was significant for fibre (%), ray (%), vessel frequency ( $\text{mm}^{-2}$ ), and fibril angle, whereas, non-significant for vessel (%) and parenchyma (%). Inter-tree variations were non-significant for all the wood traits. Variations were also significant for DBH and tree height among the progenies of clones and non-significant due to replication. It showed that progenies were different for the wood traits. Radial variations indicated the impact of age on the wood properties.

### Evaluation of Wood Properties and Growth Performance of *Eucalyptus* hybrids Raised in Multilocational Trials

The growth parameters namely tree height and DBH (diameter at breast height) were measured for each individual tree before the collection of wood samples from FRI 14 and FRI –EH001 hybrids. Wood samples were collected from 18 trees from FRI Campus.

Small radial chips were macerated for determination of fibre and vessel-length following Schultz's method (30% Nitric acid and a pinch of Potassium chlorate). Data on fibre-length, vessel-length, fibre-diameter and lumen-diameter were taken from macerated material. Basic density of wood samples was determined as the ratio of oven dry weight vs. green volume. The green volume was determined by water displacement method.

Anatomical data on fibre length, fibre diameter, wall thickness, vessel element diameter and length and specific gravity were collected from 10 trees of FRI campus. The preliminary analysis showed following results:

MANOVA revealed that both FRI 14 and FRI –EH001 hybrids were significantly different for wood traits.

Vertical variations were recorded for all the wood traits while horizontal radial variations were recorded for all the wood traits except for fibre diameter. Variation due to peripheral direction were non-significant.



FRI-14 showed better wood traits than FRI –Eh 001.

### Digitization of FRI (Dehra Dun) Herbarium

- 4814 species details prepared and entered into the database;
- 8405 herbarium specimen details have been prepared
- 4638 have been entered into the database.
- 4638 herbarium specimen details have been incorporated into the database
- 6349 specimen photos have been taken
- 7691 photos have been edited

### Study of Reproductive Biology of the Endangered Taxa *Trachycarpus takil* Becc. (Arecaceae), *Mahonia jaunsarensis* Ahrendt (Berberidaceae), *Pittosporum eriocarpum* Royle (Pittosporaceae) and *Eremostachys superba* Royle ex Benth. (Labiatae)

In this project, life cycles of four RET plant species *Trachycarpus takil* Becc., *Mahonia jaunsarensis* Ahrendt., *Cinnamomum glanduliferum* (Wall) Meissn., *Eremostachys superba* Royle ex Benth" are being critically examined in actual forest locations to find out the cause of their poor regeneration and distribution in nature. The four species selected for study are important forest species of India. These are known to show poor regeneration in their native habitat. To conserve these species, *in situ* or *ex situ*, thorough knowledge of their reproductive biology is necessary.

A hand on training was carried out in Delhi University for a month under the supervision of Prof. A. K. Bhatnager, Department of Botany, Delhi University where all the laboratory work and field work related to the project were studied. Several visits have been undertaken to different parts of Uttarakhand to exactly locate and monitor the species belonging to the project. Different tours were conducted for Pithoragarh, Chakrata, Mohand, Champawat, Chaubattiya in Uttarakhand and Jammu and Rajouri in J&K. Soil samples have been collected from all the sites for analysis. Tours were conducted to the above said places again in the flowering seasons from March to May

2012. All the samples such as flowers, buds and fruits have been collected and preserved. Analysis of these preserved specimens have been started.

### Reproductive Biology of *Aquilaria malaccensis* Lamk. a Critically Endangered and Economically Important Species for Effective Conservation

Field survey in, Gibbon WLS (Assam); Dimapur, New Besumpuie (Nagaland); Nongpoh, Darugiri, Narengri, Tura, Baghmara, (Meghalaya); Imphal and Moreh (Manipur); Agartala, Trishna WLS (Tripura) were carried out; studies on pollen biology, seed biology from soil seed bank, growth and survivability of new seedlings etc were carried out and results recorded. Pollen and seed viability studies conducted and further monitoring of natural recruitment of seedlings is in progress. Floral samples were processed for embryological studies.

### 2.1.9. Tribal and Traditional Knowledge System

#### Ethnobotanical Studies of Northern Part of Eastern Ghats in Andhra Pradesh

During the period under report, extensive field tours were undertaken in the tribal areas of Srikakulam, Vizianagaram and Vishakhapatnam districts and ethnobotanically important plant species with relevant information was collected. Ethnobotanical data on 197 plant species were collected from Savara, Khond, Jatapu, Kondadora, Nukadora, Bagatha and Porja tribes from the study area. A total of 180 plant specimens were collected, made into herbarium and identified. The ethnobotanical data was scrutinized and screened with the help of available literature. During the period of study' lesser known medicinal plants used by the tribes for various ailments viz., *Careya arborea* (for snake bite and antidiarrhoea), *Crotalaria retusa* (for epilepsy), *Drynaria quercifolia* (for bone fracture), *Hygrophila auriculata* (for Jaundice), *Pueraria tuberosa* (for stomach pain) and *Wattakaka volubilis* (for Poisonous bites), were collected.





### Ethno-medico-botanical Studies of Khasi, Garo and Karbi tribes

Seven villages i.e. Nongthymmai, Rangkasuna, Nongkhra, Marangr, Umdoh, Ronghona and Jorbil of Ri-Bhoi district, Meghalaya were surveyed and information on the use of medicinal plants by the targeted tribes (Khasi, Garo and Karbi) were collected. Cross cultural studies of targeted tribes were also done. Study revealed that there is decrease in use of medicinal plants for various ailments due to changing socio-economic situation and easily availability of modern medicines. It has been observed that younger generations are not so much interested to learn the traditional knowledge of medicinal plants from their elders. However, villagers use common medicinal plants which are found in nearby houses/ kitchen garden/road side for the treatment of various common ailments such as abdominal pain, burn injury, diarrhoea, dysentery, eczema, gastritis, headache, malaria, piles, toothache, urinary problem, jaundice, cut injury, cough, skin diseases etc. Interested villagers even planted the medicinal plants in their gardens for use. There are three categories of medicinal plants - i) easily available on the road side or in the village ii) planted by the villagers for their use and iii) medicinal plants found in forests. Preparation of detailed list of medicinal plants and their uses by the targeted tribes is in progress. One awareness programme on utilization and conservation of medicinal plants was organized at Umpher, Ri-Bhoi District, Meghalaya. 45 villagers including village headmen, ladies, old persons and young ones were present in the programme.

### Studies on Ecological and Ethno-Mycological Aspects of Wild Mushroom of Nagaland

Ethnomycological survey and collection of wild edible mushrooms has been carried out from the selected areas of Kohima, Dimapur, Mon and Mokokchung districts of Nagaland. Till date 88 Nos. of mushroom samples were collected from the survey sites. The collected samples are being analyzed in laboratory for their taxonomic identification. Some of

identified mushrooms include the species of *Pleurotus* (edible), *Schizophyllum* (edible), *Ganoderma* (medicinal) Some saprophytes/ wood decaying fungi are identified as the species of *Polyporus*, *Phellinus*, *Xylaria*, *Pycnoporus*, *Clavaria*, *Auricularia*, *Russula*, Puffball, etc. All details of sites such as topography, forest type, habitat on which mushroom is growing, specific association of fruit body with surrounding trees, herbs and shrubs were documented at the time of collection.



*Pleurotus* species



Puffball



*Xylaria* species



### Documentation and Inventorization of Indigenous Traditional Medicinal Knowledge of Jharkhand

Sadar, Churchu, Barkatha, Vishnugarh blocks of Hazaribagh district, Barwadih, Garus blocks in Latehar district, Chainpur block in Palamau district, Borio, Banhji and Mandro blocks of Sahibganj Dist. and Dalbhumgarh and Chakulia blocks of E. Singhbhum districts of Jharkhand were surveyed for collection of plant material from forests and herbal practitioners. Indigenous traditional knowledge of Kisan, Kharwar, Karmali, Birhor, Sourya Pahariya, Parhaiya, Manjhi and Sabar tribal groups of Jharkhand was also studied. Plants viz. *Vitex peduncularis* (Nagbael), *Helictres isora* (Aaintha), *Aristolochia indica* (Ishwarmul), *Hyptis suaveolens*, Hathi panjar, Kilo and koraya (*Holarrhena antidysentrica*), *Calotropis procera* (white variety), *Cyperus rotundus*, *Aeratum conizoides*, *Aristolochia*

*indica* have been collected and preserved as voucher specimens.

Nearly 90 herbal practitioners belonging to Bathudi, Birgia, Birhor, Chero, Karmali, Kharwar, Kissan, Parhaiya, Sourya Paharia and Sabar tribal communities have been interviewed so far regarding the use of medicinal herbs for curing their ailments. The tribes under this project viz. Banjara, Bedia, Bathudi, Bhumij, Chik, Baraik, Chero, Gorait, Karmali, Karma, Kissan, Lohra, Mahli and Sabar are scanty. In consonance with the NMPB's evaluator Sri V.K.Singh views during his visit to this Institute in the month of January 2012, the project has been proposed to be extended for a period of six months upto September 2012 for printing and publication of a book depicting the detailed medicinal habits of the ethnic communities in Jharkhand.