2.1 Ecosystem Conservation and Management

Overview

The growing awareness that ecosystems provide supporting, provisioning, regulating and cultural services–such as nutrient cycling, food and fresh water production, flood regulation and recreational space–has focused attention on how these services might change, and so influence human well-being as the organisms within ecosystems respond to mounting environmental pressures. To predict the responses of organisms and the services they provide – requires a detailed understanding of ecological science, where the focus is on understanding how biotic and abiotic interactions shape the structure and function of ecosystems. The purpose of the Ecosystem Conservation and Management research is to understand, interpret and apply ecological science to understand adaptive management of species, communities, and ecosystems in a changing environmental scenario.

The principal objective of ecosystem management is the efficient maintenance and ethical use of natural resources. Ecosystem management acknowledges that the interrelation of socio-cultural, economic and ecological systems is paramount to understanding the circumstances that affect environmental goals and outcomes. It is a multifaceted and holistic approach which requires a significant change in how the natural and human environments are identified. Several approaches to effective ecosystem management engage conservation efforts at both a local or landscape level and involves: adaptive management, natural resource management, strategic management, and command and control management.

The goal of a natural resource manager is to fulfill the demand for a given resource without causing harm to the ecosystem, or jeopardizing the future of the resource. Partnerships between ecosystem managers, natural resource managers and stakeholders should be encouraged in order to promote a more sustainable use of limited natural resources.

Projects under the theme

Projects	Completed Projects	Ongoing Projects	New Projects Initiated During the Year
Plan	18	19	25
Externally Aided	11	11	15
Total	**29**	**30**	**40**

2.1.2 Climate Change

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. In view of projected trends of likely impacts of climate change on forest ecosystems, it becomes pertinent to incorporate climate change consideration in planning while managing the forestry sector on long term basis. Besides, there is a dire need to concentrate on eco-regions rather than the boundaries as the unit of analysis and management.

Effect of Climate Change on the Phenology of Himalayan Rhododendrons

Study was conducted at Tungnath- Chopta of Garhwal Himalaya. Four aspects i.e., North, South, East and West and four species of Rhododendron i.e. *R. arboreum, R. barbatum, R. campanulatum* and *R. anthopogon* were selected

for phenological studies. At each site, mini-meteorology was established to collect maximum, minimum temperature, soil temperature, humidity and rainfall. The data is regularly recorded at weekly interval from each site. Analysis of associate species, their density, basal area and regeneration was carried out at each site.

R. arboreum Floral Bud Break

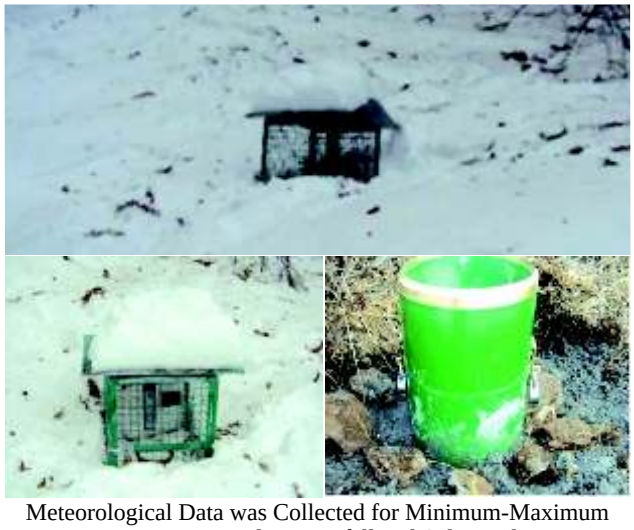
R. arboreum Flowering

R. campanulatum Floral Bud

Floral Bud Break

R. anthopogon Vegetative Bud

R. anthopogon Capsule Break and Seed Dispersal



Meteorological Data was Collected for Minimum-Maximum Temperature, Humidity, Rainfall and Solar Radiation

Assessment on Carbon Pool Potential of Important Tree Species at Different Ages, Sites and Management Regimes

The study was aimed to assess carbon pools in plantations of teak, eucalypts, casuarinas and acacias in different site conditions. The sampling was done by adopting "Average tree technique" (Arts and Mark, 1971). The sampling of plantations also covered different management practices mainly the irrigated as well as rainfed conditions. In all the plantations studied, composite soil samples were collected up to 30 cm for estimation of soil carbon as per IPCC guidelines. The results on dry matter production in the present study revealed that the difference in above ground biomass between trees of smallest and biggest diameter in even-aged plantation was 2 to 3 folds, particularly in the plantations of seedling origin. Such variations in dry matter production of sample trees within the plantations of the same age can be attributed to inherent genetic variation existing in the plantations of seed origin. With reference to average productivity of various biomass componentsin plantations of *Casuarina*, larger difference was noticed for productivity of stem, which was greater in coastal region (9.67 mt ha^{-1} $year^{-1}$) than in inland region (8.41 mt ha^{-1} $year^{-1}$). This variation in stem wood productivity between two regions studied can be mainly attributed to the change in climatic factors, particularly the intensity and distribution of rainfall. It is observed that total annual rainfall is high and distribution of rainfall also well spread in coastal region when compared with inland region. Further, soil also influenced stem wood productivity and it is observed that stem wood productivity was nearly 50 % lesser in clayey soils of vertisol, when compared to that registered in sandy (inceptisol) and red loamy (alfisol) soils. Alfisol and inceptisol provide good soil aeration, induce more nodule formation and more nutrients availability and leads to more stem wood productivity and carbon sequestration potential of plantations of *C. equisetifolia*. Hence, it is concluded that alfisol and inceptisol can be

preferred for greater carbon sequestration. A book titled "Regional yield table and carbon table for plantations of *Casuarina equisetifolia* in farmlands of Tamil Nadu" has been released based on the results of the present studies.

Evaluation of Tree Species of "Tree Cultivation in Private Land" programme for Carbon Sequestration under Elevated CO_2 Levels.

The study was undertaken to understand the response of the important tree species, which are used in the "Tree Cultivation in Private Land (TCPL) programme" of Tamil Nadu State Forest Department, to the elevated CO_2 levels. The study also intended screening and selection of species that show a positive response so that they can be planted on a large scale to increase the productivity as well as to improve the carbon sequestration potential of the plantations. The study brought out that the response of different tree species to different concentration of CO_2 and under different temperature conditions was highly varying which emphasized the need to assess all important tropical tree species individually and not to generalize the response of tree species to elevated CO_2. *Tectona grandis, Casuarina junghuhniana, Pongamia pinnata, Casuarina equisetifolia, Azadirachta indica,* and *Melia dubia* were the species which positively responded even at 900 ppm of CO_2 elevation and these species may be considered for greater carbon sequestration under elevated CO_2 and temperature levels. It was also concluded that equivalent to or even greater than inter-specific variation, there exists huge intra-specific variation, particularly in *Casuarina equisetifolia* and *C. junghuhniana*, which could be exploited for future breeding programme in developing climate ready genotypes having greater potential to sequester more CO_2. Among the species evaluated, *Tectona grandis, Gmelina arborea, Melia dubia* and *Pongamia pinnata* were observed to accumulate greater dry matter under elevated CO_2 and hence could be recommended as a "Carbon sink" species for afforestation programme for future levels of elevated CO_2.

Vegetation Carbon Pool Assessment for Andhra Pradesh North Region

Vegetation carbon pool assessment was taken up in 21 forest sites and 30 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.

National Vegetation Carbon Pool Assessment for Six Districts of Andhra Pradesh

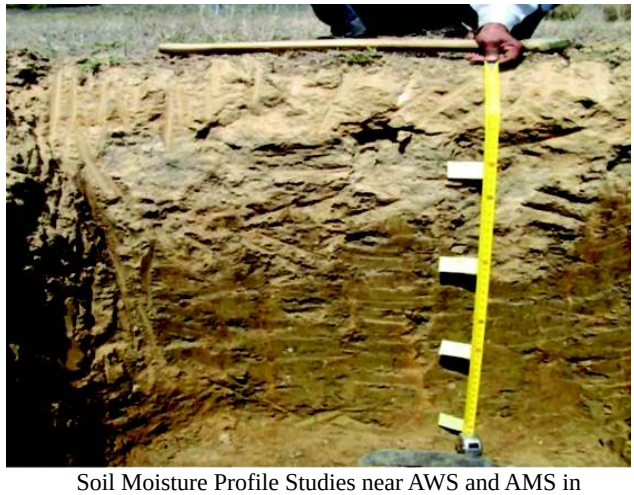
A total of 36 plots at pre-assigned geographic coordinates were studied by laying out four quadrats of 0.1 ha each. The data on above ground biomass and locality information were collected. Total forest biomass was estimated in six districts of Andhra Pradesh viz., Medak, Mahabubnagar, Guntur, Nalgonda,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

Utilization of Automatic Weather Station/ Agro-Meteorological Station Data for Agriculture, Forestry and Hydrological Applications in Madhya Pradesh

Sites were selected near Automatic Weather Station (AWS) and Agro-meteorological Station (AMS) in Kanha National Park (KNP), Bandhavgarh National Park (BNP) and Madhav National Park (MNP) in Madhya Pradesh. Grass biomass studies were conducted in the selected sites. Maximum grass production was found in September (post rainy season) and December (winter season), which gradually decreased in the month of March. Soil moisture profile at an

interval of 30 cms and till the depth 150 cms was quantified by volumetric method. AMS has been installed at Ronda in Kanha National Park, which is a plain area with clayey loam soil. In all the four seasons, soil moisture increased with depth because of vertical seepage and accumulation of water to lower horizons. The soil of the Supkhar area was sandy loam to loam. Soil moisture increased from surface till 60-90 cms or 90-120 cms, then slightly decreased due to the presence of few gravels. Maximum soil moisture was recorded in September, followed by December and March. Regression equation for quantifying above ground biomass against GBH was developed for *Shorea robusta*. Specific leaf area of major tree species of three national parks was calculated.

Grass Biomass Studies near AWS and AMS in National Parks



Soil Moisture Profile Studies near AWS and AMS in National Parks

Impact of Climate Change on Litter Microbial Dynamics in Dipterocarp Forest

The project was aimed to investigate the effect of climatic parameters on the decomposer microfungal populations in Dipterocarps forests and to develop a prediction module for the impact of climatic change on litter microbial dynamics by identifying potential bio-indicator species of microorganisms of climate change. It was observed from the findings that all decomposer microfungi did not occur in all the climatic conditions categorized to three seasons experienced by the study sites. The pattern of occurrence of each fungal species in a particular range of rainfall and temperature were recorded. It was seen that a certain group was representing a certain pattern of climatic parameters. Some species were seen in all the seasons of the year and some restricted their occurrence to a single season only. Such findings gave a basic idea of the considerable influence of climatic parameters on decomposer mycoflora. Decomposition of plant detritus in undisturbed forest ecosystems accounts for the nutrient return up to a great extent. Any alteration in microbial population which is one of the chief parameters influencing litter decomposition, the overall productivity of the forest ecosystem may be disturbed and may pose a threat if adverse depletion in decomposition may occur. The findings of the project described the role of these decomposer floras as potential climate

Collection of Sample from Litter Trap

change indicators as their occurrence represents a particular climatic condition. The findings of the project are intended to be used as baseline data for the next rolled over project entitled "CO_2 emission and microbial immobilization in Dipterocarp forest soils: effect of abiotic and biotic factors with special reference to climate change" in which the data will be simulated and more biotic and abiotic factors will be incorporated to exploit the role of these microbes as climate change indicators.

Carbon Sink and Fertility Status Relation of Soil under Different Land Use System of Some States of North-East India

Soil were characterized under selected plantation forest and other vegetations viz., Tea, Coffee, Rubber and Jhum land, Cardamom plantation areas of Assam, Meghalaya, Tripura and Nagaland states and assessed soil carbon sink under selected forest and other land use systems. Organic carbon content in soils under Cardamom plant of Sikkim state was found high and varied from 2.25 to 4.72%. Soils under Cardamom plantation of Sikkim were acidic and the pH value varied from 3.9 to 5.8 and belongs to "Sand" textural class. They were also light in weight due to high amount of organic carbon. It was found that phosphorus content in Cardamom plantation was low. Available phosphorus content of Tea plantation soil of upper Assam was low. Available phosphorus and potassium content of Coffee, Rubber and Jhum land soil belonging to Diphu and adjoining areas of Assam was low to medium. Soil Organic Carbon (SOC) was found high under Jhum land whereas it was low under Rubber plantation areas and wide variation of SOC was under Coffee plantation. All the soils were slightly acidic to neutral under Rubber, Coffee and Jhum land.

Available potassium content of Haflong and adjoining areas NC Hill of Assam was found medium for Coffee and low to high for Jhum. Phosphorus content was found low but SOC was found high. Soils were acidic, loose and porous. Available potassium content in soil under Rubber belong to Bongaigaon, Kokrajhar, Goalpara and Kamrup districts of Assam was found medium in most of the samples and in few samples low and high. Low phosphorus content and high SOC was found. Soils were found acidic.

Available potassium content of soil collected from Mokokchung found medium ranged and acidic in nature. Soil organic carbon was found high. Available phosphorous content was found low. Soils were found light having sandy clay loam to sandy loam texture. Soil organic carbon was found low under the rubber plantation area in the state of Tripura and high in Meghalaya. Available phosphorous content was low having mainly sandy clay loam texture.

Recent Jhum Land at Diphu

Coffee Plant at Fruiting Stage at Diphu

Tea Leaf Collection at Tura, Meghalaya

Paddy, Maize Cultivation in Jhum Land Tura, Meghalaya

Rubber Plantation at Tura, Meghalaya

Coffee Plantation under Betel Nut at Meghalaya

Vegetation Carbon Pool Assessment in Some Districts in Northern Rajasthan

Project was started with objectives to estimate carbon in growing vegetation and assess carbon dynamics in the forests as well as Trees Outside Forest (TOF) in Sri Ganganagar, Hanumangarh, Churu, Jhunjhunu, Sikar and Jaipur districts. A total number of 19 forest sites (76 plots) and 33 plots under Trees Outside Forest (TOF) were surveyed in these districts and trees and shrubs measured in cluster sample of four plots at each site in the forests blocks. There were 21 trees and 11 shrub species identified in the study area. The highest number of species was in Jaipur, followed by Hanumangarh forest division. Hanumangarh division showed "Desert thorn forest" of *P. cineraria* and *Z. nummularia,* but now invaded by *Prosopis juliflora,* which dominated in about 25% area. Forest cover in Churu division is dominated by *Acacia senegal* in trees and *Mytenus emarginata*/*Z. nummularia* in shrubs, whereas, Jhunjhunu is dominated by *P. juliflora*. Forest covers in Sikar division was dominated by *Anogeissus pendula* in about 75% area followed by *Boswellia serrata* in 25% area. In Jaipur, about 18% forests were dominated by *A. penduala,* 36% by *B. serrata,* 18% by *P. juliflora,* 18% by *A. senegal* and 10% by *A. catechu* tree species. Among the shrubs, the dominant species in Jaipur was *M. emarginata*.

Previously *Anogeissus pendula* Forest in Jhunjhunu

Now Dominated by *P. juliflora* Forest in Jhunjhunu

Most of the dry hilly region in North-Eastern Rajasthan is occupied by *A. pendula*, but is now infested by *P. juliflora*.

Studies on Carbon Sequestration in Different Forest Types of Rajasthan

Project was started with objectives (i) to estimate carbon stock in forest soils, (ii) to estimate carbon stock in forest litters and (iii) 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.

Twelve districts covering 238 forest blocks and 254 plots were surveyed in 2010-11, growth of trees and shrubs were measured and shrub/herbage biomass recorded. Litter, plant and soil samples were collected from the plots and analyzed for the carbon. Dune scrub areas of Jaisalmer were dominated partly by *Calligonum polygonoides* that help in control of sand drift. Alwar, Dholpur and Bharatpur were dominated by *P. juliflora*, whereas, Bhilawara was dominated by *Acacia leucophloea* as the tree species. *Anogeissus pendula* still dominated in Tonk and some parts of Bharatpur division. Ajmer division was dominated by *A. senegal*, whereas, Baran division was dominated by *Gymnosporia* spp. and *B. monopserma*. During survey in Bharatpur, a belt of *Mitragyna parviflora* was also observed, but forest is now infested by *P. juliflora*.

In 27 districts covering 588 blocks, *P. juliflora* recorded in the forest blocks of all districts except, Pratapgarh. Diameter at breast height, height and crown diameter varied from 12.26 to 48.82 cm, 1.51 to 7.83 m and 2.63 to 9.00 m, respectively, whereas, average basal area ranged from 111.3 to 2252.8 cm^2 per ha with wide spread root system. *P. juliflora* density and frequency of its occurrence (F) varied from 0.8 ha^{-1} and 2.78% in Sikar to 17.81 ha^{-1} (Pali) and 68.97% (Ajmer district), respectively. About 35.4% of forest

blocks are infested with *P. juliflora*, which is likely to increase in future.

Root Systems of *Zizyphus nummularia* (up) and *Prosopis juliflora* (down) Excavated for Biomass Showing Both Feeders as well as Anchoring Roots

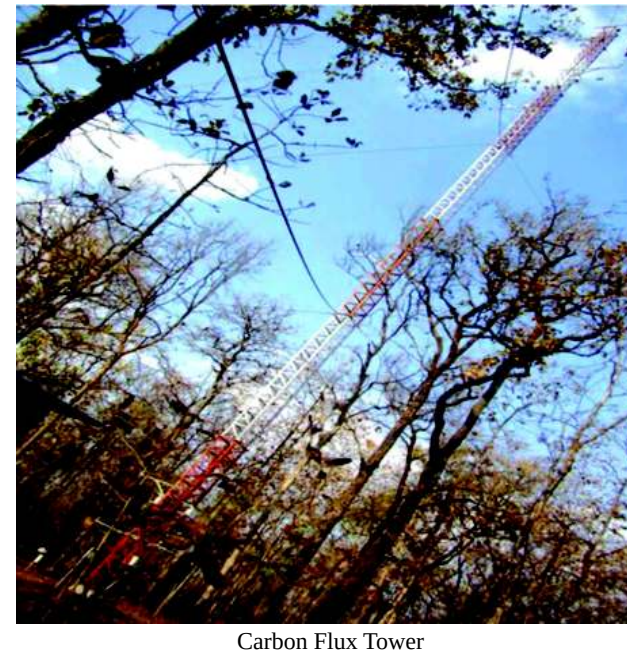
Development of Air Pollution Biomonitoring Station for Air Quality Assessment in Dehradun

Two biomonitoring stations, one at Shatabdi Van Vigyan Kendra, FRI City Campus, Dehradun and the other in the Selakui industrial area, Dehradun were set up to biomonitor the air quality of these sites by adopting active biomonitoring technique.

Plant sensitivity index to air pollution and air pollution index were also developed for evaluating the air quality status of the industrial area. Several active biomonitoring studies were performed to evaluate the air quality of both the biomonitoring stations i.e., Shatabadi Van Vigyan Kendra, FRI City Campus, Dehradun and Selakui Industrial area, Dehradun.

Vegetation Carbon Pool Assessment Project in India:

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 were installed in five major forest types of the country. Betul (teak forest) in Madhya Pradesh was one of them. The objectives of the project were to measure the vegetation and soil parameters to support modeling and to collect the data related to silviculture, inventory, management and utilization, to estimate the net ecosystem exchange of carbon.



Carbon Flux Tower

Enumeration of Trees at Site

Litter Collection

Energy and Mass Exchange in Vegetative System: Canopy Atmosphere Exchange Modelling Using Micrometeorological and Scintillometer

In-situ measurements of micro-meteorological and biophysical parameters were taken over selected pine plantation (forest ecosystem). Modelling of canopy atmospheric exchange processes and primary productivity using land surface process models was done and validation of satellite derived parameters carried out using *in situ* measurements.

2.1.3 Eco-restoration

Eco-restoration Studies in Uranium Mines

On the basis of findings by team of scientists from FRI, Dehradun and NABTD, Mumbai, in order to avoid translocation of radioactivity in the atmosphere as well as biosphere through food chain, it was recommended that:

Since tailing pond is in the vicinity of forest, propagules of deep rooted woody species may invade the area, regular vegetation monitoring on the tailing pond needs to be undertaken. Invasion of deep rooted species like *Acacia nilotica, Butea monosperma* and *Vitex negundo* etc. has to be checked through manual removal of seedlings/saplings.

Saccharum spontaneum may be allowed to grow only on the periphery of tailing pond in the form of greenbelt.

The species with minimum concentration of radio nuclides were identified as *Colebrookea oppositifolia, Dodonaea viscosa, Furcraea foetida, Imperata cylindrica, Jatropha gossypifolia, Pogostemon benghalense* and *Saccharum spontaneum*. They are non-edible, with shallow root system, evergreen with less height and more crown cover. These seven species show minimum concentration (or below detective limit) of the uptake of radionuclide by plants.

Eco-restoration and Conservation Initiatives at Danda Shrinagraja in Garhwal Himalayas

The study reveals that the people residing nearby Danda Shrinagraja are either laboures or marginal farmers having limited source of income. The produces from their agriculture and livestock used on domestic level without any commercial use. They depend on nearby forests for fuel and fodder. Open grazing is common in

the area. People collect the grass from community land and forest and keep it on lopped tress after drying it. This dried grass is used during winter. About 60% people including 40% women are literate. Every child in the villages is school going but a proper transportation is lacking. Drinking water is obtained from public tap. The common trees on farmland boundaries are *Bauhinia purpurea* (semla), *Toona cilita* (toon), *Grewia optiva* (bhimal), *Ougeinia oojeinensis* (sadhan) and *Terminalia tomentosa* (sain/asna) etc. Besides, there are some fruit trees on the farmland. These are: jackfruit, guava and citrus etc. Among agriculture crops the main crops grown are maize, wheat, madua, ramdana, urad, tor, soyabean, paddy, etc. But since few years, there is a drastic fall in the yield of these crops due to drought in the area. Regarding yield and economy based on agriculture, there is no marketing of agriculture produces as they are mostly used domestically. Plantation of *Terminalia chebula* (harad), *Terminalia balarica* (beheda), *Grevelliea robusta* (silver oak), *Bauhinia variegata* (kachnar) and *Cupressus torulosa* and some others was done. Out of these species, silver oak was found first in its performance while Harad was found second, other species showed poor performance at that site. Akhrot planted in winter of that year showed a better performance. Protection of area through social fencing and moisture retention activities also brought a remarkable change in the vegetation density. People got encouraged for adoption of forestry practices in the area through awareness programmes.

Exploitation and Utilization of Beneficial Microflora from the Sholas for the Restoration of Degraded Shola Forests in the Nilgiri Hills, Tamil Nadu

Rhizosphere soil samples collected from the root zone of different shola species in Kotagiri, Glenmorgan, Governor Shola, Kariamandu and Pykara areas in the Nilgiri Hills, Tamil Nadu were analyzed and recorded the status of AM fungal spore population and PGPR population density. Three types of AM fungi Acaulospora, Gigaspora and Glomus were recorded. Ninty four isolates of PGPRs (PSB 42 isolates, *Azotobacter* 26 isolates and *Azospirillum* sp. 26 isolates) were isolated and identified and pure cultures of these strains are maintained in the Institute's germplasm for further studies. Screening of efficient PGPR isolates was done by IAA production and phosphate solubilization and the best isolates were selected for nursery experiments. All the soil samples collected from different shola sites were analyzed and estimated for the physico-chemical properties such as pH, E.C., macro-nutrients. Nursery experiment was conducted at SFD nurseries at Coonoor and Ootacamund. Seedlings of selected shola species were inoculated with different bio-inoculants isolated from various shola soils. Study revealed that beneficial microbes (bio-fertilizers) inoculated seedlings had better seedling health and growth parameters over uninoculated (control) seedlings.

Fruits of ten shola species namely, *Michelia nilagirica, Mappia foetida, Viburnum erbuscens, Photonia notoniana, Michelia champaca, Berberis tinctoria, Syzigium cuminii, Syzigium arnottianum, Dysoxylon malabaricum* 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 fruits weight, fruit moisture content, seed moisture content, 100 seeds weight, germination %, shoot length, root length, collar diameter and seedling vigour were recorded. 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.

Preparation of the Management Plan of Asola Bhatti Wildlife Sanctuary, New Delhi

The required tasks as per the guidelines of WII for Preparation of Management Plan of protected area have been carried out. Vegetation survey including regeneration status, the assessment of the abandoned mining pits and soil sampling and analysis of the samples were carried out by FRI, Dehradun. Sample plots have been laid out and observations have been collected for assessment of inventory. For making out boundary map of the area and mapping of forest density, forest cover, forest type, the remote sensing and GIS techniques are adopted with active involvement of Forest and Ecology Division of IIRS. Field observations for this purpose have been recorded.

2.1.4 Bioremediation

Study of Bio-accumulation of Heavy Metals and its Impact on Different Plant Species

Different plant species for experimentation were sown and a waited for 3 months till the treatment given for the establishment of seedlings. The species were placed in the natural condition of central nursery of Forest Research Institute, Dehradun. Total six species (*Lagerstroemia* sp., *Holoptelea intergrifolia, Alstonia scholaris, Grevilia robusta, Dalbergia sissoo* and *Terminalia arjuna*) were watered daily (for one year). After 3 months, plant species had been ready for treatment with different doses of heavy metals. Different doses of heavy metals applied to plant soil at nursery level after different intervals. Heavy metal (Cu, Co, Cr, Pb, As) treatments with four different concentrations of 10mg/l, 20mg/l, 30mg/l and 40mg/l are applied to plant soil after different intervals till date.

Utilization of Fungi for Bio-treatment of Industrial Wastewaters

Experiments with different fungi mentioned below were conducted at different industries to test the growth and bio-remediation capacity of different fungi:- *Flavodon flavus, Oxyporus ravidus, Schizophyllum commune, Trametes versicolor, T. cingulata* and *Pycnoporus sanguineus.*

Three fungi namely *Schizophyllum commune, Aspergilus niger* and *Merulius tremolosus* showed growth in pulp and paper effluent. Only two species of fungi i.e. *Aspergillus niger* and *Trametes versicolor* showed growth in tannery effluent and also removed colour from the effluent.

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

Initial data collection for all the four dumping sites was done which include municipal solid waste generation rate (per capita per day), manual segregation of waste to know the percentage of each categories of waste (household waste, yard/garden waste, commercial/market waste), percentage of municipal solid waste that goes to Solid Waste Dumping Sites (SWDS). Procurement of secondary data from all respective municipal authorities regarding dumping site status. Calculation of Degradable Organic Carbon (DOC) was done at all the four selected municipal dumping sites, i.e.- Nanurkheda (Dehradun), Vikas Nagar, Doiwala and Rishikesh for summer, rainy and winter season to know the seasonal variation in percentage of DOC as well as the nature of the municipal solid waste. Estimation of methane emission from all the dumping sites is in the final stage.

2.1.5 Ecology and Environment

Role of Temple Forests in Rejuvenating Microclimate of Some Villages of Uttarakhand

To see the role of temple forest in rejuvenating the microclimate of Nagdev temple forest area, the temple forest was compared with a control site, which was nearby Nagdev temple area having relatively more disturbed forest.

Vegetation of both the sites was studied following standard nested quadrat method for trees, shrubs and herbs. All phyto-sociological parameters of tree, shrub and herb species common at both the sites also showed differences in these parameters at both the sites. Surface soil of both the study sites were also analysed for physicochemical attributes of their replicate samples and compared. Average values of soil samples for their different attributes have also shown clear variations in their ranges at both the sites.

Weather parameters viz. maximum, minimum temperatures, wind velocity, rainfall, sunshine hours etc. have been collected from both the study sites, compiled for monthly and annual values and compared. Daily climatic variables showed significant differences in some of the parameters. There are marked variations in the range of daily observations of all the micro-climatic parameters of both the sites. List of plant species present in Nagdev area (out side the study sites, not covered in quadrats studied) have been given along with plant species of Garhwal Forest Division.

Ecological Impact of Urbanization on Floristic Diversity in Natural and manmade Forests of Doon Valley

Increase in trees diversity, undergrowth biomass relative humidity and decrease in undergrowth species diversity and temperature was observed in the forest ecosystem as per increasing distance from urban/village habitations.

Habitations located nearby forest ecosystems show dependency on forest resources by mean of collection of fodder and fuel.

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

Monitored flowering, fruiting and seed maturity in *Rhododendron arboreum.* Permanent plots were marked for monitoring of seed germination and establishment of seedlings of *R.arboreum* and *M. esculanta* in the field. Seeds of *R. arboreum* were collected and tested for viability test in laboratory. Cyclic behavior of flowering was observed in *R. arboreum*. Seedlings establishment of *R. arboreum* and *M. esculanta* were recorded higher under open canopy as compared to the close canopy.

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

Field survey was done for selection of *Shorea robusta* (sal) and *Pinus roxburghii* (chir pine) forests. Employment of project staff and purchase of equipments were done. Survey of *Shorea robusta* (sal) forests at Thano, Lachhiwala, Timli, Chharba and Narendra Nagar was done and preliminary field data collected for the sites. For chir forests at Almus, Tyuni, Purola, Mori surveyed. Sample plots of different sizes were laid out at all these sites. Height measurement of all trees was done in all sample plots/ sites. Diameter classes of both the species at different sites have been worked out. Selection of mean trees from different diameter classes for felling at each sample plot has been done and felling of some trees of both the species has been done. Their biomass estimation is in progress.

Ecological Study of Wetland Forest Ecosystem of Doon Valley (Uttarakhand)

Asan Barage

The preliminary study revealed that the 57 plant species belonging to 27 families were recorded in the study area. Out of this, 10 tree species, 21 shrub species, 26 herb species have been recorded.

Jhilmil Area

The preliminary study revealed that the 76 plant species belonging to 30 families were recorded in the study area. Out of this, 20 tree species, 26 shrub species, 30 herb species have been recorded.

Impact of Forest Plantations on Ground Flora Diversity and Soil Characteristics Including the Prescription of Management Practices

The study, "Impact of forest plantations on ground flora diversity and soil characteristics" focuses on biodiversity dynamics as applicable to forest plantations since plantations could lend themselves to experimental investigations to a great extent. *Tectona grandis*, *Eucalyptus grandis* and *Acacia mearnsii* plantations were selected for studying the ground flora diversity, soil properties, soil microbes and soil fauna. *T. grandis* plantations were selected at Nilambur (Kerala) and Sadivayal (Tamil Nadu), *Eucalyptus grandis* and *Acacia mearnsii* plantations were selected at Nilgiris (Tamil Nadu) and Munnar (Kerala). Plant species enumerated in and around the selected plantations for quantitative assessment of ground flora diversity in different age group of Teak plantations in different plantations by laying out quadrates. Herbarium specimens were collected for species which could not be identified in the field.

Soil samples were collected from all the above plantations for studying soil properties and microflora. Soil samples collected from Nilambur and Sadivayal plantations were analyzed for soil microflora (VAM and bacteria). Soil samples collected from Sadivayal were analyzed for the soil properties.

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

Survey was conducted at Thellavagu nallah and data on flora and fauna were collected in every quarter. *Pongamia pinnata* was found to be the most dominant species in the diverted old Thellavagu nallah, whereas *Morinda tinctoria* is the most dominant species found in the diverted new Thellavagu nallah. Shannon Weiner tree species diversity index was found reasonably good in old and new nallahs with H= 1.293 and H= 2.55 respectively.

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

Four quadrats were laid i.e. three in the podu cultivated areas of Srikakulam, Bhadrachalam and Kakinada Forest Divisions and one on a control plot. Data on species occurrence were noted during two seasons and soil samples gathered for physico-chemical analysis. Soil samples are being analyzed at Forest Research Centre and ANGRU Rajendra Nagar, Hyderabad.

Seed Infestation by Insects Among the Emergent Rainforest Canopies at Makutta, Western Ghats

Laid out one-hectare sample plot and worked out species-abundance data on emergent canopies. Interception traps were set up in the one hectare sample plot. Insect emergences and extent of seed predation have been recorded. Field and lab germination studies have been carried out. Seed germination studies of important upper canopy species have been completed. On the whole, extremely variable seed predation rates were discovered across species–a few being highly vulnerable, and a few nearly excluded. High dominance and low diversity was discovered among the insect herbivores. Certain interesting patterns like that in *Dipterocarpus indicus*, where considerable temporal variation in predation pattern was discovered. Infestation pattern by the tephritid fly on seeds of *Dysoxylum malabaricum* revealed complex interactions between the tree, seed disperser and seed predator.

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 micro-climates, 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 years plantations, changing of soil properties and the similarities between plant species in each of those teak plantations and plant species in natural forest of teak.

Team at Work with Forest Officials

Teak Plantation

Preliminary survey of Barnawapara project has been completed for selection of sites and collection of maps etc. and site details have been recorded. Quadrats have been laid out in 12 compartment of teak plantation of various age groups. Enumeration of vegetation has been carried out in 21, 26, 30 and 36 years old plantation of teak. Thirty six trees, 6 shrubs and 13 herbs species have been recorded other than teak. Sixty two soil samples have been collected and analysis of soil samples is in progress.

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

Interactions between forest canopy cover and understorey vegetation for phyto-diversity conservation was studied and the effect of changing canopy structure and density on regeneration and growth of ground flora including native and alien species, edaphic and micro-climatic parameters was observed. Fifteen study sites were selected in Raigad, Ratnagiri and Sindhudurg districts (5 in each district) of Western Ghats of Maharashtra. Change in ground flora, soil characteristics and micro-climatic parameters like temperature and humidity were observed with change in canopy density. Number of species in ground flora increased with decrease in canopy density. 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. Natural regeneration of the species was also studied in the selected sites.

Counter Balancing the Detrimental Effect of Sponge Iron Factory-emitted Particulate Matters (SIFPM) with the Protective Effect of Vesicular Arbuscular Mycorrhiza (VAM) on the Growth of Weedlings 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* and *Butea monosperma* on a critical comparison with control data collected from least polluted areas. Physico-chemical estimations in terms of biochemical estimations (Chlorophyll, Sugar, Ascorbic Acid and Phenol) of leaf and soil samples are on process.

Experiments have been made with two sets at the nursery of TFRI; 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 analyses of which alongwith growth data should 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 after, 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.

Initial growth data of height (cm), number of leaves, and number of branches and collar circumference (1.5 inches above ground level) of all the 1200 plants were recorded during December 2010 to January 2011. Suspended Particulate Matter (SPM) was added in 600 of plants while 300 were maintained as control and 300 more kept to which only VAM to be added. VAM mixed with the potting media of specific number (400) of experimental plants.

- **Categories and variables**
  i. Control (Soil + FYM) 300 plants (?? baseline data)
  ii. Soil + FYM + SPM 300 plants (degrading agent▼)
  iii. Soil + FYM + VAM 300 plants (enhancing agent▲)
  iv. Soil + FYM + SPM (Pollutant▼) + VAM (Enhancer▲) 300 plants (result data)

VAM Culture

Treated Plantlets

Conservation, Management and Utilization of Selected Rattans of Assam

Surveys were carried out in Gibbon WLS, Kaziranga National Park, Dibrusaikhowa, Jeypore RF, Shillong. Soil sample were collected from rattan growing areas. Studies on phenology and growth parameters is being carried out.

Ecological Assessment of Medicinal Plants in Nambor Reserve Forest and their Socio-economic Impact on Fringe Villagers

Phyto-sociological study in Nambor reserved forest under Golaghat and Karbi Anglong district was done to identify the status of medicinal plants species in disturbed and undisturbed forest. In total 12 plots of 1 hectare were selected for the study randomly. The ecological data of 142 plant species have been collected, out of which medicinal uses and values of 85 plant species were identified based on ethnobotanic case studies. It has been observed that species like *Croton joufra, Smilax zeylanica, Rhus japonica*, and *Garcinia xanthoschymus* are threatened in the reserve. Socio-economic survey of 131 households was conducted in the fringe villages to collect information on medicinal uses of plants in their surrounding forest through a questionnaire. Emphasis was also given to focus the perception of these people about the conservation of medicinal plants. Information from different tribes was collected on the local uses of plants in different aspects apart from medicinal use. Market survey was also conducted and information of 57 medicinal plants pertaining to rate, availability and source of medicinal plants in five local markets situated in the fringe areas of the reserve i.e., Koilamati, Bukajan, Silonijan, Borpathar and Tengani was collected.

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 16 Sample plots have been laid out in the sanctuary covering four ranges.
- The sample plots have been marked semi-permanently for further evaluation of the gap dynamics. Species association patterns are being analyzed. So far 66 plant species are identified and authenticated.

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

Field surveys were conducted in Salna (Naogaon District, Assam), Gibbon WLS (Assam), RFRI Garden (Jorhat), Amguri (Sivasagar District, Assam), Dimapur, New Bisupui (Nagaland), Nongpoh, Darugiri (East Garo hill)- Meghalaya. Pollination Ecology, Embryology, Pollen biology and plant breeding are in progress.

Mapping and Quantitative Assessment of Geographic Distribution and Population Status of Plant Resources of Eastern Himalayan Region (Upper Assam unit)

Survey and sampling of 131 belt transects belonging to different sampling Grids (6.5 kms X 6.5 kms of size approximately in Assam: Jorhat, Dibrugarh, Golaghat, Lakhimpur

and Sibasagar districts) was completed. Collection of plant specimen (for preparation of herbarium), photography of all available plants in and around each belt transects were done accordingly. Information regarding girth, height, phenology was also collected as per prescribed format. The GPS location of starting point, midpoint and end point of all belt transects were noted. Information regarding tree, shrub and herb species of sampled area was documented. Herbaria of about 309 specimens were prepared following appropriate procedure. Upgradation of GIS database were done accordingly.

2.1.6 Biodiversity

Studies on Biodiversity of Parasitic Chalcidoidea (Hymenoptera) of Uttarakhand

Survey of eight districts of Uttarakhand (Dehradun, Haridwar, Tehri, Pauri, Nanital, Uttarkashi, Rudra Prayag and Chamoli) was carried out for collection of parasitic Chalcidoidea. Collection was done with the help of sweep nets and yellow pan traps. Hundreds of samples of insects were collected. Chalcidoids were sorted out in the laboratory under stereozoom microscope. Further sorting of collected specimens was done into 18 Chalcid families. Encyrtid parasitoids were identified upto genus level. From the preliminary observations, it was found that family Eulophidae was most abundant and species rich family followed by Encyrtidae, Mymaridae, Eupelmidae, Pteromalidae, Aphilinidae and Trichogrammatidae. Hundreds of hosts of these parasitoids were also collected from various localities and reared in the laboratory. Emerged parasitoids were preserved in alcohol/ card mounted. Several new species have been identified and work on their description is in progress. One new species of family Tanaostimatidae, *Cynipencyrtus indicus* Singh has been described. Genus Cynipencyrtus is recorded for the first time from India.

Recorded *Proleurocerus litoralis* Hayat and Kazmi (Encyrtidae) parsitizing egg masses of *Eurybrachys tomentosa* (Fulgoridae) from Doon Valley, Uttarakhand, which was also a new host record for the species. Earlier this species was known from females only, therefore, its males was also described. A new species of *Eutrichosomella indica* (Chalcidoidea: Aphelinidae) was described. Two new species of *Psyllaephagus* parasitizing and *Phacopteron lentiginosum* (Hemiptera: Psyllidae) forming leaf galls on *Garuga pinnata* were also described.

Taxonomic Studies on Parasitoids Belonging to Subfamily *Microgastrinae* (Hymenoptera: Braconidae) of Uttarakhand and Haryana

Survey and collection of Microgastrinae parasitoids was carried out from Uttarahkand (Doon Valley : Rajaji National Park, Mohand and Asarori Forest, Muni ki Reti, Rishikesh Forest Division, Barkot, Timili, Kalsi, Langha, Karwapani, Jhajara, Phanduwala, Lachchiwala Forest, Riawala, Chiriapur-Haridwar forest division and FRI Campus. Upper Himalaya (Forest areas of Tehri, Badshahi Thaul, Chamba, Kaddukhal and Dhanaulti) Haldwani (Ram Nagar Kaddukhal and Dhanaulti); and Haryana (Pinjor nursery, Chiken Kothi, Nolta and Jalon Forest range, Ambala Forest Division. Kalyeswer, Chhichharauli-Yammuna Nagar Forest Division). Comparison of field collected Microgastrinae parasitoids was carried out with available material in National Forest Insect Collection (NFIC) and identification was done up to species level.

Updating of Microgastrinae parasites of NFIC was done. Microgastrinae of NFIC includes 44 species in 8 genera and 4 tribes. These four tribes are Apantelini, Cotesiini, Microgastrini and Microplitini. Genera-wise number of species are: 19 species in *Apanteles*, 4 species in *Dolichogenidea*, 8 species in *Cotesia*, 1 species in *Diolcogaster*, 3 species in *Proapanteles*, 1 species in *Protomicroplitis*, 3 species in *Microgaster* and

5 species in *Microplitis*. Study was carried out on external morphology and taxonomic characters of Microgastrinae parasitoids reared in laboratory: *Apanteles galleria*: Wilkinson; *Apanteles plutellae*, Kurdjumov; *Microplitis mediator* (Haliday); *Cotesia eletrae* (Veiereck) and *Cotesia koebelei* (Riley). Key is prepared of all the described species of Microgastrinae parasitoids which were collected from Upper Himalaya, Doon Valley and Haryana.

Taxonomic Studies on Parasitoids Belonging to Subfamily Braconinae (Hymenoptera: Braconidae) of Uttarakhand

Survey was carried out for collection of parasitoids belonging to subfamily Braconinae from different sites of Uttarakhand. Sorting of the specimens belonging to Braconinae from the collection has also been carried out. Identification of one species of each genus *Bracon* and *Atanycolus* has been done. Identification of Braconin parasitoids up to species level is in progress.

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

About two thousand card mounted specimens were sorted out from the general collection. Alcohol preserved specimen were also card mounted. Following genera and species were identified and work on further identification is continued: *Pleurotroppopsis* spp. (2 species), *Aprostocetus cauperdatus*, *Tetrasticus* spp., *Neotrichoporoides* spp., *Parahorismenus* spp., *Pediobius* spp. and *Elasmus* spp.

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

Literature survey and collection was carried out from various sources including internet. About one thousand specimens were sorted out from the general collection. They were all mounted on cards. Following species were identified (*Copidosoma varicornis*, *Lakshaphagus* sp., *Neastymachus* sp. nov., *Psyllaephagus* sp. nov. (2 species). Permanent slides were prepared.

Orthopteran diversity of the Nilgiri Biosphere Reserve (NBR)

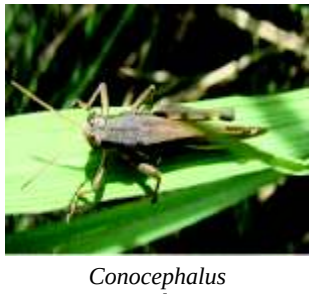
Study sites of seven habitats namely Scrub jungle (Masinagudi), Deciduous forest (Mudumalai), Shola forest (Kothagiri), Grassland (Kodanadu), Teak Plantation (Kargudi), Evergreen forest and Swamp forest (Gudalur) have been identified in NBR. Preliminarily six sites representing three habitat types viz., grassland, scrub jungle and deciduous forest (two sites/habitat types) with reference to disturbances which are anthropogenic interference such as grazing corridors and controlled fire have been identified. A total of 19 species of Orthoptera namely, *Xenocatantops humilis, Morphacris sulcata, Orthacris maindronii, Oxya nitidula, Heiroglyphus banian, Cyrtacanthacris tartarica, Acrida exaltata, Aularches scabiosa, Eyepreponemus alacris, Ailopus thalassinus, Phlaeoba infumata, Tyloterpedus varicornis, Gastrimarcus affricanaus, Hetracris pulcher, Conocephalus maculatus, Euconocephalus incertus, Himertula* spp. *Hexacentrus major* and *Gryllodes sigillatus* belonging to three different families were recorded. The family Acrididae shared the largest representation of 14 species followed by four species of Tettigoniidae and Gryllidae by one species. The species *X. humilis, C. maculatus* and *P. infumata* common in all habitat with the host range of some species has been studied.

Some of the Orthopteran species/Habitats recorded in NBR

Swamp Forest

Shola Forest

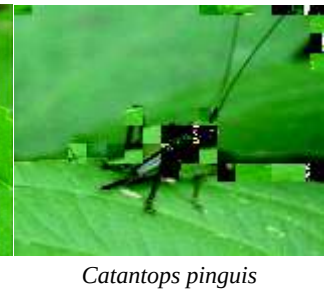
Deciduous Forest



Conocephalus maculates

Phlaeoba pictus

Gesonula punctifrons



Catantops pinguis

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

Preliminary identification of site/transects for the sampling work was carried out during the first year at the study area, Makutta, based on the observation and existence of fungal fruiting bodies. A total number of 5th transects were identified. Line transect method was followed for the actual sampling work to be carried out in the study area. Regular visit to transects for documenting the macrofungi were carried out during all the quarters. Documentation based on the prevalence of fungi during monsoon, pre and post monsoon is carried out through photographs, collections and characterization of the macrofungi. A total of 150 macrofungi were identified. Substrates of the fungi were also recorded like; fallen logs, twigs and snags. A manual is being developed for field identification of macrofungi for the study area.

Achanakmar-Amarkantak Biosphere Reserve

A complete UNESCO nomination document of Achanakmar-Amarkantak Biosphere Reserve was prepared and submitted for designation on the World Network of Biosphere Reserves. Collected literature on biosphere reserves of tropical moist/dry deciduous forest types and information on flora and fauna was updated. Meteorological data from core and buffer zones of Achanakmar-Amarkantak Biosphere Reserve were collected. Status of economically important threatened flora was recorded in buffer zone. One day workshop on identification of butterflies and birds of Achanakmar-Amarkantak Biosphere Reserve and sustainable harvesting of NTFP's was conducted in October 2010. Biannual series of information of Biosphere Reserve (BRIS) was published. Out of 12 species of butterflies and 24 species of moths collected from the buffer and transition zones of Biosphere Reserve, butterfly *Ypthima avanta* and 20 species

of moths is new addition to the insect faunal composition of Achanakmar-Amarkantak Biosphere Reserve.

Exploration and Conservation of Genetic Resources of Selected Rare and Endemic Plants of North-East India

Surveys were carried out in Karbi-anglong, Golaghat and Jorhat district, Assam and Mon and Mukokchung district, Nagaland to explore the distribution of *Livistona jenkinsiana* and *Gnetum gnemon. L. jenkinsiana* found sporadically at higher altitudes of Meghalaya. Different uses of *L. jenkinsiana* and *G. gnemon* were recorded with consultation of rural people. Rural people conserve and give care for the growth of the species, since people use the leaves for roofing and preparation of indigenous "Japi". Seeds of *L. jenkinsiana* were collected from the study site along with stump cuttings of *G. gnemon,* leaves of which are used as leafy vegetable among different communities, were also collected from Nambor Wildlife Sanctuary and raised for nursery trials in the experimental garden at RFRI for germination and survival. Survey was carried out in foothills of Mon district and Mukakchun district of Nagaland, Cheerapunjee, Mawsinram, Dawki and Nongpou of Meghalaya for inventorization and studying the distribution pattern of *Vanda coerulea* where the species are naturally grown. *Renanthera imschootiana* recorded being restricted in Ukrul district of Manipur. Study on the natural occurrence of the species, data on traditional uses of the species, their ritual and ornamental importance in the society were collected by discussion with rural people. Survival percentage was recorded. Growth data of plantlets viz., leaf number, seedling height, leaf size, internode length, number and length of aerial root were taken initially and after three month of interval. Two numbers of new shoot initiation of *Vanda coerulea* were recorded in Sphagnum (moss) based media.

A Study on the Biodiversity of the Plant Resources of the Patch Vegetations Around Rural Homestead in Jorhat District, Assam and its role in Socio-economy of the Villagers

The study was conducted with an aim to make an inventory of plant resources of the patch vegetation and its different uses by the villagers in Jorhat District, Assam. Distribution and ecology of different species were studied in 30 study sites throughout the district. As per the distribution of plants in different areas along the riversides were dominated by *Lagerstroemia-Barringtonia-Premna* and *Bombax-Trewa- Bischofia* community. On the other hand, *Artocarpus-Castanopsis-Mesua* was found towards the foothill areas of Nagaland and the foremost species in secondary patches in western part of the district was *Schima wallichii*.

Socio-economic and ecological study was also done in the selected sites. About 230 plant species used by the villagers in day to day life were recorded. The different usages of the plant resources of the patch vegetations was categorized as timber, firewood, food, medicine, fodder, feeder plant for silk worm and some other minor uses. Timber yielding plants recorded in the study areas are *Artocarpus chama, Albizzia procera, Castanopsis armata, C. tribuloides, Cinnamum glaucescens, Dysoxylum procerum, Michelia montana,* and *Schima wallichii, Stereospermum colais* etc. Some species like *Machilus bombycina, Litsea monopetala, Heteropanax fragrans* are recorded as feeder plants for silk worm. The medicinal plants recorded from the sites were *Paederia foetida , Centella asiatica, Argyreia speciosa , Spilanthes acmella, Smilex zeylanica, Cromolina odorata, Clerodendron coleobrookeanum, Eugenia balsamea* etc.

The edible fruit plants available in the patches are *Antidesma bunius, Baccaurea sapida, Dillinia indica, Garcinia morella , G. xanthochymus*

and *Syzygium cumini*, etc. Other economic plants that have been used by the villagers in different non timber usages are *Calamus tenuis, Canarium bengalense, Clinogyne dichotoma, Aquilaria agallocha,Litsea cubeba* and *Livistonia jenkinsiana*.

Two awareness programmes-one titled "Patch vegetation, phytodiversity and livelihood" security at Jhangimukh, Jorhat and "Phytodiversity of patch vegetation, its value and conservation" were also organized.

Exploration of Diversity and Utilization Potential of *Sphagnum* Species of Forestry Importance in North-East India

Surveyed different Forest and commercial nurseries and localities to explore *Sphagnum* species in North-eastern region including Arunachal Pradesh, Tripura, Mizoram, Meghalaya, Sikkim and Nagaland. Meetings with SFDs, Scientists of NBRI, Lucknow; GBPHID, Sikkim; BSI, Shillong, Dehradun and Sikkim circle; NCOR, Sikkim; SFRI, Itanagar and Universities. Collected geographical information of Sphagnum rich localities. Collected specimens from different localities of East Khasi hills and West Khasi hills and prepared herbarium. The species variability among four species of *Sphagnum* were studied . Physical property (pH) of total four *Sphagnum* species were analyzed. *Bamboosa balcooa* and *B. nutans* selected for macroproliferation with *Sphagnum* species, *Cinnamomum zeylanicum, Elaeocarpus, Gmelina arborea* and *Aqularia* were selected for air layering experiments, while some orchid species selected for potting media experiments and got positive results .

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

Fruit body samples of *Ganoderma* spp. were collected from different forest areas of Kamrup, Morigaon, Nagaon, Karbi Anglong, Sonitpur, Jorhat, Dibrugarh, Tinsukia, Cachar, Hailakandi and Karimganj districts of Assam. Morphological characters of the collected species were done for enabling their identification. Isolation of the fungus was done from the collected fruit body samples of different *Ganoderma* spp. Standard method was followed for preparation of pure culture of different samples using Potato Dextrose Agar (PDA) as growing media. These cultured samples were maintained in the laboratory by conducting regular sub culturing at 15 days interval and preserved under refrigerated condition. Microscopic characters were studied under compound microscope and observations recorded regularly. Biochemical studies: Estimation of total soluble sugar, moisture content of different samples of *Ganoderma* spp. is on. Market survey for *Ganoderma* and its product: Study on availability of *Ganoderma* products in market of Assam is going on with the help of different distributors of commercial Ganoderma products present in Assam.

Biodiversity Impact Assessment of Strategic Flaghill-Dokala Road, Pangolakha Wildlife Sanctuary, Sikkim, India

Field surveys were carried out in Pangolakha Wildlife Sanctuary along the Indo-China/Bhutan Trijunction along the alignment proposed for construction of a 33 km road passing through alpine, sub-alpine and Type 14/C2-East Himalayan sub-alpine birch/fir forests (Champion and Seth,1968) between 3,500-4,000m was awarded to RFRI, Jorhat.

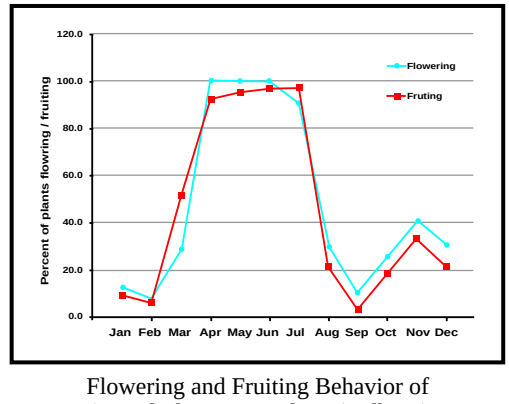
Type 14/C2-East Himalayan Sub-alpine Birch/Fir Forest on the Proposed Strategic Flaghill-Dokela Road, alignment along the Indo China Border in Sikkim

Assessment of Guggal Germplasm for Studying Population Density, Diversity, Female-male Plant's ratio for *in situ* and *ex situ* Conservation in Rajasthan

Project has three components viz., 1. survey work (to study population density and sex ratio), 2. conservation and 3. propagation. Sixteen districts viz; Ajmer, Barmer, Bhilwara, Churu, Jaisalmer, Jalore, Jhunjhunu, Jodhpur, Karoli, Nagaur, Pali, Rajsamand, Sawai Madhopur, Sikar, Sirohi and Udaipur were surveyed. Data on number of plants and associated species were recorded in sample plots (size 0.1 ha) with GPS locations. Spatial variation in the *Commiphora wightii* was clearly evident within the area. A positive association was recorded with species like; *Euphorbia caducifolia, Acacia senegal, Boswellia serrata, Anogeissus pendula, Capparis decidua* and *Zizyphus nummularia*. It was found that in hilly areas, on rocky tracks, *C. wightii* usually grows on the foot of hills. It grows well in sandy desert areas (Barmer and Jaisalmer). Plants in high density were found in Sawai Madhopur, Jhunjhunu, Barmer, Jalore, Sikar, Karoli districts, while in Nagaur, Pali, Jaisalmer Sirohi districts low density of guggal plants were observed. In ravines of Chambal river at Mandrayal range in Karoli district, it is widely distributed and density of guggal was 47 plants per hectare. High density of guggal plants were recorded in four places viz. Kot (Udaipurwati) forest block of Jhunjhunu, Tajpur (Sawai Madhopur), Kiradu (Barmer) and Chekla (Jalore). After survey of 16 districts, guggal was found in 61 forest blocks of 15 districts. In Churu, no guggal population was recorded. Male plants were not seen during survey.

Conservation: Germplasm was collected for *ex situ* conservation from identified 80 Candidate Plus Plants (CPPs). About 948 cuttings of CPPs with detail records were raised in vegetative propagation area.

Propagation: Guggal population at Kaylana (Jodhpur) was selected for annual studies of flowering and fruiting behaviour in Rajasthan where *Commiphora wightii* is growing in natural habitat. Observations on flowering and fruiting were recorded in each month from 66 guggal plants growing in this area. Annual pattern of flowering and fruiting is given in graph. In Jodhpur, guggal plants produced fruits twice a year i.e. from April to July (main fruiting season) and from October to December (delayed fruiting season). No fruiting was observed in Barmer and Jaisalmer districts during surveyed in the month of November and December. Immature fruits were observed in Ajmer, Jodhpur and Pali districts during survey in the month of August, October and November, respectively. These immature fruits were collected (from Barli and Arna sites of Jodhpur district) for *in vitro* germination. Mature fruits were not available at any of sites surveyed during this period (from August to December 2010).



Flowering and Fruiting Behavior of Guggal Plants at Kaylana (Jodhpur)

From Kaylana (Jodhpur) field, mature fruits were collected in March. Two types of seeds, viz., black and white were observed in mature fruits. The seeds were then air dried and kept in separate labelled air tight plastic containers at room temperature. Both black and white seeds were sown. Only the black coloured seeds were viable, while white seeds were non-viable. Germination percentage of black seeds was found to be 40% and germinated within 5-16 days after sowing.

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 to select *Prosopis juliflora* rich sites in Jodhpur, Pali and Churu District. Associated floral and faunal diversity was recorded of the selected sites. *P. juliflora* density was worked out in orans, gochars, reserved forest, saline lands, wastelands, water bodies and agriculture fields. The most common trees found associated with *P. juliflora* were *Anogeissus* species, *Prosopis cineraria*, *Tamarindus indica*, *Acacia nilotica*, *Capparis decidua*, *Salvadora* spp., *Azadirachta indica*, *Acacia tortilis*, *Acacia leucopholea*, *Acacia senegal*, *Zizyphus* spp. and *Agele marmelos.* Other floral diversity included *Calotropis procera*, *Tephrosia purpurea*, *Cassia auriculata*, *Aristida royleana*, *Aerva tomentosa*, *Leptadenia pyrotechnica*, *Euphorbia cauducifolia*, *Cenchrus ciliaris*, *Cyperus rotundus*, *Cynodon dactylon*, and *Chloris* spp. In *P. juliflora*, inflorescence varied from 5.1 cm to 11.1 cm. Size of pods varied from 7.6 cm to 20.1cm. Highest size of inflorescenece and pods were recorded in *P. juliflora* growing near water bodies.

Five groups of soil arthropods and entomofaunal invertebrates and four groups of vertebrates were associated with *P. juliflora*. Fauna associated with inflorescence and pods were observed and identified as 2 species of Hymenoptera: *Apis dorsata* and *Apis florea*; 2 species of Diptera and 2 species of Lepidoptera from Jodhpur district. Sap sucker *Oxyrachis tarandus* were observed feeding and breeding on the stem and branches and feeding on the green pods in association with black ants. They were predated upon by 3 natural biological predators identified as 1 species of reptile and 2 species of insectivorous birds. Two species of seed bruchids; *Bruchus chinensis* and *Caryedon serratus* were recorded from dried pods. One species of rodent was observed feeding on the semi-dried pods of *Prosopis juliflora*.

It was found that seeds are utilized as fodder, harvested tree used as fuelwood, bio-fencing, fencing, charcoal manufacturing and making parts of agricultural tools. Dried twigs of *P. juliflora* were also used to protect young planted saplings under various programmes. Dried twigs used for nest building by avian species. *Acacia auriculiformis* was not observed during the study period.

Fauna associated with exotic *Leucaena leucocephala* was identified and documented as *Apis dorsata*, *Apis florae* and *Polistes* spp. (Hymenoptera). The pods and seeds are eaten by *Psittacula krameri* especially the females. No insect was observed feeding on the pods or seeds of *Leucaena leucocephala*. It was found that *Acacia tortilis* pods were eaten by hanuman langurs *Semnopithecus entellus*.

Ecological Assessment of Floristic Diversity in Kalatop Khajjiar Wildlife Sanctuary of District Chamba, Himachal Pradesh

Phyto-sociological studies in the already selected sites were conducted by laying out the quadrats of different sizes randomly and seperately for trees, shrubs and herbs in different altitudinal zones. In this process, total number of plant species in Talai-I beat, recorded were 149 belonging to 55 families and 133 genera with dominance of *Quercus leucotrichophora*, *Picea smithiana*, *Berberis lycium*, *Cotoneaster microphyllus*, *Sarcococca saligna*, *Vibernum erubescens*, *Rumex hastatus*, *Valeriana jatamansii* and *Bupleurum falcatu* whereas, in Khajrot beat, the total number went upto 105, belonging to 60 families and 95 genera with the dominance of *Picea smithiana*, *Sarcococca saligna* and *Valeriana jatamansii.* The total number of plant species recorded in Khajjiar beat were 101, belonging to 54 families and 95 genera with the dominance of *Persea duthiei*,

Coniferous Forest in the Sanctuary

Dactylorhiza hatagirea

Malaxis muscifera

Picea smithiana, Sarcococca saligna, Vibernum erubescens, Polygonum capitata and *Bergenia ciliata.* However, in Kangarrakh beat of the sanctuary area, number of plant species went upto the total of 127 belonging to 65 families and 119 genera with the dominance of *Pinus wallichiana, Pinus roxburghii, Berberis lyceum, Anaphalis triplinervis, Nasturtium officinale* and *Commelina paludosa.* The recordings of plant speices in Ala beat, reflected a total of 93 species belonging to 44 families and 87 genera with the dominance of *Picea smithiana, Sarcococca saligna, Vibernum erubescens, Valeriana jatamansii* and *Arisaema intermedium.* Similar recordings when made in Dainkund beat revealed a toal of 102 plant species belonging to 54 families and 95 genera. The dominant species recorded were *Cedrus deodara, Picea smithiana, Sorbaria tomentosa, Vibernum erubescens, Valeriana jatamansii* and *Erigeron multiradiatus* whereas, in Lakadmandi beat the total number of plant species recorded was 81, found belonging to 52 families and 76 genera. The dominant species were *Quercus leucotrichophora, Cedrus deodara, Sarcococca* and *Valeriana jatamansii.* Talai-II beat of the sanctuary area revealed 109 plant species belonging to 58 families and 102 genera with the dominance of *Cedrus deodara, Berberis lycium, Sarcococca, Bergenia ciliata, Valeriana jatamansii* and *Pilea scripta.* In Kalatop beat, total number of species recorded were 142 belonging to 71 families and 127 genera with the dominance of *Cedrus deodara, Berberis lycium, Sarcococca saligna, Bergenia ciliata, Pilea scripta* and *Valeriana jatamansii.*

In totality, the total number of plant species in the sanctuary area was 232 belonging to 76 families and 218 genera.

The field recordings also showed the presence of 100 plants species of medicinal importance from Kalatop-Khajjiar wildlife sanctuary, 7 species viz., *Cinnamonum tamala, Dioscorea deltoidea, Paris polyphylla, Podophyllum hexandrum, Polygonatum verticillatum, Taxus wallichiana, Zanthoxylum armatum* fall in the category of threatened plants. Also conducted the ethnobotanical study in 14 villages surrounding the sanctuary area and documented 45 plant species being used by the local populace for their day to day requirement.

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

The Noctuidae or owlet moths are a family of robustly-built moths that includes more than 35,000 known species out of possibly 100,000 totals, in more than 4,200 genera. They constitute the largest family in the Lepidoptera. Their distribution is worldwide with about 1,450 species found in Europe. Most have drab forewings,

Diversity of Moth Recorded During Night Hours on Illuminated Shrubs in Kinnaur

although some have brightly coloured hindwings. There are usually few differences between the sexes. The Noctuidae are also remarkable for containing an extraordinary number of species whose caterpillars are able to feed on certain poisonous plants without harm. These foodplants - namely Solanaceae (e.g., Nicotiana) and Fabaceae (e.g., Sophora) - contain chemicals that would kill most insects trying to feed on them.

During the period, the field survey was conducted in additional sites including the areas located in Kinnaur. Damage done to the host (only selected coniferous and associated vegetation) by these species was also recorded. Individuals of 17 sub-families out of 35 Noctuid sub-families have been collected with maximum individuals of the sub-family Hadeninae. A total of 2740 and 1360 specimens of Lepidoptera moths were collected from different conifer sites during 2009 and 2010 respectively. Out of these 663 and 737 specimens collected during 2009 and 2010 respectively belong to the Noctuid moths. Out of this collection, 117 species have been identified. 69 species of moths were dissected so as to study wing venation and genitalia for taxonomic updates. 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.

Phyto-diversity Assessment of Khasi Sub-Tropical Wet Hill Forest in Meghalaya

Literature survey was done intensively to keep an update of the research work in similar themes at RFRI, Jorhat; FRI, Dehradun and BSI, Shillong, as well as online sources. Phyto-sociological studies in Riat-Khwan Reserve Forest, Meghalaya were carried out by laying down 40 Quadrates for trees. Data collected pertaining to the anthropogenic activities around the periphery of the study area was recorded. Herbarium specimens were collected and 93 plant specimens were processed for identification at BSI, Shillong.

Assessment of Phyto-diversity Dynamics for Conservation in Jeypore Reserve Forest

Data for Phyto-sociological studies were collected from 7/10 sites for vegetation analysis and natural regeneration. One hundred species of plants have been identified so far. Density, frequency and basal area of plants have been calculated for two locations. A demonstration plot of one hectare was established in field. A training programme on the awareness of biodiversity and its conservation was also conducted in study area for eco-development committee members, rural people and staff of state forest department. Analysis of physico-chemical properties of soil is in progress.

2.1.7 Invasion

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

Regeneration of dominant tree species after removal of Lantana was studied under Sal and mixed vegetation communities in Rajaji National Park. Vegetation structure and composition as influenced by removal of Lantana was assessed under Sal and mixed vegetation communities and planted forest of Eucalyptus in Rajaji National Park. Soil moisture and soil temperature was monitored in Lantana removal and Lantana invaded sites under Sal and mixed vegetation communities. Appreciable changes in the dominance of some native understorey vegetation such as *Adhatoda vasica*,

Murraya koenigii and *Ehretia laevis* have been recorded as a result of removal of *Lantana* from the park area. Appreciable change in the dominance of grass i.e. *Chloris dolichostachya* has been recorded in planted forest ecosystem as a result of removal of *Lantana*.

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 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.

Hyptis suaveolens in Mixed Forest

Lantana camara in Teak Forest

Cassia tora

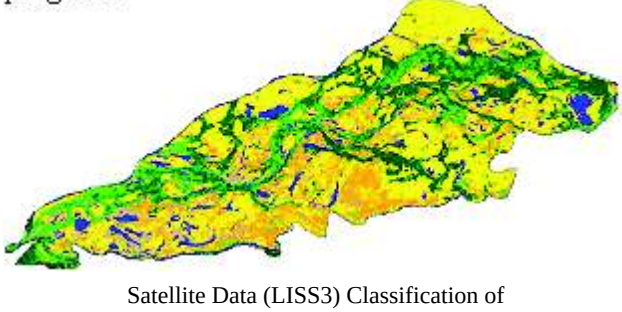
Hyptis suaveolens Infestation

- Preliminary survey of four districts (Jabalpur, Mandla, Katni and Seoni) has been completed for selection of site and collection of maps etc.
- Site details of the study sites have been recorded.
- 144 quadrats (1x1 m) for herbs and grass have been laid out in all sites and vegetation parameters recorded.
- Fourty eight quadrats (5x5 m) laid out for the study of shrubs and saplings along with invasive species.
- Fourty eight quadrate 20m x 20m for the enumeration of the species have been laid out in all districts.
- Total 39 FIS recorded.
- Phenological observations have also been recorded.

Investigations on Ecology of *Mimosa* invasion in Kaziranga National Park, Assam

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. Higher resolution satellite images (LISS 4, PAN) was procured from National Remote Sensing Centre, Hyderabad. Preparation of High resolution vegetation map of Baguri range is completed and Kohora range is in progress. GPS location (both polygons and points) of *Mimosa* patches were examined in the image thoroughly. Phyto-sociological study was carried out in

3 different *Mimosa* infested sites. Recorded phyto-sociological and regeneration data of all plant species found in tall grassland. Data on diameter and height of all the tree species were taken and all the individuals of shrubs/tall grass in each quadrate were counted. Computing and further analysis of data is in progress. Data recording on phenological events of *Mimosa* was also completed and phenograms were prepared. Seeds from healthy *Mimosa* plants identified in invaded areas were collected from Western, Central, Eastern and Buraphar 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 laid out. The seed burial effect, biomass analysis at different environment gradient and seed soaking in water at different intervals experiments under progress.



Satellite Data (LISS3) Classification of Kaziranga National Park, Assam, India

2.1.8 Forest Botany

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

The objective of this project is 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 micro-photographs 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'.

Fluorescent Studies of Indian Woods

Fluorescence is a new aid to analytical work and is finding increasing application in the characterization of a variety of products. Fluorescence is greatly intensified when viewed in ultra-violet light. Bodies, which exhibit little or no fluorescence when viewed in sunlight, begin to show brilliant and often characteristic fluorescence under ultra-violet light. So far, the application of this method for the study of wood has been scanty. The study on wood fluorescence got impetus after the same was mentioned under the feature list given by International Association of Wood Anatomists (1989) and mentioned as one of the important feature for wood anatomical studies. Thus, this study on the Fluorescence behaviour of Indian woods had been undertaken. Under this project, data was collected for 750 species (5000 wood samples) and reported.

Taxonomic and Anatomical Studies of Exotic *Pinus* Species

The genus *Pinus* consists of 110 species (Richardson, 1998) mainly distinguishable based on needles, cone structure etc. In India, 5 species are reported to be occurring in the temperate regions (Chauhan et al., 1996). Preliminary survey of the available literature indicate that species level identification of many of the exotic *Pinus* species has not been possible through their microstructure, and groups have been formed consisting of several species. Thus, it has become imperative to carry out study on the morphology and anatomy of exotic Pines for the purpose of their efficient utilization. This required morphological studies for identification of exotic *Pinus* species in field, literature survey to enlist areas in India having plantations of these exotic *Pinus*, their collection from their plantation areas and subsequent anatomical studies. Thus, the objective of the project was to carry out taxonomic and anatomical studies of exotic *Pinus* species. Herbarium and wood samples were collected from Champavat Forest Division,

Pithoragarh (Anusandhan Nursery & Suipatan, Lohaghat; Punethi Van Panchayat and Sukkhidhang, Champavat), Kalika Research Centre Ranikhet (Pinatum), Chakrata and Kalsi Forest Division and FRI. Following species were studied for their microstructure (71 wood samples) as per feature list given by International Association of Wood Anatomists (124 features) (IAWA, 2004)- *P. densiflora, P. elliotii, P. greggii, P. montezumae, P. oocarpa, P. patula, P. pseudostrobus, P. rigida, P. taeda, P. eldarica, P. halepensis, P. leiophylla, P. kesiya, P. oocarpa, P. patula, P. caribaea, P. echinata, P.merkusii, P. arizonica, P. durangensis, P. engelmannii, P. pringlei, P. brutia, P. corsica, P.edulis, P. monophylla, P. insularis, P. jeffreyi, P. torreyana, P. taiwanensis, P. nigra, P. formosana, P. jezoensis, P. koymai, P. mayri, P. polita, P. densiflora, P.armandii, P. koraiensis, P. laricio, P. lambertiana, P. montana, P. resinosa, P. ponderosa, P. sylvestris, P. strobus* and *P. monticola.*

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 are being looked upon as alternate source for many end uses like tool handles, furniture, agriculture implements etc. Also, stems of many shrubs are 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 are 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. 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 *Melastoma malabathricum, Oxypora paniculata, Osbeckia crinita, Azima tetracantha, Salvadora persica, Rhodomyrtus tomentosa, Psidium guajava, Myricaria squamata, Woodfordia fruticosa, Rosa lechenauitiana, 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 growth parameters namely tree height and Diameter at Breast Height (DBH) were measured for each individual before the collection of wood samples. Study material was collected from 100 progenies of *Populus deltoids* 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. Data for fibre length, diameter, wall thickness, vessel element length and diameter and specific gravity for 30 progenies were completed.

Digitization of FRI (Dehradun) Herbarium

- One thousand six hundred seventy four species details prepared; 1381 entered into the database.
- Eleven thousand nine hundred twenty specimen details prepared; 7861 specimen details have been incorporated into the database.
- Sixteen thousand nine hundred fourty one specimen photos have been taken and 13056 photos have been edited.

2.1.9 Tribals 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 antidysentery), *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.

Utilization Pattern of Plants in Ethno-medicinal uses Prevalent in Tribal Pockets of Satpura plateau in Madhya Pradesh

The traditional healers prevalent in the area of present study were in the district of Jabalpur, Mandla, Katni and Chhindwara who belong to Baiga, Gond, Bhariya, Kol tribes located in the Satpura eco-region of MP. These folk healers have inherited the art of healing, curing the patient by using medicinal and aromatic plants found in forest ecosystem around their tribal localities. These healers know the properties of large number of plants found in forest ecosystem which needs to be documented and scientifically examined for cure of ailment. Gradually, such plants are uprooted from forest in wild forms and due to heavy exploitation, many of these species are in the stage of being extinct category due to commercial utilization. Accordingly, such information on traditional knowledge has been documented on priority basis along with the commercial utilization of medicinal plants by traditional healers and several pharmaceutical companies involved in trade of this region.

Field survey was conducted to identify rich tribal pockets in Mandla, Jabalpur, Katni and Chhindwara districts of MP for documentation of traditional knowledge from traditional herbal healers. In all the 507 plants of medicinal value, which are being utilized by 134 traditional herbal healers of tribal pockets of above four districts for cure of various diseases prevailing among tribal/ local people were documented.

Existing utilization pattern along with formulation and duration of treatment etc. of medicinal plant being utilized by traditional herbal healers against various common diseases were also documented. Survey of Mandla, Jabalpur, Katni, Satna, Chhindwara, Bhopal and Sagar districts of MP were carried out to document the channels involved in marketing of herbal plants. Sixty eight traders involved in trading of herbal plants/parts were contacted to collect the information on trading. The price structure of sale of raw herbal medicinal plant parts was collected from local traders. Market day of tribal villages of Mandla, Jabalpur, Katni and Chhindwara districts, where, trading of raw and finished products take place was also visited and the information on trade was recorded.

Andrographis paniculata

Leea macrophylla

Details of Medicinal Plants, Traditional Herbal Healers and Traders Documented

District	Medicinal plants documented	Traditional herbal healers	Traders
Mandla	133	31	11
Jabalpur	128	38	10
Katni	119	35	10
Chhindwara	127	30	21
Sagar	-	-	02
Bhopal	-	-	07
Satna	-	-	07
TOTAL	**507**	**134**	**68**

Awareness was created through local contacts to the tribal people, traditional herbal healers and villagers of the study area regarding utilization of medicinal plants, importance and sustainable uses of herbal medicinal plants and their conservation during the field visits.

Ethno-Medico-Botanical Studies of Khasi, Garo and Karbi tribes

Nine villages namely, Morokdola, Sonaigaon, Aparikola (Kamrup District, Assam) and Pillingkata, Maikhuli, Umpher, Amphenggre, Matchkre, Umlangpur (Ri-Bhoi District, Meghalaya) were surveyed and information on the use of medicinal plants by Khasi, Garo and Karbi tribes were collected. In some villages meetings were also organized in the community hall for covering the maximum villagers. An enormous wealth of indigenous knowledge accumulated over long past and passed down from generation to generation with oral tradition. However, due to lack of documentation and present day communication facilities and availability of doctor or pharmacy nearby, use of medicinal plants for various ailments has been gradually decreased. Study revealed that common medicinal plants which are found nearby houses/ kitchen garden/road side etc. are still in use by the villagers for the treatment of various ailments. These are *Leucas aspera, Clerodendron viscosum, Ageratum conyzoides, Centella asiatica, Cuscuta reflexa, Lantana camara* and *Mimosa pudica*, etc. Some villagers who are interested in traditional knowledge collected plants of medicinal use and planted in their kitchen garden/ compound or as pot plants and use them when required. For example *Clerodendrum colebrookianum, Bryophyllum pinnatum, Oroxylum indicum, Aloe vera, Malastoma malabathrikum P aederia foetida, Houttuynia cordata, Terminalia chebula, Cinnamomum tamala* and *Rauvolfia serpentina* etc. Khasi tribe use *Abroma augusta* for curing urinary problem and *Thysonaela maxima* for keeping eye cold and clean. Different plant species used as medicine for various ailments were recorded.

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 Sahibgang district 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 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* collected and preserved as voucher specimens.
- Nearly 90 herbal practitioners belonging to Bathudi, Birgia, Birhor, Chero, Karmali, Kharwar, Kissan, Parhaiya, Sourya Pahariya and Sabar tribal communities were interviewed, so far, regarding the use of medicinal herbs for curing their ailments.