

2.1 Ecosystem Conservation and Management

Overview

Due to its sheer size and its range of topography, altitude and climate, India exhibits a rich variety of ecosystems, including forests, grasslands, deserts, wetlands, mangroves and coral reefs. These habitats provide for basic needs such as food, fibre, medicine, fodder, fuel wood and timber of a large section of the Indian population. However, in many parts of the country, there are serious threats to ecosystem health and consequently, to human livelihoods as well. Based on an analysis of these trends, it is possible to articulate India's conservation priorities in support of environmental sustainability. There may be six conservation priorities, each of which require specific improvements in knowledge, in capacity and in governance at the local, regional and national level.

- Managing protected areas, reserved forests and other habitats controlled by the state in a manner that balances conservation imperatives with local needs, synthesises scientific conservation principles with indigenous knowledge and provides local communities a long term stake in conservation.
- Enhancing India's cooperation with other countries on issues where national, regional and global conservation concerns converge.
- Influencing mainstream policy and programmes to recognise the trade-offs between economic and environmental considerations, and to integrate conservation concerns into the process of decision making.
- Employing effective instruments that encourage environmentally sensitive resource use and discourage unsustainable practices by resource users.
- Designing special measures to ensure the survival of fragile ecosystems in different parts of the country.
- Promoting community conservation of common pool resources, whether owned by the state or by local entities.

Projects under the theme

| Project | Projects Completed During the Year | Ongoing Projects | New Projects Initiated During the Year |
|------------------|------------------------------------|------------------|--|
| Plan | 12 | 23 | 08 |
| Externally Aided | 09 | 10 | 11 |
| Total | 21 | 33 | 19 |

2.1.2 Climate Change

Climate Change as on date has become one of the most important global environmental challenge because of its multi-faceted implications and disproportionate impact on various sectors including forestry. Accordingly, in the present scenario, issue of highest importance to the developing countries including India, is reducing vulnerability of their natural and socio-economic systems to the projected climate change since these countries are bound to face the challenges of promoting mitigation and adaptation strategies for overall development. Addressing all these issues in a most effective way, the strategy requires a good scientific understanding and coordinated actions both at the national and at the global level.

Effect of Climate Change on the Phenology of Himalayan Rhododendrons

Efforts were made to study the effect of climate change on the phenology of five *Rhododendron* species of western Himalaya. It has been observed that flowering, fruiting, seed



setting and dispersal is advanced by 15 days to one month at all altitudes (*R. arboreum* and *R. barbetum* at 6000-8000 ft.; *R. campanulatum*, 10000-11000 ft.; *R. lapidotum* and *R. anthopogon*, 12000-13000 ft. altitudes). The seedlings of *R. campanulatum* which is a timber line species were observed growing slightly upwards from their natural range, which is an indication of movement of species to the next zone.



R. arboreum

R. barbetum



R. campanulatum moving upwards



R. campanulatum

R. anthopogon



R. lapidotum

Studies on Response of Important Tree Species to Elevated CO₂ Levels under Simulated Temperature and Moisture Regimes at Seedling Stage

Automated Open Top Chambers' have been established to conduct climate change research with particular reference to studies on response of tree species to elevated CO₂ as well as temperature. As per the programme, three months old seedlings of Teak, Casuarina, Eucalyptus, Ailanthus, Neem and Bamboo were exposed to elevated CO₂ levels in open top chambers at 600 ppm and 900 ppm for a period of three months. Simultaneously, seedlings were also kept in control in open top chambers without CO₂ enrichment. Another set of seedlings was also kept in control outside the chamber in the ambient environment. Observations on growth parameters revealed that there exists significant variation in growth with reference to CO₂ enrichment and control environment. Secondly, the response of seedlings to elevated CO₂ level highly varied among species. Overall the response was positive in terms of height growth. Teak, Casuarina, Eucalyptus and Ailanthus registered greater growth under elevated levels of CO₂ whereas Neem registered the maximum growth under elevated temperature than elevated CO₂. The growth of Bamboo was not positively affected by elevated CO₂ or temperature. The biochemical studies are in progress.

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

By surveying 69 plantations of *Casuarina equisetifolia* in Tamil Nadu and felling 200 trees under different soil types and under irrigated and rainfed conditions, the dry matter production and carbon stock in biomass were estimated. Similarly, 243 Eucalyptus trees were sampled



from 81 plantations and 21 *Acacia mangium* trees in 7 plantations for biomass estimation. Soil samples collected from these plantations were analyzed for organic carbon and various other properties. In Teak plantations, carbon pool assessment is being carried out.

Vegetation Carbon Pool Assessment Andhra Pradesh North Region

Vegetation Carbon Pool Assessment studies were conducted in 11 field sites of Srikakulam, Vizianagaram and Visakhapatnam districts in Andhra Pradesh. Growth parameters that are height, girth, biomass 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. Estimation of biomass of trees outside forests is scheduled in 40 sites.

Tropical Forest tree species for their potential as carbon sink

Regression equations were developed for *Tectona grandis*, *Shorea robusta* and *Eucalyptus hybrid* and quantified carbon using these equations in plantations and agroforestry systems. Agroforestry systems were established with *Dalbergia sissoo*, *Eucalyptus hybrid* and *Pongamia pinnata* and *Tectona grandis* as tree species and *Triticum aestivum*, *Cicer arietinum*, *Withania somnifera*, *Hordeum vulgare* and *Avena fatua* as agricultural crops. *Triticum aestivum* crop sequestered maximum carbon in agroforestry systems with *Dalbergia sissoo* and *Tectona grandis* as tree species, followed by *Withania somnifera* and *Cicer arietinum*. Maximum reduction in carbon sequestration in

agroforestry systems with 15 years old *Tectona grandis* and *Dalbergia sissoo* occurred in *Cicer arietinum*, followed by *Triticum aestivum* and *Withania somnifera*.



Agroforestry system consisting of *Tectona grandis* and *Hordeum vulgare* established at TFRI campus

Vegetation Carbon Pool Assessment in Some Districts in Northern Rajasthan

Assessment of carbon in growing vegetation and carbon dynamics in the forests as well as Tree Outside Forest (TOF) were carried out in Shri Ganganagar, Hanumangarh, Churu, Jhunjhunu, Sikar and Jaipur districts of Rajasthan. A total number of 19 forest sites (76 plots) and 33 plots under tree outside forest have been surveyed in these districts and trees and shrubs have been measured in cluster sample of four at each site in forests. In TOF, some agriculture land, community land, state highway, national highway, railway tract, drainage line and village connecting roads have been surveyed, growth variables measured. Biomass of ultimate branches of a representative tree of different girth classes were recorded both for fresh and dry samples.

Studies on Carbon Sequestration in Different Forest Types of Rajasthan

With the objective to provide an estimate of carbon stock of forests in Rajasthan, twelve districts covering 336 forest blocks and 446 sites in these blocks have been surveyed and growth of



trees and shrubs measured and shrub/herbage biomass recorded. Litter, plant and soil samples have also been collected from the plots. Per cent Soil Organic Carbon (SOC) and Soil Inorganic Carbon (SIC) varied widely among the district. SOC varied from 0.17% in Hanumangarh district to 0.99% in Banswara, whereas, SIC varied from almost nil in Jhunjhunu to 1.12% in Chittorgarh district. Fresh aboveground and belowground biomass of *Leptadenia pyrotechnica* ranged from 0.09 to 19.0 kg and 0.05 to 20.0 kg, respectively with R/S ratio ranging from 0.29 to 2.63 (average of 0.97).

Sand dune scrub in Barmer district are found to be dominated partly by *Calotropis procera* with tree girth of 92 cm, height of 6.5 m and crown diameter of 6.6 m and with root:shoot ratio of 0.68. *Capparis decidua* tree dominated area with growth variables of 190 cm girth, 5.5 m height and 5.6 m crown diameter have also been observed in Jalore forest division. In growth variables of *Leptadenia pyrotechnica* collar girth, height and crown ranged from 5.26-40.50 cm, 55.0-233.0 cm and 36.0-380.0 cm, respectively. A mixed forest of *Mangifera indica* has been observed in Sirohi forest division.



Desert dune scrub of *L. pyrotechnica* and *Colligonum polygonoides* in Barmer



Mangifera indica mixed forest in Sirohi



Euphorbia caducifolia scrub forest in Barmer



Calotropis procera in desert dune scrub in Barmer



Capparis decidua in desert dune scrub in Jalore

Impact of Climate Change on Litter Microbial Dynamics

For studying the impact of climate change on litter microbial dynamics in Dipterocarp Forest in north-east India, eighteen species of microfungi responsible for Dipterocarp leaf litter decomposition of Deomali Reserve forest (Arunachal Pradesh) and Moreh (Manipur) were isolated in different seasons of the year along with three thermotolerant genera (*Aspergillus* sp., *Chaetomium* sp. and *Rhizomucor* sp.) using serial dilution-plate count method. *Aspergillus* sp. did not survive at 55°C and beyond and maximum growth was observed at 35-45°C. In case of *Chaetomium* sp. range of optimal growth temperature was found to be 55-60°C and that of *Rhizomucor* sp. was 45-55°C. The studies on population dynamics of microfungi showed a considerable variation in different seasons depending on the rate of decomposition. Maximum degree of decomposition and microfungal population were observed in rainy season followed by spring and minimum in winter. Higher rate of decomposition was recorded in below ground condition (just below surface layer) as compared to above ground soil. These data (2009-10) were compared for



assessing the changes in litter decomposition rate within the last decade (1999-2000) and results show a decline in decomposition rate from 1.07 to 1.01 and decrease in lignin concentration and increase in nitrogen concentration for the same area.

Development of Remote Sensing Based Bio-climatic Index

Validation of changes in timberline and other classes over the few decades in relation to the altitudinal gradient was assessed. Vegetation ingression in alpine regions of Bedini bughiyal Chamoli Garhwal was analysed. An area of change for ground verification (species composition) has been demarcated. The seedlings and saplings of tree line vegetation specially *Rhododendron campanulatum*, *Abies pindrow* and *Quercus semicarpifolia* were found moving towards alpine zone.

Utilization of Automatic Weather Station/ Agrometeorological Station Data for Agriculture, Forestry and Hydrological Applications

Sites were selected near Automatic Weather Station (AWS) and Agrometeorological Station (AMS) in Kanha National Park (KNP), Bandhavgarh National Park (BNP) and Madhav National Park (MNP). Grass biomass studies were conducted in at selected sites. Soil moisture profile up to the depth of 1.50 m was measured at an interval of 30 cm. Surface and sub-surface soil samples were collected and analysed in laboratory.



Conducting Soil Moisture Profile Studies near AMS at Kanha National Park



Conducting Grass Biomass Studies near AWS at Kanha National Park

Energy and Mass Exchange in Vegetative System

Micrometeorological station has been established in Pine plantation (forest ecosystem) in F.R.I. campus, Dehradun with the objectives to measure micrometeorological and biophysical parameters over Pine plantation, modelling canopy atmospheric exchange processes and primary productivity using land surface process models, validation of satellite derived parameters using *in-situ* measurements.



Micrometeorological Station in F.R.I. Campus

2.1.3 Ecology & Environment Eco-restoration

Eco-restoration Studies in Uranium Mines

A marked improvement was recorded in tailing covered soil properties with the age of bio-reclamation. The accumulation and subsequent decomposition of plant residues have resulted in building the organic matter with an associated increase in nutrient enrichment. The organic carbon and nitrogen contents tend to increase with age. The availability of nitrogen and phosphorous increased with age. The exchangeable cations showed marked improvement with concentration of potassium increasing progressively and attaining a net annual gain of 8.51 kg/ha at the age of two years. The plant species present have, thus, strongly influenced by physico-chemical properties of the tailing covered soil in short period of time. 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. The seven species selected show minimum concentration or below detective limit of the uptake of radionuclide by plants. Roots of the selected species were confined to the 30 cms. layer of soil and not penetrating the tailings. Growth, diameter, basal area was the same as in natural ecosystem so tailing covered soil impact was found negligible.

Development of Site Specific Regeneration Augmentation Plan for Potential Degraded Areas in Western Ghats, Kerala

Experimental sites were identified at Pudur, Siruvani, Thathangalam and Panthanthodu in Attapaddy Reserve Forests. Inventory of species in and around the experimental plots was prepared. Quantitative assessment of vegetation in and around the experimental plots was also made and recorded the GBH of all the woody species. Pioneer and canopy tree species were selected for different forest sites. Pioneer species selected are *Maesa indica*, *Macaranga indica*, *Clerodendrum viscosum*, *Olea dioica* and *Syzygium cumini* for evergreen forest areas (Siruvani, and Panthanthodu); *Clerodendrum viscosum*, *Holarrhena pubescens*, *Helicteres isora*, *Wrightia tinctoria*, *Glycosmis mauritiana* and *Erythrina indica* for moist deciduous forest area in Thathyangalam; *Annona squamosa*, *Tarennia asiatica*, *Dodonaea viscosa*, *Glycosmis mauritiana*, *Clausena dentata*, *Cassia auriculata* and *Mundulea sericea* for dry deciduous sites in Pudur area.

A trial was established in Siruvani with five selected pioneer species for studying their performance. Two species (*Tarennia asiatica* and

Dodonaea viscosa) were planted in the dry deciduous forest site at Pudur.

Seeds of *Glycosmis mauritiana*, *Dodonea viscosa*, *Mundelia sericea*, *Cassia auriculata*, *Narengi crenulata*, *Cipadessa baccifera*, *Clerodendrum viscosum*, *Helicterus isora*, *Holarrhena pubescens*, *Wrightia tinctoria*, *Mallotus philippensis*, *Mallotus tetracoccus* and *Olea dioica* were collected for germination and nursery studies

SUCCESS STORY

Eco-restoration of Tsunami Devastated Coastline of Andaman Group of Islands

A project was initiated during 2005 immediately after the Tsunami occurrence in 2004. The objective of the project was to develop shelterbelt plantations in the north, middle and south Andaman Islands using the most appropriate seed source and adopting modern nursery and plantation technology. It also aimed at capacity building of field staff of Andaman and Nicobar Forest Department in these techniques as the project progressed. Nearly 40 ha of shelterbelt plantations have been established in the three group of islands during the project period with the active collaboration of the Forest Department. All these plantations established well with a stocking of over 80%. The local community was involved in all field activities in every location and they are also partners in protecting these biowalls. Establishment and maintenance of these plantations also created livelihood opportunities in the form of employment availability during the critical post-Tsunami period and a major part of the work force constituted women.



Eco-restoration of Degraded Community Land

Eco-restoration of degraded community land by planting suitable tree species was initiated at Danda Shrinagraja in the District Pauri of Garhwal. Initially the forest tree species like *Terminalia chebula*, *T. balarica*, *Juglans regia*, *Grevillia robusta* and *Melia composita* etc. were planted. *Grevillia robusta* was found performing better and was most suitable for the site. An awareness programme on the eco-restoration and conservation by disseminating information on the species planted at experimental site was carried out for the local people.

Impact of Invasive Species on Forest Ecosystem

Invasive species invasion is a serious problem in some of the most biologically sensitive zones of the country because these species often alter the structure and composition of native ecosystem and therefore threatens the indigenous biodiversity.

Investigations on ecology of *Mimosa invisa* invasion in Kaziranga National Park, Assam was carried out. Biological invasions and the presence of exotic species is a pervasive and costly environmental problem that has been the focus of intense management activities over the last decades. Grid map of size 810 m x 810 m of the study area was generated. Classification of course resolution satellite images (LISS 3) was done. Questionnaire based appraisal survey for presence/absence of Mimosa in each forest 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 was prepared. Phyto-sociological study has been carried out in 3 different Mimosa infested sites in Bagori Range of Kaziranga National Park. Data recording on phenological events of Mimosa was 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. Seed germination trials were laid out in laboratory and nursery conditions. Field trials for seedling emergence from soil seed bank were also laid out. A Questionnaire (in vernacular language) was prepared and questionnaire based appraisal survey for existing Mimosa control measures were carried out.



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

Ecological Impact Assessment of Invasion of *Lantana*, its Removal and Subsequent Restoration of Habitat

Vegetation analysis in three years old Lantana removal and Lantana invaded sites in natural forests of Rajaji National park in Uttarakhand was done. Regeneration study of



Invasion of Lantana in the Park Area



Growth of Native Understory Vegetation after Removal of Lantana



dominant tree species in Lantana removal sites was carried out. Impact on plant species diversity and richness as a result of Lantana invasion, removal and subsequent restoration in Eucalyptus plantation areas in Rajaji National Park was also assessed. Marked changes in the dominance of certain understory native vegetation in mixed and Sal dominated vegetation communities was recorded as a result of removal of Lantana.

Bioremediation

Bioremediation of Bauxite Residue Through Bio-inoculants

Bioremediation is a low cost and environmental friendly technique which uses plants and microbes to clean up moderately contaminated areas and problematic soil. Bauxite residue (Red mud) is an industrial waste by product of Alumina industry. Blue Green Algae culturing was developed and propagation of BGA cultures is in progress. Under this project different species of Cyano-bacteria cultures are being propagated and their effect on red mud amelioration has been studied. Nursery experimental trial to study the effect of Bauxite residue and amendment of bioinoculation of Cyano-bacteria cultures on selected species viz. *Dalbergia sissoo*, *Prosopis juliflora*, *Acacia auriculiformis*, *Pithecelobium dulce* and *Cassia siamia* is in progress.

Fungi for Bio-treatment of Waste Water

Experiments with different fungi viz. *Flavodon flavus*, *Oxyporus ravidus*, *Schizophyllum commune*, *Trametes versicolor*, *T. cingulata* and *Pycnoporus sanguineus* were conducted at different industries to test the growth and bioremediation capacity.

Forests Rejuvenating Microclimate of Some Villages

Studies on phyto-sociological parameters viz. density, frequency, abundance, basal area,

Important Value Index (IVI), species diversity index, concentration of dominance and evenness, physico-chemical properties of the soil and daily Meteorological data collected from the two i.e. Nagdev Temple, Puri and Control selected sites showed that there was difference in vegetation and soil aspects of the study sites, but significant differences recorded in weather data of the sites.

Ecological Impact of Urbanization on Floristic Diversity

Increase in trees diversity, undergrowth biomass, relative humidity and decrease in undergrowth species diversity and temperature was observed in the forest ecosystem with respect to distance from urban/village habitations. Habitats located nearby forest ecosystems showed dependence on forest resources for collection of fodder and fuel wood.

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

Air pollution biomonitoring station was established in Selakui Industrial Area, as well as Shatabdi Van Vigyan Kendra, Dehradun. Plant sensitivity index to air pollution and air pollution index were 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 bio-monitoring stations i.e. Selakui Industrial Area and Satabdi Van Vigyan Kendra.

Impact of Tourism on Environment of Roopkund and Pindari Areas of Nanda Devi Biosphere Reserve (NDBR)

There were not much effect of tourism or tourist activities on vegetation, soil, water and landscape of the area. Socio-economic studies of both the areas reveal that the people are very poor; they lack basic amenities like schools (High school onwards), hospitals, telephones, electricity, even



roads to most of the villages. Local people don't have much participation in tourism of the area. Some strategies to promote tourism and local people's participation have been suggested.

Impact of Human Induced Disturbance on Regeneration and Population Structure of *Rhododendron arboreum* and *Myrica nagi*

The flowering, fruiting and seed maturation of *Rhododendron arboreum* in Garhwal Himalaya were monitored. Seeds were collected and tested for viability in laboratory. Permanent plots were marked for monitoring of seed germination and establishment in the field. Establishment of seedlings and saplings in open and close canopy areas was studied. Cyclic behavior of flowering was observed in *R. arboreum*. The number of seedlings and saplings of *R. arboreum* and *M. nagi* were recorded higher in open and exposed areas as compared to dense canopy forest area.

Application of GIS for Monitoring Forest Database

Establishment of GIS laboratory was done for systematic creation, management and up-gradation of GIS based forest-database of North-East India. Geographical Information System have brought revolution in inventorying, monitoring and management of natural resources and provided a powerful tool to the scientists/decision makers. GIS is capable of providing solution to the space and time bound queries in most cost and time effective manner.



Geoinformatics Laboratory RFRI, Jorhat

Keeping in view of the importance and utility of GIS in creation, manipulation and overall management of huge forest-database of this region, the present project was formulated and executed. The project was completed successfully and a full-fledged Geoinformatics Laboratory was established in Rain Forest Research Institute, Jorhat premises with all basic facilities including state of the art hardware, software, data and skilled manpower. Four hundred fifty (450) numbers of Survey of India Topographic sheets of 1:50k and 1:25k scale have been procured from Survey of India, N.E. Circle, Shillong. All are stored and georeferenced in digital format. Forest cover map procured from FSI, Dehradun is re-projected and hyperlinked. Geo-referencing and digitization of soil types, soil erosion, physiographic, geology, and agro-ecology maps is completed. Digitization of Reserved forest from available SOI toposheets is completed. Hyper linking of all available utility and topographic vector layers is completed as a part of creation of GIS based forest data base for entire North-East India.

Identification of Suitable Tree Species for Biodrainage

Effect of seven tree species including *Acacia nilotica*, *Albizia lebbek*, *Albizia procera*, *Dalbergia sissoo*, *Eucalyptus* hybrid, *Pongamia pinnata* and *Terminalia arjuna* planted along the left bank canal of Bargi command area, Jabalpur on underground water table was observed using observation wells. Simulated experiments were conducted in lysimetric tanks to observe the



Lysimetric Experiments Conducted at TFRI Campus



Plantation along Left Bank Canal of Bargi Command Area, Jabalpur

effect of tree species on water table as well as effect of water table on growth and biomass of the species.

Efficacy and Economics of Water Harvesting Devices in Controlling Run-off Losses and Enhancing Biomass Productivity in Aravalli Ranges

Adoption of different rainwater harvesting techniques (contour trench, gradonie, box trench and V-ditch) on a degraded hilly area in Banswara has improved the biodiversity in the area. There is increase in number of grass and herbs species in the experimental plots and 92 numbers of species recorded in October 2009 as compared to 39, 75, 81 and 81 species in 2005, 2006, 2007 and 2008, respectively. Number of species was lowest in 10-20% slope (4.99 m^{-2}) and increased downward being highest in $<10\%$ slope (6.22 m^{-2}). Dry matter production was 246.82 g m^{-2} in $<10\%$ to 355.86 g m^{-2} in $>20\%$ slope. Among the treatments, dry matter production was 336.99 g m^{-2} in V-ditch plots as compared to 272.81 g m^{-2} in control plots. As a result of protection and afforestation, there was increase in water, fodder and fuelwood availability in the area.

2.1.4 Biodiversity

Biodiversity Assessment and Conservation

India being the seventh largest country in the world and Asia's second largest nation has now emerged as the twelfth largest economy in the world. The ever growing economy and the vision 2020 of India will directly impinge upon the natural resources, particularly, the remaining forest ecosystems and is certainly becoming a matter of concern. Being a mega biodiversity country, forests in India play the critical role while

providing several ecosystem services which are mostly unaccounted for in the economic terms.

a. Eastern Himalaya

Quantitative Assessment and Grid Based Mapping of Plant Resources of Upper Assam Region

The eastern Himalayan region of India is one of the twenty five hotspots of biodiversity in the world. The region is estimated to house nearly seven thousand species of plants including those of medicinal value and otherwise, economically important ones. The quantitative assessment and grid based mapping of the plant resources of upper Assam region was initiated. Survey and sampling of 131 belt transects belonging to different sampling grids ($6.5 \text{ km} \times 6.5 \text{ km}$ of size approximately) is completed. The sampling grids were selected from the districts of Jorhat, Dibrugarh, Golaghat, Lakhimpur and Sivasagar. 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 etc was also collected as per prescribed format. The GPS location of starting point, midpoint and end point of all belt transects are 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.

Phytodiversity of Jeypore Reserve Forest

Studies on the assessment of "Phytodiversity dynamics" for conservation in Jeypore Reserve Forest was conducted. The floristic composition of the tropical wet evergreen ecosystem and regeneration status of trees were assessed and a sample plot (1 ha) was laid out *in-situ*. Sampling has also been carried out for two locations for trees, shrubs and herbs. Data on natural regeneration status of trees was also collected from the study site.



SUCCESS STORY

Role of the Villagers on Conservation of Phytodiversity

Documentation of plant resources of the patch vegetation and its different uses by the villagers in Jorhat district, Assam was conducted. Distribution and ecology of different species of plants were studied in 24 study sites selected throughout the district. Socio-economic survey was conducted in nearby villages of the selected patch vegetation to understand the dependency and the role of the villagers on conservation of phytodiversity. About 230 species of plants used by the villagers were recorded which includes timber, fire-wood, food, medicine, fodder, feeder plant for silk worm and some other minor uses. Important timber yielding trees recorded in the study area are *Terminalia myriocarpa*, *Artocarpus chama*, *Michelia montana*, *Castanopsis armata*, *C. tribuloides*, *Steriospermum chelonoides*, *Mesua ferrea* and *Schima wallichii*. Some species like *Machilus bombysina*, *Litsea monopetala*, *Litsea cubeba* and *Heteropanax fragrans* are being used by the villagers as feeder plant for silk worm rearing. The patches nearby riverside areas are dominated by *Lagerstromia speciosa*, *Biscofia javanica*, *Bombax ceiba*, *Barringtonia acutangula* along with *Calamus tenuis* and *Clinogyne dichotoma*. Some other economic plants recorded are *Aquilaria agallocha*, *Canarium resiniferum*, *Salix tetrasperma*, *Licuala peltata* and *Livistona jenkinsiana* etc. The different edible fruit giving plants available in the patches are several species of *Garcinia* sp., *Syzygium* sp., *Dileinia indica*, *Chrysophyllum lanceolatum*, *Baccaurea sapida*, *Flacourtie jangomas* and *Elaegnus caudata*. An enquiry into the history of these patch vegetations was done and it has been found that due to the expansion of some other land use practices like agriculture, sericulture, tea cultivation and extension of village area the patch vegetation areas are reducing at a rapid rate.

Rattan Species Diversity in Assam

Exploration of rattan species was carried out in Dihing-Patkai Wildlife Sanctuary, Dibrusaihkhwa Biosphere Reserve, Gibbon Wildlife Sanctuary, Kaziranga National Park, Karbianglong Wildlife Sanctuary, Nambor-doigrung Wildlife Sanctuary and Pobha reserved forests of Lakhimpur and Poba reserved forest of Dhemaji districts of Assam. Rattans are found in clustered pockets in Karbianglong Wildlife Sanctuary, Nambor-doigrung Wildlife Sanctuary Dihing-Patkai Wildlife sanctuary, Kaziranga National Park. While, in Gibbon Wildlife Sanctuary, Dibrusaihkhwa Biosphere reserve rattans clumps occurred scattered in distribution. Thirteen rattan species were identified namely: *Calamus tenuis*, *C. floribubdus*, *C. flagellum*, *C. guruba*, *C. latifolius*, *C. nambareinsis*, *C. khasianus*, *C. kingianus*, *C. gracilis*, *C. erectus*, *C. leptospadix*, *Daemonorops jenkinsiana* and *Salacca secunda*. Highest species diversity was achieved in Karbianglong Wildlife Sanctuary, from where 12 rattan species were reported highest density of rattan (532.3 ± 12.0 individuals/ha) was found in Kaziranga National Park, with total regeneration of 289.8 ± 5.0 individuals/ha. Propagules of all the rattan species were collected from study sites, conserved and established in a demonstration plot in Botanical Garden, Rain Forest Research Institute, Jorhat, Assam.

Biodiversity Studies of Orthoptera in Kaziranga National Park

Biodiversity studies of Orthoptera in Kaziranga National Park, Assam, revealed a total of 36 species of grasshoppers belonging to 30 genera, and 4 families in different habitats viz., forestlands, savannahs and grasslands of KNP. The family Acrididae had the largest species



representation (19 species) followed by Tettigoniidae (9 species), while the least representation was recorded in Gryllidae family with 3 species only. The grasslands of KNP harboured greater number of *Orthoptera* species (21 species) followed by savannahs and forestlands (19 species). Besides, the population fluctuations of *Orthoptera* species showed a considerable variation depending on the seasons of the year and species diversity were lowest in January-April where as, it was maximum in the months of July-August.

Phytodiversity of Nambor Reserve Forest

A phyto-sociological study in Nambor reserve forest was carried out through quadrat method and at each location 1ha. plot was established. Data on various ecological parameters like frequency, density, basal area, etc. were collected for 96 species. Socio-economic survey in the fringe villages & market survey at Koilamati & Shilonijan areas was done.

b. Western Himalaya

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

The phyto-sociological analysis of vegetation was conducted for Kalatop Khajjiar Wildlife Sanctuary under altitudinal gradients. In Dankund to Jyot, total number of plant species were 70 with the dominance of *Picea smithiana*, *Viburnum erubescens* and *Bergenia ciliata*. In Dankund to Ala, total number of plant species were 94 and dominant species were *Picea smithiana*, *Sarcococca saligna*, *Viburnum erubescens* and *Valeriana jatamansii*. In Matuni to Kakala, total number of plant species were 106 and dominant species were *Picea smithiana*, *Sarcococca saligna* and *Valeriana jatamansii*. In Madrani to Khajjiar, total number of plant species were 103 and dominant species were of *Persea*

duthiei, *Picea smithiana*, *Sarcococca saligna* and *Valeriana jatamansii*. In Dankund to Khadgot, total number of plant species was 108 and dominant species were *Cedrus deodara*, *Picea*, *Sarcococca saligna*, *Sorbaria tomentosa* and *Rumex napalensis*. In Kalatop to Kakala area, total number of plant species were 97 and dominant species were *Cedrus deodara*, *Sarcococca saligna*, *Rumex napalensis* and *Valeriana jatamansii*. In Kalatop to Talai area, total number of plant species were 115 and dominant species were *Cedrus deodara*, *Sarcococca saligna*, *Bergenia ciliata* and *Pilea scripta*. In Khajjiar to Parel, total number of plant species were 129 and dominant species were *Pinus roxburghii*, *Quercus leucotrichophora*, *Rubus niveus*, *Rhododendron rboreum*, *Anaphalis triplinervis*. In Gate to Jyot, total number of plant species were 107 and dominant species were *Quercus leucotrichophora*, *Picea smithiana*, *Berberis aristata*, *Viburnum erubescens*, *Rumex nepalensis* and *Anaphalis triplinervis*. In Lakadmandi to Khajjiar, total number of plant species were 103 and dominant



Digitalis purpurea



Calanthe tricarinata



A View of Khajjiar Lake



species were *Cedrus deodara*, *Sorbaria tomentosa* and *Valeriana jatamansii*. The maximum number of species were recorded in Khajjiar to Parel (129) followed by Kalatop to Talai (115) and Dankund to Khadgot (108). The ethnobotanical study was conducted in 8 villages and documented 40 plant species used for different purposes. The threatened plant species recorded from the areas were; *Podophyllum hexandrum*, *Taxus wallichiana*, *Zanthoxylum armatum* and *Cinnamomum tamala*.

An Ecological Assessment of Floristic Diversity in Hemis High Altitude National Park, Ladakh, Jammu & Kashmir

The ecological and taxonomic studies in Rumbak Valley of the Hemis High Altitude NP were conducted. Various points taken for detailed study were Umrutse (4200 m), Ganda La (5100 m), Stok La (5000 m), Manskarmoh (4800 m), Changma (4300 m), Stok (3900 m) etc. Floral collections were also taken from the Spituk, Martselang, Mathod and Hemis region of the park. In-depth ecological and taxonomic studies in Markha Valley of the area were conducted at various high altitude camp sites; viz,



Surveying the Phytodiversity in the Hemis High Altitude National Park, Ladakh, Jammu & Kashmir



Waldheimia glabra



Thermopsis barbata

Chilling (3800 m), Kaya (3700 m), Skyu (3800 m), Markha (4000 m), Shingo (4200 m), Chalak (3900 m) etc. Floral collections of unique specimens for herbaria was made. Ethno-botanical information were collected via informal chats/discussions with village elders, guides and amchis.

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

The moth (Lepidoptera) samples were collected from Malan, Sairighat, Townbhrari, Theog, Shimla, Janjheli, Khajjiar, Narkanda, Akpa, Bharmour, Manali, Pattan Valley and Asrang. Damage done to the host (only selected conifers and associated vegetation) by these species was also recorded. The pest status of noctuid species of respective hosts has been given in parenthesis i.e. *Trichoplusia orichalcea* Fabricius (Polyphagous, herbs of the Deodar forests), *Agrotis segetum*, (cutworm of deodar and other conifers, polyphagous), *Agrotis ypsilon*, (cutworm of deodar and other conifers, polyphagous), *Spodoptera lituro* Fabricius (Polyphagous), *Spodoptera cilium* Guenee (Polyphagous) and *Plecoptera reflexa* Guen. (Major pest of *Dalbergia sissoo* in the zone of Chirpine).

Fourteen study sites were selected and 2740 specimens of Lepidoptera were collected from these sites. Out of these, 663 were noctuid and only 66 species were identified. Data on herb, shrubs and trees were recorded from three sites. Description of wing venation and genitalia of 45 identified species has been completed. To understand the habitat of the noctuid moths, the data on plant biodiversity of 3 sites have been analysed till date and the plant biodiversity data



Fig: 3a to 3h species of the Genus *Chrysodeixis*

of fir and spruce forest of Manali shows that the number of tree species were 8 with the dominance of *Picea smithiana* followed by *Abies pindrow*. Number of shrub species were 14 with the dominance of *Berberis aristata* followed by *Rubus niveus*. Number of Herbs species was 55 with the dominance of *Anaphalis triplinervis* followed by *Fragaria indica*. Index of dominance (C value) for tree, shrub and herb species was 0.328, 0.099 and 0.035 whereas; diversity index (H') was 1.408, 2.458 and 3.630 respectively. It is concluded that distribution of most of plant species was contiguous. In another site i.e. deodar forest of Manali, the number of tree species was 2 with the dominance of *Cedrus deodara* followed by *Pinus wallichiana*. Number of shrub species was 17 with the dominance of *Sarcococca saligna* followed by *Cedrus deodara* sapling. Number of herbs species was 52 with the dominance of *Rumex nepalensis* followed by *Gerardiana diversifolia*. Index of dominance (C value) for tree, shrub and herb species was 0.927, 0.120 and 0.041 whereas; diversity index (H') was 0.161, 2.422 and 3.457 respectively. Distribution of most of plant species was contiguous in this area also. After identification, the host plant will also be confirmed by consulting the literature available for the species.

Ecological Studies of Prominent Species (*Capparis spinosa*, *Ribes orientale*, *Caragana gerardiana*, *Colutea nepalensis*, *Cratagus songarica*, *Elaeagnus angustifolia*, *Hippophae rhamnoides* and *Rosa webbiana*) of Cold Deserts

Detailed ecological studies for the identified species were carried out at Gue, Tabo, Mane, Ladang, Kurith, Hurling and at Samdoh falling in Spiti Valley; Sisso, Gondhla and Udaipur in Lahul valley and Spillo, Pooh and Khab etc. in Kinnaur district of Himachal Pradesh.



Colutea nepalensis



Cratagus songarica-through Cuttings



Cratagus songarica-through Seeds



Field Plantations of Different Species



Ribes orientale

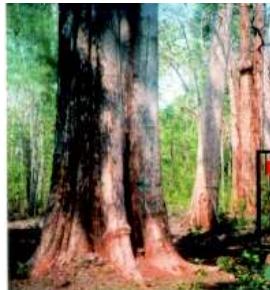


c. Central India

Plant Diversity in Sal and Teak Ecotone Zone

Two ecotone sites, one in Jagdalpur (Chhattisgarh) and another in Umaria (M.P.) were studied. Two sites dominated by sal and teak forest near ecotone zone have also been selected for comparative study. Number of trees, shrub and herb species were found comparatively more in ecotone zone than in teak and sal of both the study sites. The data showed that the surface soil of teak forest was neutral (7.0) to slightly alkaline in nature, whereas, in sal forest, soil was acidic (5.5). The pH of the soil of ecotone zone was found in between (6.2) of teak and sal forests. Organic carbon percentage was almost same (1.12%) in ecotone and sal forest, whereas, in teak forest, the value was comparatively low (0.65%). The following indicator species are found in both the ecotone sites: *Dalbergia latifolia*, *Litsea gluiosa*, *Terminalia chebula*, *Sterculia urens* and *Holarrhena antidysentrica* tree species; *Litsea gluiosa* shrub and *Diospyros melanoxylon* in herb/seedling stage. Phytosociological study showed that the diversity of trees, shrubs and herbs were high in ecotone site. However, in pure sal and teak forest, the same was recorded comparatively low.

Among tree species, *Tectona grandis* was found dominant and having highest IVI in



Teak Trees in Ecotone Zone, Jagdalpur, CG



Sal and Teak Trees in Ecotone Zone, Umaria, MP

ecotone zone of both the sites. *Shorea robusta* in sapling stage was found dominant species in Jagdalpur and at Umaria sites, *Cassia tora* was found to be having the highest IVI. Temperature difference of 1°C was observed in general in both locations (inside and outside forest). Ecotone and teak forest showed very less variation but temperature was obviously higher than sal forest. The temperature of sal forest (inside forest) was recorded comparatively low.

Humidity percentage in sal dominated area of two sites was comparatively high whereas, in teak dominated area of both the sites, the values were comparatively less. In ecotone zones, the values were found in between. Microfloral study revealed that fungal population in ecotone zone of Jagdalpur and Umaria site were comparatively more than that in pure sal and teak forest.

Achanakmar-Amarkantak Biosphere Reserve

Documentation of data on vegetation status, number of species of flora, fauna, threatened species and human population of all three zones of Achanakmar-Amarkantak Biosphere Reserve was done and existing information updated. The inventory of flora includes 1111 species of angiosperms, 16 gymnosperms, 40 pteridophytes, 16 bryophytes, 130 lichens, 178 fungi and 7 species of algae. The inventory of fauna included 27 species of mammals, 142 birds, 15 lizards & snakes, 10 amphibians, 16 fishes, 27 beetles & cricket, 85 butterflies & moth and 5 species of centipedes. Survey of NTFP's revealed nearly 39 species in village market trade. Biannual Biosphere Reserve Information Series (BRIS) Vol. 1 (1 & 2) was published and circulated among scientists and BR managers. Besides this, a questionnaire proposed by Seville strategy under Madrid action plan was prepared. A complete document on Achanakmar- Amarkantak Biosphere Reserve for nomination in the World Network of



Biosphere Reserve was prepared and submitted to State Forest Department of Chhattisgarh.

Ecological dynamics of vegetation structure and assessment of morphological adaptive variation to create base line data in Selected Species in Dalma Wildlife Sanctuary was taken up during the year 2009-2010. The cumulative physical achievements were as follows:-

- A total of 16 sample plots are laid out in the sanctuary covering four ranges.
- Plant specimens are collected and herbari are prepared.
- So far 66 plant species are identified and authenticated.
- Few species of elephant food like *Mallotus philippensis* were collected for bark and leaf nutrient estimation.

d. Southern India

Structure, Diversity and Germination Syndrome in Tropical Evergreen Forest Findings: A Case Study from Western Ghats of Karnataka using Permanent Preservation Plots (PPPs)

Vegetation analysis of data collected of PPPs in 3 sites; Makuta, Muchiladuka and Malemane falling in South, Central and Northern part of Tropical Wet Evergreen Forests of Western Ghats, Karnataka from 1937-2008 completed. Parameters like diversity index, similarity index, population structure worked out. Regeneration trends of these forest types represented by the PPPs worked out according to four regeneration category classes. Among the dominant species in Makutta and Malemane, *Kingiodendron pinnatum* had the maximum MAI of 1.49 cm and followed by *Vitex altissima* 1.39 cm and *Dipterocarpus indicus* 1.32 cm, while minimum, MAI was by *Knema attenuate* (0.48cm). There was problem in regeneration class IV where the seedlings failed to get established due to anthropogenic pressures particularly in Makutta than in Malemane. Similar trend was also

observed in the case of endemic and RET species in both Makutta and Malemane.

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

Insect emergences and extent of seed predation were recorded in rain forest canopies at Makutta, Western Ghats. Field and lab germination studies for *Dipterocarpus indicus* were carried out. Sampling work during the pre-monsoon period yielded seed fall from very few species – *Knema attenuata* and *Dipterocarpus indicus*. Although *Knema* had low infestation by insects (<5%), all the seeds of *Dipterocarpus* were damaged by insects. Seed predation of *Vateria indica* was substantive while it was low in *Knema attenuata*, *Myristica* sp. and *Dipterocarpus indicus* during June 2009. Seed fall during January to March 2009 was extremely poor and no insect emergence was recorded from the seeds.

Ex-situ conservation initiative

- Preparation of species inventory and quantitative assessment of threatened species of Delhi, Uttarakhand and U.P. Establishment of Bamboosetum at Delhi.
- The *ex-situ* conservation of *Dendrocalamus strictus* field germplasm bank was established at F.R.I. campus. The germplasm of this species had representatives of 16 states of the country.
- The field germplasm bank of 15 Hill bamboo species was established at Field Research station Khirshu, Pauri Garhwal.



Field Germplasm Bank of *Dendrocalamus strictus* at F.R.I. campus



- A clonal nursery for multiplication and demonstration of various propagation technologies of bamboo was established at city centre F.R.I. under a National Bamboo Mission funded project.



Germplasm Bank Bamboo Species Research Station, Khirshu, Pauri Garhwal

To minimize the pressure on our reserve forests, quality planting material of promising indigenous fuel wood and fodder tree species was produced for tropical, sub tropical and temperate tree species and more than 60,000 seedlings and rooted cuttings of these prominent species were distributed among farmers of Uttarkashi, Rudraprayag and Dehradun districts of Uttarakhand.



Collection of Fuelwood and Fodder from Forest

SUCCESS STORY

Bamboo Propagation Technology

Due to unavailability of seed, bamboo propagation for producing plantation stock is always a problem for foresters, farmers and industries. A good success has been achieved by Forest Research Institute, Dehradun for developing farmer's friendly, low cost propagation technology of bamboos by rooting of single nodal juvenile shoot cuttings and branch cuttings. This technology was experimented initially for three varieties of *Bambusa vulgaris* var. green, wamin and striata in which more than 50% cuttings were rooted. Other important bamboo species are under experimental stages.

Vegetative Propagation Technologies of Bamboos



Rooting of Single and Bimodal Branch Cuttings



Rooting of Single Nodal Juvenile Cuttings of *Bambusa vulgaris*



2.1.5 Forest Botany

Impact of Biotic Factors on Forest Biodiversity

Biodiversity assessment and cause of degradation in Delhi ridge forest was carried out. The major factors responsible for habitat degradation were identified as spread of invasive species (*Prosopis juliflora* and *Lantana camara*), grazing, lopping, development activities, etc. Species richness and diversity index were low in the threatened sites. Superior material of number of indigenous species (*Diospyros montana*, *Balanites aegyptica*, *Pongamia pinnata*, *Azadirachta indica*, *Albizia lebbeck*, *Cassia fistula*, *Holoptelea integrifolia*, *Bombax ceiba*, *Pterospermum acerifolium*, *Holoptelea integrifolia*, *Dalbergia sissoo*, *Ziziphus mauritiana* and *Butea monosperma*) of the area were raised in the nursery and were re-introduced.

At Khirsu, Pauri Garhwal and surrounding areas were under various degree of threats mainly because of invasive species (*Eupatorium adenophorum*, *Lantana camara* and *Argemone mexicana*), fire, development activities, grazing etc. The regeneration of major tree species is affected by these threats. Species such as *Myrica*, *Rhododendron* and *Berberis* etc. were considered for *ex-situ* conservation.

Nanda Devi Biosphere Reserve (NDBR) was impacted with peripheral villages through the biotic influence of cattle, sheep, horses and goats. Rare and threatened plants of medicinal and economic values of the region are *Picrorhiza kurrowa* (kadawi), *Saussurea lappa* (kuth), *Aconitum heterophyllum* (Atees), *Vicatica stewartii* (Kala jeera), *Swertia chiraita* (chiraita), *Allium consanguinum* (Jambu), *Dactylorrhiza hatazeira* (Hatha-jhari), *Artemisia* species (Badrinath tulsi) and *Rosa webbiana* etc.

In Dudhwa National Park, invasion of invasive species (*Lantana*, *Ageratum*, *Argemone* etc.) was major factor for habitat degradation. A list of 60 threatened species was prepared. To educate the local people about the biodiversity conservation and utilization, training programmes were organized and lectures were delivered in various Van Vigyan Kendras.

An expert system entitled 'Wood Anatomy Information system' has been developed with the help of National Informatic Centre, New Delhi. Database of commercial timbers of India was created. The software allows quick retrieval of information based on well-organized data of Timber species arranged in a very systematic manner along with the photographs. Identification of Indian Timber samples has become very quick and simplified. Identification is made with minimum number of anatomical features. Fast retrieval of desired features for desired species is possible. Expert system reduces the dependency of the researchers and wood users on the infra-structure like Xylarium and micro slides. Unique anatomical features combinations corresponding to families, genus and species are available.

Digitization of Forest Research Institute (Dehradun Herbarium) Herbarium

Five thousand seven hundred seventy two species details and 27515 specimen details were prepared. Nine hundred eighty nine genera, 4725 species detail and 20015 specimen details were incorporated into the database. Forty eight thousand four hundred two specimen photos were taken and 25491 photos were edited. Three thousand one hundred seventy five species detail and specimen details were edited.

Revision of Indian Woods—their Identification, Properties and Uses—Volume II

Revision of Indian Woods—their Identification, Properties and Uses – Volume II was undertaken by adding microstructure details



and latest information on wood properties and uses.

Taxonomic and Wood Anatomical Studies of Exotic *Pinus* species

Taxonomic and wood anatomical studies of exotic *Pinus* species was undertaken to differentiate various tropical *Pinus* species.

Fluorescent Studies of Indian Hardwoods

Studies was undertaken with the objective to study the fluorescent behaviour of all Indian hardwoods for the purpose of their identification.

Inheritance Pattern of Wood Anatomical Traits in *Populus deltoides* Bartr. Ex Marsh

Seven hundred (700) samples from 60 ramets of parents (G48 and G3) and F₁ and F₂ offspring's were collected for intra and inter ramet variations and to observe the inheritance pattern of wood traits. The important findings of the project are as under:

- Variance ratio test (F) revealed that both G3 and G48 clones were significantly different for fibre length, fibre diameter, vessel element diameter and specific gravity.
- The fibre length, fibre diameter, vessel element length and wall thickness is higher in G48 (female) clone than G3 (male).
- Vessel element diameter and specific gravity were higher for G3 (male clone).
- It showed that female clone have better fibre dimensions while male have better specific gravity.
- Specific gravity and vessel element dimension were significantly varied from pith to periphery locations.

- Intra-ramet variation for height was significant for vessel element diameter and specific gravity.

Assessment of Wood Properties and Growth of Clones of *Populus deltoides* Bartr. ex Marsh

Samples from 50 progenies raised by WIMCO Seedlings Ltd. were collected and being analysed for different wood traits.

Field Evaluation of Tissue Culture Plants of *Eucalyptus* hybrids

Two promising F₁ hybrids of *Eucalyptus*; FRI 5 (*E. camaldulensis* X *E. tereticornis*) and FRI 14 (*E. torreliana* X *E. citriodora*) were multiplied through tissue culture and planted in field. Plants were in sixth year of age. There is significant variation in characters studied such as plant height, Clear Bole Length (CBL), diameter and volume, of both hybrids across the sites. In FRI 14, height and diameter at breast height was maximum at Kharkan site Hoshiarpur while in FRI 5, height and diameter at breast height was maximum at Haldwani site.

Creation of seed database on economically important forestry species of Jharkhand aiming at functioning of forestry seed certification agency was taken up during the year 2009-2010. The cumulative physical achievements were as follows:-

- Collection of seeds of more than 20 species for physical and physiological studies.
- Studies on physical parameters of seeds (i.e. seed weight, length and width, volume, colour, seed/fruit weight etc.) of collected species.
- Studies on initial moisture content and germination percentage and rate of seeds of collected species.



- Experimentation on seed storage in different types of containers under ambient and cold temperatures.
- Viability of stored seeds analyzed after 3 months, 6 months and 1 year storage.

2.1.6 Tribals and Traditional Knowledge System

Ethnobotanical Studies of Northern Part of Eastern Ghats in Andhra Pradesh

Ethnobotanically important plant species were identified and listed for Srikakulam, Vizianagaram and Visakhapatnam districts of Andhra Pradesh.

- Ethnobotanical data on 180 floral taxa from Savara, Khond, Jatapu, Kondadora, Nukadora, Bagatha and Porja tribes in respective regions were recorded.
- Utilitarian aspects of important medicinal plants such as *Alocasia fornicata* (Wounds), *Argyreia nervosa* (Boils and blisters), *Arisaema tortuosum* (Ulcers), *Caesalpenia bonduc* (Body pains), *Careya arborea* (Fibre), *Clerodendrum serratum* (Bone fracture), *Curculigo orchioides* (Stomach pain), *Curcuma pseudomontana* (Skin diseases), *Diospyros malabarica* (Bone fracture), *Ficus racemosa* (Jaundice), *Holoptelea integrifolia* (Cough and cold), *Lippia javanica* (Insecticidal), *Mucuna pruriens* (Muscle pains), *Pavetta indica* (Wounds), *Polyalthia suberosa* (Fever), and *Zinziber roseum* (Menstrual disorders) were recorded for the first time

A total of 143 plant specimens were collected, made into herbarium and identified. Scrutinized and screened collected ethnobotanical data with available literature.



Argyreia nervosa



Careya arborea

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

Documentation of traditional knowledge was done from traditional herbal healers from tribal pockets of Mandla, Jabalpur, Katni and Chhindwara districts of MP. In all 327 plants of medicinal value, which are being utilized by 80 traditional herbal healers of tribal pockets of the above four districts for cure of various diseases prevailing among tribal/local people were documented.

Existing utilization pattern alongwith formulation and duration of treatment etc. of medicinal plants 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. 37 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.

Pamphlets and slogan were published on uses and conservation of medicinal plants for distribution and creating awareness among tribal and local communities.

Potar (*Smilex zeylenica*)Hathfan (*Leea macrophylla*)

Documentation and Inventorization of Indigenous Traditional Medicinal Knowledge

Documentation and inventorization of indigenous traditional medicinal knowledge of Jharkhand, Sadar, Churchu, Barkatha and 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.

- Kisan, Kharwar, Karmali, Birhor, Sourya Pahariya, Parhaiya, Manjhi and Sabar tribal groups of Jharkhand were 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* and *Aristolochia indica* were collected and preserved as voucher specimens.
- Nearly 85 herbal practitioners belonging to Bathudi, Birgia, Birhor, Chero, Karmali, Kharwar, Kissan, Parhaiya, Sourya Paharia and Sabar tribal communities have been interviewed so far regarding the use of medicinal herbs for curing their ailments.