

Biodiversity Conservation and Ecological Security



Biodiversity is the variety of life on the earth and a steady stream of ecosystem services supported and maintained by it are essentially required for the ultimate benefit of human welfare and survival. It is beyond any doubt that though the compelling theoretical knowledge about essential connections between ecosystem service generation, biodiversity and resilience in socio-ecological systems already exists, yet it has been convincingly shown that ecosystem flows are continuously being eroded, but we still lack to a great extent the spatially explicit quantitative assessments for translating this theoretical knowledge into practice.

ICFRE is actively engaged in various research and development activities related to biodiversity conservation and ecological security including organization of seminars/ workshops/trainings, celebration of International Day for Biological Diversity and publication of books/brochures etc.

Research works on biodiversity and ecological security related aspects taken up by ICFRE and its institutes are mentioned below:



3.1 Biodiversity Conservation

Study-cum-survey to assess the demand and supply of medicinal plants in India-in the national perspective, as well as in respect of the international market (ICFRE)

Information was collected on consumption of medicinal plants by AYUSH industries, rural households and folk healers/ traditional practitioners throughout the country. Trade data from markets across the country was also collected. First and second progress report of the project have been submitted to the National Medicinal Plants Board, Ministry of AYUSH, Government of India. National consultation meeting of the project regarding finalization of draft final report of the project was also organized.

Benefits of the research: The study will provide the estimated annual demand and supply of herbal raw drugs; estimated annual trade value of herbal raw drugs; estimated annual domestic turnover of herbal industry; estimated supply of herbal raw drugs; medicinal plant species in high commercial demand (≥ 100 MT/ Year) and domestic trade of herbal raw drugs in the country.

Study on Indigenous knowledge and documentation of extent of utilization of herbs in folk- medicines prevalent in tribal pockets of Madhya Pradesh (TFRI)

The study was conducted in districts of Chhatarpur, Panna, Satna, Jabalpur, Seoni, Chhindwara and Hoshangabad. The survey recorded information from tribal communities belonging to Saur, Raj Gond, Gond, Khirwar, Bhariya and Mawasi. Information was collected from vaidraj and local community regarding use of indigenous flora for their health care needs; information on existing flora, and information on utilization and collection methods of plants. Twelve plant species were documented in Chhindwara and Hoshangabad districts, which are over exploited on account of trade and high volume utilization in ethno-medicines by traditional healers.

Benefits of the research: Generation of information on health care needs-use and collection practice of herbs will help in biodiversity conservation, preparation of People's Biodiversity Registers and regulating

Access – Benefit sharing regimes (ABS).

Population dynamics of threatened medicinal plant species growing in buffer zone of Tadoba Andhari Tiger Reserve Maharashtra (TFRI)

Based on survey in tiger reserve, 714 plant species were recorded. Out of which, 98 species were used by traditional healers for preparation of various herbal formulations. Population dynamics of medicinal plant species, *Uraria picta* (Dabra) and *Andrographis paniculata*



Field survey in Tadoba Andhari Tiger Reserve

(Kalmegh) were studied in Buffer zone of Tiger Reserve. Seeds from Mul population of *Uraria picta* and Nimelda population of *Andrographis paniculata* can be used for artificial propagation as these populations showed high seed production and viability.

Benefits of the research: Assessment of the regeneration of the species in their natural habitat will be useful for conservation of the medicinal plants in their natural habitat.

Inventorization, characterization and conservation strategies of selected rare and endangered plant species of India (FRI)

Quantitative estimation of *Ilex pseudo-odorata*, *Catamixis baccharoides* (Vishpatri), *Sophora mollis*, *Pittosporum eriocarpum*, *Indopiptadenia oudhensis*, *Mahonia jaunsarensis*, *Trachycarpus takil*, *Cyathea spinulosa* and *Itea nutans* was carried out from their respective locations. *Ex-situ* conservation of threatened species (*Ilex pseudo-odorata*, *Catamixis baccharoides*, *Sophora mollis*, *Pittosporum eriocarpum*, *Indopiptadenia oudhensis*, *Mahonia jaunsarensis* and *Trachycarpus takil*)

was taken up in Botanical Garden of FRI.

Benefits of the research: Outcome of the study will be useful in conservation of endangered plant species.

Floral Biodiversity Survey in the State of Bihar (FRI)

Qualitative and quantitative survey of 10 districts of Bihar was carried out. The study revealed that *Bauhinia scandens* var. *horsfieldii* (Kachnar), *Cycas pectinata* (Cycas), *Drypetes assamica* (Torulelu), *Ficus benjamina* (Weeping Fig), *Ficus saemocarpa*, *Pterospermum acerifolium* (Kanak Champa), *Trevesia palmata* (Snowflake) and *Xantolis tomentosa* (Indian Bully Tree or kantabohul) were rediscovered after a lapse of 93 years. Two endemic species (*Leucas helicterifolia* and *Carum villosum*) and several new records (*Erathenum montanum*, *Mallotus ferrugineus*, *Olex nana*, etc.) were reported from West Champaran district.

Benefits of the research: Database of floral biodiversity in Bihar will help in better planning for management of forest and wildlife.

Prioritization of floristic diversity: Developing conservation strategies for important species in Shimla Water Catchment Sanctuary, Himachal Pradesh (HFRI)

The floristic and phyto-sociological studies were carried out after frequent surveys in different blocks and beats of the sanctuary by laying out quadrats of different sizes for trees, shrubs and herbs. A total of 250 species were identified till last sampling of which, 23 were trees, 39 shrubs, 161 herbs and 7 were climbers. Maximum numbers of trees were found belonging to the family Pinaceae and Fagaceae whereas; maximum shrub species



Bistorta amplexicaulis



Ranunculus diffuses



Geranium wallichianum

were from family Fabaceae and Rosaceae. As far as herb species are concerned they were found belonging to family Asteraceae.

Benefits of the research: The study is focussed upon the assessment of floristic diversity, distribution pattern of native and endemic species of the area, identification of threat categories of floristic diversity and prioritization of potential habitats, communities and species for conservation in the sanctuary. The outcome will help the state forest department in developing strategies for the specific site management of the area.

Plant Diversity Studies in Shikari Devi Wildlife Sanctuary of District Mandi, Himachal Pradesh for Long Term Ecological Monitoring (HFRI)

Floristic and phyto-sociological studies were carried out in three of the selected sites of Shikari Devi Wildlife Sanctuary by laying out different size quadrats for trees, shrubs and herbs. In Bhaind beat (2400-2700 m above MSL) total number of trees, shrubs and herbs species were 9, 15 and 37 with the dominance of *Picea smithiana*, *Indigofera heterantha* and *Valeriana jatamansi*, respectively. In Bhermari beat (2500-2800 m above MSL), total number



of trees, shrubs and herbs species were 7, 12 & 47 with the dominance of *Cedrus deodara*, *Prinsepia utilis* and *Valeriana jatamansi*, respectively. At elevation 2800 m-3100 m above MSL, total number of trees, shrubs and herbs species were 5, 7 & 50 with the dominance of *Quercus semecarpifolia*, *Cotoneaster microphyllus* and *Anaphalis triplinervis*, respectively. In Fatehpur beat (2400 - 2700 m above MSL), total number of trees, shrubs and herbs species were 9, 10 & 37 with the dominance of *Abies pindrow*, *Sarcococca saligna* and *Valeriana jatamansi* respectively. At elevation of 2700 - 3000 m above MSL, total number of trees, shrubs and herbs species were 4, 8 and 36 with the dominance of *Picea smithiana*, *Cotoneaster microphyllus* and *Iris* spp. respectively. At elevation of 3000 - 3300 m above MSL, total number of trees, shrubs and herbs species were 5, 8 and 42 with the dominance of *Quercus semecarpifolia*, *Salix denticulata* and *Anaphalis triplinervis* respectively. Five threatened plant species viz; *Angelica glauca*, *Betula utilis*, *Taxus wallichiana*, *Polygonatum verticillatum* and *Rhododendron campanulatum* has been recorded from the studied sites as per available list of threatened plants. The ethno-botanical data has been collected from eight villages through semi-structure questionnaires and about 25 plants of ethno-botanical importance have been listed out.

Benefits of the research: This study aims at assessment of species richness and community structure including documentation of the species of ethno-botanical importance and also in identification of the threatened or abundant species of the sanctuary. The outcome will help the state forest department in developing strategies for the management of the sanctuary area.

Development of agro-techniques for organic cultivation of *Tribulus terrestris* L. (Gokru, Gokrusura) and *Cissus quadrangularis* L. (Hadjor, Harjor) medicinal plants extensively used in traditional system of medicine (Ayurveda, Unani and Chinese) (IFP)

Cissus quadrangularis cuttings collected from Khilari and Chamranga forests of Ranchi District of Jharkhand when treated with different concentrations of plant growth regulators (IAA, IBA and NAA) showed 95% success rate. Propagation of juvenile shoots of *Tribulus*

terrestris cuttings obtained from the dry and arid zones of Jodhpur did not exhibit much success even with application of plant growth regulators. The survival percentage of the cuttings in hycopots was very low. The seeds of both *T. terrestris* and *C. quadrangularis* were subjected to various physical and chemical treatment and they expressed only 10% and 15% germination respectively. Freshly harvested seeds of *Tribulus terrestris* when allowed to germinate in sand exhibited 55-60% germination.

Benefits of the Research: Technology has been developed for mass propagation of *Cissus quadrangularis* (Hadjor, Harjor) by way of shoot cuttings. Propagation techniques have also been developed for *Tribulus terrestris* (Gokru, Gokrusura). These two species are rare in the wild not only due to overexploitation, but also due to the serious fact of habitat destruction. The findings of this project will be of immense help towards the better understanding of agro-technology and nursery techniques of these species. The quantum of raw material required by herbal and pharmaceutical industries can be easily met by scientifically cultivating these plants.

By providing good agricultural practices on these two species to farmers the rate of extraction from natural forests will diminish thereby contributing to conservation of biodiversity and environment. The results will make available profitable cultivation methods to the people which will encourage them to enhance livelihood options by cultivating these medicinal plants rather than extracting them from the wild.

Coordinated project on Integrated management of Khejri mortality for socio-economic upliftment in Rajasthan (AFRI)

The project has following seven components:

Forest Protection Studies: The observations on the effect of mechanical ploughing on the natural regeneration of Khejri revealed that tractorization does not play direct role in mortality of Khejri but reduces the population of Khejri by damaging the new sprouts and lateral roots of the tree which play significant role in invasion of pathogen. Pathogenecity test of *Ganoderma* has been established and confirmed as major biotic factor for khejri mortality.

Genetics: Progeny trials that were earlier

established with 30 families at AFRI Genetics Field at Jodhpur and with 52 families at Samaspur were maintained. Growth data from Jodhpur trial recorded and analyzed. Highly significant variation was observed for collar diameter as well as height amongst families with survival percentage in Jodhpur trial as 78%.

Biotechnology: Fresh cultures for shoot multiplication were initiated from stem nodal segments. Since rooting is the biggest impediment in the development of the *in-vitro* regeneration protocol for Khejri, the primary emphasis was on rooting experiments. Experiments with (a) chronic auxin application (IBA and NAA used alone and in combination, from 1.0 to 15 μ M supplemented in White's medium for extended periods 4+4 weeks) and (b) acute auxin application [dipping in 5 and 10 mM IBA and NAA for 20 second (Pulsing)] followed by culture establishment was carried out. The second treatment gave better results in terms of *in-vitro* root initiation, but the explants did not survive. Material for DNA extraction was collected from 16 khejri trees (13 selected+3 diseased). DNA extraction, purification and quantification were completed. ISSR marker screening was completed.

Biochemical Studies: Observations were recorded from nursery experiment to study the efficacy of salicylic acid and jasmonic against *Ganoderma* and analysis work is in progress. Analysis of bark and root samples of infected and healthy trees of *Prosopis cineraria* (khejri) from different districts was done through study

of the variation in proline contents. In bark samples, average proline content was less in healthy trees (1.08 μ moles/gm) and higher in infected trees (5.15 μ moles/gm). This trend was same in root samples (4.99 μ moles/gm in healthy and 7.76 μ moles/gm in infected trees). Similarly, Phenol content of bark was higher in infected trees (6.1 mg/g) and lower in healthy trees (3.76 mg/g).

Extension Component: Khejri mortality problem and its management was demonstrated in various farmers' fairs through display board for public awareness. Pamphlets about management of khejri mortality problem were also distributed to farmers during these fairs. Various groups of farmers from khejri mortality-affected area visited the institute to discuss khejri mortality problem and its management. Farmers were briefed about the causes and possible best practices to follow for management of khejri mortality in their areas. Pamphlets summarizing the best practices were also distributed to them during their visit.

Benefits of the research: Process developed for the rearing of root borer (*Acanthophorus serraticornis*) larvae for IPDM development, identified biochemical markers for identification of diseased trees and interim management practices of khejri mortality. Results of progeny trials and DNA marker will help in genetic improvement of *Prosopis cineraria*. Management of khejri mortality problem through prophylactic and IPDM practices and use of seeds of plus tree will help to achieve better financial gain.



Gall infestation in Khejri



Close-up of Inflorescence gall due to mites



Ganoderma root rot in Khejri

Entomo-pathological problems in Khejri



Establishing Arachnarium at TFRI, Jabalpur (M.P.)

Under this project, a checklist of 100 species of spiders has been finalized. Motinala Forest Range, Bichhia and Bijadandi forest area were surveyed and four aquatic habitats were selected where "Hydrophilic" spider families are found. Moreover, one species of *Pisaura* (Fish Eating Spiders) was also recorded. Four families of spiders reared in the laboratory, viz. Pisauridae (A family of water loving spiders), Araneidae (A family of web-building spiders), Oxyopidae (A family of Lynx spiders) and



Arachnarium of TFRI, Jabalpur

Lycosidae (A family of wolf spider), were released in the Arachnarium. During the study, *Nilus phipsoni* of family Pisauridae were collected which is new record to the state of Madhya Pradesh.

Benefits of the research : Standardization of rearing and breeding techniques of social spider (*Stegodyphus sarasinorum* of the family ERESIDAE) in the Arachnarium. Development of low-cost bamboo-made structure implant social spider colonies in the field to control

insect pests. Evaluation of use of predatory spiders as a bio-control agent against agricultural and forestry pests. The Arachnarium besides its educative value helps dispel Arachnophobia (fear of spiders). This will result in increased awareness and biological control of forest/agricultural pests using spiders.

Biology and bio-control potential of *Termitoloemus marshalli* Barnov -a voracious predator of termites, *Odontotermes* spp (FRI)

Termitoloemus marshalli has been found to be a possible bio-control agent of mound-building termites. The adults are predaceous on worker and soldier termites, whereas larvae feed on dead termites killed by the adults. The killing spree of the flies is very remarkable and promising as a bio-control agent of termites, thus may have a great potential in termite management. This small predator-cum-scavenger fly are able to enter the deep and dark galleries of termite mounds and kill both the soldiers and workers, though the fate of queen termite is not yet clear and require further studies.

Benefits of the research: New knowledge generated on natural insect bio-control agent of mound building termites can be utilized for their biological control.

Biodiversity of parasitic Hymenoptera (FRI)

Two parasitic Hymenoptera species (*Paraphaenodiscus udayveeri* and *Oligosita ferozepurensis*) new to the science have also been described.

Benefits of the research: New discoveries of parasitic wasps add to the insect fauna of India.



Termitoloemus marshalli Barnov (Diptera, Calliphoridae, Bengaliinae): (Left) Two files attacking a worker of *Odontotermes giriensis* and (right) cadavers of termite workers and soldiers killed by the files



They are the natural enemies of insects and can be used in biological control programmes.

Taxonomy and Molecular Analysis (through RAPD-PCR) of Moths (Lepidoptera) of Cold Deserts (Spiti and Leh) of Indian Himalayas (HFRI)

Moths were collected from selected sites of cold deserts (Keylong, Pooh, Tabo, Kaza and Leh) for taxonomic and molecular study. A total of 170 specimens of 58 moth species were collected and identified. Maximum number of species identified belonged to the family Noctuidae (31) followed by Microlepidoptera (8 species) and Geometridae (19 species). Maximum number of species were collected from Keylong (41 species) followed by Pooh (35 species), Kaza ((27 species), Tabo (26 species) and Leh (24 species).

Benefits of the research: Molecular techniques for identification of lepidopteron species especially of the Cold Desert area (Lahaul & Spiti) was standardised.

Value additions of plants of agricultural and horticultural importance by application of root endophyte and nitrogen fixing prokaryote *Azotobacter* spp. (AFRI)

Piriformospora indica, a root endophyte, known for its ability to promote growth in many plant species was tested along with a plant growth promoting bacteria in combination and alone on four different plant species in nursery viz. Neem (*Azadirachta indica*), Khejri (*Prosopis cineraria*), Senna (*Cassia angustifolia*) and Isabgol (*Plantago ovata*). Different parameters viz., flowering status, percentage germination, collar diameter, shoot length, root length, number of leaves, biomass (wet and dry), sturdiness quotient, quality index and vigour index were recorded.

Benefits of the research: Outcome of the project will lead to production of quality planting material which will increase in productivity of Senna, Neem, Khejri and Isabgol.

3.2 Forest Botany

Preparation of user-friendly data-base of phyto-diversity in Satpura plateau agro-climatic zone of Madhya Pradesh (TFRI)

Data collection on floristic diversity of Satpura Plateau eco-region was carried out through collection of secondary data and a total of 1,335 species have been tabulated. Database structure was designed based on the available information. A user-friendly interface for data entry, editing and retrievals was developed using Dot net technology.

Benefits of the research: A database on higher plants of Satpura-Plateau region is being developed. The research project will lead to the development of consolidated information about the trees, herbs, shrubs, grasses, medicinal plants, RET species and species of conservation concern. Digital herbarium of the Satpura region with interactive user-friendly interface will be developed.

Digitization of Herbarium/Forest flora (FRI)

Digitization of valuable authentic herbarium specimens (22,850) has been carried out. Web-based plant database of ligneous flora





with digital images along with identification key has been completed for forest flora of Manipur.

To identify the ligneous flora on the spot, a software has been developed for digitization in such a manner that anyone can identify a species through different search option like binomial nomenclature system, local name, common name, English name or any plant-based character like habit of plant, colour of flower, type of flower arrangement, leaf shape, fruit type, bark and even through locations. A checklist of 312 ligneous flora has been prepared in which number of tree species were

203, followed by shrubs (83) and climbers (26).

A checklist of 439 ligneous flora of Haryana has been prepared for 21 Forest Divisions viz. Ambala, Kaithal, Kurukshetra, Yamuna Nagar, Morni- Pinjore, Jind, Hisar, Fatehabad, Bhiwani, Sirsa, Gurgaon, Faridabad, Palwal, Mewat, Rewari, Mahendragarh, Rohtak, Karnal, Panipat, Sonapat and Jhajjar. Out of 439 recorded ligneous flora, the total numbers of tree species were 214, followed by shrubs (175) and climbers (50).

Benefits of the research: Digitized herbarium will be useful in identification of flora.

3.3 Ecology and Environment

Allelopathic potential in regeneration of Sal (*Shorea robusta*) forests (FRI)

Ardisia solanacea (Bisi), *Eupatorium adenophorum* (Snake Root or Kalo banmara), *Lantana camara* (Phool Lakarhi, Lantana, raimunia) and *Ageratum conyzoides* (Goat weed) have inhibitory effects on seed germination and growth of seedlings of *Shorea robusta* under nursery stage. The extent of reduction in seed germination of sal was determined.

Benefits of the research: The findings will be useful in enhancement of natural regeneration of sal.

Population structure, regeneration status and pollination ecology of *Dalbergia latifolia* (Indian rosewood) and *D. sissoides* (Malabar black wood/ Kala-shisham) (IFGTB)

Population status and regeneration of *Dalbergia latifolia* (Indian rosewood) and *D. sissoides* (Malabar black wood/Kala-shisham) were assessed in four Forest Divisions in Tamil Nadu, viz. Harur, Theni, Gudalur and Tirunelveli. The populations in these divisions were dominated by trees of higher girth classes/ old trees. The density of the trees was found low to medium. The natural regeneration was also very poor, and in most of the cases, it was less than one per 100 m². Phenological and pollination ecological studies of *D. sissoides* were carried out in Sholayur area of Mannarkad Forest Division in Kerala and various phenological events and pollination

mechanisms studied. *D. sissoides* was found out-crosser with insects like bees and butterflies acting as the pollinating agents.

Benefits of research: Both the species dealt with are precious timber species and their genetic resource is dwindling at a faster rate. Hence the identification of populations *in-situ* and information on the status will go a long way in conservation of genetic resources of these species. Conservation measures for the genetic resources of Dalbergias is likely to give rich dividends through genetic improvement and popularisation of the species among farming communities.

Evaluation of performance of Shola species of the Nilgiris under projected climate change conditions (IFGTB)

A study on the Shola forests of Nilgiris the institute generated bench mark information on the floristics, community ecology and forest dynamics of three Shola patches. Community ecological studies were conducted by establishing six 0.1 ha relevés, each comprising ten non-contiguous 25 m² quadrats. Enumeration of all individuals ≥ 1 cm DBH was done in the plots. The data were analysed for details of structure and composition, dominance, species richness, biodiversity content and population structure of selected tree species. Chain link fencing enabled improving the biodiversity within the patches. Climatic factors were observed to affect the flowering and fruiting phenology of the Shola species.



Benefits of research: The study on the shola forests of Nilgiris generated bench mark information on the floristics, community ecology and forest dynamics of the three shola patches in Glenmorgan and Pykara which have been subjected to anthropogenic pressure, and protection has been attempted using chain link fencing. Climatic factors were observed to affect the flowering and fruiting phenology of the shola species. For species which show alternations in flowering and fruiting, re-introductions can be carried out to increase the number. "A pictorial guide on Shola trees" was brought out.

Carbon sequestration through afforestation at Rourkela Steel Plant, Odisha (TFRI)

An average of 0.88% soil organic carbon was found in 200 soil samples collected from Rourkela Steel Plant, and soil carbon content was 32.19 t C/ha. Other physico-chemical characteristics of soil samples were estimated. Allometric equations for quantifying biomass, thereby carbon, by non-destructive method against Girth at Breast Height (GBH) have been developed. A two days training on 'Carbon Sequestration' for the staffs of Steel Authority of India was conducted at Rourkela Steel Plant on 1 & 2 December 2015. Data has also been collected on atmospheric CO₂ from 15 locations in different seasons.

Benefits of the research: Development of method of carbon estimation in trees by non-destructive method. Assessment of carbon stock and its management, increased Carbon sequestration and Carbon credits.

Studies on soil profile attributes under forest and jhum land areas of some selected sites of Nagaland state (RFRI)

A total of 54 soil profiles were studied and 225 soil samples collected from natural forests, tea gardens and Jhum lands of Mokokchung, Wokha, Mon, Dimapur and Kohima districts of Nagaland. Soil samples were analyzed for soil organic carbon, pH, electrical conductivity, texture, bulk density, available nitrogen, available phosphorus, available potassium, cation exchangeable capacity, exchangeable calcium, magnesium, sodium and potassium of all the soil samples. Forest vegetation growth data were also collected from the sites.

Benefits of the research: This project will generate data about status of soil profile under the forest and jhum lands of Nagaland. This database will be helpful to the managers of land in taking decision regarding soil management in the State.

Impact of *Mikania micrantha* Kunth. ex H.B.K. (Japanilata) on micro-environment of native species in Bherjan-Borjan-Padumoni Wildlife Sanctuary, Dilli Reserve Forests and Abhayapur Reserve Forests of Upper Assam (RFRI)

Floristic survey was carried out in pre-monsoon, monsoon, post-monsoon and winter seasons in *Mikania* (Japanilata) infested and un-infested areas. Infestation of *Mikania* was recorded mainly in periphery than in core areas. Maximum species richness was documented in Abhayapur Reserve Forest. Vegetation analysis was done to quantify the dominance spectrum of existing species of different strata level. *Dipterocarpus retusus* (Hollong) was the predominant species followed by *Vatica lanceifolia* (Morsal) in Dilli Reserve Forest and Abhayapur Reserve Forest. Highest regeneration of *Dipterocarpus retusus*, *Mesua ferrea* (Nahar) and *Vatica lanceifolia* was observed in un-infested areas of Dilli Reserve Forest and Abhayapur Reserve Forest, whereas seedling population of *Terminalia* species and *Phoebe goalparensis* (Bonsum) was high in Bherjan-Borjan-Padumoni WLS. In



Mikania infested forest areas, top canopy was dominated by deciduous species typically of short leafless period such as *Bombax ceiba* (Simolu), *Ficus hispida* (Khahata Dimoru), *Premna latifolia* (Gohora) etc. A total of 378 soil samples were collected from infested and un-infested sites, and analyzed for pH, bulk density, organic carbon, nitrogen, phosphorus and potassium.

Benefits of the research: The study will be helpful to quantify the role played by the invasive weed in modifying the natural regeneration of the forest species, thus changing the floristic structure in the long run. The information will, in turn provide inputs for developing effective management strategy of the invasive weed.

Ecological studies on distribution patterns and food plant resources of butterflies along altitudinal gradients in different ecosystems of Western Himalayan Sub-Alpine Forests of Himachal Pradesh (HFRI)

A total 254 specimens of 63 species of butterfly were collected out of which 59 were identified and characterized. Host plants of butterfly



species were monitored, collected and identified. Data was compiled for statistically

analyzing the biodiversity status of butterflies in the sub-alpine forests. Wing venation and genitalia were studied to update the identifying features of the species.

Benefits of the research : The assessment will benefit the scientific community pertaining to the ecological studies on distribution patterns and food plant resources of butterflies along altitudinal gradients in different ecosystems of Western Himalayan Sub-Alpine Forests of Himachal Pradesh.

Creating awareness for revival, recharging, sanitation and hygiene of natural water resources through adoption of scientific intervention in model village Lanabanka, Distt. Sirmour, HP (HFRI)

Three natural water resources were repaired, preparation of compost from locally available material was demonstrated and farmers were also provided with vermi-beds for the preparation of the same. Farmers were imparted training about taking up plantation activities on their farm bunds and around natural water resources. Interaction meetings were held to carry out further the cause of awareness for water conservation, sanitation and hygiene. Two training programmes on water conservation, sanitation, hygiene and organics and an exposure visit to Nauni Panchayat (District Solan) to learn and adopt various water conservation measures, sanitation and hygiene were demonstrated for replication in village Lanabanka by the farmers. The water quality of seven natural water sources were also got tested for its potability.

Benefits of the research: Creating awareness amongst the rural masses pertaining to rain water harvesting, water sanitation, organic farming and tree planting around natural water sources.



Repair of Natural water sources and installation of vermi-beds on farmers' field



Training and Exposure Visit of the Farmers to Nauri, Solan

3.4 Eco-restoration

Reclamation of laterite lands using beneficial microbes in Kasargod District (IFGTB)

With a view to reclaim laterite lands with suitable tree species inoculated with suitable beneficial microbes such as mycorrhizal fungi and nitrogen fixing bacteria like *Azospirillum* and phosphobacterium on selective plant species like *Butea monosperma* (Palasham), *Swietenia macrophylla* (Mahogany), *Ailanthus triphyssa* (Perumaram / Mattipal), *Holoptelea integrifolia* (Elm / Aaya) and *Gmelina arborea* (Kumil) were raised on laterite soil collected from Kannur laterite areas of Kerala.

The arbuscular mycorrhizal (AM) fungi: *Glomus geosporum* and *G. fasciculatum* were isolated from the rhizosphere of *Acacia auriculiformis* grown in Bhavikonam laterite areas of Kerala. The Phosphorus Solubilizing Bacteria (PSB), *Bacillus megaterium* and *Azospirillum* isolated from the laterite soils and *Rhizobium* isolated from the root nodules of *Acacia auriculiformis* were mass produced and inoculated individually and in combinations with the seedlings of *Butea monosperma*, *Swietenia macrophylla*, *Ailanthus triphyssa* and *Holoptelea integrifolia* raised on laterite soil and evaluated for growth parameters in the nursery experiments.

The study revealed that *Swietenia macrophylla* and *Ailanthus triphyssa* were the suitable tree species for laterite soils treated with beneficial microbes. 600 seedlings of these species were planted at laterite lands of Karmamthodi, Bhavikonam range of Kasargod District of Kerala. The seedlings were prior

inoculated with *Azospirillum*, AM fungi and Phosphobacterium so as to improve the growth on laterite lands. From the field experiment it is understood that *A. triphyssa* and *S. macrophylla* are the suitable tree species with bio-inoculants for planting in laterite lands.

Benefits of research: Technology/Technique for afforestation of laterite degraded area with suitable tree species using beneficial microbes has been developed and standardized under the project. Beneficial microbes which can survive and promote the growth of the tree species in laterite soil were tested and identified. The technique developed would greatly benefit the Forest Department to vegetate the barren laterite lands and increase the green cover of the country. Reclamation of barren laterite land with beneficial microbes without using any chemical fertilizers is cost effective and eco friendly.

Phyto-remediation of soil for productivity enhancement during land disposal of effluent (AFRI)

The study is being conducted since 2012 in factorial completely randomized design (CRD) consisting of two factors namely irrigation (Normal water at $\frac{1}{2}$ ET (evapo-transpiration) - control; Effluent water at $\frac{1}{2}$ ET; Effluent water at $\frac{3}{4}$ ET and Effluent water at 1.00 ET) and tree species (*Azadirachta indica* (Neem), *Eucalyptus camaldulensis* (Safeda), *Prosopis cineraria* (Khejari), *P. juliflora* (Vilayati Babul), *Tamarix aphylla* (Farash), *Salvadora persica* (KharaJhal) and *Salvadora oleoides* (Meethajhal)). Results suggest that all three growth parameters viz. height, collar diameter



and crown diameter are affected by species but not by irrigation levels. However, both these factors influenced growth independently as the interaction variance between them was found to be non-significant. The results also indicated that as expected species has greater influence on growth parameters regardless of irrigation with effluent water. In field experiment, maximum height and crown diameter was recorded from effluent irrigation treatment at 1ET while maximum collar diameter was produced with effluent irrigation at $\frac{3}{4}$ ET. Growth in these species indicates that they can be utilized to produce biomass utilizing effluent water.

Benefits of the research: Utilization of effluent water in growing wood lot will lead to increased biomass production.

Impact of *Prosopis juliflora* (Vilayti babul) on biodiversity, rehabilitation of degraded community lands and as a source of livelihood for people in Rajasthan State (AFRI)

Check list of trees both exotic and indigenous species, shrubs, grasses and climbers associated with *Prosopis juliflora* (Vilayti babul) in seven different agro-climatic zones was prepared. Ten species of Coleoptera (*Mylocerus* sp.), four species of Odonata, two species of Orthoptera, three species of Hemiptera, ten species of Hymenoptera, three species of Lepidoptera, two species of Mantodea and four species of Arachnida, found in association with *Prosopis juliflora* have been identified. Two species of Hymenoptera: Formicidae (ant) are recorded for the first time from Rajasthan from Rajsamand and Barmer district.

Benefits of the research: Role of *Prosopis juliflora* in biodiversity and rehabilitation of degraded community land will be known.

Ecological restoration study in coal mines of NCL, Singrauli, M.P. (FRI)

The study was carried out under age-series of rehabilitated areas in nine collieries of Northern Coalfields Limited, Singrauli. Under site quality amelioration for different tree plantations after 29 years, sand percentage was found reduced maximum from 84.67% to 69.33% in *Pongamia pinnata* (Karanj) and *Azadirachta indica* (Neem) plantations, and silt percentage was found increased maximum from 13.33% in

recent OB dumps to 24.67% in mixed plantation of *Prosopis juliflora* (Jangli Kikar) and *Holoptelea integrifolia* (Chirol). Clay percentage, organic carbon, soil carbon content (t ha^{-1}) were recorded maximum under mixed plantation whereas available nitrogen content was found maximum under *Dalbergia sissoo* (Shisham) plantation.

Benefits of the research: The identification of species combination and the time required for achieving the success of restoration will be ascertained, which can be used in framing the restoration programme of coal mined out areas in our countries.

Identification and reclamation of 10 hectares of degraded land & biodiversity development at NCL, Singrauli (FRI)

The project is being implemented in 5 ha each at Nigahi and Krishnshilla of NCL, Singrauli. Top soil spread, mulching and planting of different grasses, shrubs and trees by way of seed sowing and seedlings planting of different plant species including timber, fodder, medicinal plants have been practised both at Nigahi and Krishnshilla. Based on two years data, the highest survival percentage was recorded for *Dalbergia sissoo* (Shisham), *Gmelina arborea* (Gamhar), *Albizia lebbek* (Safed Siris), *Pongamia pinnata* (Karanj), *Bauhinia variegata* (Kachnar) and *Phyllanthus emblica* (Aonla). The growth of planted species in term of diameter was recorded highest for *G. arborea*, *B. variegata*, *Ficus racemosa* (Gular), *Neolamarckia cadamba* (Kadamb) and *D. sissoo*.

Benefits of the research: Package of practices developed for restoration of coal mined out area will be helpful in restoration of other similar coal mined out areas in our country.

Drainage and replenishment study of mined area of various rivers of Uttarakhand (FRI)

This study was carried out in rivers of Dehradun, Pauri, Udham Singh Nagar and Nainital districts of Uttarakhand. Most of rivers of these districts including tributaries of Ganga such as Pili Nadi, Ravasan-1, Ravasan and Kotavali in Haridwar are ephemeral in nature. Under this project, the analysis of grain size distribution was done which helps to estimate sediment deposition and safe limit for extraction/ removal of deposited river bed



material (RBM) available in the various rivers. Drainage study of rivers was done with help of mapping of watershed by Arc GIS. The available amount in terms of RBM was calculated for each river.

Benefits of the research: The study will be beneficial to Forest Departments, Pollution Control Board and Mining Department etc. The study will also support the researchers from various disciplines such as ecology, climate change, environment and hydrology.

Assessment of hydrological services imparted by forest of Kempty watershed (Mussoorie) (FRI)

The watershed maps have been digitized for geo-morphological analysis. Soil and water quality parameters have been analyzed as initial information of the watershed.

Benefits of the research: The data being generated on hydrological services provided by forest of Kempty watershed would benefit local

population and forest department.

To act as technical advisor/expert for the ecological restoration works being undertaken by BCCL on OB dumps/mined out areas (44.0 ha) (FRI)

The project is being implemented in 44.0 ha of coal mined OB dump out areas distributed in nine collieries of BCCL, Dhanbad. The ecological restoration work in nine collieries is being carried out by the BCCL under supervision and guidance of F.R.I. Growth of planted species in all nine sites was recorded. Soil samples for analysis of physical, chemical and microbial biomass were collected and analyzed.

Benefits of the research/work: From the study, identification of species combination and time required for achieving the success of restoration will be ascertained which can be applied in framing the restoration programme in coal mined out areas of our country.

3.5 Seed Science and Technology

Study on diversity and dynamics of the soil seed bank in Nambor Reserve forest, a tropical semi-evergreen forest of Assam (RFRI)

A total of 142 plant species were recorded in Nambor RF, but only 16 species were observed in soil seed bank. The soil seed bank density was highest in a mixed forest followed by *Shorea robusta* (Sal), *Tectona grandis* (Chegun) and *Lagerstroemia speciosa* (Azar) dominated forests. In all four sites, species richness of the standing vegetation was much higher than that of the seed bank. The Sorensen similarity index indicated that the similarity between vegetation and soil seed banks was not high. Species richness among the seed banks was as follows: Mixed forest >

Sal dominated forest > Teak dominated forest > *Lagerstroemia speciosa* dominated forest. The most frequently detected species in all sites were *Oplismenus burmannii*, *Oplismenus compositus* and *Spermacoce articularis*.

Benefits of the research: The study will throw light on the pattern of natural regeneration in these forests, and help to identify those species that are having problems of regeneration. It will also provide information on the seed bank of invasive species in the forest area. The information will be helpful in developing strategies for improving regeneration status of the forest and eliminating invasive species.

