COMPLETED PLAN PROJECTS DURING THE YEAR 2007-08

FRI

Project 1: Inventorization and monitoring of biodiversity of threatened wetland sites of Doon Valley and surroundings, Uttarakhand [FRI-250/Bot-33/2003-08]

Findings: Monitoring the floral diversity of threatened wetland sites of Doon Valley was conducted. Threatened habitat characterization and species categorization criteria using well defined indicators were developed. Activities responsible for depletion of wetland sites of Doon Valley and adjoining areas were identified. Systematic account on rare and threatened and wetland specific species was completed with emphasis on diagnostic feature, pictorial support, threatened and conservation aspects and uses. Nine publications were made and papers presented in National Seminar/Conference.

Project 2: Assessment of wood quality parameter in seed raised plantations of different age series of *Dalbergia sissoo* Roxb. [FRI-299/Bot-44/2005-08]

Findings: Variations due to height, location and direction were found significant. Direction, location and height showed impact on wood element variations. Wood element dimensions were found to have increased with the age except fibre wall thickness. Presence of morphologically distinguishable heart and tension wood was found varying significantly in the trees of different diameters and also at different heights. It showed the impact of growth on the heartwood and tension wood formation. Inter and intra-tree radial and vertical variations in the dimensions of wood anatomical parameters were significant. It showed that homogenous wood properties from the seedling seed raised trees of *Dalbergia sissoo* even at the age of 33 years are not noticeable till the trees are over 35 years. In general, growth parameters showed increasing trend with fibre length. R^2 values indicated that NEP (Net Ecosystem Productivity), NPP (Net Primary Productivity), tree volume and diameter were the growth parameters. Lower rainfall coupled with higher temperature appears to affect the wood anatomical dimensions. Eight years old clonal plantation shows similar anatomical properties while seedling raised plantation showed variability in wood traits within the population at the same site.

Project 3: Regeneration study on *Quercus semecarpifolia* and *Carpinus viminea* [FRI- 324/ Silva- 26/ 2005-08]

Findings: Seeds of *Carpinus viminea* were collected from Mandal forest and Nainital Forest Division (Uttarakhand). TTZ test was conducted to check the viability of seeds. Seed parameters, such as seed length, breadth, 1000 seeds wt, moisture %, number of seeds in 1 kg were recorded. Seeds were then stored at different temperature i.e. 15^oC, 5^oC and room temperature. Seeds were kept for stratification treatment. Soil study was carried out to see the impact of soil on regeneration of *Carpinus viminea* and *Quercus*

semecarpifolia. Survival, height and collar diameter of the transplanted seedlings were recorded quarterly.

Seeds of *Carpinus viminea* collected from Mandal possessed 45 to 70% emptiness and 13% moisture while the seeds collected from Nainital exhibited 40 to 60 % emptiness and 15 % moisture content. Germination of seeds stored at 5ºC increased to 43% after 4 months of storage and seed stored at room temperature lost viability completely after six months. Stratified seeds retained 32% viability after a month of stratification after which it declined gradually and was 6% after 10 months of storage.

All the transplanted seedlings are surviving and their average height was 40 to 45 cms after 10 months.

Project 4: Studies on soil geological and geo-morphological linkages with different forest communities for sustainable management of Uttaranchal Forests [FRI-314 / FSLR-19 /2005-08]

Findings: The study was carried out in Kempty range of Mussoorie forest division, Uttarakhand. Soils of the area belong to Mollisols and Ultisols order and are members of fine loamy, mixed, messic family. It has been observed that Mollisols occur on limestone, dolomite, slate and quartzite parent material at higher altitudes (Kempty and Sainj blocks) having *Quercus leucotrichophora* and *Pinus roxburghii* vegetation. Barren land soils of Gandiyala block also occur on Mollisols order. Ultisols occur on phyllite, sandstone, shale and quartzite at lower altitude (Mailgarh and Kheragarh blocks) having *Dalbergia sissoo* and miscellaneous forests. Statistical analysis of soil showed that source of variation in different soil characteristics are significant for clay, pH, CEC, exchangeable Na, available N and water holding capacity for replications. Higher Ca: Mg ratio in upper horizons as compared to lower ones indicates the role of vegetation on pedogenesis. Geology, soil, vegetation and drainage maps of the study area have been prepared. There is mutual relationship between vegetation and soil which is governed by climate and aspect. The study further indicated that relief and age acting on geology govern the existing soil whereas effect of altitude and climate on geology gives rise to natural vegetation. Climate and aspect on a particular site has given rise to existing floristic composition and also different pedogenic processes active at any site.

Project 5: Soil and vegetation survey and preparation of Pedonarium in New Forest, Estate [FRI-316/FSLR-21/2005-08]

Findings: The soils of New Forest Estate are near neutral in reaction, loamy in texture, deep with gravels and stones in deeper layers and are very fertile. Their physical and chemical conditions are suitable for the plant growth and the organic carbon, major nutrients and micro nutrients are available in adequate quantities. The soils do not suffer from any serious constraint. The soils supporting tree cover are richer in organic carbon and nutrients and have better physical attributes in comparison to the soils under other land uses. The soils were classified in 3 classes at order level and in 5 classes at family level. The pedonarium of soils representing tree cover, grass land, agricultural land and

river bed has been prepared and displayed for the benefit of students, scientists and academicians.

Project 6: Effect of different plantations on soil properties and carbon store [FRI-315/FSLR-20 /2005 -08]

Findings: This study was carried out in the soils under poplar, eucalypts, shisham and teak plantation grown at different sites in Haryana and Uttaranchal to evaluate the fertility status of soil and its comparison to barren land and to estimate soil organic carbon pool. The study leads to infer that the soils supporting teak, eucalyptus and shisham were more fertile in Uttarakhand as compared to Haryana. These soils contained higher amount of nutrients and better physical properties. Organic carbon, available nitrogen, available phosphorous, porosity and maximum water holding capacity were higher i.e. 17.82, 3.14, 49.31, 4.17 and 3.55 percent respectively, in the soils under poplar in Haryana as compared to Uttarakhand, while bulk density was lesser (1.64 %), indicating better soil health in Haryana compared to Uttarakhand. The soils under eucalyptus in Uttarakhand have relatively higher organic matter (42.44 %), available nitrogen (57.28 %), available phosphorus (14.04 %), available potassium (15.68 %), porosity (3.28 %) and maximum water holding capacity (6.42 %) as compared to the soils of Haryana. Soils having higher amount of nutrients under plantations were more fertile as compared to barren land. The inference was further strengthened by productivity indices of soils of Uttarakhand and Haryana under plantations. Soil productivity index was higher under eucalyptus, shisham and teak plantations in Uttarakhand while in poplar it was higher in Haryana. Soil organic carbon pool was higher in the soils under eucalyptus, shisham and teak in Uttarakhand while it was higher in the soils under poplar in Haryana. Soils under plantations were better enriched in the nutrients and have higher soil organic carbon pool, as compared to barren land in both the states. Soils under plantations in Uttarakhand have 27.83 t/ha SOC pool as compared to 24.66 t/ha in Haryana. There was an increase of 10.29 t/ha in SOC pool in Uttarakhand in comparison to 9.30 t/ha in Haryana under plantations over barren land.

Project 7: To study ecological succession in restored mined land

Findings: Ecological succession was studied in the rock phosphate mine Maldeota. The study site is divided into the five plantation types namely Khair plantation type, Shisham plantation type, mixed plantation type, natural plantation type and Pine plantation type.

The maximum amount of phosphorous was recorded in Shisham plantation type and lowest was recorded in Pine plantation type. The Magnesium content was highest in Pine plantation type and lowest in Shisham plantation type. Similarly, the amount of Potasium was hightest in natural plantation type and lowest in Shisham plantation type. The Calcium content was highest in mixed plantation type and lowest in Shisham plantation type. The dominant tree species in the Khair plantation type is *Acacia catechu* while in shrubs *Lantana camara* was the most dominant species. In case of herbs, the most dominant species was *Bidens biternata.*

In Shisham plantation type, the most dominant tree species was *Dalbergia sissoo* while in case of shrubs *Lantana camara* was the most dominant species. Similarly in case of herbs was *Bidens biternata* followed by *Murraya koenigii.*

In mixed plantation area the dominant tree species was *Adina cordifolia* followed by *Acacia catechu.* In shrubs the most dominant species was *Lantana camara* while in case of herbs, the dominant species was *Achyranthes aspera.*

In natural plantation type, the most dominant tree species was *Bauhinia variegata* while in shrubs, *Adhatoda vasica* domintes the plantation type. In herbs the most dominated species was *Bidens biternata.*

In Pine plantation area, the most dominant species was *Pinus roxburghii* while in shrubs, the most dominant species was *Lantana camara* and in herbs the most dominated species was *Muraya koenigii.*

Project 8: To study the undergrowth ecology of natural and manmade forests of Tarai belt of Uttaranchal

Findings: Study was carried out in tarai belt of Central Tarai Forest Division and Hardwar Forest Division under natural forests, teak plantations and miscellaneous plantations having different age and forest floor conditions. It was observed that *Mallotus philippensis* was invaded in teak plantation. Basal area and under growth biomass was much more under miscellaneous plantations than teak plantations. Biotic stresses invited invasion of *Parthenium* weeds and grasses. Natural regeneration of teak was observed in natural forest floors. Miscellaneous plantations are ecologically better than monoculture and therefore, suggested to adopt in mass

Project 9: Evaluation of the principal chemical constituent of medicinal plants available with NWFP Division [FRI– 300/Chem./14]

Findings: Plant species under the project were propagated in the nursery of NWFP Division at FRI and Chakrata. Analysis of *Andrographis paniculata* (Andrographolide), *Bergenia ligulata* (Bergenin) and *Oroxylum indicum* (mixture of oroxylin – A and chrysin) was carried out for the harvested plant material at different times. Total ash, water soluble ash, acid insoluble ash, alcohol soluble extractives and water soluble extractives for the above plant species were also estimated. Thin layer chromatography, examination of all the above plant species were also carried out. No considerable variation in the above ingredients was observed for the above medicinal plants.

Project 10: Genetic evaluation of selected genotypes for exploring clonal forestry potential in *Dalbergia sissoo* [FRI/319/G&TP-16/2005-08]

Findings: The trial was maintained properly and gap filling was done wherever required. The wood samples have been collected and are being tested for anatomical and wood properties. The half yearly observations have been collected and being analyzed to understand early patterns and genetic relatedness. A clonal multiplication garden or the

vegetative multiplication garden has been established at the Forest Research Institute, Dehradun.

Project 11: Follow up project on advance genetic improvement in seed production areas, seed orchards and progeny trials of different forest tree species in Punjab [FRI-339/G&TP-17]

Findings: A seed production area of 5 ha of *Acacia catechu* has been measured and analyzed. The report has been prepared and submitted to the CF (R&T) for obtaining the necessary permission to carryout the culling operation.

The seedling seed orchard of *Dalbergia sissoo* at Mattiwara, Ludhiana has been assessed or measured, analyzed and upgraded by culling of inferior families. Similarly, a clonal seed orchard of *Dalbergia sissoo* at Pindori Mindo Mind, Hoshiarpur was measured and upgraded to the advanced generation seed orchards. The plants to be culled and retained were marked in the field and accordingly the culling was also completed.

The advance generation clonal seed orchard of *Dalbergia sissoo* has also been established at Pindori Mindo Mind, Hoshiarpur. The CSO has been planted adopting double row orchard design so that maximum cross breeding is encouraged and inbreeding is minimized. The orchard consists of 30 clones and 60 ramets of each clone.

Project 12: Studies on enhancement of natural durability of bamboo and plantation grown species with conventional/eco-friendly preservatives [FRI-236/FPD (WP)-43/2003-08]

Findings: PATENT for a "New eco-friendly economical and non-hazardous wood preservative ZiBOC- comparable to CCA" was applied in December 2007.

Thirty six months study of ZiBOC at 0.5, 1.0 and 2.0% conc. exhibited complete protection of chir veneer samples in field ground test where as control were badly damaged. Stake test at three agroclimatic zones exhibited complete protection of stake samples at three and four percent concentration. The findings are comparable with CCA. The shelf life of preservative ZiBOC was tested for two years at room temperature and 9^{o}C. No precipitation of individual components and on visual observation no change in colour was observed. Borax: Boric acid, CCA and CCB treatment by different processes of five bamboo species exhibited good protection of bamboo in ground as compared to control. Results establish non durable nature of untreated bamboo.

Project 13: Exploration of copper lignin complexes for wood preservation and effect of post treatment processes on precipitation or fixation in wood [FRI-252/FPD (WP)-44 2003-08]

Findings: PATENT for a "New efficacious eco-friendly wood preservative lignin copper complex A and B" Patent applied PAT/4.19.14/03046/2003.

Studied the efficacy of prophylactic treatments of black liquor with and without copper sulphate, against sap stain fungus *Alternaria alternata* on *Populus deltoides* (Poplar).

Study suggests that complete protection of Poplar can be achieved for a longer duration by prophylactic treatment of black liquor and copper sulphate at various dilutions as compared to all other known methods. Different treatment methods to treat Mango wood was followed with Copper Lignin complex A and B, only dip diffusion for one week and hot and cold method for 48 hours gave good retention.

Project 14: Development of eco-friendly water repellent preservative finishes for handicrafts items [FRI-307/FPD(WP)-52/2005-08]

Findings: Samples of mango wood were treated with copperised cashew nut shell liquid preservative by dip treatment method for 10 to 15 minutes. The samples were then finished with four polish treatments viz. sprit polish, linseed oil polish, Wax polish and clear varnish. The following results were obtained:

1. Gloss of the samples treated with preservative plus finishes increased up to 38% as compared to samples treated with finish alone.
   Percent increase in gloss is in the order:- Sprit polish > linseed oil polish > Wax polish > clear varnish.
2. Study on the performance of different finishes shows that gloss at different humidity conditions exhibited that loss in gloss of the samples that received double treatment i.e. preservative and polish was less as compared to the samples that received polish treatment.
   Percent loss in gloss is in the order- Clear varnish > Wax polish > sprit polish > linseed oil polish.
3. Fungus attack was observed on samples that received polish treatment only.
4. Study on the effect of UV radiation on the performance of different finishes shows that loss in gloss of the samples that received polish treatment was more as compared to the samples that receive polish and preservative treatment.

Project 15: Effect of Ammonia Fumigation on glue line strength of plywood from plantation species [FRI-312/FPD(CW)-57/2006-08]

Findings: The combi plywood boards were prepared using poplar and eucalyptus veneers and then fumigated with Ammonia for various duration of time. Veneers of poplar and eucalyptus for face and back were first fumigated with Ammonia for various duration of time and than combi plywood boards were prepared. It is observed that the glue line strength reduces when the veneer as well as combi plywood was fumigated with Ammonia. The duration for the fumigation of combi plywood with Ammonia was optimized.

Project 16: Velocity gradient induced single glass modified solar kiln for drying of timber and NWFPs [FRI-310/ FPD(WS)/55, (2005-08)]

Findings: A modified solar kiln has been installed. Its work efficiency has been studied throughly. Results are encouraging as the cost of the new kiln is about 25 to 30% less than the prevalent model, design is simpler so that specialist carpenter is not required and the modified kiln is equally efficient in seasoning of wood.

Project 17: Evaluation of physical and mechanical properties of *Leucaena leucocephala* (Subabul) and classification and grading of timber for different end uses [FRI-309/ FPD(TM) – 54]

Findings: Physical and mechanical properties of *Leucaena leucocephala* (Subabul) were determined on material obtained from Andhra Pradesh and Dehra Dun. For evolving a criterion for classification of the species for different end uses, strength coefficient was worked out. On the basis of strength, the species is found suitable for structural use, door and window shutters / frames, furniture and cabinet making, flooring, tool handles, packing cases, dunnage pallets and expendable pallets etc.

Project 18: Bending and compression properties of small diameters round plantation timbers [FRI-311/ FPD(TM) – 56]

Findings: Plantation timbers of small diameter viz. *Eucalyptus* spp. (Eucalyptus), *Dalbergia sissoo* (Sissoo) and *Melia azedarach* (Persian lilac) were tested in round form for determination of its bending and compression properties. It was found that, Fibre Stress at Elastic Limit (FSEL) is higher in round form than the sawn values for all three species. Bending stiffness (MOE) of *Melia azedarach* (Bakain) and *Dalbergia sissoo* is also found higher in round form than in the sawn form. However, *Eucalyptus* spp. is found less stiff in round form.

Project 19: Evolving kiln schedules under vacuum drying for selected plantation species [FRI-308/FPD (WS)-53/2005-08]

Findings: A tentative schedule to dry *Populus deltoides* to less than 15 % MC levels from 90 % MC levels in two steps of vacuum level-temperature combinations has been developed. In the case of *Tectona grandis*, drying rates of 0.75 %/hour compared to the 0.18 %/hour that is usually observed in conventional methods could be achieved through vacuum press drying. The results are indicative of the possibility of this technique being effective in faster drying of this moderately refractory species.

Project 20: Assessment of shisham die back (decline) in Northern India and its remedial measures [FRI-245/Path-12; 2003-08]

Findings: The main aim of the project was to assess the mortality of *Dalbergia sissoo* in India, find out the causes of mortality and suggest effective management strategies. In order to test the genetic resistance of trees against wilt, seeds were collected form all over the country from 107 healthy trees in 25 heavily infected localities. All the test provenances were inoculated with three strains of *Fusarium solani* f. sp. *dalbergiae* and on the basis of survival of seedlings the provenances were grouped in very resistant (91-100% survival), moderately resistant (51-80% survival), susceptible (31-50% survival) and very susceptible (< 30% survival). All very resistant and resistant provenances were further tested by stressing them by flooding the pots for 10 days and the resistance was found to persist in at least two seed sources of Rakh Bhuru, Amritsar and Thano Range, Dehradun.

Twenty strains of *Pseudomonas fluorescens* were collected from the rhizoplane of healthy trees growing in heavily infected localities in H.P., Uttarakhand, U.P., Haryana, Punjab and Delhi. Antagonistic interaction of *P. fluorescens* was tested against *F. solani.* Most effective strain was identified from Kankupur (Distt. Sultanpur, U.P.) and was brought in powder preparation. Improvement in survival of seedlings was recorded after the *F. solani* infected seedlings were treated with *P. fluorescens*.

Field trials were conducted in a 5 years old plantation of *D. sissoo* at Nihal Gate range under Tarai Central forest division, Haldwani. Out of eight combinations of biocontrol agents, systemic fungicides and insecticide, treatment T_3 (*Pseudomonas fluorescens* in FYM) gave the maximum survival.

Morphological characterization of the pathogen was done using four nutrient media viz. Potato Dextrose Agar (PDA) Czapk's Dox Yeast Extract Agar (CDYEA), Malt Extract Agar (MEA) and Joff's Medium (JM). PDA supported slow growth while the fastest growth was on Joff's medium. The pH requirement of the pathogen was tested at seven pH ranges from 4-10 with an interval of 1. The final pH of the medium was found to be altered in both the extremities (4 to 10 pH) to near neutral at 6.5 to 7.0.

The temperature requirement was studied between 10^0C to 35^0C at an interval of 5^0C. The isolates grew best on 20^0C and 25^0C. Least growth was observed in 10^0 and 15^0C.

Analysis of soil for its quality and org. C, org. M, Av. N, Av. K, Av. P, pH and electrical conductivity was tested in healthy and diseased sites. Heavy clay content in soil favoured the disease. Whereas availability of minerals was affected in the trees growing in diseased localities.

Effect of biofertilizers on the development of symptoms was studied after growing the seeds in 5 different biofertilizers and inoculating them with *F. solani* by root dip method. The biospirillum (*Azospirillum* spp.) was found the best followed by *P. fluorescens* in protecting the seedlings from fungal attack.

Project 21: Screening for disease resistance in genetic material raised under tree improvement programme [FRI-207/Path-13/2002-07]

Findings: The study has brought out useful information of practical application in field about the disease resistant and susceptible clones of *Dalbergia sissoo* and Eucalypts.

Screening was done against following major diseases, which were identified after initial surveys in Clonal Seed Orchards, Seedling Seed Production Areas and Seed Production Areas of *Dalbergia sissoo* raised at Paonta Sahib (Himachal Pradesh), Lachchiwala, Dehradun (Uttarakhand), Bhitmera, Hissar (Haryana), Mirpur, Chachrauli (Haryana), Chandigarh (UT), Pandori Mindomind, Hoshiyarpur (Punjab) under Planting Stock Improvement Programme of FREE Project of World Bank: *Ganoderma lucidum* root rot, *Maravalia* leaf and petiole rusts, *Colletotrichum* leaf blight, *Rhizoctonia* leaf blight, *Phoma nivea* cankers, *Helminthosporium* twig blight and *Colletotrichum* pod blight. The resistant and susceptible clones have been identified against different diseases after artificial inoculations as well as in field under natural conditions for five consecutive

years, which can be safely considered that the clones found resistant over a five years duration have inherent resistance against the disease and there were no escapes from the diseases. Information about some disease resistant material has been given in following paragraphs.

Clone Nos. 219 (Compt. No. Birpur 4A, Bhambhar Beat, Tulsipur Range, Gonda Forest Division, U.P.), 194 (Compt. No. 2, Hasanpur Beat, Tulsipur Range, Gonda Forest Division, U.P.), 266 (Compt. No. 3, Lalpani Beat, Rishikesh Range, Dehradun Forest Division, Uttarakhand), 304 (Beat Uttrinala, Shyampur Range, Haridwar Forest Division, Uttarakhand) and 276 (Lalpani beat, Rishikesh Range, Dehradun Forest Division, Uttarakhand) were best performers for height growth, girth, clear bole and showed resistance against *Ganoderma lucidum* root rot disease. Clone No. S-167 (Rajaji National Park Chilla, Kunau range, Uttarakhand), S-57 (Khalawala Range, Ambala Division, Haryana), S-106 (Birdwal range, Hanumangarh Division) and S-124 (Kosi riverbank, Sunsaria Inerva, Nepal) were resistant to leaf and petiole rust disease whereas Clone Nos. S-19 and S-89 were the susceptible clones. Three clones viz. 9 (Pathari Range, Haridwar Forest Division, 41 (Hasanpur Compt., Tulsipur Range, Gonda Division) and 66 (Chhachhrauli Range, Yamuna Nagar Division, Haryana) were found resistant to *Colletotrichum* leaf and twig bight disease. Clone Nos. 210 (Tulsipur, North Gonda Forest Division), 174 (Chilla, Rajaji N.P.), 239 (Benketwa, N. Gonda), 85 (Hanumangarh, Raj. 12 A Kola), 36 (Tulsipur, N. Gonda), 49 (Trilokpur, N. Gonda), 57 (Khalawa, Ambala), 236, 237 (Benetwa, N. Gonda) and 189 (Janakpur, Gonda) showed resistance against stem and twig canker disease.

In eucalypts out of 94 families, Nos. 2, 17, 20, 68, 72, 73, 76, 78, 85, 86, 88, 90, 91 and 93 showed resistance (disease incidence < 5%) against *Cylindrocladium* leaf and seedling blight disease in nursery whereas in plantation, only three families Nos. 20, 72 and 73 showed resistance (disease incidence < 10%) against this disease.

Project 22: Biological control of *Lantana camara* and *Parthenium hysterophorus* by fungal pathogens [FRI-206/Path-12/2002-07]

Findings: For managing *Lantana camara* spread through seeds, application of *Phomopsis archeri, F. moniliforme* and *C. gloeosporioides* was suitable for killing inflorescences in order to reduce the setting of seeds. However, the host specificity testing should precede their employment for weed control. None of the fungi could kill *L. camara* though *P. archeri* substantially damaged their stems. Herbicides viz. paraquat, glyphosate, 2,4 D, atrazine, pendimethalin and alachlor were toxic to *P. archeri, F. moniliforme, C. gloeosporioides*, *Curvularia lunata* and *F. solani*. They can be applied sequentially but not by combining in a tank mix. Adjuvants commonly available in the market for use with herbicides were toxic to fungal pathogens. They should not be mixed with fungal pathogens during their application to weeds. Sublethal doses of glyphosate or atrazine when applied with *P. archeri* sequentially controls *L. camara*. However, because of the environmental concerns, as sublethal dose for atrazine is high, sequential application of glyphosate and *P. archeri* should be preferred. The researches for integration of mycoherbicidal strategy with herbicides for *L. camara* management is at preliminary stage and extensive field trials are

required to make it commercially viable. The present study suggests integration of glyphosate with *Phomopsis archeri* for field trials.

Project 23: Preparation of management plan of Sukhna Wildlife Sanctuary and Working Plan of Chandigarh Forest Division (2004-08) [FRI-273/RSM–15/Ext.]

Findings: The first ever Management Plan of Sukhna Wildlife Sanctuary for the period from 2007-08-07 to 2016-17 has been submitted after incorporation of comments of the funding agency. 3 Zone Plans and 7 Theme Plans have been proposed as management interventions for scientific management of the sanctuary.

The Final Working Plan for the period of 10 years from 2007-08 to 2016-17 has been submitted after incorporation of comments of the funding agency. Three Working Circles viz. Protection W.C., Urban Forestry W.C. and Rejuvenation of Lake and Water Bodies W.C. have been proposed for scientific management of forests.

Project 24: Preparation of local volume tables of Khair, Sal, Shisham and Teak for UP Forest Development Corporation, Lucknow (2003-08) [FRI-255/RSM–15/Ext.]

Findings: Local volume tables of Khair, Sal and Shisham have been prepared and submitted to the C.M.D., U.P. Forest Dev. Corporation, Lucknow. Field data of Teak have been collected and analyzed for preparation of volume table and final report was completed.

Project 25: Study of current market prices of timber in the states of Jammu & Kashmir, Himachal Pradesh and Nagaland

Findings: The market rates of timber, auction prices, DGS&D rates during earlier years was collected. The data was tabulated to arrive at the present DGS&D rates which need to be applicable in each State in relation to the government auction price and escalation in market rates of timber. A price matrix was prepared and escalation in prices derived statistically. Final report was completed.

Project 26: Status of wood based industries in Kumaon, Uttaranchal (2006-08) [FRI-366/RSM–17/Ext.]

Findings: Inventorization of wood-based industry in Udhamsingh Nagar and Nainital was carried out. Demand and supply status of raw material was studied and the data compiled. The final report was completed.

Project 27: Evaluation of natural termite resistance in timber species [FRI-303/FED-20]

Findings: Eight imported timber species were procured from the local timber market, got them identified from the Wood Anatomy Branch, FRI and were tested in the laboratory for their natural resistance against subterranean termites. Only two species, Ivory coast teak and *Cryptomeria japonica* proved very resistant to termites (Category I);

three species, Malaysian Sal (Yellow meranti group and Red meranti group) and *Pinus sylvestris* belong to resistance class (Category II), one species each belongs to poorly resistance class (Category: IV: *Pseudotsuga* sp.) and perishable class (Category V , *Betula* sp.). Among the Indian woods, *Grevillea robusta* and *Eucalyptus* hybrid belong to resistance class (Category II) and Poplar proved poorly resistant (Category IV). The final report was completed.

Project 28: Integrated Pest Management of major pests in nurseries and plantations with special emphasis on biopesticides and microbial pesticides [FRI –198/ENT.13]

Findings: Studied the seasonal life cycle of five new important pests on poplar and four new pests on shisham identified and isolated fourteen new entomopathogenic fungi from dead and diseased larvae of major pests of poplar and shisham. Screened out different parts of 50 plants and identified 35 plants having biopesticidal properties. Out of which 7 selected plants were further subjected to extraction in different solvents and their efficacy tested in the laboratory against the major pests. Also tried these and compared them with commercially available microbial pesticides and botanicals in the laboratory and in field experiments. The project has been completed.

Project 29: Studies on wooden pallets using jointed sections for industrial purposes from plantation timbers [FRI-380/FPD (TE)-66]

Findings:

1. Both jointed and unjointed pallets can safely hold load upto 2400 kg for both Poplar and Eucalypts, much higher than the normal load capacity of 1000 to 1200 kg.
2. Load-deflection behaviour of jointed and unjointed pallets made of Poplar and Eucalyptus are almost same.
3. Deflections at the middle is significantly lower than the edges and become almost constant after certain load.
4. At the middle point, the deflection of pallet starts decreasing or become constant while deflections at the edges continue to increase with load.
5. Pallet with jointed pieces of top deckboard uphold more load (shock) during rough handling. It may be due to the discontinuity offered by the jointed piece in spreading shock through out the pallet.
6. Poplar pallets perform better in corner drop test due its light weight. Disadvantage of Eucalypts pallet is its heavy weight that offers weighty handling and poor performance in drop test.

Project 30: To develop medicinal plant nursery for generating awareness amongst local people [FRI-254/CSFER-05]

Findings: Demonstration plots of medicinal plants of *Asparagus racemosus* (Satawar), *Catharanthus roseus* (Syn. *Vinca rosea*) (Sadabahar), *Tinospora cordifolia* (Giloe), *Chlorophytum arundinaceum* (Safed Musli), *Rauvolfia serpentina* (Sarpgandha), *Barleria prionitis* (Kalabansa), *Plantago ovata* (Isabgol), *Plumbago zeylanica* (Chitrak), *Aloe vera* (Gheequar), *Cassia aungustifolia* (Sanay), *Gymnema sylvestre* (Gudmar), *Acorus calamus* (Butch), *Abelmoschus moschatus* (Mushkdana), *Andrographis paniculata* (Kalmegh), *Psoralea cordifolia* (Bawachi), *Ocimum sanctum* (Tulsi), Mentha, *Cyperus rotundus* (Nagarmotha) and *Rauvolfia serpentina* (Sarpgandha) were established at Central Padilla Nursery. Planting stock of important species as *Asparagus racemosus, Andrographis paniculata* and *Barleria prionitis* has been raised for distribution to the local people in extension programmes. Training-cum-demonstration programme on cultivation of medicinal plants was organized at Central Research Nursery during the project period.

IFGTB

Project 1: Enhancing productivity in *Casuarina* species through inter-provenance and inter-specific hybridization [IFGTB/RP-30/2003-08]

Findings: Forty families of inter-provenance and inter-specific hybrids of *Casuarina equisetifolia* and *C. junghuhniana* were produced through control pollination. Three field tests were established at Veedur (Tamil Nadu), Panampalli (Kerala) and Sriharikota (Andhra Pradesh) to test the performance of F_1 progeny. All the tests were assessed for height and survival at 6 months age. Survival was more than 90% in Veedur and Panampalli and 85% in Sriharikota. Inter-specific hybrid families showed better height growth than local seedlings and seed orchard progenies of pure species. The best inter-specific hybrid family showed 35 to 53% better height growth than local seedlot and 17 to 21% over orchard progenies. The average height of the best 5% of trees was 49 to 68% more than that of local seedlot and 29 to 32% over orchard progeny. The trials will be maintained upto 5 years age and periodic assessment of growth and form traits will be gathered for further ranking of families and individuals.

Hybrid trial of Casuarina showing vigorously growing interspecific hybrid trees and slow growing trees of parent species (Panampalli, Kerala)

Project 2: Status and floristic diversity of sacred groves – the only remnants of natural forests in Alappuzha District, Kerala [IFGTB/RP-35/2005-08]

Findings: Alappuzha is the smallest (1414 km^2 area) district in Kerala with a high population density (1492 persons per km^2) and is the only district in the State without natural forests. The sacred groves of the district attract utmost attention as they are the only remnants of natural forests once present. Undertaken field survey in all the six taluks of the district covering 91 villages and enumerated 1128 sacred groves. The total area recorded under these groves was 83.55 ha. Nearly 40 per cent of the groves had sacred pond associated with it. Considerable variations were observed with respect to extent of the groves and species composition. Area of these groves ranged from 0.003 to

36 acres. Most of the groves are abode of many endemic and rare plant species. A total of 687 plant species belonging to 493 genera and 127 families have been identified from these groves. Many sacred groves in the district face threat due to the dense human population and change in socio-economic status. Break up of ancestral joint family system to nuclear families is the major reason for deterioration of these valuable resources. Sanskritisation and changes in beliefs are also attribute to this denudation. Over exploitation of the resources by 'Ulladans' a tribal community and removal of litter alongwith the seeds from the floor have also led to its retrogression to a great extent. Exotic weeds namely, *Mikania micrantha, Lantana camera* and *Chromolaena odorata* overgrow the native species and play a major role in degradation. Sacred groves require complete protection from human interferences and is the only way to preserve these priceless treasures of nature. 'Ulladans' should be made aware of the importance of the vegetation system and the rational and sustainable exploitation of the resources. People who clear the grove after transferring the deities to the serpent worship temples for various developmental activities should also be sensitized to avoid further damage. Officials of Forest Department, Research Organizations, NGOs and Educational Institutions should take lead in imparting knowledge on the functional role and importance of sacred groves. They also should help in ecological restoration of the retrogressing sacred groves by way of selecting and planting suitable plant species. In general, each sacred grove was found to possess its own unique biological, ecological, cultural and economic dimensions. Financial supports / rewards to the individuals and trusts maintaining these groves will go a long way in preserving them intact for posterity.

Project 3: Studies on seed handling and storage behaviour of important NTFP species [IFGTB/RP-34/2005-08]

Findings: Suitable seed handling techniques for four important NTFP species namely, *Calophyllum inophyllum, Decalepis hamiltonii, Garcinia gummigutta* and *Sapindus emarginatus* were standardized. Fruits of *C. inophyllum* have to be picked up at yellow-green stage of fruit maturity. Seeds were found to be desiccation sensitive with a Lowest Safe Moisture Content of 15%, and studies showed that seeds can be stored for 30 days at temperature range of 10 to 20°C to prolong viability. Significant reduction in carbohydrate content and oil content could be the key factors involved in reducing viability within a period of 30 days, a tendency common in recalcitrant seeds. It is, therefore, advisable to store seeds in sealed polythene bags at a temperature range of 10 to 20°C.

D. hamiltonii seeds extracted from fruits collected during late March-April were found to be well matured and recorded 83% germination. Soaking in hot Water (60°C) for 24 hrs was found to improve germination significantly to 98% than control. Germination on paper medium followed by transplanting to root trainers with red earth, sand and FYM (1:1:1) was found suitable for this species. Low temperature storage was not favourable and ambient storage (32±1°C) was found the best. *Decalepis* seeds can be classified as intermediate in storage behaviour with more inclination towards recalcitrance. Ambient storage of fresh seeds in sealed polybags upto 2 months is advisable. Depulping *G. gummigutta* fruits to extract seeds followed by abrasion of seeds with sand and washing with kerosene were found suitable pretreatments for cleaning seeds and rendered them suitable for germination. Shade drying seeds for 2 weeks was found suitable than sun drying and seed were desiccation tolerant. Upto 6 months, seeds withstood ambient temperature whereas upto one year storage 20°C was found favourable. The seeds did not show good storage response to different pre-storage trials

such as seed dusting with protectants and moist sand storage. Seeds could be classified as intermediate in nature. Thus, storing *G. gummigutta* seeds in air tight pet jars without any storage treatments is the most suitable one.

S. emarginatus seeds with initial moisture content of 8.826 % showed germination of 62.5%. Pretreatments did not improve germination. Increasing trend in carbohydrate content over a period of 12 months storage could be attributed to setting of improved desiccation tolerance in the seeds. Seeds can be classified as orthodox in nature. *S. emarginatus* seeds can be safely stored in sealed polybags at room temperature or in a refrigerator upto 9 months.

Flowering, fruiting, seeds and seedlings of *Sapindus emarginatus*

IWST

Project 1: Studies on gas permeability of secondary species of timbers [IWST/WSP/X-19/2003-08]

Findings: In transverse direction, the permeability of *Acacia auriculaeformis* and *Acacia mangium* was very low as compared to axial direction. However, permeability in *A. mangium* was relatively higher than that of *A. auriculiformis*.

Heartwood specimen of *Eucalyptus camaldulensis, E. grandis* and *E. tereticornis* did not indicate flow rates. On the other hand, considerably higher permeability was measured in sapwood specimens of *E. camaldulensis* and *E. tereticornis*. On the contrary, permeability in sapwood of *E. grandis* was found to be lower as compared to the other two species measured.

Project 2: Study the variability in growth stresses in clones of *Eucalyptus* [IWST/ WSP/X-56/2006-08]

Findings: A total of 15 clones of *Eucalyptus tereticornis* of ITC, Bhadrachalam growing at Nagroor, near Bangalore and 10 clone from IFGTB Coimbatore were evaluated for the growth strain. It was observed that clone number 116 and 3 (about 400 micro strain) had lowest strain while clone number 10, 71 and 115 had maximum level of growth strain (about 1000 micro strain) from Bangalore region. Wood from clone with highest growth strains also exhibited highest volumetric shrinkage. From IFGTB Coimbatore, clone number 53 had minimum value (568 micro strain) while clone numbers 17 and 19 had maximum level of growth strain (1555 and 1546 micro strain respectively). It was observed that clones from Coimbatore had more strains than that of Bangalore region. Green density of the clones from Bangalore was found to be almost constant (about 1000 kg/m^3) while the basic density varied from 550 to 750 kg/m^3.

Project 3: Studies on chemical modification of wood by vapour phase treatments [IWST/WSP/X-61/2006-08]

Findings: The chemical modification of sapwood portion of the four wood species under viz. Rubber wood (*Hevea brasillensis*), Radiata pine (*Pinus radiata*), Mango wood (*Mangifera indica)* and Chir pine (*Pinus roxburghii)* can be treated in vapour phase by benzoyl chloride at boiling temperature in the glass reaction vessel. The optimized condition i.e. with 4 % lead acetate as catalyst, pyridine as swelling agent and time of treatment in vapour phase 6 hours gave the highest Weight Percent Gains (18-35 WPG).

Chemical modification of wood by vapour phase treatments are most effective in Mango wood (*Mangifera indica)* followed by Rubber wood (*Hevea brasillensis*), Chir pine (*Pinus roxburghii)* and Radiata pine (*Pinus radiata*). Modified wood shows high Anti swelling efficiency and resistance against Termites.

Project 4: Extraction and separation of chemical constituents of *Dysoxylum malabaricum* Bedd. wood [IWST/CFP/X-52/2005-08]

Findings: Hydro distillation of powdered *Dysoxylum malabaricum* wood yielded an essential oil = 0.6% W/W. GC-MS analysis of the essential oil showed the presence of 28 important chemical compounds. Ethyl acetate extract of *Dysoxylum malabaricum* wood having pleasant odour gave positive tests for terpenoids and flavonoids. Ethyl acetate extract of *D. malabaricum* wood at 0.5% concentration showed strong inhibition against wood decaying fungi namely *Polyporus meliae* (Brown rot) and *Thyromycis hirsutus* (White rot) Among various experiments conducted to reduce mortality of *D. malabaricum* seedlings and increase survival percentage, adding of locally available mulch around seedlings increased survival percentage to a great extent.

Project 5: Development of methods for detection of adulterants and evaluation of quality parameters for assessing purity of Jigat [IWST/CFP/XI-71/2007-08]

Findings: Binding property of the Jigat has been standardized by measuring its viscosity. This property of Jigat raw material is very useful to prevent peel off of finished bathis. A simple laboratory method has been developed to determine quantity of Jigat in adulterated samples by UV spectroscopic method. The developed method will help to meet the needs of end users/stake holders. FTIR spectra were taken to differentiate functional groups of pure and adulterated samples of Jigat. Samples received from agarbathi industries/ Jigat traders for its authentication were used to study the percentage of Jigat in the adulterated mixture.

Project 6: Development of methods for detection of adulterants and determining purity of sandal oil [IWST/CFP/XI-72/2007-08]

Findings: A simple method using UV-spectroscopy has been developed for estimation of sandalwood oil in adulterated mixture. The developed method will help to meet the needs of end users/stakeholders. Solubility test using 70 % ethyl alcohol for different adulterated mixture has been studied. This will give preliminary idea of type of adulterant in the mixture. Refractive index study, optical rotation study for pure sandal oil and different adulterated mixture has been studied which also gives idea about possible adulterant in the mixture. Samples received from end users for its authentication were used to study the percentage of sandal oil in the adulterated mixture.

Project 7: Investigations on the resistance of commercially available bamboo species in Karnataka against insect borer and termite [IWST/WBD/X-45/2004–08]

Findings: The major borer identified to cause damage to commercial bamboo was *Dinoderus minutus* and the minor borers were *Lyctus africanus* and *Heterobostrychus aequalis*. The annual loss of revenue caused by insect borers in bamboo depots is around 25%. The bottom portion of the culm was found on an average to be more durable against borers and fungal attack. Bamboo from wet zone and dry zone were evaluated separately against termites and fungi. Commercially available bamboo *D. strictus* was found to be more durable against termites and fungi than *B. bambos*. Project is completed as on 31st March 2008. Project completion report is under preparation.

Project 8: Clonal test trials on *Casuarina equisetifolia* L. in north coastal Andhra region [IWST/WBD-Marine/X-004/2003-08]

Findings: Ten clones of *Casuarina equisetifolia* L. procured from Regional Forest Research Centre, Rajahmundry and planted in Chippada VSS as per Randomized Row Planting Design. Soil samples were collected and analyzed for nutrient status which revealed that the soils are devoid of any nutrients. Survival percentage of the plantation revealed that 3 clones performed well with survival over 50% as compared to other clones. Growth parameters in terms of height, basal stem diameter and average branching pattern at ground level were recorded for all the clones. Growth performance in terms of height of all the clones is good. Basal stem diameter above ground of all the clones showed good girth. The trials with the clones revealed that the clone CP4202-M is the most suitable for plantation on degraded soils.

Project 9: Periodical income generation for communities involved in coastal plantation (Old title: Community involvement in coastal forestry through periodical returns by value added produce) [IWST/WBD-Marine/X-24/2003-08]

Findings: Seeds of *Eucalyptus citriodora* Hook. were procured and nursery raised in Chippada VSS area in Visakhapatnam district. Two hectares were planted with *E. citriodora* interspersed with *Casuarina equisetifolia* L. in Quinquinox Design and one hectare was planted with only *E. citriodora.* The spacing adopted in two hectares was 3 x 3 m and 2.5x 2.5 m and in one hectare it was 2 m x 2 m. Soil was analyzed for nutrient status and it was found that it was devoid of any nutrient. The average growth in terms of height of *C. equisetifolia* was 15 m which generally is useful for different end uses. Growth in terms of average girth was 38.50 cm which yields good amount of timber. Herbage of *E. citriodora* was harvested at quarterly intervals and essential oil distilled. On an average, the oil yield was 2.866 kg per hectare. The oil quality was assessed by Chemistry of Forest Products Division, IWST, Bangalore. The studies revealed that the *E. citriodora* plantation along with traditional *C. equisetifolia* will be beneficial for coastal communities in poor quality soils as in Chippada VSS. Trials on NTFP species, i.e., *Aloe vera* (L.) Burm. f., *Gymnema sylvestre* (Retz.) R. Br. ex Schultes and *Asparagus racemosus* Willd. revealed that the soil and weather conditions were not congenial for the species and mortality was recorded. Perhaps, these species can not be adapted for plantation in coastal localities.

Project 10: Environmental impact of leachates from Copper-Chrome-Arsenic (CCA) wood preservative under marine condition [IWST/WBD-Marine/X-23/2003-08]

Findings: A total of 200 mango stakes of 40 x 5 x 2.5 cm size were prepared, trimmed, planed, air dried and treated with CCA preservative. Treated stakes were converted into 600 test panels and 400 reference pieces. Macro grain pattern of all 600 panels was analyzed based on the nature of grain. "End penetration test" performed on all panels and preservative distribution recorded. Additionally, 120 untreated mango panels were prepared to serve as controls. Wood boring samples from all panels were obtained for chemical analyses. All treated panels were end sealed with suitable paint(s) to arrest preservative leaching. All treated panels were sorted into four CCA retention groups. Panels in triplicate of the 4 groups and controls were prepared into 200 test ladders. All the 200 test ladders were exposed to marine conditions at Visakhapatnam harbour. Test panel sets were retrieved at cumulative intervals and analyzed for preservative contents. Copper and chromium contents were found to have reduced in all treated mango timber panels exposed for different periods of time. Leaching rate of the two metals gradually decreased with progressing durations of panel exposure. As regards the impact of CCA leachates on colonization of biofoulers, it was found that these animals got abundantly recruited on all treated panels. Impact of copper and chrome leachates was also negligible on the biota growing in the test vicinity. However, the leaching metals were found to have proved lethal to the settling wood borer larvae.

Project 11: Studies on recruitment and metamorphosis of marine woodborer larvae [IWST/WBD-Marine/X-22/2003-08]

Findings: Teredinid wood borers trapped in the field were brought to the laboratory and *Lyrodus pedicellatus* and *Teredo parksi* maintained for generations by infesting fresh test coupons to serve as stock of larvae. Inocula of two species of algae, i.e. *Isochrysis* sp. and *Chaetoceros* sp. were procured and tested for their preference as food for the larvae. It was found that there was not much difference in recruitment and metamorphosis of larvae under the influence of the algal feed. Test coupons were immersed in the harbour for facilitating formation of primary film. Different bacteria were isolated from the primary film, maintained as pure cultures and identified through biochemical tests. Wafers of pine wood were coated with individual bacteria and tested against teredinid larvae for their recruitment response.

Project 12: Studies on seed source variation, determination of age of the trees and establishment of germplasm bank in Sandal [IWST/TIP/X-47/2005-08]

Findings: Variability was found in 20 different seed sources collected from States of Karnataka, Tamil Nadu and Kerala with reference to seed and seedling traits. An *ex situ* seedling germplasm bank has been established at Gottipura, Hoskote, Bangalore. Study on core sample revealed that, it is difficult to predict age of sandal tree because of high variability in number of rings. It has also been found that sandal trees above 30 cms girth is nearly absent in natural populations of Karnataka and Tamil Nadu States.

Project 13: Carbonisation of selected fuelwood species [IWST-34/WE-1/2004-June 2007]

Findings: The yield and other properties (Calorific value, proximate and elemental analysis) of charcoal prepared from *Casuarina equisetifolia*, *Eucalyptus* hybrid, *Acacia nilotica*, and *Acacia auriculaeformis* at different experimental conditions (carbonisation

temperature, soaking time, heating rate etc.) were evaluated. The carbonization was carried out at 300, 400, 500, 600, and 800 ^{o}C at 1 h and 3 h soaking time and three different heating rates of 4 ^{o}C/min, 8 ^{o}C/min and 12 ^{o}C/min. In all the species studied in this work, the char yield decreases significantly with the increase in the carbonization temperature. Fixed carbon content, ultimate carbon and ash content increases with the increase in carbonization temperature, whereas the volatile content and ultimate hydrogen was found to be decreasing with the temperature. There was a slight decrease in the yield and a marginal increase in the fixed carbon content with increase in the soaking time from 1 h to 3 h. The yield of charcoal prepared at 12^{o} C min $^{-1}$ was slightly less as compared to its value at 4^{o} C min $^{-1}$. However, the change in heating rate of the wood has marginal effect on the yield and chemical composition of the chars. Calorific values of the wood chars found to increase with increase in the carbonization temperature. The yield of charcoal was different for the different wood species under similar carbonization temperature. Wood species have different anatomical properties. Porosity of wood also determines the yield and chemical composition of char. The presence of extractives also affects the final yield of charcoal.

A detailed study of variation of fuelwood properties (proximate and elemental analysis) of *C. equisetifolia*, *E.* hybrid and *A. auriculaeformis* with age and height of tree has been carried out. The fuel properties of *E.* hybrid and *A. auriculaeformis* are not significantly affected by the harvesting age. Therefore, it can be recommended that plantations should aim towards increasing the biomass yield by adopting proper silivicultural methods, when they are grown for bio-energy purposes. The results of this study also suggest that the fuel properties of *C. equisetifolia* are better in mature tree as compared to lower age trees**.**

TFRI

Project 1: Eco-Rehabilitation of limestone mine of overburden in Madhya Pradesh [065/TFRI/2004/Ecol.-1(6)]

Findings: *Acacia nilotica, Dalbergia sissoo, Leuciana leucocephala* and *Acacia catechu* among Nitrogen Fixing Tree species (NFTs) and *Jatropha curcus, Gmelina arborea, Eucalyptus* hybrid, *Simaruba glauca, Holoptellia integrifolia* and *A. indica* among non-NFT's were found best suited in overburden dumps of limestone mine areas. Application of a combination of *Rhizobium*, VAM and phosphorous solublizing bacteria helped attaining maximum height and collar diameter in *Albizia procera.* Shoot height and root weight of *A. procera* were found significant at 5% level. Among nitrogeneous fertilizers, ammonium nitrate increased maximum height of *A. procera.* Mulching was found to have significant positive response in height increment of *Albizia procera*. Leaf litter followed by husk and grass mulches helped good shoot growth.

Project 2: Effect of microbial inoculants on growth and productivity of safed musli (*Chlorophytum borivillianum*) [082/TFRI-2005/Patho – 1(11)]

Findings: *Clorophytum borivillianum* (Safed Musli), an important medicinal plant, is being widely cultivated by farmers as it requires marginal soil for growth and

development and has good market for its produce. In the present study effect of VA mycorrhizae, *Azospirillum*, PSB in the establishment of Safed Musli was undertaken. On the basis of experimental results, it has been found that the growth and saponin contents were enhanced by application of VAM, *Azospirillum* and PSB treatment. This combined treatment of biofertilizers was found superior.

Project 3: Studies on the role of Actinomycetes in controlling root diseases of *Tectona grandis, Albizia procera, Dalbergia sissoo* and *Acacia nilotica* in nurseries [072/TFRI-2004/Patho–2(9)]

Findings: One actinomycete (*Streptomyces* sp.) and three bacteria were isolated from soil and was screened in the laboratory for antagonistic activity against pathogens of forest tree species viz. *Alternaria alternata, Curvularia lunata, Sarocladium oryzae, Fusarium oxysporum*, *Ganoderma lucidum* and *Macrophomina phaseolina.* The culture filterate of these antagonistic organisms were also tried to control the seed microflora of *Albizia procera, Dalbergia sissoo* and *Acacia nilotica.* A formulation contains farm yard manure and chicken manure was selected after growing *Streptomyces* sp. in seventeen different substrates. *Streptomyces* sp. was also multiplied in bulk by using lab fermentor in liquid PDA medium. The inoculum was prepared in bulk by using farm yard manure as the carrier for field application. The bulk culture of bacteria was prepared in PDA broth as well as in lignite. Post-emergence damping-off disease of *A. procera, A. lebbek* and *D. sissoo* and *Acacia nilotica* were also controlled by using above formulation. The use of this bio-agent also safe guards the soil from pesticidal residue in nursery and plantations. It is self-multiplying in soil and appears a new species of *Streptomyces.* It is concluded that this *Streptomyces* sp. and antagonistic bacteria (T_1, T_2, T_3) can be used to control the different pathogens which are responsible for seed deterioration, causing seed borne infections, root rot and damping off diseases of above selected species in nursery.

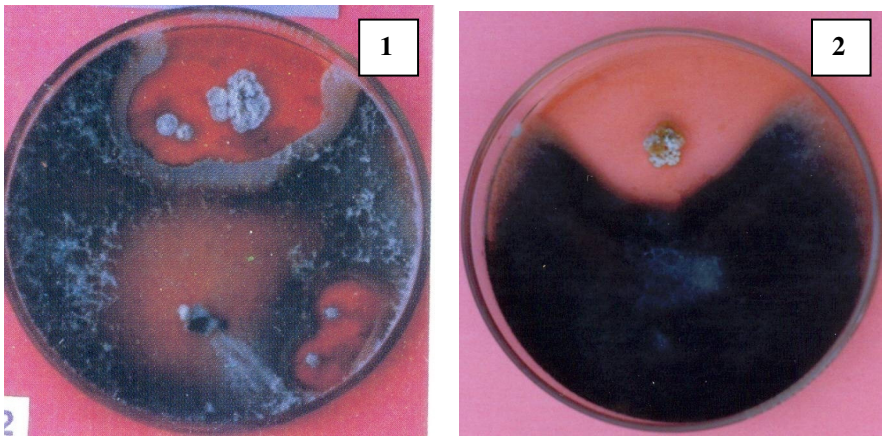

Fig. 1-2 Antagonistic effect of streptomyces.
1. Phytophthora, 2. *Alternaria alternata*

Project 4: Standardization of the cultivation technique and utilization of laccate, stipitate species of Ganodermataceae (*G. lucidum*) [056/CFRHRD-2003/2(6)]

Findings: Field surveys were conducted in different agro-ecological zones of M.P., C.G. and M.S. Total 89 samples of *Ganoderma* were collected. Screening of *Ganoderma* strains were conducted by adopting cellulose degrading capability. Estimation and production of glucanase by four selected strains of *Ganoderma lucidum* was also carried out. Cellulolytic adequacy index capacity has been tested for 19 isolates of *G. lucidum* and two strains have been selected.

Medicinal mushroom of Central India

Project 5: Studies on inheritance pattern of selected wood traits in teak (*Tectona grandis* L.) [068 / TFRI / 2004 / Gen-3 (9)]

Findings: Analysis of variance of growth and wood traits of the progenies of different parents in the trials at Lohara (Chandrapur) and Mohogata (Nagpur) showed significant variation at family level for all the traits except bark thickness. The important wood traits viz., specific gravity, heartwood percentage, sapwood percentage, fibre length, fibre diameter, fibre lumen diameter, vessel length and vessel diameter showed highly significant variation at family level.

The study also revealed moderate estimates of genetic gain for growth and wood traits from both the trials, which indicated that significant genetic gains can be realized through a moderately intensive selection programme. Some of the families showed good GCA for important growth and wood traits. The good general combiners identified in the present study can be used for establishment of advanced generation seed orchards and breeding arboreta for improvement of teak for specific or combination of above traits.

Project 6: Chemical investigations on biologically active chemicals of forest species and their utility for pest control [069/TFRI-2004/NWFP-1(9)]

Findings: *Jatropha curcas* seed oil was modified and different physico-chemical properties were assessed. *J. curcas* seeds were collected from different regions of India and estimated oil percentage and antinutritional constituents, saponins and phytates. Maximum oil percentage (kernel basis) 59.78 % was recorded in the seeds collected from Alirajpur, Jhabua (Madhya Pradesh) while oil percentage in different seed sources ranged from 37.88 to 59.78%. Toxic content phytates and saponin ranged from 4.35 to 9.10% and 0.52 to 2.52%, respectively. There was no correlation between oil concentration and toxic content.

Biological activities of different oil component were assessed against termite (*Odontotermes* spp.), fungi (*Fusarium oxysporum* and *Alternaria alternata*), bacteria (*Pseudomonas tectonae*) and weed (*Parthenium hysterophorus*). 4.7% weight loss of wooden block was recorded in control while minimum weight loss (1.4%) was observed in 10% formulation of sulphated oil when tested against termites. Maximum fungal inhibition (75%) was recorded in diterpenoid fractions. Diterpenoid fraction showed potential efficacy against *A. alternata* and *P. tectonae*.

Herbicidal activity of *Jatropha* oil component was also assessed against a weed *Parthenium hysterophrus.* There was 100% root inhibition over the control.

Project 7: Evaluation of wild edible plants of central region for polysaccharides and other food [070/TFRI-2004/NWFP-2(10)]

Findings: Sal dominated forest areas of Mandla (Kalpi, Narayanganj, Bichiya, Anjanai and Mangli) of Madhya Pradesh were surveyed and wild edible fruits of Manhar (*Randia dumatorum*) and fruit bodies of edible fungi, Putpura (*Asterus hygromatricus*) were collected. Polysaccharide content (starch/carbohydrate) and other nutrient composition of fruit bodies of *A. hygromatricus* and *R. dumetorum* were estimated. Fruit bodies contain high carbohydrate (29.48% and 35.41%) in outer and inner part respectively and fruits of *R. dumetorum* contain high carbohydrate (18.93%). *A. hygromatricus* is the good source of protein. Water soluble vitamins (ascorbic acid and thiamine) were also present in both *R. dumetorum* and *A. hygromatricus.* Minerals viz., calcium, phosphorus and magnesium were also found in appreciable amount.

The rhizomes of *C. angustifolia*, *C. pseudomontana*, *C. speciosus*, *E. nuda* and *P. tuberosa* rhizomes /tubers are eaten raw or as vegetable in different parts of central region. Polysaccharide (starch) contents in tubers varied from 25.82-38.30%. Maximum content was estimated in the tubers of *P. tuberose* followed by *C. angustifolia,* only 25.82% starch recorded in *E. nuda.* Physico-chemical properties of starch were also determined. Lipid/oil content was also estimated in species, which contribute high energy value of tubers. 6.16% oil was found in *P. tuberosa* followed by *C. pseudomontana* (4.79%). Results showed that species are rich in mineral content. The percentage of potassium, magnesium, sodium ranged from 1.26 to 2.11%, 0.12 to 0.22% and 0.12 to 0.28% respectively. The amount of sodium and magnesium was comparatively low. Phenolic acids were also identified and quantified in species with the help of HPLC.

Diosgenin contents was estimated in *Costus speciosus* collected from different localities of central region. Maximum diosgenin content was found in the rhizomes collected from Kanker followed by Mandla samples. Durg (CG) contained 2.11% diosgenin, while Dhamtari samples possessed 1.37% diosgenin respectively. Anti nutritional contents, phenol was ranged from 0.24-1.09%. Maximum phenols was found in *P. tuberosa.* The tannin content of tubers varied from 0.03-0.34%. Level of oxalate in different tubers ranged from 0.02-0.09% which was considerably lower than those found in most other starchy staples. All the plant species contain high food value. Food energy provided by the edible parts of the species varied from 126 g calories to 336 g calories which is comparable with other commonly used edible species.

RFRI

Project-1 Stability test of various clones and progenies for different characters in *Gmelina arborea* [RFRI/ TI-10/2003-06]

Findings: Progeny trial studies of selected families revealed better performance of progenies at Teliamura, Tripura (with 69% survival, 5.9 m height and 17.0 cm collar diameter) as compared to Imphal, Manipur (with 62% survival, height 3.4m and collar diameter 10.4 cm). Genetic and environment interaction was found significant at 0.001 level of significance both for height and collar diameter. This shows that progenies differ significantly in their performance at these two different sites. Half-sib progenies of RRI/GA31 clone registered maximum germination per cent. The overall germination was recoded to be 26%. The tetrazolium test revealed 12 % partially viable and 1% non-viable seeds. Seeds of progeny number RFRI/GA/43 were found to be most (93%) viable compared to other progenies.

Project-2 Bioecological studies of seed insect pests of *Dipterocarpus retusus* [RFRI/FE-12/2005-08]

Findings: A total of 9 species with seven genera belong to the order Coleoptera and Lepidoptera was recorded as insect pests on the seeds of *D. retusus*. *Thamnurgides monoceros* Beeson (Coleoptera: Scolytidae) and *Enarmonia pulverulla* Meyrick (Lepidoptera: Tortricidae) were recorded 100 percent frequency, correspondingly the relative density was also recorded high values for *E. pulverulla* (38.68) followed by *T. monoceros* (25.79) during the survey periods. Damage loss of seeds due to seed insect pests of Dipterocarps was made. The percent insect infestation on seeds of *D. retusus* collected from forest floor ranges between 42.86 and 77.40. However, only 37.5 to 58.18 percent of insects' infestation was observed in aerial collection.

Project 3: Genetic improvement and clonal propagation of *Dipterocarpus retusus* [RFRI/TI-11/2004-07]

Findings: Among seventeen progenies and check planted in Seedling Seed Orchard (SSO) at RFRI campus the progenies DMP-9, DMP-2, and JKG-2 were found to be superior for traits viz. plant height (Ht), Diameter at Breast Height (DBH), height at first branching and Crown Diameter (CD). Under development of clonal propagation protocol 17-20% rooting was achieved in shoot cuttings of three genotypes of *D. retusus*. There is no report of rooting of the species. A follow up project on clonal propagation has been continued from 2007-10.

HFRI

Project 1: Introduction and performance trial of *Paulownia* species for agroforestry in different agro-climatic zones of Himachal Pradesh [HFRI-026/08 (AGF-02) PLAN 2003-08]

Findings: As a result of various combinations tried with *Paulownia* in different agroforestry trials, the species showed that, *Paulownia fortunei* exhibit, better growth performance in lower and in mid-hill zones whereas, *Paulownia tomentosa* performed well in the high hills in the State of Himachal Pradesh. Accordingly, the species can be recommended for its integration in various agroforestry systems. Also organized three trainings and published technical manual on *Paulownia* for the ultimate benefit of different stakeholders.

Project 2: Diagnostic survey and appraisal of existing agroforestry systems in mid and high hills of Himachal Pradesh [HFRI-028/08 (AGF-03) PLAN/ 2003-08]

Findings: On the basis of structure and functions of components, five types of the existing agroforestry systems were identified viz. Agri-silviculture, Horti-agriculture, Horti-agri-silviculture, pastoral-silviculture and Horti-pastoral both in mid and high hill temperate regions of Kullu district, Himachal Pradesh. Data for biological yield and economic returns of different existing agroforestry systems have been collected for evaluating the technological gaps, if any.

Project 3: Natural enemy complex of key and potential pests of five *Quercus* species of Himachal Pradesh [HFRI-027/06(FPT-05) PLAN 2003-2008]

Findings: The entomo-pathogenic fungus which was collected from IGM larval cadaver, were cultured in PDA media for extraction. The culture was maintained and when sporophores were grown, fungus was identified on the basis of spore characteristics as *Beauveria bassiana*. Bioassay experiment to evaluate the pathogenic efficacy of *Lymantria obfuscata* Nuclear Polyhedrosis Virus (LONPV) was also carried out and 92% mortality was recorded from 3rd instar larvae to 6th instar larvae, whereas 1st and 2nd instar larvae were found more resistant to the virus. One egg parasitoid was got identified from FRI, Dehradun, as *Anastatus kashmirensis* Mathur (Eupelmidae: Chalcidoidea: Hymenoptera). Laboratory culture of about 1000 individual of IGM is being maintained for future experiments. As per the extension activity, a one day villagers training on the control of Indian Gypsy Moth was organized at Sarhan, Sirmour district, in Himachal Pradesh.

IFP

Project 1: Studies on variability of bamboo species, their performance, conservation and economics with reference to Bihar, Jharkhand and West Bengal [IFP-016/SLR -4/2002 - 08]

Findings: By conducting field survey, the number of species in different States encountered were 10 species (in Bihar), 11 species (in Jharkhand), 25 species (in North-West Bengal) and 8 species (in South West Bengal). Two hundred eighty one soil samples were collected and analyzed for correlation studies. For *ex-situ* conservation, plantation of 620 superior rhizomes of bamboos of the study sites at Udai Singh Jot, ERS, Sukna, Netaipur, Midnapore, FRC, Mandar and IFP, Ranchi are being maintained. Trials on

bamboo vegetative propagation, time of nursery propagation and age of culm etc. were standardized. Nutrient cycling in bamboo stands were assessed.

Project 2: Creation of germplasm resource bank of threatened medicinal plants of Darjeeling Himalayas [IFP-018/EBC-1/2003 - 08]


Germ Plasm Resource

Findings: *Ex-situ* medicinal plant garden was created with 11 species namely *Acorus calamus, Currculigo orchioides, Dioscorea deltoidea, Hedychium spicattum, Rauvolfia serpentine, Asparagus racemosus* Wild, *Embelica officinalis*, *Gloriosa superba, Ocimum sanctum, Tinospora Cordifolia, Curcuma caesia*. Eighty five thousand no. of QPMs of medicinal plant were produced, of which 56000 nos. of planting materials were distributed to the farmers, NGOs and States Forest Department of Sikkim and West Bengal for cultivation / trail/ demonstration. Besides, trial plot was created at research plot at Udaising Joth for yield assessment and demonstration to the farmers and Foresters. Remaining 29000 planting materials are ready for distribution during the year 2008-09.

CSFER

Project 1: To develop medicinal plant nursery for generating awareness amongst local people [FRI-254/CSFER-05]

Findings: Demonstration plots of medicinal plants of *Asparagus racemosus* (Satawar), *Vinca rosea* (Sadabahar), *Tinospora cordifolia* (Giloy), *Chlorophytum arundinaceum* (Safed Musli), *Rauvolfia serpentina* (Sarpgandha), *Barleria prionites* (Kalabansa), *Plantago ovata* (Isabgol), *Plumbago zeylanica* (Chitrak), *Aloe vera* (Gheequar), *Cassia aungustifolia* (Sanay), *Gymnema sylvestre* (Gudmar), *Acorus calamus* (Butch), *Abelmoschus moschatus* (Mushkdana), *Andrographis paniculata* (Kalmegh), *Psoralea cordifolia* (Bawachi), *Ocimum sanctum* (Tulsi), Mentha, *Cyperus rotundus* (Nagarmotha) and *Rauvolfia serpentina* (Sarpgandha) was established at central Padilla nursery. Planting stock of important species as *Asparagus racemosus, Andrographis paniculata* and *Barleria prionites* has been raised for distribution to the local people in extension programmes. Training-cum-demonstration programme on cultivation of Medicinal Plants have been organized in Central Research Nursery during the project period.

FRC

Project 1: Screening of natural populations of *Lagerstroemia* spp. for domestication [FRC-05/TI-02/2003-07]

Findings: Two species of *Lagerstroemia* prevalent in AP and Karnataka were surveyed and several populations were identified. The processes of germplasm collection and multiplication by vegetative means have not been successful. The seed from different places is collected and planted from the better known populations.

Project 2: Natural variation studies in Rosewood (*Dalbergia latifolia* Roxb.) for tree improvement [FRC -04/TI-02/2003-07]

Findings: The number of plus trees were marked in various parts of the AP and Karnataka. There is a total of 399 trees raised from 48 plus tree population from both Karnataka (100) and from A.P. (299). Apart from this, a total of 30 root suckers survive in the field which was well maintained.

Project 3: Estimation of variability in *Pterocarpus marsupium* and germplasm collection [FRC-07/TI-04/2003-07]

Findings: The number of plus trees were marked in various parts of the Andhra Pradesh and Karnataka. A total of 400 seedlings were planted in FRC Campus from selected mother trees from different places.

Project 4: Studies on phenotypic variation in *Pterocarpus santalinus* and collection of germplasm [FRC-04/TI-01/2003-07]

Findings: Survey was conducted in AP in the districts of Kurnool, Cuddapah and Chittoor and identified prominent trees for collection of germplasm. Vegetative propagation technique has been standardized. Propagated 250 plants from different collections and maintained them well.

Project 5: Dynamics of insect populations in cotton based agroforestry systems of Andhra Pradesh [FRC-08/EB-04/2003-08]

Findings: An agroforestry system with six tree species and cotton as intercrop was established in an area of two ha in FRC, Hyderabad campus. The tree components are *Eucalyptus* sp., *Azadirachta indica, Annona squamosa*, *Emblica officinalis*, *Moringa oleifera*, and *Dendrocalamus strictus.* Central idea of the project is to study the insect pest dynamics in diversified habitat conditions. Data on incidence of insect pests and their natural enemies were recorded on intercrop as well as tree components.