

PROJECTS COMPLETED DURING THE YEAR 2007-08

PLAN PROJECTS

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°C, 5°C 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 5°C 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 Uttarakhand 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 Potassium was highest 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* dominates 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°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 thoroughly. 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 from 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 Thanu Range, Dehradun.

Twenty strains of *Pseudomonas fluorescens* were collected from the rhizosphere 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 Kankapur (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 T₃ (*Pseudomonas fluorescens* in FYM) gave the maximum survival.

Morphological characterization of the pathogen was done using four nutrient media viz. Potato Dextrose Agar (PDA) Czapek'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 10⁰C to 35⁰C at an interval of 5⁰C. The isolates grew best on 20⁰C and 25⁰C. Least growth was observed in 10⁰ and 15⁰C.

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 bio-spirillum (*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), Lachhiwala, 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, Uttarakhand (2006-08) [FRI-366/RSM-17/Ext.]

Findings: Inventorization of wood-based industry in Udham Singh 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* (Sarp Gandha), *Barleria prionitis* (Kalabansa), *Plantago ovata* (Isabgol), *Plumbago zeylanica* (Chitrak), *Aloe vera* (Gheequar), *Cassia augustifolia* (Sanay), *Gymnema sylvestre* (Gudmar), *Acorus calamus* (Butch), *Abelmoschus moschatus* (Mushkdana), *Andrographis paniculata* (Kalmegh), *Psoralea cordifolia* (Bawachi), *Ocimum sanctum* (Tulsi), *Mentha*, *Cyperus rotundus* (Nagarmotha) and

Rauwolfia serpentina (Sarp Gandha) 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.