

M.Sc. FORESTRY AND BIODIVERSITY COURSE CURRICULUM

2020



**DEPARTMENT OF FORESTRY AND BIODIVERSITY
TRIPURA UNIVERSITY (A Central University)
SURYAMANINAGAR, AGARTALA – 799 022
TRIPURA, INDIA**

Programme Objective:

Post Graduate programme in Forestry and Biodiversity have been developed after identifying the needs of present Forestry and Biodiversity scenario and demand of professionals, having the understanding of special fields and subjects in forestry and biodiversity sector, including govt., corporate and private sectors. The package under core courses has been prepared keeping in view the production, management, conservation of forests, its rich biodiversity and plantations. The present syllabus is prepared to make it a professional programme with ample scope for specialization in the upcoming subject areas relevant for the sector, industries and other stake holders, thus broadening the scope and potential for employment for the Post Graduate students of Forestry and Biodiversity. The students will be given a set of twenty (20) courses (including practical Courses) which will be compulsory for undertaking the PG programme at Master level. The courses are called Core courses of Forestry and Biodiversity with specialized course called as elective course. These courses have been developed after identifying the needs of present Forestry and Biodiversity scenario and demand of professionals, having the understanding of special fields and subjects in forestry and biodiversity sector, including govt., corporate and private sectors. The package under core courses has been prepared keeping in view the production, management, conservation of forests, its rich biodiversity and plantations

Duration of Course and System of Education

The total duration of this programme shall be two years which will be covered in four semesters. The core courses and the foundation courses will be common for all students and the elective course (one in semester III) will have to be selected amongst the set of 4 courses by each student. The students will have to propose a research problem before the fourth semester in the form of synopsis which has to be approved by the students advisory committee. During the fourth semester the student has to complete the research work and by the end of the fourth Semester they have to prepare a Master's Thesis which will be mandatory for the partial fulfillment of the degree programme. The Master's thesis has to be prepared in consultation with the Major Advisor (mentor) and the students Advisory Committee and finally approved in the colloquium seminar which will be delivered by the student before the Advisory Committee in the presence of faculty members and students of the Department.

A mentor shall be allotted at the start of the 1st Semester to each M Sc Student by the DRC.

Examination and Evaluation System

It is proposed that this degree Programme will adopt the CBCS (semester) pattern as followed for other degree programmes in Tripura University.

There shall be minimum two internal evaluation of 30% marks (Internal) in the form of presentation, Viva Voce, Assignment or examination and final External theory examination of 70% marks (External). The syllabus of the concerned course shall be sent to the external examiners who shall set the question papers and also evaluate the answer books. The practical examination will be conducted internally by the course instructors and one external examiner nominated by the HOD or as desired by the COE/Hon'ble VC from time to time.

Programme structure:

The Programme consists of Core Courses, Foundation Courses, and other specialized requirements totaling to 96 credits. One credit is equivalent to one hour of teaching (lecture or term paper) or two hours of practical work/field work per week. Each semester consists of 18 weeks (approx.) of academic work equivalent to 90 actual teaching days. 3 credit hours of term Paper is allotted in 3 courses with the objective to develop the skill of research writing. In this course students have to review literature in their field of interest related to the topics of this course. They have to prepare a project report on a particular topic under the supervision of faculty and submit it.

The programme structure and respective credits are given below as:

Course Structure	Credit
Core courses	55
Elective (other Departments)	08
Elective (from Department)	04
Skill Course	03
Industrial Exposure	02
Master's thesis	16
Master thesis seminar	02
Total	90



TRIPURA UNIVERSITY
Department of Forestry and Biodiversity

SEMESTER I- 21Credits (Core Course (C): 17 Credits; Elective Course (F): 4 Credits)

Course Code	Name of the Course	Credit Distribution			Total Credit	Marks (Scaled)
		L	T	P		
FB 701C	Principles of Silviculture	3	0	1	04	100
FB 702C	Forest Biometry	2	0	1	03	100
FB 703C	Biodiversity and Conservation	3	0	1	04	100
FB 704C	Forest Ecology	2	0	1	03	100
FB 705C	Forest Protection	2	0	1	03	100
CSK-II-E	Computer Skills	4	0	-	04	100
Sub-Total		16	0	5	21	600

SEMESTER II- 26 Credits (Core Course (C): 22 Credits; Elective Course (F): 4 Credits)

Course Code	Name of the Course	Credit Distribution			Total Credit	Marks
		L	T	P		
FB 801C	Forest Policy, Laws and International Conventions in Biodiversity Management	2	1	-	03	100
FB 802C	Forest Utilization & Forest based Industries	2	-	1	03	100
FB 803C	Biosystematics	3	-	1	04	100
FB 804C	Forest Genetics and Tree Improvement	2	-	1	03	100
FB 805C	Climate change and Forestry	2	1	-	03	100
FB 806C	Forest Biotechnology	2	-	1	03	100
FB 807C	Nursery Technology and Plantation Techniques (Skill Course)	1	-	2	03	100
STAT-E	Bio Statistics	4	-	-	04	100
Sub-Total		18	2	6	26	800

SEMESTER III- 25 Credits (Core Course (C): 21 Credits; Elective Course (E): 4 Credits)

Course Code	Name of the Course	Credit Distribution			Total Credit	Marks
		L	T	P		
FB 901C	Forest Resource Management and Valuation	2	1	-	03	100
FB 902C	Medicinal and Aromatic plants	2	-	-	02	100
FB 903C	Wildlife Management and Eco-development	3	-	1	04	100
FB 904C	Forest Soil & Watershed Management	2	-	1	03	100
FB 905C	Wood Science and Technology	2	-	1	03	100
FB 906C/906E	Application of Remote Sensing and Geographic Information System in Forestry	2	-	2	04	100
FB 907C	Industrial Attachment (In between 2 nd Sem-3 rd Sem)	-	-	2	02	100
One Elective Course		3	-	1	04	100
Sub-Total		16	1	8	25	800

SEMESTER IV- 18 Credits (Core Course (C): 18Credits)

Course Code	Name of the Course	Credit Distribution			Total Credit	Marks
		L	T	P		
FB 1001C	Master's Thesis	-	-	16	16	100
FB 1002C	Master Thesis Seminar	-	-	2	2	100
Sub-Total		-	-	18	18	200

LIST OF ELECTIVE COURSE

Course Code	Elective Course	Credit	
		Theory	Practical
FB 901E	Agroforestry	03	01
FB 902E	Reproductive Biology and Breeding Methods in Forest Trees	03	01
FB 903E	Environmental Impact Assessment	03	01
FB 904E	Forest Biology & Tree Physiology	03	01

FB 701C: PRINCIPLES OF SILVICULTURE

UNIT: I

Silviculture: Definition, history, objectives and scope, status of forest cover in India. Major forest types of India –forest composition and structure. Locality factors influencing forest growth and distribution in India. Seed production, seed periodicity, seed dispersal, seed collection and processing, seed dormancy, seed germination, methods of seed viability estimation and measurement of seed vigour; Regeneration: Natural and Artificial regeneration. General nursery techniques. Tending and cultural operations in forestry.

UNIT: II

Silvicultural system of management; Silvics of important tree species-Distribution, morphology, phenology, growth behaviour, silviculture characters, nursery techniques, , protection and utilization of the following tree species:*Cedrus deodara*, *Pinus kesiya*, *Gmelina arborea*, *Shorea robusta*, *Tectona grandis*, *Dalbergia sissoo*, *Acacia* spp., *Albizia* spp., *Terminalia* spp., *Dipterocarpus* spp., Bamboospecies.

Practical:

1. Study of Composition of nearby forest areas and to know the different species.
2. Phenological study of some important tree species.
3. Regeneration survey of mixed and pure forests
4. Identification on different types of coppices in the forest.
5. Visit to different sites to study silvicultural operations undertaken as part of forest management.
6. Identification of tree seeds and study of their physical characteristics such as seed moisture, weight, and purity analysis.
7. Study on germination behavior of tree seeds in seed body and controlled conditions.
8. Determination of seed viability and vigour tests.

Suggested Readings:

1. Baldwin, H. I. 1942. *Forest Tree Seeds of the North Temperate Region*. Periodical Experts Book Agency, New Delhi.
2. Champion, H.G. and Seth, S.K. 1968. *The revised survey of the forest types of India*. Manager of Publication, Govt. of India, Delhi.
3. Dwivedi, A.P. *A text book of Silviculture*. International Book Distributor, Dehra Dun.
4. Khanna, L. S. 1985. *Principal and practice of Silviculture*. International Book Distributor, Dehra Dun.
5. Negi, S.S. 1985. *General Silviculture*, Natraj Publication, Dehra Dun
6. Prakash, R. and Khanna, L. S. 1979. *Theory and Practice of Silvicultural Systems*. International Book Distributor, Dehra Dun.
7. Negi, S. S. 1998. *Forest Tree Seeds*. International Book Distributors, DehraDun.
8. Prasad, R. and Kandya, A. K. 1992. *Handling of Forestry Seeds in India*. Association Publishing Company, New Delhi.
9. Verma, M. M.; Arora, N. and Mirakhur, R. K. 1990. *Seed Analyst Manual*. Lad Computer Services Pvt. Ltd, New Delhi.

FB 702C: FOREST BIOMETRY

Credits: 2+0+1=3

UNIT I

Measurement of tree parameters. Determination of tree age and dendrochronology for growth history and climate change studies.

Estimation of volume, growth and yield of individual tree and forest stands. Volume tables, yield and stand tables.

UNIT II

Forest inventory, sampling methods adopted in forestry, Use of GIS in forest inventory. Quantification of regeneration and stand establishment. Measurement of crown density and crown ratios. Simulation techniques. Growth and yield prediction models – their preparation and applications.

Practical:

1. Application of different sampling methods.
2. Calculations of volume of felled as well as standing trees.
3. Volume table preparation.
4. Preparation of yield and stand table.
5. Quantification of regeneration and stand establishment.
6. Measurement of crown density and crown ratios.
7. Crown profiling of trees and stand.
8. Dendrochronological studies.

Suggested Readings

1. Avery, T. E. and Burkhart, H. E. 2002. Forest Measurements. 5th Edition. McGraw Hill, New York.
2. Beers, T. W. and Miller, C. I. 1973. Manual of Forest Mensuration. T & C Enterprises, West Lafayette, IN
3. Chapman, H. H. and Meyer, W. H. 1949. Forest Mensuration. McGraw-Hill, New York.
4. Chaturvedi ANand Khanna LS. 1994. *Forest Mensuration*. International Book Distributor.
5. Hamilton, G. D. 1975. Forest Mensuration Hand Book. Her Majesty's Stationary office, London.
6. Husch, B.; Beers, T. W. and Kershaw, J. A. 2003. Forest Mensuration. 4th edition. John Wiley and Sons, INC, Hobokon, New Jersey.
7. Simmons CE. 1980. *A Manual of Forest Mensuration*. Bishen Singh Mahender Pal Singh, Dehradun.

FB 703C: BIODIVERSITY AND CONSERVATION

Credit: 3+0+1=4

Unit I

Basic concepts of biodiversity, Biodiversity- definition, levels and types; Factors promote high diversity, latitudinal and altitudinal gradients of biodiversity; biodiversity extinctions; biodiversity values-evolutionary, economic, social, cultural and intrinsic values, threats to biodiversity-Indian context, important threatened/endemic plant and animal taxa of India, biodiversity and ecosystem services; Climate change and biodiversity; Biodiversity of Indian subcontinent: biodiversity hotspots, their characteristic flora and fauna, Biodiversity resources of north-east India, threatened vascular plant species in India, specially emphasize on North east India; Threatened categories, biological invasions and Biodiversity, Biodiversity and Biotechnology, Biopiracy.

History of biodiversity conservation; Biodiversity conservation strategies: *in situ* conservation: Biosphere reserve, sanctuaries, national parks, *ex situ* conservation: botanical garden, zoological garden, *in vitro* conservation: germplasm or gene bank, tissue culture; Global approaches to biodiversity conservation, Indigenous approaches to biodiversity conservation, biodiversity & ethnomedicinal resources, Indian initiatives in biodiversity conservation-biodiversity act 2002, Biodiversity Rules 2004, national biodiversity strategy and action plan (NBSAP), Plant Varieties Protection and Farmer's Rights Act, 2001, National biodiversity authority (NBA) etc; protected area network (PAN)-biosphere reserves, national park, sanctuary, community conservation area, important bird areas in India, ecological sensitive zone; important protected areas of North East India; biodiversity conservation in North East India/Tripura- problems and prospects ethnobotany in the conservation of plant genetic resources; traditional knowledge digital library (TKDL).

Unit II

International programmes for biodiversity conservation, convention on biological diversity (CBD), CITES, ITTA, UNFCCC, Kyoto Protocol, TRIPS, Ramsar Convention on Wet Lands, Cartagena Protocol on Bio-Safety 2000 (CPB); The Basel Convention on the Control of Trans-boundary Movement of Hazardous Wastes and their Disposal, The Montreal Protocol, IPR.

Phytogeography and zoogeographical regions, Introduction of species, Theories of distribution, Endemism, Community concept; Community composition, qualitative and quantitative characters of community; methods of studying vegetation; Techniques for survey and assessment of endangered and threatened plant species, species diversity and stability relationship; Diversity indices, Plant and animal communities in forest, grassland, desert and mangrove ecosystems; high altitude communities; zonation and stratification of plant and animal communities.

Suggested Readings:

1. Gaston, K.J and Spicer, J.I. 2004. *Biodiversity: An Introduction*. Blackwell Publishing Company, USA.
2. Richard. B. Primack. 1998. *Essentials of conservation biology*. Sinauer Associates, Inc. USA.
3. Maiti P.K. and Maiti P. 2011. *Biodiversity Perception, Peril and Preservation*. PHI Learning Private Limited, New Delhi.

4. Ray S. and Ray A.K. 2010. Biodiversity and biotechnology. New central book Agency (P) Ltd. Kolkata.
5. Agarwal, S.K. 2002. *Biodiversity conservation*. Rohini Publishers, Jaipur.
6. Nautiyal, S and Kaul, A.K. 1999. *Forest Biodiversity and its conservation Practices in India*. Oriental Enterprises, Dehradun.
7. Ian. F. Spellberg. 1992. *Evaluation and Assessment for Conservation*. Chapman Hall, London, UK.
8. David, E.B. and Joel, T.C., 2003. *Monitoring Ecosystems*. Island Press, Washington, DC
9. Stanley, A.H., 2002. *Managing our wildlife resource*. Prentice-Hall, USA.
10. Benson, E.E., 1999. *Plant conservation Biotechnology*. Taylor and Francis Ltd. London.
11. Agrawal, K.C., 2000. *Wildlife of India: Conservation and Management*. Nidhi Publishers, India
12. Sinha, P.C., 1998. *Wildlife and forest conservation*. Anmol Publication Pvt. Ltd, New Delhi.
13. Edward, O.G., 2004. Ex situ plant conservation. Island Press, Washington, DC

Practical:

1. Determination of minimal quadrat size by the species area curve methods.
2. Study of vegetation by Line transect/belt transect/quadrat methods.
3. Determination of frequency/Density/Abundance/IVI of vegetation.
4. Determination of minimum number of quadrat to be laid down in the field under study.
5. Measurement of Different Biodiversity Indices (Simpson's Biodiversity Index, Shannon's index, Brillouin index)
6. Study of vegetation of the given area by physiognomic method – Biological spectrum method.
7. Estimation of plankton frequency in the aquatic system.
8. Ecological census techniques- wild animal census.

FB 704C: FOREST ECOLOGY

Credit: 2+0+1=3

UNIT:I

Concept of forest ecosystem, Significance of forest, forest ecosystem structural and functioning, forest diversity indices (alpha diversity, beta diversity, gamma), Forest productivity (primary and secondary productivity), Measurement of forest productivity, Methods of developing allometric equations relating girth and biomass of trees, concept of succession

Nutrient cycling in forest: nutrient uptake, retention and return, source of nutrients. Nutrient input (wet, dry and weathering), accumulation and return through litter fall, acid precipitation, organic matter decomposition, nutrient release and output through runoff and leaching, nutrient conservation strategies in forest. Examples of forest Carbon and N cycles.

UNIT:II

Concept of global change ecology, major global change issues (increasing atmospheric CO₂ concentration, alterations in biogeochemistry of nitrogen, land use change and biodiversity), impact of human activities on global change

Global cycles of carbon and nitrogen with emphasis on major pools, fluxes and transformations, perturbations in global carbon and nitrogen cycles, human influences on global carbon and nitrogen cycles, major impacts of global ecological changes on forests.

Suggested readings:

1. Barnes, B V; Zak, D R; Denton, S R and Spurr, S R (1998). Forest ecology (4th edition). John Wiley and Sons
2. Burton V. Barnes, Donald R. Zak, Shirley R. Denton, Stephen H. Spurr. 1998. Forest Ecology. John Wiley & Sons
3. Champion, H.G. and Seth, S.K. (1968). A revised survey of the forest types of India (Reprinted 2004). Natraj Publication, Dehradun.
4. Kimmins, J.P. (2004). Forest ecology (2nd edition). Pearson Education.
5. Perry, DA, Oren, R and Hart, S.C. (2008). Forest Ecosystems (2nd edition) The John Hopkins University press , Baltimore

Practical:

1. Monitoring of micro-meteorological parameters
2. Determine the community structure of a forest stand.
3. Calculate the turnover rate of different plant components
4. Determine the litter accumulation/decomposition in a forest stand.
5. Determine the biomass of tree species by allometric method
6. Study the community structure of wetland ecosystem
7. Determine the net ecosystem productivity in forest ecosystem.
8. Estimation the carbon stock in forest ecosystem.

FB 705C: FOREST PROTECTION

Credits: 2+0+1=3

UNIT: I

General Concept and Forest Fire; Factors affecting forest health; grazing & browsing, adverse climatic factors, acids rains & air pollutants, weeds and other invasive species. Forest fire (History, types, main causes, prevention and control), Evaluation of losses due to forest fire.

Forest Pathology; Concept of disease & Koch's postulates. Biodegradation of wood; Heart rots Important fungal diseases of seedlings in forest nursery, forest dieback, Role of mycorrhiza in tree health.

UNIT: II

Forest Entomology; Insect-plant relationship, population dynamics of forest insects, Insect feeding groups, Insect pests of Commercially important tree species.

Principal Methods of Pest Management; Chemical control; Biological control of insect pests and diseases of forest trees. Integrated Pest Management.

Practical:

1. Identification of diseases of forest nursery seedlings
2. Collection, identification and preservation of disease specimens of forest plants.
3. Collection and preservation of forest insects.
4. Familiarization with the meteorological and plant protection equipment.
5. Preparation of herbarium of forest weeds.
6. Laboratory tests for estimating decay resistance in wood.
7. Extraction of spores of arbuscular mycorrhizal (AM) fungi from soil.
8. Isolation and identification of fungal flora in decayed wood.

Suggested Readings:

1. Agrios, G.N., 2005. *Plant Pathology*. Elsevier Academic Press, USA.
2. Bihari, B., 1992. *Forest Entomology*. Bishen Singh Mahendra Pal Singh, Dehradun.
3. Boyce, J.S., 1961. *Forest Pathology*. McGraw-Hill Book Co Inc, New York.
4. Brown, A.A. and Davis, K. P., 1973. *Forest Fire: Control and Use*. McGraw-Hill, Inc. USA
5. Dhaliwal, G.S and Arora, R., Principles of Insect Pest Management, Kalyani Publishers, Ludhiana.
6. Khanna, L.S., 1982. *Forest Protection*. Khanna Bhandu, Dehradun.
7. Negi, S.S., 1999. *Handbook of Forest Protection*. International Book Distributors, Dehradun.
8. Negi, S.S., 2002. *An Introduction to Forest Pathology*. International Book Distributors, Dehradun.
9. Pedigo, L.P., 2002. *Entomology and Pest Management*, Prentice-Hall of India, New Delhi.
10. Rawat, G.S and Nautiyal, S., 1999. *Forest Fire and its Control Measures*. Oriental Enterprises, Dehra Dun.
11. Speight, M.R and Wylie, F.R., 2001. *Insects Pests in Tropical Forestry*. CABI International, UK
12. Tery, A., 1984. *Diseases of Shade Trees*. Academic Press, Inc, London

FB 801C: FOREST POLICY, LAWS AND INTERNATIONAL CONVENTIONS IN BIODIVERSITY MANAGEMENT

Credits: 2+1+0=3

UNIT I

Forest policy – Relevance and scope; National Forest Policy – 1894, 1952 and 1988; General principles of criminal law; Indian Penal Code, criminal procedure code; Indian evidence act

applied to forestry matters. Forest laws; Indian Forest Act –1927, Forest Conservation Act 1980, Wildlife Protection Act 1972

UNIT II

Environmental protection Act 1986; Biodiversity Act, 2002, Schedules tribes (Recognition of forest rights), Act, 2007. Intellectual Property Rights; Important case studies and landmark judgments. International conventions of forestry issue. e.g. Role of international treaties like CITES, IUCN, RAMSER, CBD etc.

Suggested Readings

Divan S and Rosencranz A. 2002. *Environmental Law and Policy in India*. Oxford University Press, New Delhi.

Indian Forest Acts (with short notes) 1975. Allahabad Law Agency.

Jha L K. 1994. *Analysis and Appraisal of India's Forest Policy*. Ashish Publ. House.

National Forest Policy 1952. Ministry of Food and Agriculture, New Delhi.

National Forest Policy 1988. Ministry of Environment and Forests, New Delhi.

Negi S S. 1985. *Forest Law*. Natraj Publishers.

Saharia V B. 1989. *Wildlife Law in India*. Natraj Publ.

Wilson B, Van Kooten G C, Vertinsky I, Arthur L. 1998. *Forest policy ---International case studies*. CABI publishing, UK.

FB 802C: FOREST UTILIZATION & FOREST BASED INDUSTRIES

Credit: 2+0+1=3

UNIT I

Non-timber forest products of India and Northeast India; plant based NTFP products, bamboo and Cane Utilization and Management, animal based NTFP products, mineral products, Trade and development of NTFP; Policy and legal issues, Management requirements, Methods of survey, classification, collection, processing and utilization of NTFPs. Forest harvesting practices; logging and extraction techniques, transportation, storage and sale.

UNIT II

Description of different forest based industries. Use of wood of lesser known forest species for commercial purposes, Importance of forest based industries in relation to Indian economy. Destructive distillation of wood. Saccharification of wood.

Cell wall constituents, Chemical composition of oleoresin and its importance; Structural difference among different gums; Chemical nature and uses of volatile oils, tannins, forest based dyes and pigments.

Suggested Readings

Gupta T., Gularia A. 1992. Non Wood Forest products in India: Economic Potentials. Oxford and IBH publishing Co. New Delhi.

Nautiyal S and. Kaul A.K. 2003. Non-Timber Forest Products of India. Jyothi Publishers and Distributors, Dehra Dun.

Mehta T. 1981. A Handbook of Forest Utilization. Periodical Expert Book Agency.

Krishnamurthy T. Minor Forest Products of India. Oxford & IBH.

Practical:

1. Field study for NTFP collection and documentation.
2. Exposure to wood seasoning, preservation and composite wood preparation
3. Acquaintance with various felling and conversion tools and their maintenance.
4. Visit to nearby wood based industries Identification of various wood defects.
5. Determination of cell wall constituents of wood.
6. Determination of calorific value of wood.

FB 803C: BIOSYSTEMATICS

Credit: 3+0+1=4

UNIT-I

Taxonomy of flowering Plants: Introduction: Concept of species, variation; Theory of plant taxonomy- Introduction to major plant groups and evolutionary relationships, History of plant taxonomy, Binomial nomenclature, Code of nomenclature, Systems of classification and their application, Biosystematics with use of ecology, palynology; Study of important plant families of flowering plants, Use of taxonomic literature, herbaria, cultures and databases; Documentation and dissemination- Collection and preservation techniques, Botanical Garden, Function of Botanical gardens, Recording information in field and laboratory, Photography, Illustration, Description of species, Referencing and citation, Preparation of keys, reports, Computerized database generation for dissemination, Modern taxonomy, Major groups in Gymnosperm, Reproduction in Gymnosperms.

Taxonomy of non-flowering Plants: Study of Identification-Morphology/characters of major groups in Algae, (Cyanophyta, Chlorophyta, Charophyta, Xanthophyta, Phaeophyta, Rhodophyta); Bryophytes and Pteridophytes; Structure and Reproduction in Bryophytes; Structure and Reproduction in Pteridophytes; Importance of Algae, algae, Bryophytes and Pteridophytes.

UNIT-II

Taxonomy of Microbes: Magnitude, occurrence and distribution, Outline classification of microorganisms;

Fungi- Criteria for classification and identification, Types of vegetative and reproductive forms, fruiting bodies, life cycles, Taxonomic keys and importance.

Bacteria- Occurrence, shape and arrangement of bacterial cells, Structure and multiplication of bacterial cell, classification as per Bergey's Manual of Systematic Bacteriology.

Virus-history of virology, General characteristics of viruses – size, shape and chemical composition, properties used for classification of viruses, isolation and identification of viruses.

Practical:

1. Study of the locally available plants based on Macro and Micromorphology
2. Description and identification at family, genus and species levels using standard taxonomic Keys (Floras).
3. Identification of key characters in a lower group of taxa and construction of keys.
4. Studies on Herbarium techniques
5. Identification of some locally available Bryophytes
6. Identification of some locally available Pteridophytes
7. Identification of the animals by use of Taxonomic Keys, morphological characters and other identifying features.
8. Preservation techniques of some animals for future studies.
9. Collection and identification of fungi from field.
10. Isolation of microorganisms through culture method.
11. Gram staining method for bacterial identification.

Suggested Readings:

V. N. Naik. *Taxonomy of Angiosperms*.

Heywood. *Families of Flowering plants*.

Pandey. *Angiosperms: Taxonomy, Anatomy, Economic Botany & Embryology*.

Sing, Jain. *Taxonomy of Angiosperms*.

Dr. S. G. Date. *Key to family of Angiosperms*.

Burgey's manual of systematic bacteriology

J. T. Bonner., *Researches on cellular slime moulds: selected papers*

Dr. M. G. Watve. *Microbiology: A practical approach*

Stanier et al., *General Microbiology*

Prescott et al., *Microbiology*

Pelczar., *Introduction to Microbiology*

Mueller, G.M., Bills, G.F., Foster, M.S. (2004) *Biodiversity of Fungi: Inventorying and monitoring methods*. Elsevier Academic Press Publication.

Burgey's manual of determinative bacteriology- 8th edition

Biswas, S.B. and Biswas, A (1976) *An introduction to Viruses*. Vikas Publishing House, new Delhi.

FB 804C: FOREST GENETICS AND TREE IMPROVEMENT

Credits: 2+0+1=3

UNIT: I

Basic genetics principles - genomes and genes, genome structure, genetic code and gene expression, sources of genetic variation, Population genetics – Hardy-Weinberg equilibrium, gene frequencies, factors affecting allele frequencies, inbreeding and forces of evolution.

Mating system of forest trees – Reproductive phenology, flowering, pollination vectors, threats to pollination, incompatibility mechanism, out crossing, selfing, pollen handling, pollen dispersion. Tree Breeding- Variation in trees. Natural variation, Geographic variation. Selection and management, species and provenance selection. Quantitative genetics.

UNIT: II

Seed orchard – types, establishment, management and records; Progeny trials; Genotype – environment interaction; Planning and strategies of a tree improvement programme. Breeding trees for specific purpose (Pest, disease and adverse environment). Species and racial hybridization and its application; Biotechnology for tree improvement; Seed technology and Certification

Practical:

1. Numerical analysis of population genetics questions
2. Plus tree selection
3. Variation analysis in a forest population.
4. Numerical questions on quantitative genetics,
5. Study of pollination system of some tree species.
6. Pollen viability and germination tests.
7. Visitation rate and foraging behavior of Pollinators.
8. Practice of cutting, grafting budding and air layering.

Suggested Readings:

1. Becker, W. A. 1975. *Manual of Quantitative Genetica*. Student Book Corporation, Washington State University, Pullman, Wash.
2. Boulter, S. L., Kitching, R. L., Zalucki, J. M. and Goodall, K. L. 2006. *Reproductive Biology and Pollination in Rainforest Trees: Techniques for a Community-level Approach*. Practical Manual. Cooperative Research Centre for Tropical Rainforest Ecology and Management. Rainforest CRC, Cairns, Australia
3. Mandal, A. K. and Gibson, G. L. (eds.) 1998. *Forest Genetics and Tree Breeding*. CBS Publishers and Distributors, New Delhi.
4. White, T.L., Adams, WT. and Neale, DB. 2007. *Forest Genetics* (Winner of a 2009 Outstanding Academic Title (OAT) award) CABI Publishing , Oxfordshire, UK.
5. Wright, J. W. 1976. *Introduction to Forest Genetics*. Academic press, New York.

FB 805C: CLIMATE CHANGE AND FORESTRY

Credits: 2+1+0=3

UNIT I

Forests and climate change; Status of forests in global climate change. Harnessing Forests for Climate Change Mitigation, National action plan on Climate Change of India: aim and objectives. International climate negotiation, UNFCCC, IPCC, CoP :LULUCF, REDD++ and

CDM.

Silviculture and sustainability-criteria and indicators for sustainable plantation forestry in India-CIFOR guidelines. Silvicultural and stand management strategies for carbon sink maximization and source minimization. Adaptive silviculture for climate change.

UNIT II

Deforestation and degradation trends at global, national and regional levels. Mega development projects, conservation of native and threatened species, management and rehabilitation plans.

Restoration forestry-silvicultural treatments for habitat restoration, catchment area treatments, Role of canopy in regulating functional inputs to stand: canopy and forest continuum, Continuous Cover Forestry. Carbon sequestration potential of Trees Outside forests (TOFs), homegardens and urban forests.

Suggested Readings:

1. Anderson P and Palik B. 2011. *Silviculture for Climate Change*. U.S. Department of Agriculture, Forest Service, Climate Change Resource Center.
2. *Climate Change: Challenges To Sustainable Development in India*. 2008. Research UNIT (Larrdis) Rajya Sabha Secretariat, New Delhi.
3. *Greenhouse Gas Emission from Agricultural System*, Published by IPCC- USEPA *Climate change and global crop productivity* Ed. by K R Reddy and HF Hodges CABI Publishing.
4. IPCC Assessment Report. 2007. *Climate Change Journal Climate Change: Source, Impact and Policy*, Proceeding of 2nd World Climate Conference. Ed. by J Jager and HL. Ferguson, Cambridge University Press.
5. John Houghton. *Global Warming* (4th), Cambridge Press.
6. Robert M, Clausen and Henry L Gholz. *Carbon and Forest Management*. School of Forest Resources and Conservation. University of Florida, Gainesville, FL 32611, USA.

FB 806C:FOREST BIOTECHNOLOGY

Credit: 2+0+1=3

UNIT-I

Principles and requirements of plant tissue culture; cellular totipotency, callus and multiple shoot induction, micro-propagation, protoplast isolation and fusion, cybrids, somaclonal variation, single and suspension cell cultures, somatic embryogenesis; meristem culture and virus free plants, haploid production, embryo rescue, acid and salt tolerant plants, artificial seed production and cryopreservation.

Introduction to nucleic acids-DNA and RNA as molecules of life, discovery, structural and functions of DNA, nucleotides and nucleosides; genetic code, replication, transcription and

translation of DNA; molecular basis of mutation; chloroplast, mitochondrial and plasmid DNA-structure and functions; PCR, gel electrophoresis, SDS PAGE.

UNIT-II

Principles, tools & techniques in plant genetic engineering/ recombined DNA technology-vector and enzyme mediated transfer of plant genes, structure and function of Ti and Ri plasmids, reporter genes; direct gene transfer-electroporation, particle bombardment, biolistic gun; GMO; genetically modified forest crops-application in improving yield and quality, *Nifgene* in legume and non-legumes, stress tolerance, herbicide & disease resistance in forest crops.

Genetic diversity- concept, analysis of karyotype variation, genetic erosion, Techniques to assess genetic diversity- Molecular approaches to assessing genetic diversity, molecular maps and markers- RAPD, RFLP, AFLP, STS, microsatellites, etc.; Sampling strategies for genetic diversity assessment, sufficiency of sampling procedures, Effects of sampling on genetic diversity, Factor influencing levels of genetic diversity in woody plant species. Conservation of genetic diversity. Introduction to bioinformatics, biological databases-characteristics and categories.

Suggested Readings

An Introduction to Plant Tissue Culture, 1st Edition (1992). K.K. De, New Central Book Agency, Kolkata.

Introduction to Plant Tissue Culture (2007) M.K. Razdan, India Book House Pvt. Ltd., New D

DNA Fingerprinting in Plants-Principles, Methods and Applications, 2nd Edition (2009), K. Weising, H. Nybom, K. Wolf and G. Kahl, CRC Press (Taylor and Francis Group, Boca Raton (First Indian Reprint, Saurabhi Printers Pvt. Ltd.).

Gaston, K.G. (2004). *Biodiversity: an introduction* (2nd edition). Blackwell Science Ltd.

Geethabali, R.R. (2002). *Biodiversity: monitoring, management, conservation and enhancement*. APH Publishing, New Delhi.

B.G. Glick and J.J.(2001). *Molecular Biotechnology: Principles and applications of Recombinant DNA* (2nd Edition). Pasternak, ASM Press, Washington D.C. (First Indian Reprint, Replika Press Pvt. Ltd., New Delhi).

S. Mahesh, (2008). *Plant Molecular Biotechnology*. New Age International Publishers, New Delhi

Practical:

1. Demonstration of plant tissue culture methods

i) Preparation of Reagent/stock solutions

ii) Demonstration of various sterilization technique.

iii) Preparation of Medium

iv) Explant preparation

v) Culture inoculation on culture medium

vi) Sub-culturing.

2. Demonstration on gel electrophoresis

FB 807C: NURSERY TECHNOLOGY AND PLANTATION TECHNIQUES

Credit: 1+0+2=3

UNIT-I

Plantation forests; Plantation establishment; Planting; Beating up, Choice of species; Intercultural operations; Plantation maintenance; Thinning; Energy and industrial plantation species; Plantation economics.

UNIT-II

Nursery: Importance; Guidelines of good nursery; Certification related to nursery; Use of growth regulators; hardening of plants in nurseries. Propagation Structures Mist chamber, humidifiers, greenhouses, glasshouses, cold frames, hot beds, poly-houses, nursery (tools and implements)

Practical:

Learning Objectives: This course will expose the students to develop their skills on the following plantation and Nursery techniques:

Plantation: Planting- layout, time of planting, planting pattern, spacing, gap filling, planting methods, direct seeding. Enrichment planting, nurse and cover crops. Intercultural operations; Plantation maintenance; Thinning - physiological and mensurational - on stand development. Exercise on Plantation economics.

Nursery: Nursery Record Management; Basics of Propagation; sexual and asexual methods; Nursery techniques. Use of growth regulators in seed and vegetative propagation; selection and maintenance of mother trees, collection of scion wood stick; Micrografting, hardening of plants in nurseries. Insect/pest/disease control in nursery. Study of tools, materials and operations for establishment of plantations.

1. Site selection and site preparation.
2. Exercises on planting and tending.
3. Study of the special techniques for difficult sites.
4. Exercises on protection of plantations.
5. Exercise on plantation layout.
6. Collection of data for survival and growth performance.
7. Use of fertilizers, weedicides for plantation management
8. Media for propagation of plants in nursery beds, pot and mist chamber.
9. Preparation of nursery beds and sowing of seeds.
10. Raising of rootstock.
11. Seed treatments for breaking dormancy and inducing vigorous seedling growth.

12. Preparation of plant material for potting.
13. Hardening plants in the nursery.
14. Practicing different types of cuttings, layering, graftings and buddings etc.
15. Use of mist chamber in propagation and hardening of plants.
16. Preparation of plant growth regulators for seed germination and vegetative propagation.
17. Visit to a tissue culture laboratory.
18. Maintenance of nursery records.
19. Use of different types of nursery tools and implements for general nursery and bud wood certification.
20. Cost of establishment of a mist chamber, greenhouse, glasshouse, polyhouse and their maintenance.
21. Top grafting, bridge grafting and nursery management.
22. Nutrient and plant protection applications during nursery.

FB 901C: FOREST RESOURCE MANAGEMENT AND VALUATION

Credits: 2+1+0=4

UNIT I

Principles and Peculiarities of forest management. Objects and purpose of management. Sustained yield; management and administrative units, Rotations, Normal forest. Estimation of growing stock and increment. Yield regulation, Working Plan Economics of nature of crop; Role of economics in forestry and its limitations in decision-making.

UNIT II

Economics of nature of crop; Role of economics in forestry and its limitations in decision-making. Application of microeconomics in solving forest resource problems. Demand and Supply- Concepts of forest products; Equilibrium point. Utility: concepts; Cost: Cost of production; Production Theory; Utility theory of production and marginal products in forestry. Market: Main features of market; Market of various forest products. Valuation of non-market goods services and economics of multiple-use, Eco-system Analysis; Economic and Financial Analysis of Forestry Projects

Suggested Readings

- Davis, L.S. and K.N. Johnson. 1987. *Forest management*. Third Edition. McGraw Hill Book Company, New York. 790 p.
- Desai, V. 1994. *Forest management in India - Issues and problems*. Himalayan Publi. House. Bombay. 358 p.
- Jerram, M.R.K. 1982. *A textbook of forest management*, International Book Distributor, Dehradun.
- Kerr JM, Marothia DK, Singh K, Ramaswamy C & Beritley WR. 1997. *Natural Resource Economics : Theory and Applications in India*. Oxford & IBH.
- Osmaston, F.C. 1984. *Management of forests*, International Book Distributor, Dehradun.
- Nautiyal JC. 1988. *Forest Economics – Principles and Applications*. Natraj Publications, Dehradun.

Ram Prakash. 1986. *Forest management*, International Book Distributor, Dehradun.
Sharma LC. 1980. *Forest Economics, Planning and Management*. International Book Distributors, Dehradun.
Sharpe GW, Hendee CW & Sharpe WE. 1986. *Introduction to Forestry*. McGraw-Hill.

FB 902C: MEDICINAL AND AROMATIC PLANTS

Credit: 2+0+0=2

UNIT I

History, scope, opportunities and constraints in the cultivation and maintenance of medicinal and aromatic plants in India (emphasize will be given on North East India); Importance, origin, distribution, area, production, climate and soil requirements, propagation and nursery techniques, planting and after care, cultural practices, training and pruning, nutritional and water requirements.

Plant protection, harvesting and processing of important medicinal and aromatic plants of North East India. Study of chemical composition of a few important medicinal and aromatic plants, extraction, use and economics of drugs and essential oils in medicinal and aromatic plants. Post-harvest handling – Drying, Processing, Grading, Packing and Storage, processing: Distillation methods, advanced methods, Solvent extraction process, steam distillation, Perfumes from non-traditional plants, Quality analysis, Value addition, Aroma chemicals, quality standards and regulations, Institutional support and international promotion of essential oil and perfumery products; Drug adulteration.

UNIT II

Therapeutic and pharmaceutical uses of important Medicinal Plants: *Zanthoxylum*, *Curcuma caesia*, *Saracaasoca*, *Aconitum heterophyllum*, *Panax pseudoginseng* and *Swertiachirata*, *Sugandh mantra*, *Coleus*, Glory lily, Senna, Periwinkle, *Phyllanthus*, *Pyrethrum*, *Cinchona*, *Rauwolfia*, *Dioscorea*, Isabgol, *Aloe vera*, Belladonna, *Solanum viarum*, Mints, *Piper longum*, Ashwagandha, Guggul, Opium poppy, Java Citronella, Lemon grass, Palmarosa, Annatto, Vetiver, Rosemary, Gharu, Scented Geranium, Patchouli, Basil, Artemisia, Thyme, Ambrette, French Jasmine, Tuberose, Lavender and other species relevant to the North East India. Organic cultivation of medicinal plants, GAP for medicinal plants and Institutions involved in medicinal plants promotion, Endangered Medicinal Plants of India specially North East India, Post-harvest management model of commercially important medicinal crops in NER

Suggested Readings:

1. Cultivation of Medicinal and Aromatic Crops. (2004), Azhar Ali Farooqi, B. S. Sreeramu, Universities Press, Hyderabad, India.
2. Hand book of medicinal and aromatic plants: cultivation, utilisation and extraction processes. (2007), Engineers India Research Institute, New Delhi, India
3. Textbook of Medicinal and Aromatic Plants. (2018), Amritpal Singh Saroya, Indian Council of Agricultural Research, New Delhi.
4. Medicinal and Aromatic Crops at a Glance (2017), Mamta Dall, Kapil Sihag, Bhani Ram Dall, Jain Brothers, new Delhi, India.

5. Medicinal and Aromatic Plants with colour plates (2010), R. K. Gupta, CBS Publication and Distributors, New Delhi.

FB 903C: WILDLIFE MANAGEMENT AND ECO-DEVELOPMENT

Credits: 3+0+1=4

UNIT I

Biodiversity and Wildlife. Principles of management, animal-habitat studies, conservation biology, management of animal communities, habitat management. Wildlife Management Plan

Wildlife behavior studies, Man animal conflict, Wildlife census; Captive wildlife; Captive breeding for conservation. Central Zoo Authority of India. Wildlife (Protection) Act, 1972; Forest Conservation Act, 1980; FCA in relevance to Wildlife areas;

UNIT II

Conservation strategy and life support systems, protected area network, agencies for conservation of Wildlife, human dimension, wildlife in managed forests; Eco development in support of conservation & protected area management, animal habitat studies, Scope of eco development, thrust areas in eco development, planning and implementation; Eco development: Macro and micro planning, Case studies

Practical:

1. Field Visits and Field Exercises
2. Audio video Demonstrations
3. Case studies related to man animal conflict, habitat development and biodiversity conservation

Suggested Readings

- Berwick SH and Saharia VB. 1995. *Wildlife Research and Management*. OUP, New.
- Dasmann RF. 1982. *Wildlife Biology*.
- Karanth KU and Nichols JD. 2002. *Monitoring Tigers and Their Prey: A Manual for Researchers, Managers, and Conservationists in Tropical Asia*. Bangalore, India: Centre for Wildlife Studies.
- Krebs C and Davis N. 1978. *Introduction to Behavioral Ecology*. Oxford University Press
- Lever C. 1985. *Naturalised Mammals of the World*. John Wiley, London.
- Mills LS. 2013. *Conservation of Wildlife Populations Demography, Genetics and Management* (Ed.2). Wiley-Blackwell.
- Rajesh G. *Fundamentals of Wildlife Management*, Justice Home, Allahabad.
- Reena Mathur. 1985. *Animal Behaviour*. OUP, Delhi.
- Wodroffe G. 1981. *Wildlife conservation and Modern Zoo*. Saiga Publishing Co., England.

FB 904C: FOREST SOIL & WATERSHED MANAGEMENT

UNIT I

Concepts of soil and soil science, Composition of Earth crust and its relationship with soils. Weathering and Soil formation, soil classification; Forest soils – distinguishing features; soil physical and chemical properties; Forest soil organic matter; Decomposition, nutrient cycling. Soil biota, Soil fertility, Essential plant nutrients, Nitrogen and Carbon cycle; Mycorrhizal associations in forest soils, soil degradation, management interventions of forest soils.

UNIT II

Watershed management- History, Concept, Identification, Objectives and Principles of Watershed Management, Physiographic features of watersheds, ground water recharge, evapo-transpiration and stream flow. Hydrological cycle and characteristics of small and medium watersheds precipitation.

Water resource development, Forest features of hydrologic significance,. Hydrological evaluation of land treatment; water conservation and water harvesting - principles and important techniques, structures – types & design. Sedimentation- sources, estimation, sediment bank treatment techniques.

Suggested Readings

Brady N.C., and Weil R.R. 2007. *The Nature and Properties of Soils*. 14th Ed., Prentice Hall, New Jersey
Santhi and Sellamuthu (2008) *Fundamentals of forest soils*, Satish serial publishing house, Delhi.

Hamilton IS. 1988. *Tropical Forest Watersheds. Hydrologic and Soil Response to Major Uses of Conservation*. International Book Distributors, Dehra Dun.

Hewlett, JD and Nutter, WL 1969. *An outline of forest hydrology*. University of Georgia Press, Athens.

Moorthy VVN. 1990. *Land and Water Management*. Kalyani Publishers.

Murty JVS 1995. *Watershed Management in India*. Wiley Eastern, New Delhi.

Practical:

1. Soil Field Excursion and study on soil profile.
2. Processing of soil samples for analysis, estimation of pH, bulk density, porosity, moisture, texture, nitrogen, phosphorus, potassium, organic carbon and organic matter.
3. Identification of common microorganisms in different ecosystems.
4. Field visit to study various engineering measures for soil and water conservation.
5. Preparation of an integrated watershed development project for a micro/macro watershed in co-ordination with concerned department for identified area.
6. Measurement of slope and identification of contour points in a field with simple and low cost methods.

7. Socio-economic and resource survey for a small watershed.

FB 905C: WOOD SCIENCE AND TECHNOLOGY

Credits: 2+0+1=3

UNIT: I

Kinds of woods; Wood properties - gross anatomical features of wood, physical features of wood. Electrical, thermal and acoustic properties of wood. Mechanical properties of wood; natural characteristics affecting mechanical properties of wood, reaction wood, fire performance characteristics of wood. Suitability of wood for various uses; Extractives in wood

UNIT: II

Wood Water relations- Drying/seasoning of Wood, Refractory classes of timbers, Classification of timbers based on durability. Defects of timber- natural and seasoning defects, bio-deterioration of wood, wood preservation; Wood machining. Dimensional stabilization of wood.

Important qualities and examples of structural and specific utility timbers. Composite wood- Plywood, Particle board, Laminated wood, Block board, Fiber board manufacture and utility. Improved wood- compreg, impregnated wood, heat stabilized wood; Synthetic wood technology- Wood plastic composites.

Practical:

1. Different kinds and types of wood available as raw material.
2. Determination of moisture content and shrinkage of different wood species.
3. Determination of specific gravity and bending properties of various wood species.
4. Analysis of biodeterioration of wood, treatment of wood with different preservatives.
5. Collection wood samples of various species and identification of their anatomical features and physical features.
6. Timber identification. Procedures for field identification of timbers.
7. Study of physical features of wood. Study of gross features of wood. Study of anatomical features of wood.
8. Visit to Saw mill and wood workshops to know the machinery and equipments; storage; various sawn forms.

Suggested Readings:

1. Anon, 1972. *Indian Forest Utilization* Vol 1&2, FRI, Dehra Dun.
2. Anon, 1996. *Wood Preservation Manual*. FAO, Rome
3. Mehta, Tribhawan., 1981. *A handbook of Forest Utilization*. International Book Distributors, Dehra Dun.
4. Rao, K.Ramesh and Juneja, K.B.S, 1992. *Field Identification of fifty important timbers of India*. ICFRE, Dehra Dun. 123p.

5. Simpson, W.T.1989. *Drying wood: a review. Drying Technology*. An International Journal, Pt. 1. 2(2): 235–265, Pt. 2, 2(3): 353–368.
6. Eaton, R.A.; Hale, M.D.C. 1993. *Wood: decay, pests and protection*. New York, NY: Chapman & Hall.
7. Hunt, G.M.; Garratt, G.A.1967. *Wood preservation*. 3rd Edition. The American Forestry Series. New York, NY: McGraw–Hill.
8. Bodig J and Benjamin AJ. 1993. *Mechanics of Woods and Woods Composites*. Krieger Publish Company.
9. Brown HP. 1925. *An Elementary Manual on Indian Wood technology*. Central Publication Branch, Government of India, Calcutta.
10. Brown HP. 1985. *Manual of Indian Wood Technology*. International Books and Periodicals Supply Service, New Delhi.
11. Hill CAS. 2006. *Wood Modification: Chemical, Thermal and other Processes*. John Wiley and Sons Ltd.
12. Hoadley B. 2000. *Understanding Wood: A Craftsman’s Guide to Wood Technology*. Taunton Press. Newtown, USA.
13. Kollmann FFP and Cote WAJ. 1968. *Principle of Wood Science and Technology*. Vol I, Solid wood. George Allen and Unwin Ltd London, Springer-Verlag, Berlin, Heidelberg, New York.
14. Panshin AJ and De ZC. 1980. *Textbook of Wood Technology*, 4th Ed. McGraw-Hill. New York.
15. Walker, J.C.F., Butterfield B.G., Langrish T.A.G., Harris J.M., Uprichard J.M. 1993. Primary wood processing-principles and practices. Chapman and Hall, London.595 pp.
16. Pandey C.N. and Jain V.K. 1992. *Wood Science and Technology*. ICFRE [Indian Council of Forestry Research and Education],FRI, Dehradun.144 pp.
17. Kumar S. and Dev I.1993. *Wood Preservation in India*. ICFRE [Indian Council of Forestry Research and Education],FRI, Dehradun.262 pp.
18. Rajput S.S., Shukla, N.K., Gupta, V.K and Jain J.D. 1996. *Timber mechanics-strength,classification and grading of timber*. . ICFRE [Indian Council of Forestry Research and Education],FRI, Dehradun.189 pp.
19. Thyagarajan C. 2010. *A text book of an insight into wood processing technology*. AWTC, IWST, Bangalore.254 pp.

FB 906C/906E: APPLICATION OF REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM IN FORESTRY

Credits: 2+0+2=4

UNIT I

Satellite remote sensing and recent developments in geomatics, different satellite missions of India and abroad. Spatial and spectral resolution of different data products and applications. Geo-referencing of topo-sheets and satellite imagery, Satellite Image Interpretation, Digital Image Processing (DIP); RS softwares, Application of Remote Sensing in forest resource management.

UNIT II:

GIS for the collection, storage and spatial analysis for geo-referenced forest resources data and information. Integration of spatial data analysis systems with knowledge-based systems and/or simulation systems for the development of information/decision support systems for forest management. GIS application in FRM.

Practical

1. Thematic layers build up, overlaying and their integration using software package Interpretation of satellite data and digital image processing.
2. Preparation of thematic maps.
3. Preparation forest biomass and carbon map, fire affected areas assessment, Preparation of change detection map, classification of LULC using softwares.

Suggested Readings

- A Preliminary Overview. *Journal of Latin American Geography*.
- Bolstad P. 2005. *GIS Fundamentals: A first text on Geographic Information Systems, Second Edition*. White Bear Lake, MN: Eider Press.
- Buzai GD and Robinson D. 2010. *Geographical Information Systems in Latin America, 1987-2010*.
- Campbell JB and Randolph HW. 2011. *Introduction to Remote Sensing*. Fifth Edition, The Guild Press, New York.
- Chang K. 2007. *Introduction to Geographic Information System, 4th Edition*. McGraw Hill.
- Elangovan N. 2006. *GIS Fundamentals, applications and implementation*. New India Publ. Agency, New Delhi.
- Guruganam B. 2009. *Geographic Information System*. New India Publ. Agency, New Delhi.
- Harvey and Francis. 2008. *A Primer of GIS, Fundamental geographic and cartographic concepts*. The Guilford Press.
- Jackson MJ. 1992. *Integrated Geographical Information Systems*. International Journal of Remote Sensing.
- Joseph G. 2005. *Fundamentals of Remote Sensing*, Second edition. Universities Press.
- Lillesand TM and Kiefer WR. 1994. *Remote sensing and Image Interpretation*, Fourth edition. John Wiley & Sons, Inc., USA.
- Reddy AM. 2014. *Text book of Remote Sensing and Geographic Information System*. 4th edition, BS Publication, Hyderabad.

FB 907C: INDUSTRIAL ATTACHMENT

Credit: 0+0+2=2

The students will be divided into various groups comprising 5 students per group based. Each group will be attached with a forest based industry/Institutes. After the completion of the attachment, the students should prepare a Report describing the activities exposed to during the period of his/her attachment. Each of the students must make a presentation his/her report in front of the Examiners for final evaluation.

FB 901E: AGROFORESTRY

Credit: 3+0+1=4

UNIT I

Definition and concepts of Agroforestry; Agroforestry research and development; Goals, objectives and strategies of National Agroforestry Policy 2014; Classification of agroforestry systems; Benefits and constraints of agroforestry; Agroforestry practices and systems in different agro-ecological zones of India; Shifting cultivation, Taungya, Homegarden, Alley cropping, Plantation crop combinations, Homegarden, Traditional agroforestry systems of northeast India.

Characteristics of agro forestry trees; General principles of plant productivity; Component interactions; Concept of allelopathy and its impact on agroforestry; Tree Domestication in Agroforestry; Plant management practices in agroforestry; Forage and fodder production through agroforestry; Resource use-efficiency in agroforestry.

UNIT II

Nutrient cycling in agroforestry; Land capability classification and land evaluation; Biomass production; Carbon sequestration potential in agroforestry. Phyto-remedial potential of agroforestry.

Criteria of an ideal agroforestry design, productivity, sustainability and adoptability; The Diagnosis and Design (D & D) methodology, Field experiments in agroforestry, Ecological basis of Agroforestry, Economic analysis of agroforestry system, Sociocultural considerations, Pest and disease management, Evaluation of agroforestry systems.

Suggested Readings

- Dwivedi A.P. (1992) Agroforestry: Principles and Practices. Oxford & IBH.
Jha, L. K. (2009) Advances in Agroforestry, APH Publishing Corporation, New Delhi.
Nair P.K.R., Rai M.R. & Buck LE. (2004) New Vistas in Agroforestry. Kluwer.
Nair P.K.R. (1993) An Introduction to Agroforestry. Kluwer.
Ong C.K. & Huxley P.K. (1996) Tree Crop Interactions – A Physiological Approach, ICRAF.
Young A. (1997) Agroforestry for Soil Management, CABI.

Practical:

1. Visit to agroforestry sites to study different crop combinations
2. Structural analysis and plant composition in different agroforestry systems
3. Economic evaluation of agroforestry systems
4. Sociocultural evaluation of agroforestry systems
5. Field exercise on plot demonstration showing root distribution of different plants.
6. Identification and characterization of manures and fertilizers.
7. Effect of different cropping systems on soil erosion and water quality.

**FRBD 902E: REPRODUCTIVE BIOLOGY AND BREEDING METHODS IN
FOREST TREES**

Credits: 3+0+1=4

UNIT I

Reproductive biology in forest trees; pollination syndromes; Modes of reproduction and their breeding systems and sex expression. Out-crossing mechanism in forest trees; Environmental effects on sex expression. Floral biology. Initiation and development.

Modes of pollination; Pollen dispersion distances, pollinators and their energetics. Attractants for pollinators. Pollen handling forced flowering for seed orchard manipulation. Fertilization in hardwood and softwood species. Seed dispersal and gene flow.

UNIT II

Genetic constitution of tree populations, half-sib, full-sib family in trees. Hardy-Weinberg equilibrium, changes in gene frequency through selection, migration, mutation and population sizes. Long-term and short-term breeding populations. Selective breeding methods; Grading system and regression systems, mother tree selection, subjective evaluation. Selection for different traits.

Genetic testing programmes – mating designs. Improvement through progeny testing; Experimental designs in genetic testing. Breeding methods for wood quality, diseases and pest resistance, drought and salt resistance. Marker assisted selection.

Practical

1. Sex expression in forest trees.
2. Out crossing mechanisms in forest trees.
3. Measurement of pollen flow in wind-pollinated and insect-pollinated species.
4. Pollen viability and fertility.
5. Seed dispersal mechanism.
6. Grading system of plus trees in natural stands.
7. Mating designs
8. Selection for biotic and abiotic stresses.

Suggested Readings

- Acquaah G. 2012. *Principal of Plant Genetics and Breeding*. John Wiley & Sons, Ltd, UK.
- Almeida OJG, Cota K Sánchez JH and Paoli AAS. 2013. *The systematic significance of floral morphology, nectaries and sugar nectar concentration in epiphytic cacti of tribes Hylocereeae and Rhipsalideae (Cactaceae)*. Persp. Plant Ecol. Evol. Syst. 15: 255-268.
- Barrett SCH. 2006. *Ecology and Evolution of Flowers* [electronic resource]. (Eds.) L.D. Harder SCH. Barrett. Oxford Univ. Press, New York, U.S.A.
- Bawa KS and Hadley M. 1990. *Reproductive Ecology of Tropical Forest Plants*. UNESCO Man and Biosphere Series.

- Briggs and Walters SM. 1984. *Plant Variation and Evolution*.
- CláudiaInês da Silva and Helena Maura TorezanSilingardi. 2006. *Reproductive Biology of Tropical Plants* - International Commission On Tropical Biology and Natural Resources. Encyclopedia of Life Support Systems (EOLSS)
- Falconer DS and Mackay TFC. 1995. *Introduction to Quantitative Genetics*. 4th edition. Longman, Essex
- FAO. 1985. *Forest Tree Improvement*, FAO Publication.
- Khosla PK. 1981. *Advances in Forest Genetics*. Ambika Publ., New Delhi.
- Mandal AK and Gibson GL. (Eds.). 1997. *Forest Genetics and Tree Breeding*. CBS.
- Sedgley and Griffin. 1989. *Sexual Reproduction of Tree Crops*.
- Spencer C H, Barrett, Robert I, Colautti and Christopher G Eckert. 2007. *Plant Reproductive Systems and Evolution during Biological Invasion*. Wiley Online Library. (<https://doi.org/10.1111/j.1365-294X.2007.03503.x>).

FRBD 903E: ENVIRONMENTAL IMPACT ASSESSMENT

Credits: 3+0+1=4

UNIT I

Elaboration of steps in traditional EIA process; The importance of SEA as a tool for assessing impacts of policy, plan and programmes. Relevance of SEA as a global tool for addressing cumulative, regional and landscape level impacts. Examples of SEA and SEA like approaches from India; Key example of good SEAs from around the world. Introduction to tools and techniques.

UNIT II

Introduction to some recent approaches of economic valuation of impacts and their application in impact assessment and presentation of case studies. Principles and concepts of offsets, type 01 offsets, examples of bio-banking and wetland banking and marketbased mitigation strategies. Comparison of EIA approaches in other countries in South Asia. Life Cycle Assessment Approach in Impact assessment. Impact Assessment for addressing climate change.

Practical:

1. Scoping for Hypothetical or real EIA study
2. Scoping based on scenario projection through visuals (Some select films can be used)
3. Review of EIA Reports and preparing comments for appraisal of project
4. Development of Alternatives based on details available for project planning to ensure least impact option
5. EIA Report writing with case studies
6. Seminar on select topics

FB 904E: FOREST BIOLOGY & TREE PHYSIOLOGY

Credit: 3+0+1

UNIT I

Plant Nutrients: Mineral nutrients- absorption, translocation and utilization of mineral salts, Nitrogen metabolism, Water relation, Transport and translocation of water and solute, Salt and drought tolerance physiology in relation to production of biomass. Transpiration and osmo-regulation in relation to stress physiology.

Plant biochemistry and metabolism: Photosynthesis: Carbon partitioning, light reactions. General concepts. Organization of light-absorbing Mechanisms of electron transport. The carbon reactions. The Calvin-Benson cycle. Inorganic carbon-concentrating mechanisms: the C₃, C₄ and CAM carbon cycle. The impact of environmental conditions on photosynthesis. Overview of plant respiration. Glycolysis. The citric acid cycle. The oxidative pentose phosphate pathway, mitochondrial electron transport and ATP synthesis. Respiration in intact plants and tissues. Photorespiration.

UNIT II

Growth, development and differentiation: Study of tree structure, study of secondary wood; growth, development and function, Factors affecting growth of trees, Phytohormones- Auxins, Gibberellins, Cytokinins, Ethylene, Abscisic Acid, Phytochrome; their mechanism of action, Role of growth hormones in vegetative propagation. Signaling and integration: auxin and GA, Biosynthesis and elicitors: ethylene and ABA

Reproductive Physiology: Physiology of flowering, Regulation of sexuality, photoperiodism in trees relating to the growth and regeneration, Vernalisation, Physiology of Embryo growth, Fruit Development and Ripening, Seed physiology – Germination and seed dormancy, The mechanism and regulation of seed dormancy and germination, molecular dissection of seed quality, The biophysical basis of seed longevity, Bud dormancy, Abscission and senescence.

Suggested reading:

The Embryology of Angiosperm- S. P Bhatnagar, P K Dantu S. S Bhojwani,

The Plant Physiology – Ross and Salisbury

Textbook of Plant Physiology – C.P. Mallik and A.K. Srivastava, Kalyani Publisher, New Delhi

Physiology of Woody Plants – *Dr. Stephen G. Pallardy*, Science Direct

Tree Physiology - Meinzer, Frederick C., Niinemets, Ülo; Springer

Forest tree Physiology – E. Dreyer, Elsevier

Practical:

1. Separation of Plant pigments by chromatography
2. To study the effect of light intensity (by changing the distance) on the rate of carbon sequestration.
3. To study the effect of light quality on the rate of carbon sequestration.
4. Effect of sodium bicarbonate/temperature/pH on the rate of carbon sequestration

5. Studies on seed viability
6. Effect of water soaking of seeds on germination.
7. Effect of soaking of seeds in salt solution of different molarity on germination.
8. Demonstrate the effect of different chemicals on seed germination.

FB 1001C: SYNOPSIS of Master's Research

The DRC will allot the supervisors at the end of the 2nd Semester for the Master's Thesis. There can also be a co-supervisor from outside the department if the expertise required is not available within the department.

The Synopsis on the thesis should be on a prescribed format and should be forwarded by the Supervisor. The synopsis seminar has to be delivered by the M Sc student before submission of the synopsis in front of the DRC. The date of seminar for project planning and synopsis submission shall be fixed by the Supervisor. The approved problem of research as finalized by the DRC i.e. title of the proposed research and objectives shall be final.

If the synopsis is not submitted as mentioned above, the student shall not be allowed to register for Research Credits.

FB 1002C: MASTER'S THESIS

Requirements for the M Sc degree shall include successful completion of scientific investigation and creditable research to be submitted in the form of a thesis, which must be an original contribution to knowledge characterized either by the discovery of facts and their significance or by a new interpretation of facts or theories. In either case, it should evince the candidate's capacity for critical examination and sound judgement. The topic of thesis should be distributed among the students from diverse areas of study.

Right from the initiation of the project work, each candidate will have to periodically present progress report in form of seminar in addition to regular discussion with the supervisor, which will be considered for Internal Evaluation under **FB 1003C: MASTER THESIS SEMINAR** before the members of Student Advisor Committee and all the faculty members and students of the Department.

The final thesis submitted by the students will be evaluated by an external examiner (from outside the University).

A Postgraduate student should submit 3 copies of the thesis and soft copy along with the plagiarism check report duly signed by the candidate and supervisor. Acceptance of the thesis for evaluation shall be governed by the regulation related to plagiarism issued by the UGC from time to time. The HOD will forward the soft copy to the External Examiner at least one week before the date fixed for evaluation by the Examiners. One copy of the thesis shall be kept with the supervisor, second copy will be given to the students and the 3rd Copy will be retained by the HOD. On successful pass of the examination all the thesis shall be sent for uploading in the departmental website.

FB 1003C: MASTER THESIS SEMINAR

The student has to deliver a seminar before the DRC, faculty members and students (M Sc and Ph D) of the Department where he/she will make a presentation of the research work including methodology, outcomes, recommendations, conclusions etc as per the date of examination notified by the Controller of Examination, Tripura University.