NAVSARI AGRICULTURAL UNIVERSITY

Restructured and Revised Syllabi of Post-graduate Programmes

Forestry

Year 2022

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NAVSARI AGRICULTURAL UNIVERSITY

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Foreword

Presently we are at the dawn of an age of unprecedented technological change. Every day the technologies are astonishing through innovation, refinement and refurbishment. If we will not keep ourselves updated with the pace of refinement of the technologies, we may expel out of the development. Being a pillar of higher education and research in the field of agriculture and allied sciences, our responsibilities are double. Our education system needs to be rejuvenated instantaneously to develop competency and fundamental principles of the society. In anticipation of this, central government introduced National Education Policy-2020 which is more flexible, holistic and multi-disciplinary. The ICAR is sensible enough and has striving best to bring necessary reforms in agricultural education through constituting National Core Group (NCG) and BSMA Committees for revision and restructuring of Post-graduate and Doctoral syllabi of agriculture and allied sciences. The committee has thoroughly restructured the syllabus of Masters' and Doctoral programmes in 79 disciplines, introduced new courses under the dynamic leadership of stalwarts of agricultural sciences Dr. T. Mohapatra (DG ICAR & Secretary DARE, New Delhi), Dr Arvind Kumar (Chairman, NCG), Dr R.C. Agrawal (DDG Agri. Edn) and to his predecessor Dr N. S. Rathore, Dr. G. Venkateshwarlu (Member-Secretary, NCG and former ADG, EQR) and Dr. P. S. Pandey (ADG, EP & HS). To restructure and articulate the entire syllabi of agriculture and allied sciences, 19 different BSMA Committees performed outstanding job in many marathon meetings and brain storming sessions.

Since the syllabi was restructured and articulated considering national significance, there would have been few topics which does not fetch national attention, however, are indispensible from the Gujarat agriculture point of view. Therefore, to implement these recommendations in all the SAUs of Gujarat *viz*., Navsari Agricultural University, Navsari, Junagadh Agricultural University, Junagadh, Anand Agricultural University and Sardarkrushinagar Dantiwada Agricultural University, Dantiwada we reviewed and added certain topics without imposing much stress in the semester. We have not compromised with any of the content prepared by the expert team so that our student does not remain deprived of any opportunity in national level competition. I personally thanks all my colleges Vice Chancellors of SAUs of Gujarat Dr. K. B. Kathiria (AAU, Anand), Dr. R. M. Chauhan (SDAU, Dantiwada), Dr. N. K. Gontia (JAU, Junagadh) for showing faith in NAU, Navsari and bestowing the responsibilities of Nodal University for the finalizing the same. All the faculty members of all the SAUs of Gujarat has done marvelous work of reviewing these and provided their suggestion to make it more relevant to Gujarat state in the close coordination of Dr. T.R. Ahlawat, Nodal Director of Research & Dean PGS, NAU, Navsari. I acknowledge their contribution and congratulate them for coming out with this excellent document.

Jay Jawan, Jai Kisan, Jay Jay Garvi Gujarat

Date : 20-07-2022
Navsari

(Z. P. Patel)

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Message

Curricula improvement is a continued process for upgrading national agricultural education system. The Indian Council of Agricultural Research (ICAR) has been continuously striving to bring necessary reforms for quality assurance in agricultural education. Therefore, the council has constituted a National Core Group (NCG) for development of Academic Regulations for Masters' and Ph.D. programmes by revision of syllabi every now and then. On the recommendations of the NCG, 19 Broad Subject Matter Area (BSMA) Committees were constituted for revising the syllabus in consultation with all the stakeholders to meet the challenges and harness opportunities in various disciplines of agriculture and allied sciences. It is obvious that a paradigm shift is necessary in academic regulations to comply with various provisions of the National Education Policy-2020. Hence, due care has been taken and flexible, multi-disciplinary and holistic approach have been followed while restructuring the syllabi to provide quality higher education. Major emphasis of the revision in the curricula is to enable an individual to study specialized areas of interest in depth and also to develop intellectual curiosity, scientific temper and creativity. Opportunities have also been given to the students/individuals to select the courses to support their planned academic activities, to register for online courses and to pursue internship for development of entrepreneurship during Masters' programme. Moreover, the concept of Teaching Assistantship has been introduced to provide experience to the Ph.D. scholars on teaching, evaluation and other related academic activities. Upon intensive discussion with the subject experts and on the basis of feedback from the faculties and students, the syllabus of Masters' and Doctoral programmes in various disciplines are restructured and new courses introduced. The syllabus has been revised suitably with the view to equip the students to gain knowledge, enhance their employability and entrepreneurial skills and build themselves to prepare for global competitiveness.

The adoption of the new and restructured Post Graduate curricula and syllabi as recommended by ICAR is to be adopted by all the state Agricultural Universities. The revised curricula and syllabi contains lecture schedule for both theory and practical of various courses, list of relevant reference books, list of related journals and websites for the benefit of students and teachers. I appreciate the endeavour made by the faculty and all the contributors for giving their valuable inputs and for preparing the syllabi for bright future of the students.

Date : 27-07-2022
Sardarkrushinagar

(R. M. Chauhan)

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Message

Indian Agriculture is evolving and advancing adopt against a variety of challenges and problems. The scientists of one of the world's largest National Agricultural Research System (NARS) including ICAR institutes and State Agricultural Universities (SAUs) are working hard to ensure the sustainable growth of the Indian agriculture despite these challenges. The Indian Council of Agricultural Research (ICAR) constituted 19 BSMA (broad subject matter area) committees with eminent agricultural scientists, academics, and subject matter specialists and revised the Post Graduate syllabus of Agriculture, and allied sciences in India so that the students can equip themselves with knowledge of recent developments and future technologies. According to the Ancient Indian Vedic Education System "The basic aim of all training, whether literary or vocational, should be to make the student fit to become a useful member of society". The State Agricultural Universities of Gujarat are always working on the same concept by leading in the country to take the challenge to implement the modern education system as well as syllabus. I am glad to know that the publication on "BSMA syllabus for SAUs of Gujarat" has been prepared for revision and restructuring of Post-graduate and Doctoral syllabi as per recommendation of ICAR-BSMA along with consideration of local need. The adoption of BSMA syllabus will make the competent PG students of SAUs of Gujarat to fall into step with knowledge of modern and emerging technologies. I convey my gratitude to all the members of various BSMA committees for SAUs of Gujarat for their fruitful inputs. I complement the efforts of Director of Research and Dean, PG Studies of Navsari Agricultural University, Navsari for compilation of this report to ensure timely implementation of BSMA in SAUs of Gujarat and also to his counter parts at JAU, AAU and SDAU.

Date : 23-07-2022
Junagadh

(Naredra Kumar Gontia)

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Message

Review and revision in curriculum are imperative means not only to modify the program, but also enable teachers to espouse the ways curriculum interacts with learners in a real education milieu. It becomes more valued for post graduate programs in agricultural streams, as it takes care of interests/abilities of both the learners and teachers. The key paybacks remain elimination of needless contents, introduction of latest/updated smart methods of teaching, newer content/knowledge/practices, better connectiveness across students' theory courses and learning practices, and object-based learning experiences with recent technological impacts.

ICAR and SAUs are incessantly striving to fetch essential reforms in this direction for quality assurance in higher agricultural education. Based upon rigorous efforts from National Core Group and 19 Broad Subject Matter Area (BSMA) Committees (casing 79 disciplines), revision and restructuring of Post-graduate and Doctoral syllabi has been successfully attained by having fruitful consultation with all the stakeholders to harness opportunities across various disciplines of agriculture and allied sciences. It will certainly cater the need of paradigm shift in academic regulations to comply with various provisions of recently implemented National Education Policy-2020. It looks very pleasing to realize that the respective Committees have taken due care by adhering towards core functional elements of NEP-2020; namely flexibility, multi-disciplinary/holistic approach, better options on elective courses, online courses, internship /entrepreneurship elements. Added attractive ingredients are the teaching-assistantship for Ph.D. scholars, equipping students to attain skillful knowledge & employability with global competitiveness.

I wish to extend my heartful complement and best wishes for ICAR authorities as well as expert faculty members involved with different BSMA committees for their useful efforts. It is certainly going to be a path providing document for guiding demand driven quality PG education across various agricultural and allied disciplines in ICAR-SAU system. My specific and deep sense of gratitude goes to the Vice Chancellors of other 3 SAUs as well as Deans, Directors, Professors, Heads, faculty members and students at four SAUs of Gujarat who contributed nicely by their effective participation and interaction.

Date : 25-07-2022
Anand

(K. B. Kathiria)

NAVSARI AGRICULTURAL UNIVERSITY

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Preface

It is indeed awesome that our agriculture and allied education system has been in the coziest hand since its instigation. The resonance of this is well echoed through the series of incredible revolutions in agriculture which have been true architecture of economic and social structure of the nation. Looking at the burgeoning population and multiple challenges to the society, we need to stretch out to a greater strength to ensure perpetual prosperity. Recently government introduced National Education Policy-2020 which shall usher in a paradigm shift in the education system. Accordingly, ICAR, New Delhi constituted a National Core Group (NCG) and 19 Broad Subject Matter Area (BSMA) Committees for restructuring of Master's and Ph.D. curriculum, syllabi and academic regulations for the disciplines under agricultural sciences. SAUs of Gujarat are passionate to bring necessary reforms to assure the admirable education to their apprentices and aspirants.

We are indeed fortunate that Navsari Agricultural University, Navsari got a chance to serve as Nodal Institute to coordinate the implementation of various recommendations of the recommendation of BASMA in all the disciplines of SAUs under the dynamic leadership of Hon Vice Chancellor Dr. Z.P. Patel. We had three tiers system for the refinement of the same, where in the first subject specialists of all the SAUs in the chairmanship of identified convener thoroughly studied and recommended suggestions, which were further discussed at the university level and recommended. Finally we had a meeting at NAU, Navsari and finalized all the suggestions in the presence of all the Vice Chancellors, Director of Research & Dean PGS, Deans and Principals of various faculties of all the SAUs. I am indeed very much grateful to the all the Hon Vice Chancellors, Dr. Z. P. Patel (NAU, Navsari), Dr. K. B. Kathiria (AAU, Anand), Dr. R. M. Chauhan (SDAU, Dantiwada), Dr. N. K. Gontia (JAU, Junagadh) for showing confidence in me and my predecessor Dr. S. R. Chaudhary. I sincerely admire the help and guidance received from my counterparts Dr. M. K. Jhala (AAU, Anand), Dr. B. S. Deora (SDAU, Dantiwada) and Dr. D. R. Mehta (JAU, Junagadh) for their superb support. I am also thankful to all the staff members of the office of Director of Research & Dean PGS for their wonderful support in various activities of coordinating and compiling.

The commitment and cooperation of all the conveners, Deans & Principals, Registrars of all the SAUs of Gujarat is sincerely acknowledged.

I hope these curriculum, syllabi and academic regulations would come out true to its anticipated benefits to various provisions of National Education Policy-2020.

Date : 22-07-2022
Navsari

(T. R. Ahlawat)


कृषिमूला सृष्टिः
NAVSARI AGRICULTURAL UNIVERSITY


कृषिमित् कृषस्व


॥ कृषिमूलम जगत् सर्वम् ॥


AAU
कृणवन्तो राष्ट्रं कृषि संपन्नम्


भाकृअनुप
ICAR

Contents

Forest Biology and Tree Improvement

Course Titles with Credit Load M.Sc. in Forest Biology and Tree Improvement

Course Code	Course Title	Credit
Major Courses		
FBT 501 *	Applied Forest Tree Improvement	2+1
FBT 502	Forest Ecology and Biodiversity Management	2+1
FBT 503*	Breeding Methods in Forest Trees	2+1
FBT 504	Reproductive Biology of Forest Trees	2+1
FBT 505	Tree Seed Orchards	2+1
FBT 506*	Quantitative Genetics in Forest Tree Breeding	2+1
FBT 507	Forest Genetic Diversity and Conservation	3+0
FBT 508*	Biotechnology in Forestry	2+1
FBT 509	Clonal Forestry	2+0
FBT 510	Forest Ecophysiology	2+1
FBT 511	Physiology of Woody Plants	2+1
FBT 512	Breeding for Insect Pest and Disease Resistance in Trees	2+1
FBT 513	Tree Seed Technology	2+1
Minor Courses		
	Courses from Silviculture and Agroforestry or Forest Products and Utilization or Forest Resource Management	06
Supporting Courses		
FOR 511*	General Statistical Methods and Computer Applications	2+1
	Note: The student may choose the above mentioned Supporting Course or other courses provided the opted courses are related to the research problem selected by the student and be mandatorily approved by the Student Advisory committee/HOD".	

FBT 591*	**Master's Seminar**	**1+0**
ii) Thesis Research		
FBT 599	**Master's Research**	**0+30**

***Compulsory Core Courses**

Course Contents

FBT 501 APPLIED FOREST TREE IMPROVEMENT 2+1

Objective

To acquaint the students about general principles of tree breeding with examples of important trees.

Theory UNIT I

General concept of forest tree breeding, tree improvement and forest genetics.

UNIT II

Reproduction in forest trees, dimorphism, pollination mechanism. Pollen dispersal, pollinators. Attractants for pollinators

UNIT III

Variation in trees, importance and its causes. Natural variations as a basis for tree improvement. Geographic variations – Ecotypes, clines, races and land races.

UNIT IV

Selective breeding methods- mass, family, within family, family plus within family. Plus tree selection for wood quality, disease resistance and agroforestry objectives. Selection strategies and choice of breeding methods and progress in selective breeding in forest trees.

UNIT V

Seed orchards – type, functions and importance,Genetic testing- mating designs and field designs. Progeny and clone testing estimating genetic parameters and genetic gain, clonal and breeding values. Average performance of half sibs and full-sibs. GxE interaction in trees.

UNIT VI

Heterosis breeding: inbreeding and hybrid vigour. Manifestation and fixation of heterosis. Species and racial hybridization. Indian examples – teak, shisham, eucalypts, acacias, poplar etc.

UNIT VII

Polyploidy, aneuploidy and haploidy in soft and hard wood species. Induction of polyploidy.

UNIT VIII

Elements of biotechnology in tree improvement.

Practical

Floral biology, modes of reproduction and modes of pollination in forest trees. Estimating pollen viability. Controlled pollination and pollen handling. Manipulation of flowering through hormones. Identification of ecotypes, races and land-races in natural forest. Visit to species, provenance and progeny trials. Selection of superior phenotypes. Marking of candidate trees, plus trees and elite trees. Visit to seed orchards. Comparison of parents and their putative hybrids. Induction of polyploidy through colchicine treatment. *In vitro* propagation, Molecular markers.

Suggested Readings

Dutta M and Saini GC. 2009. *Advances in Forestry Research in India*, Vol. XXX. Forest Tree Improvement and Seed Technology. International Book Distributors.

Finkeldey R and Hattemer HH. 2006. *Tropical Forest Genetics*. Springer.

Mandal AK and Gibson GL. (Eds). 1997. *Forest Genetics and Tree Breeding*. CBS. Sedgley M and Griffin AR. 1989. *Sexual Reproduction of Tree Crops.* Academic Press.

Surendran C, Sehgal RN and Paramathma M. 2003. *Text Book of Forest Tree Breeding*. ICAR. White TL, Adams WT and Neale DB. 2007. *Forest Genetics*. CABI, UK.

Wright JW. 1976. *Introduction to Forest Genetics*. Academic Press.

Zobel BJ and Talbert J. 1984. *Applied Forest Tree Improvement*. John Wiley and Sons.

Lecture schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	General concept of forest tree breeding, tree improvement and forest genetics	1
2	Reproduction in forest trees - dimorphism, pollination mechanism, pollen dispersal, pollinators, attractants for pollinator	5
3	Variation in trees importance and its causes. Natural variation as a basis for tree improvement. Geographic variations – ecotypes, clines, races and land races	2
4	Plus tree selection for wood quality, disease resistance and agroforestry objectives	2
5	Selective breeding methods- mass, family, within family, family plus within family	2
6	Selection strategies and choice of breeding methods and progress in selective breeding in forest trees	2
7	Progeny and clone testing. Estimating genetic parameters and genetic gain Clonal and breeding values	2
8	Seed orchards – type, functions and importance, Genetic testing- mating designs and field designs	2
9	Average performance of half sibs and full sibs, GxE interaction in trees	2
10	Heterosis breeding: inbreeding and hybrid vigour Manifestation and fixation of heterosis. Species and racial hybridization. Indian examples – teak, sal, shisham, eucalypts, acacias, pines and poplars	3
11	Polyploidy, aneuploidy and haploidy in soft and hard wood species.Induction of polyploidy	2
12	Mutation breeding	2
13	Elements of Biotechnology in tree improvement	5
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Floral biology, modes of reproduction and modes of pollination in forest trees	2
2	Estimating pollen viability. Controlled pollination and pollen handling	2
3	Manipulation of flowering through hormones	2
4	Identification of ecotypes, races, and land-races in natural forest	1
5	Visit to species, provenance and progeny trials	1
6	Selection of superior phenotypes. Marking of candidate trees, plus trees and elite trees	1
7	Visit to seed orchards	1
8	Comparison of parents and their putative hybrids	1
8	Induction of polyploidy through colchicine treatment	1
9	In vitro propagation	2
10	Study of molecular markers	2
	Total	**16**

FBT 502 FOREST ECOLOGY AND BIODIVERSITY MANAGEMENT 2+1

Objective

To develop understanding among students about ecological aspects of forest, conservation of forest resources and biodiversity, consequences of depleting biodiversity and concept of sustainability.

Theory

UNIT I

Hierarchy issues in ecology and ecosystem.Advanced topics in forest ecology including forest population, forest community dynamics, forest community structure and analysis, forest productivity, ecology of forest landscapes spatial heterogeneity and ecological succession

UNIT II

Conservation of natural resources (hotspot areas, wildlife sanctuaries, national parks, biosphere reserve). Climate change, Global warming and forests. Green house effect and its consequences. Ozone depletion. Conservation laws and acts. Forest genetics resources of India: timber and non timber species. Survey exploration and sampling strategies Phytogeography and vegetation types of India.

UNIT III

Documentation and evaluation of forest genetical resources (FGR), *in situ* and *ex situ* conservation of gene resources. Phytodiversity and its significance to sustainable use. Handling and storage of FGR. Intellectual property rights. Quarantine laws and FGR exchange.

Practical

Study of forest community structure and its successional status, Estimation of productivity of forest ecosystem. Study tours to different regions of the state to study forest vegetation, Collection

and preservation of specimen, Methods of vegetation analysis. Measurement of biomass and productivity. Quantification of litter production and decomposition, Visit to national parks, wildlife sanctuaries. Botanical gardens and arboreta.

Suggested Readings

Burton V Barnes, Donald R Zak, Shirley R Denton, Stephen H Spurrs. 1998. *Forest Ecology*. Wiley.

David A Perry, Ram Oren and Stephen C Hart. 2008. *Forest Ecosystems*. 2nd ed. Baltimore: Johns Hopkins University Press.

Grzegorz Mikusiński , Jean-Michel Roberge Robert Fuller , 2018. *Ecology and Conservation of Forest Birds (Ecology, Biodiversity and Conservation)*.Cambridge University Press.

Guy R Larocque. 2016. *Ecological Forest Management Handbook (Applied Ecology and Environmental Management*). Taylor & Francis.

Jha BC, Pandey BN, Jaiswal K, Katiha PK, Pandey PN, Sharma AP. 2012. *Biodiversity: Issues Threats and Conservation.* Narendra Publishing House, Delhi.

Kumar Biju. 2013. *Biodiversity and Taxonomy*. Narendra Publishing House, Delhi.

Mahato B, Pandy BN, Singh LB, Panday PN, Singh RK. 2010. *Text Book of Environmental Pollution*. Narendra Publishing House, Delhi.

Pandey PN. 2009. *Biodiversity and Environment Ecology*. Narendra Publishing House, Delhi. Raymond A Young and Ronald L Giese. 2003. *Introduction to Forest Ecosystem Science and Management*.

Wiley. Thomas Eugene Avery and Harold Burkharts. 2001. *Forest Measurements.* McGraw-Hill Education.

Theory

Lecture Schedule

Sr. No.	Topic	No. of Lecture (s)
1	Hierarchy issues in ecology and ecosystem	3
2	Advanced topics in forest ecology including forest population, forest community dynamics, forest community structure and analysis	3
3	Forest productivity, ecology of forest landscapes spatial heterogeneity and ecological succession	3
4	Conservation of natural resources (hotspot areas, wildlife sanctuaries, national parks, biosphere reserve)	3
5	Climate change, global warming and forests. Green house effect and its consequences	2
6	Ozone depletion. Conservation laws and acts	2
7	Forest genetics resources of India: timber and non timber species	3
8	Survey exploration and sampling strategies Phytogeography and vegetation types of India	2
9	Documentation and evaluation of forests genetical resources (FGR)	2
10	*In situ* and *ex situ* conservation of gene resources	3
11	Phytodiversity and its significance to sustainable use. Handling and storage of FGR	3
12	Intellectual property rights	2
13	Quarantine laws and FGR exchange	2
	Total	**33**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Study of forest community structure and its successional status	2
2	Estimation of productivity of forest ecosystem	2
3	Study tours to different regions of the state to study forest vegetation	2
4	Collection and preservation of specimen	2
5	Methods of vegetation analysis	2
6	Measurement of biomass and productivity	2
7	Quantification of litter production and decomposition	2
8	Visit to national parks, wildlife sanctuaries, botanical gardens and arboreta	2
	Total	**16**

FBT 503 BREEDING METHODS IN FOREST TREES 2+1

Objective

To acquaint the students about the concepts of sub-selection, population structure for breeding and production, genetic testing and making designs.

Theory

UNIT I

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.

UNIT II

Long-term and short-term breeding populations. Selective breeding methods- mass, family, within family, family plus within family. Grading system of plus trees in natural stands and plantations selection index, regression systems, mother tree selection and subjective evaluation. Selection for different traits.

UNIT III

Genetic testing programmes – mating designs, complete designs – nested designs, factorial, single pair mating, full diallel, half diallel and partial diallel, incomplete pedigree designs – open pollinated mating and polycross mating. Improvement through progeny testing.

UNIT IV

Experimental designs in genetic testing. Breeding methods for wood quality, diseases and pest resistance, drought and salt resistance. Testing procedures for genetic advancement. Marker assisted selection.

UNIT V

Tree improvement case histories.

Practical

Half-sib, full-sib family in trees. Grading system of plus trees in natural stands. Mating designs, complete pedigree designs – nested designs, factorial, single pair mating, full diallel, half diallel and partial diallel, incomplete pedigree designs – open pollinated mating and polycross mating. Selection for biotic and abiotic stresses.

Suggested Readings

Acquaah G. 2012. *Principal of Plant Genetics and Breeding*. John Wiley & Sons, Ltd, UK. Falconer DS and Mackay TFC. 1995. *Introduction to Quantitative Genetics*. 4th edition. Longman, Essex

Mandal AK and Gibson GL. 2002. *Forest Genetics and Tree breeding*. CBS Publishers Namkoong G, Kang HC and Brouard JS 1988. *Tree breeding: Principles and Strategies*. Springer Verlag, New York.

Surendran C, Sehgal RN and Parmathama M. (Eds.). 2003. *A Text Book of Forest Tree Breeding*. ICAR.

White TL and Hodge GR 1989. *Predicting Breeding Values with Applications in Forest Tree Improvement.* Kluwer Academic Publishers, Boston.

White TL, Adams WT and Neale DB. 2007. *Forest Genetics*. CABI Wright JW. 1962. *Genetics of Forest Tree Improvement*. Academic Press. Wright JW. 1976. *Introduction to Forest Genetics*. Academic Press.

Zobel BJ and Talbert J. 1984. *Applied Forest Tree Improvement*. John Wiley and Sons.

Theory

Lecture Schedule

Sr. No.	Topic	No. of Lecture (s)
1	Introduction	1
2	Hardy-Weinberg equilibrium, changes in gene frequency through selection, migration, mutation and population sizes	5
3.	Grading system of plus trees in natural stands and plantations regression systems, mothertree selection, subjective evaluation	2
4.	Selective breeding methods-mass, family, within family, family plus within family	2
5.	Long-termand short-term breeding populations	4
6.	Genetic testing programmes–mating designs, Incomplete pedigree designs – open pollinated mating and polycross mating	2
7.	Complete designs (nested designs, factorial, single pairmating, full diallel, half diallel and partialdiallel)	2

9.	Marker assisted selection	2
10	Breeding methods for disease resistance	2
11.	Breeding methods for water stress	2
12.	Breeding methods for pest resistance	2
13.	Tree improvement case histories. Breeding strategy for pines and eucalyptus	4
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Grading system of plus trees in natural stands, plantation	1
2.	Mating designs	1
3.	Complete designs – nested designs	2
4.	Factorial	4
5.	Single pair mating	2
6.	Full diallel, Half diallel and Partial diallel	4
7.	Incomplete pedigree designs – open pollinated mating and polycross mating	2
	Total	16

FBT 504 REPRODUCTIVE BIOLOGY OF FOREST TREES 2+1

Objective

To impart the knowledge of reproduction in forest tree species to the students and to make them understand the mechanism of breeding and sex expression.

Theory

UNIT I

Importance and application of reproductive biology in tree breeding. Crop characteristics-growth and development (both vegetative and reproductive)

UNIT II

Floral diversity and pollination. Flower types pollination syndromes and their evolution. Plant – pollinator systems. Diversity of pollination syndromes in selected plant families. Modes of reproduction-sexual, asexual and vegetative and their breeding systems and sex expression, monoecy, dioecy and its evolution.

UNIT III

Floral attractants and rewards biology of floral and extrafloral nectaries examples of plant insect interactions involving pollination. Floral characteristics of the main pollination syndromes.

UNIT IV

Environmental effects on sex expression. Floral biology initiation and development. Modes of pollination self and out-crossing.

UNIT V

Fertilization in hardwood and softwood species. Seed dispersal and gene flow.

Practical

Sex expression in forest trees. Out crossing mechanisms in forest trees. Measurement of pollen flow in wind-pollinated and insect-pollinated species. Pollen viability and fertility. Seed dispersal mechanism.

Suggested Readings

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.*

Cláudia Inês da Silva and Helena Maura Torezan Silingardi. 2006. *Reproductive Biology of Tropical Plants* - International Commission On Tropical Biology and Natural Resources. Encyclopedia of Life Support Systems (EOLSS)

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).

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Importance and application of reproductive biology in tree breeding	1
2	Crop characteristics-growth and development (both vegetative and reproduction)	4
3	Floral diversity and pollination. Flower types : Pollination syndromes and their evolution; Plant – pollinator systems, Diversity of pollination syndromes in selected plant families	4
4	Modes of reproduction: sexual, asexual and vegetative and their breeding systems and sex expression, monoecy, dioecy and its evolution	5
5	Environmental effects on sex expression	3
6	Floral biology. Initiation and development. Modes of pollination; self and out-crossing	3
7	Floral attractants and rewards; Biology of floral and extra floral nectarines; Examples of plant insect interactions involving pollination. Floral characteristics of the main pollination syndromes	5
8	Fertilization in hardwood and softwood species	3
9	Seed dispersal and gene flow	4
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Sex expression in forest trees	2
2.	Out crossing mechanisms in forest trees	3
3.	Measurement of pollen flow in wind-pollinated and insect-pollinated species	3
4.	Pollen viability and fertility	2
5	Seed dispersal mechanism	3
6	Study of reproductive biology of Eucalyptus, Pine, Shishum etc.	3
	Total	**16**

FBT 505 **TREE SEED ORCHARDS** **2+1**

Objective

To develop understanding among students about tree seed orchards.

Theory

UNIT I

Importance of genetically improved seed in plantation forestry. Status of seed production among major plantation species. Short term supply of superior seed.

UNIT II

Selection and delineation of seed stands, seed production areas, seed zones, seed ecological zones.

UNIT III

Seed orchard: need, evolving seed orchards, containerized seed, hybrid and research seed orchards; first, second and advanced generation seed orchards. Seed orchard genetics: random mating, gamete exchange and parental balance. Estimation of genetic parameters from seed orchard data. Ortet age and its effect on seed production.

UNIT IV

Importance of progeny testing. Establishment of seed orchards, selection and preparation of orchard site, isolation, orchard size, and designs. Seed orchard management: rouging, silvicultural practices to increase seed yield.

UNIT V

Pest and disease management. Seed collection and record keeping, seed orchard registration and documentation. Importance of seed orchards in gene conservation.

Practical

Visits and study of seed orchard designs. Estimation of overlap in flowering among genotypes. Study of inter and intra-clonal variation in floral, seed characters. Effect of girdling on flowering. Plant growth regulator application for flower induction. Pollen viability/fertility. Assessment of pollen dispersal. Supplemental mass-pollination. Effects of foliar application of fertilizers on seed set. Estimation of genetic parameters for a few traits. Estimation of parental balance.

Suggested Readings

Faulkner R. 1975. *Seed Orchard* Forestry. Commission Bull. No. 34.

Fins L, Friedman ST and Brotschol JV. 1992. *Handbook of Quantitative Forest Genetics*. Kluwer. Khosla PK. 1981. *Advances in Forest Genetics*. Ambika Publ., New Delhi.

Mandal AK and Gibson GL. (Eds.). 1997. *Forest Genetics and Tree Breeding*. CBS. Nanson A. 2004. *Genetics of Forest Tree Breeding*. Agronomic Press

Surendran C, Sehgal RN and Parmathama M. (Eds.). 2003. *A Text Book of Forest Tree Breeding*. ICAR.

Wright JW. 1976. *Introduction to Forest Genetics*. Academic Press.

Zobel BJ and Talbert J. 1984. *Applied Forest Tree Improvement*. John Wiley & Sons.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1.	Importance of genetically improved seed in plantation forestry	1
2.	Status of seed production among major plantation species	2
3.	Short term supply of superior seed	1

4.	Selection and delineation of seed stands, seed production seed zones, seed ecological zones areas,	4
5	Seed orchard: need, evolving seed orchards, containerized seed, hybrid and research seed orchards; first, second and advanced generation seed orchard. Seed orchard genetics: random mating, gamete exchange and parental balance	6
6	Estimation of genetic parameters from seed orchard data. Ortet age	3
7	Importance of progeny testing and its effect on seed production	2
8	Establishment of seed orchards, selection and preparation of orchard site, isolation, orchard size, and designs	4
9	Seed orchard management: rouging, silvicultural practices to increase seed yield. Supplemented mass pollination. Pest and disease management. Seed collection and record keeping, seed orchard registration and documentation	5
10	Importance of seed orchards in gene conservation	2
11	Status of seed production among major plantation species	
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Grading system of plus trees in natural stands, plantation	1
2	Visits and study of seed orchard designs.	2
3	Estimation of overlap in flowering among genotypes.	2
4	Study of inter and intra-clonal variation in floral and seed characters.	2
5	Effect of girdling on flowering.	2
6	Plant growth regulator application for flower induction.	2
7	Pollen viability/fertility.	1
8	Assessment of pollen dispersal.	2
9	Supplemental mass-pollination.	2
10	Effects of foliar application of fertilizers on seed set.	1
	Total	**16**

FBT 506 QUANTITATIVE GENETICS IN FOREST TREE BREEDING 2+1

Objective

To impart knowlewge in the field of biometry as applied to breeding, population, provinces and making experiment in forest genetics and tree breeding.

Theory

UNIT I

Historical aspects of quantitative genetics. Inheritance of continuously varying characters, Genetic variance and its partitioning, models of gene action. Multiple factor hypothesis (Nilsson-Ehle (1908) and East (1915) experiments.

UNIT II

Mating systems, population structure in random mating. Hardy Weinberg law, Effect of selection, mutation, migration, genetic drift; on genes and genotypic frequency.

UNIT III

Inbreeding, effects of inbreeding in various populations. Heterosis, causes of heterosis and its utility in

various plants.

UNIT IV

Significance and estimation of genetic variance components. Heritability, its estimation by various methods and significance.

UNIT V

Natural selection, fundamental theorem of natural selection (Fisher 1930). Selection responses. Correlation and its utility. Partitioning of correlation into direct and indirect effects.

UNIT VI

Mating design, combining ability, general and specific combining ability and methods of its estimation.

UNIT VII

Genotypic x environment interaction, its significance. Various procedures for the estimation of genotypic x environment interaction.

Practical

Exercise on polygenic inheritance. Proof that quantitative characters are inherited in Mendelian fashion, estimation of genotypic and phenotypic variance in an experiment, estimation of additive and dominance components of variance through various procedures, mating designs and estimation of components of genetic variance, proof of population genetics law, exercise on calculation of gene and genotypic frequency, estimation of heterosis, estimation of heritability (broad sense and narrow sense) by various methods, genotypic and phenotypic correlation coefficients, partitioning of correlation into direct and indirect effects, estimation of general combining ability and specific combining ability, estimation of genotypic x environment interaction.

Suggested Readings

Acquaah G. 2012. *Principal of Plant Genetics and Breeding*. John Wiley & Sons, Ltd, UK. Kute N and Shinde G. 2016. *Principles of Biometrical Genetics*. Daya publishing.

Fins Lauren, Friedman ST, Brotschol JV. (Eds.). 1992. *Handbook of Quantitative Forest Genetics.*

Springer, Netherlands.

Gene Namkoong. 1979. *Introduction to Quantitative Genetics In Forestry. Technical Bulletin No. 1588.* Forest Service United States Department of Agriculture Washington,D. C.

Singh RK and Chaudhary BD. 1985. *Biometrical Methods in Quantitative genetical Analysis.*

Kalyani Publishers, New Delhi.

Theory
Lecture Schedule

Sr. No.	Topic	No. of Lecture (s)
1.	Historical aspects of quantitative genetics	1
2.	Genetic variance and its partitioning, models of gene action	3
3.	Inheritance of continuously varying characters	2
4.	Multiple factor hypothesis (Nilsson-Ehle (1908) and East experiments (1915)	2
5.	Mating systems, population structure in random mating	3
6	Hardy Weinberg law, effect of selection, mutation, migration, genetic drift: on genes and genotypic frequency	3
7	Inbreeding, effects of inbreeding in various populations	2
8	Heterosis, causes of heterosis and its utility in various plants	2

9	Significance and estimation of genetic variance components. Heritability, its estimation by various methods and significance	2
10	Natural selection, fundamental theorem of natural selection (Fisher 1930)	2
11	Selection responses. Correlation and its utility. Partitioning of correlation into direct and indirect effects	2
12	Mating designs	3
13	Combining ability, general and specific combining ability and methods of its estimation	2
14	Genotypic × environment interaction, its significance. Various procedures for the estimation of genotypic x environment interaction	3
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Grading system of plus trees in natural stands, plantation	1
2	Polygenic inheritance	2
3	Proof that quantitative characters are inherited in Mendelian fashion	1
4	Estimation of genotypic and phenotypic variance in an experiment through various procedures	2
5	Mating designs and estimation of additive and dominance components of variance components of genetic variance	3
6	Proof of population genetics law	1
7	Calculation of gene and genotypic frequency	1
8	Estimation of heterosis, estimation of heritability (broad sense and narrow sense) by various methods	2
9	Genotypic and phenotypic correlation coefficients, partitioning of correlation into direct and indirect effects	1
10	Estimation of general combining ability and specific combining ability	1
11	Estimation of genotypic x environment interaction	2
	Total	**16**

FBT 507 FOREST GENETIC DIVERSITY AND CONSERVATION 3+0

Objective

To provide the knowledge about the genetic diversity in forest tree species, their distribution, assess and analysis and methodologies of *in-situ* and *ex-situ* conservation.

Theory UNIT I

Phytodiversity-concept, levels ecosystem. Genetic diversity and differentiation-definition, characteristics and importance for tree breeding. Genetic erosion. Techniques to assess genetic diversity. Analysis of karyotypic variation.

UNIT II

Molecular approaches for assessing genetic diversity. Inventory and monitoring biodiversity: sampling strategies for genetic diversity assessments sufficiency of sampling procedures, neutral allele model and optimal allocation of sampling efforts.

UNIT III

Methods of sampling of genetic diversity. Factors influencing levels of genetic diversity in woody plant species. Conservation of genetic diversity Conservation biology & invasive species.

UNIT IV

Laws and policies. Methods for maintenance of conservation: gene banks, arboreta, botanical gardens, breeding populations as repositories of gene conservation. Rare, threatened biodiversity, endangered and endemise plants

UNIT V

Techniques for survey and assessment of endangered plants. Rarity patterns and endemism. Concept of island biogeography. Managing corridors and natural habitat fragments.

UNIT VI

Monitoring and recovery plans for endangered plants. Plant community reserves. Managing wild flora tourism impacts and eco tourism and urban forestry of rare/exotic plants. Implications of rarity.

Suggested Readings

Engles JMM, Rao VR Brown AHD and Jackson MT. 2002. *Managing Plant Genetic Diversity*. CABI & IPGRI.

FAO. 1985. *Forest Tree Improvement*, FAO Publication.

Fins L, Friedman ST and Brotschol JV. 1992. *Handbook of Quantitative Forest Genetics*. Kluwer. IPGRI. 2004. *Forest Genetic Resources Conservation and Management.* Vol. 1, 2 and 3.

Khosla PK. 1981. *Advances in Forest Genetics*. Ambika Publ., New Delhi.

Mandal AK and Gibson GL. (Eds.). 1997. *Forest Genetics and Tree Breeding*. CBS.

Surendran C, Sehgal RN and Parmathama M. (Eds.). 2003. *A Text Book of Forest Tree Breeding*. ICAR.

Wright JW. 1976. *Introduction to Forest Genetics*. Academic Press.

Zobel BJ and Talbert J. 1984. *Applied Forest Tree Improvement*. John Wiley and Sons.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Phytodiversity-concept, levels ecosystem	2
2	Genetic diversity and differentiation-definition, characteristics and importance for tree breeding	3
3	Genetic erosion. Techniques to assess genetic diversity	3
4	Analysis of karyotypic variation	2
5	Molecular approaches for assessing genetic diversity	3
6	Inventory and monitoring biodiversity	3
7	Sampling strategies for genetic diversity assessments sufficiency of sampling procedures	2
8	Neutral allele model and optimal allocation of sampling efforts	3
9	Methodsof sampling of genetic diversity	2
10	Factors influencing levels of genetic diversity in woody plant species	2
11	Conservation of genetic diversity conservation biology & invasive species	2
12	Laws and policies	2
13	Methods for maintenance of conservation: Gene banks, arboreta, botanical gardens, breeding populations as repositories of gene conservation	3

14	Rare, threatened biodiversity, endangered and endemise plants	1
15	Techniques for survey and assessment of endangered plants	3
16	Rarity patterns and endemism	2
17	Concept of island biogeography. Managing corridors and natural habitat fragments	2
18	Monitoring and recovery plans for endangered plants	2
19	Plant community reserves	2
20	Managing wild flora tourism impacts and eco tourism and urban forestry of rare/ exotic plants	2
21	Implications of rarity	2
	Total	**48**

FBT 508 BIOTECHNOLOGY IN FORESTRY 2+1

Objective

To impart knowledge about different aspects of biotechnology in forestry

Theory

UNIT I

Introduction. Cloning, need for cloning, problems with cloning. Traditional cloning techniques versus micro-propagation, prospects of micro-propagation in forestry. Techniques procedures and problems in micro propagation, case studies. Protocols for micro-propagation.Preconditioning of explants, surface sterilization, nutritional media, other environmental factors controlling micro- propagation, choice of explants for micro-propagation. Micro propagation of juvenile material. Micro propagation of mature trees. *In vitro* propagation of plants with low sexual reproduction rates, miscellaneous application.

UNIT II

Initiation and maintenance of callus. Organogenesis and somatic embryogenesis – factors influencing somatic embryogenesis-applications in forestry, Somatic seeds, encapsulation techniques. Somaclonal variation, genetic and epigenetic variation, exploitation in forestry. Cell suspension cultures. Anther and pollen cultures. Triploids through endosperm culture, embryo culture. Monoploid production by chromosome elimination. Applications of *In vitro* fertilization, isolation, purification and culture of protoplasts, protoplast fusion and somatic hybridization. Cryopreservation, storage of plant genetic resouces. Production of secondary metabolites by cell cultures. Meristem culture, virus free plants.

UNIT III

Genetic engineering - application in forestry Isozymes, restriction fragment length polymorphisms (RFLPs), randomly amplified polymorphic DNAs (RAPDs) and microsatellites. Genetic fingerprinting, Marker assisted selection. Different PCR techniques: their characteristics, with advantages and disadvantages.

UNIT IV

Quantification of genetic diversity, genotype verification and delineation. Introduction of genes. Promoters and marker genes. disease resistance, herbicide tolerance and tolerance to salt and other stresses.

Practical

Introduction to tissue culture lab. Aseptic techniques. Preparation of culture media,formulation of different culture media. Induction and maintenance of callus, regeneration of plants from callus, regeneration of plants from embryoids. Cell suspension culture, Micropropagation techniques. Anther and pollen culture. Quantification of tissue culture, Isolation and culture of protoplasts. Marker assisted RFLP in test trees. Study of PCR techniques used in tree improvement. Application of GENALEX 'bolt on' for excel, arlequin, PopGene and FSTAT for Wright's F- statistics and analysis of molecular variance (AMOVA).

Suggested Readings

Bajaj YPS. 1986. *Biotechnology in Agriculture and Forestry.* Springer Verleg, New York. Bonga JM and Durjan J. 1987. *Cell and Tissue Culture in Forestry Vol. I & II*. Martinus Nijost Publishers, Dordrecht.

Hainer R. 1996. *Biotechnology in Forest Tree Improvement*. (FAO Bulletin 1994) International Book Distributors. Dehra Dun.

Muchugi A, Kadu C, Kindt R, Kipruto H, Lemurt S, Olale K, Nyadoi P, Dawson I and Jamnadass R. 2008 *Molecular Markers for Tropical Trees, A Practical Guide to Principles and Procedures*. ICRAF Technical Manual no. 9. Dawson I and Jamnadass R. eds. Nairobi: World Agroforestry Centre.

Murphy TM and Thompson W F. 1988. *Molecular Plant Development*. Prentice Hall, Engleward, cliffe, New Jersey.

Russel GE. 1988. *Biotechnology of Higher Plants*. Intercept publishers, Nimborne, Dorset. Russell Haines. 1994. *Biotechnology in Forest Tree Improvement with Special Reference to Developing Countries*. Food and Agriculture Organization of the United Nations, Rome.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Prospects of micro-propagation in forestry	1
2	Techniques, procedures and problems in micro propagation - case studies	2
3	Protocols for micro-propagation, choice of explants for micro- propagation preconditioning of explants, surface sterilization, nutritional media - other environmental factors controlling micro- propagation	2
4	Micro propagation of juvenile material - Micro propagation of mature trees, In vitro propagation of plants with low sexual reproduction rates, miscellaneous application	2
5	Initiation and maintenance of callus, organogenesis and somatic embryogenesis, factors influencing somatic embryogenesis- applications in forestry, Somatic seeds, encapsulation techniques.	3
6	Somaclonal variation, genetic and epigenetic variation, exploitation in forestry	2
7	Cell suspension cultures, anther and pollen cultures, triploids through endosperm culture, embryo culture	2
8	Monoploid production by chromosome elimination	1
9	Applications of *In vitro* fertilization	1
10	Isolation, purification and culture of protoplasts, protoplast fusion and somatic hybridization	3
11	Cryopreservation, storage of plant genetic resources.	1
12	Production of secondary metabolites by cell cultures	2
13	Meristem culture - virus free plants	1
14	Genetic engineering - application in forestry,Isozymes, Restriction Fragment Length Polymorphisms (RFLPs), Randomly Amplified Polymorphic DNAs (RAPDs) and Microsatellites	3
15	Genetic fingerprinting, marker assisted selection. Different PCR techniques: their characteristics, with advantages and disadvantages.	3
16	Quantification of genetic diversity, genotype verification and delineation	2
17	Introduction of enes, Promoters and marker genes. Disease resistance, herbicide tolerance and tolerance to salt and other stresses	2
	Total	**33**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Introduction to tissue culture lab	1
2	Micropropagation :Aseptic techniques, Preparation of culture media, Formulation of different culture media, explants inoculation, subculture and *in vitro* rooting	4
4	Induction and maintenance of callus, regeneration of plants from callus	
5	Cell suspension culture	2
6	Anther and pollen culture	2
7	Isolation and culture of protoplasts	2
8	Study of PCR techniques used in tree improvement. Testing of clonal fidelity through molecular markers	3
9	Application of GENALEX 'bolt on' for Excel, Arlequin, PopGene and FSTAT for Wright's F-statistics and Analysis of Molecular Variance (AMOVA)	2
	Total	**16**

FBT 509 CLONAL FORESTRY 2+0

Objective

To provide information about genetics, conservation, biotechnological approaches for trees in clonal forestry system for higher biomass/yield productivity

Theory

UNIT 1

Introduction to Clonal Forestry. History of clonal forestry. Clonal propagation. Clonal planting. Strategies for clonal forestry for higher productive potential.

UNIT II

Juvenility and maturation, rejuvenation and maintainance, regulation of phase changes, markers of phase changes. Breeding strategies using vegetative propagation- selection and breeding for extreme genotypes. Physiological research for higher productivity of clonal forest. Field design, testing and evaluation of clones. Genetic gains from breeding with clonal option. Clonal conservation approaches- management of populations for genetic diversity and gain.

UNIT III

Biotechnological approaches for clonal forestry, Plant tissue culture, micropropagation, Rejuvenation of tissues from mature trees, Testing of Clonal fidelity using molecular markers.

Suggested Readings

Ahuja MR and Libby WJ. 1993. Clonal Forestry I Conservation and Application. Springer Ahuja MR. 1992 Micropropagation of Woody Plants: Volume 41 (Forestry Sciences). Springer AhujaMR and LibbyWJ. 1993. Clonal Forestry II Genetics and Biotechnology. Springer Mandal AK and Gibson GL. 2002. Forest Genetics and Tree Breeding. CBS Publishers, New Delhi

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Introduction to clonal forestry; History of clonal forestry	2
2	Clonal propagation	4
3	Clonal planting, strategies for clonal forestry for higher productive potential	2

4	Juvenility and Maturation, rejuvenation and maintainance, regulation of phase changes, markers of phase changes	3
5	Breeding strategies using vegetative propagation- selection and breeding for extreme genotypes	4
6	Physiological research for higher productivity of clonal forestry.	3
7	Field design, testing and evaluation of clones	3
8	Genetic gains from breeding with clonal option. Clonal conservation approaches-management of populations for genetic diversity and gain	4
9	Biotechnological approaches for clonal forestry- plant tissue culture-micropropagation	3
10	Rejuvenation of tissues from mature trees	2
11	Testing of clonal fidelity using molecular markers	2
	Total	**32**

FBT 510 FOREST ECOPHYSIOLOGY 2+1

Objective

To under stand dynamics of forest ecosystem and role of stress in forest productivity.

Theory

UNIT I

Forest environment interactions, Forest ecosystems, Geographic and climatic factors. Environmental factors influencing forest growth and productivity. Sun and shade plants.

UNIT II

Influence of temperature, water stress and nutrient availability and disturbance in the forest on tree growth and forest productivity.

UNIT III

Dynamics of forest ecosystems, energy, productivity and biomass. Decomposition and nutrient cycling.

UNIT IV

Stand structure and micro-climate, energy relationships canopy energy balance. Partitioning absorbed energy. Radiation penetration into and absorption by canopies. Air temperature and humidity in forests. Turbulent transfer process above forests.

UNIT V

Transpiration and evapotranspiration from forest canopies. Estimation of ET.

UNIT VI

Stress - avoidance and tolerance mechanisms. Temperature stress – low temperature stress - physiology of resistance to frost. Heat stress, heat injury, heat avoidance and tolerance mechanism. Radiation stress, mechanism of shade tolerance, water logging, physiology of resistance to water logging. Drought stress, salt and ion stress.

Practical

Morphological, anatomical and physiological variations between sun and shade plants, Estimation of leaf area, LAI, Estimation of biomass production of trees of different species, Estimation of microclimatic elements as influenced by stand structure, Estimation of evapotranspiration, Measurement of radiation in different types of forest and agroforestry systems.

Suggested Readings

Kozlowski TT, Kramer PJ and Pallardy GS. 1991. *The Physiological Ecology of Woody Plants.*

Academic Press, New York.

Kramer PJ. 1972. *Plant and Soil Water Relationships*. TMH Edition, Tata McGraw Hill Publ. Co., New Delhi.

Ksenzhek OS and Volkov AG. 1998. *Plant Energetics*. Academic Press, New York.

Lack AJ and Evans DE. 2001. *Plant Biology- Instant Notes*. Vina Books Pvt. Ltd., New Delhi. Lambers H, Chaplin FS and Pons TL. 1998. *Plant Physiological Ecology*. Springer, New York Larcher W. 2003. *Physiological Plant Ecology*. 4th edn, Springer-Verlag, Germany

Luttge U. 2008. *Physiological Ecology of Tropical Plants*. Springer-Verlag, Germany

Moore TC. 1989. *Biochemistry and Physiology of Plant Hormones*, 2nd ed. Springer Verlag, Berlin.

Taiz L and Zeiger E. 2007. *Plant Physiology*, 4th ed. Sinauer Associates Inc. Publishers, Sunderland.

Wilkins B M. 1984. *Advanced Plant Physiology*. ELBS/ Longman Pub. Co.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Forest environment interactions, forest ecosystems, geographic and climatic factors. Environmental factors influencing forest growth and productivity. Sun and shade plants	3
2	Influence of temperature, water stress and nutrient availability and disturbance in the forest on tree growth and forest productivity	3
3	Dynamics of forest ecosystems, energy, productivity and biomass. Decomposition and nutrient cycling	3
4	Stand structure and micro-climate, energy relationships, Canopy energy balance. Partitioning absorbed energy	3
5	Radiation penetration into and absorption by canopies. Air temperature and humidity in forests. Turbulent transfer process above forests	3
6	Transpiration and evapotranspiration from forest canopies, Estimation of ET	3
7	Stress - avoidance and tolerance mechanisms	2
8	Drought stress	3
9	Temperature stress, low temperature stress, physiology of resistance to frost	3
10	Heat stress, heat injury, heat avoidance and tolerance mechanism	3
11	Radiation stress - mechanism of shade tolerance	1
12	Water logging, physiology of resistance to water logging	1
13	Salt and ion stress	2
	Total	**33**

Practical

Sr. No	Topic	No. of Practical (s)
1	Morphological, anatomical and physiological variations between sun andshade plants	3
2	Estimation of leaf area, LAI	2
3	Estimation of biomass production of trees of different species	3
4	Estimation of microclimatic elements as influenced by stand structure	3
5	Estimation of evapotranspiration	2
6.	Measurement of radiation in different types of forest and agroforestry systems	3
	Total	**16**

FBT 511 PHYSIOLOGY OF WOODY PLANTS 2+1

Objective

To acquaint students about the concepts of physiology for understanding its use in increasing productivity of forest stands

Theory

UNIT I

Introduction , Tree physiology. Growth, phases of growth, growth curve, factors affecting growth.- Wood formation

UNIT II

Plant cell as a structural and functional unit. Organization of cells and tissues, morphogenesis.

UNIT III

Structure of leaves, stem wood , bark and roots in trees. Functions and process in plant growth and development.

UNIT IV

Photosynthesis, structure of photosynthetic tissues and organs, enzyme, energetics and factors influencing photosynthesis. Photorespiration, its mechanisms and significance, factors affecting photorespiration.

UNIT V

Respiration, mechanisms, enzymes, energetics and factors influencing respiration. Respiratory quotient.

UNIT VI

Water relations of trees, absorption, ascent of sap. Translocation of solutes, phloem loading and phloem transport. Transpiration, mechanisms and factors influencing, regulating transpiration, antitranspirants.

UNIT VII

Mineral nutrition. Mineral salt absorption and translocation, deficiency and toxicity of mineral nutrients. Diagnosis of mineral deficiency.

UNIT VIII

The enzymes, nomenclature and classification, structure and compositioned. Mode of action. Phytohormones, auxins, GA, cytokinins, ABA, ethlynene. Biosynthesis and biochemical activity of plant hormones. Synthetic plant growth regulators. Growth retardants.

UNIT IX

Nitrogen fixing trees, Nitrogen metabolism. N_2 fixation, physical and biological. Nitrogen assimilation, Amino acid and protein synthesis.

UNIT X

Fat metabolism. Carbohydrate metabolism.

Practical

Preparation of growth curves of different tree seedlings. Study of structure of leaves, Measurement of photosynthesis. Observing structure of plant cells and leaves in C3 and C4 species,Studying stomata in different tree species and working out stomatal frequency. Measurement of stomatal size in different tree species. Estimation of transpiration rates in different trees, Isolation and estimation of chlorophyll. Observing xylem vessel size variation in tree species. Estimation of plant water status by different methods. Nutrient deficiency symptoms in tree seedlings.

Suggested Readings

Dreyer E. 2011. *Forest Tree Physiology*. University of Minnesota, Elsevier

Kramer PJ and Kozlowsky TT. 1979. *Physiology of Woody Plants*. Academic Press.

Kramer PJ. 1972. *Plant and Soil Water Relationships*. TMH Edition, Tata McGraw Hill Publ. Co., New Delhi.

Ksenzhek OS. and Volkov AG. 1998. *Plant Energetics*. Academic Press, New York.

Lack AJ and Evans DE. 2001. *Plant Biology- Instant Notes*. Vina Books Pvt. Ltd., New Delhi. Larcher W. 2003. *Physiological Plant Ecology*. 4th edn, Springer-Verlag, Germany

Luttge U. 2008. *Physiological Ecology of Tropical Plants*. Springer-Verlag, Germany Malik CP and Srivastava. 2015. *Textbook of Plant Physiology*. Kalyani Publishers, Mumbai

Moore TC. 1989. *Biochemistry and Physiology of Plant Hormones*. 2nd ed. Springer-Verlan, Berlin.

Noggle RG. and Fritz GJ. 2010. *Introductory plant physiology*. Sinauer Associates Inc. Publishers, Sunderland

Pallardy HG. 2008. *Physiology of Woody Plants*. Elsevier, Amsterdam

Taiz L and Zeiger E. 2007. *Plant Physiology* 4th ed. Sinauer Associates Inc. Publishers, Sunderland.

Zimmerman MH and Brown CL. 1971. *Tree structure and Function*, Springer Verlag.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Introduction, Tree physiology, growth, phases of growth, growth curve factors affecting growth, wood formation	3
2	Plant cell as a structural and functional unit. Organization of cells and tissues morphogenesis	2
3	Structure of leaves, stem wood , bark and roots in trees. Functions and process in plant growth and development	4
4	Photosynthesis, structure of photosynthetic tissues and organs, enzyme, energetics and factors influencing photosynthesis. Photorespiration, its mechanisms and significance, factors affecting photorespiration	4
5	Respiration, mechanisms, enzymes, energetics and factors influencing respiration. Respiratory quotient	3
6	Water relations of trees, absorption, ascent of sap. Translocation of solutes – Phloem loading and phloem transport. Transpiration, Mechanisms and factors influencing,regulating transpiration, antitranspirants	4
7	Mineral nutrition, Mineral salt absorption and translocation, deficiency and toxicity of mineral nutrients. Diagnosis of mineral deficiency	3
8	The enzymes, nomenclature and classification, structure and composition – Mode of action. Phytohormones – auxins, GA, cytokinins, ABA, ethlynene biosynthesis and biochemical activity of Plant hormones. Synthetic plant growth regulators. Growth retardants	3
9	Nitrogen fixing trees, Nitrogen metabolism. N2 fixation, physical and biological. Nitrogen assimilation, Amino acid and protein synthesis.	3
10	Fat metabolism. Carbohydrate metabolism	3
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Preparation of growth curves of different tree seedlings	2
2.	Study of structure of leaves. Observing structure of plant cells and leaves in C3 and C4 species	2

3.	Measurement of photosynthesis	2
4.	Studying stomata in different tree species and working out stomatal frequency and size	1
5.	Estimation of transpiration rates in different trees	2
6.	Isolation and estimation of chlorophyll	1
7.	Observing xylem vessel size variation in tree species	1
8.	Estimation of plant water status by different methods	3
9.	Nutrient deficiency symptoms in tree seedlings	2
	Total	16

FBT 512 BREEDING FOR INSECT PEST AND DISEASE RESISTANCE IN TREES 2+1

Objective

To impart knowledge about mechanisms of disease & insect pest resistance in trees, breeding methodology to incorporate disease & insect pest resistance.

Theory

UNIT I

Need for disease resistance in forest trees, Process of infection. Variability in plant pathogens. Types of resistance. Inheritance of resistance. Disease resistance mechanisms in trees, Clonal resistance. Disease resistance breeding techniques. Techniques of isolating resistant genes; developing disease resistant transgenic plants.

UNIT II

History and importance of insect pest resistance, types and mechanism of resistance. Insect-tree relationships. Basis of resistance: Induced resistance and acquired resistance. Defense mechanisms against insects. Factors affecting tree pest resistance. Breeding for insect resistance.

Practical

Disease progression in relation to resistance, disease resistance in clonal plantations and seed orchards, hypersensitivity and its mechanisms, disease resistance screening. Screening for insect pest resistance; chemical and morphological characterization of susceptible / resistance tree species. Defence strategies of woody plants.

Suggested Readings

Dube HC. 2014. *Modern Plant Pathology*, Second Edition. Agribios, Jodhpur (India). Harsh NS. 2012. *Disease Resistance in Genetic Material in Tree Improvement Programme.* Lambert Acad. Publications.

Heybroek HM, Stephan BR and Weissenberg KV. 1990. *Resistance to Diseases and Pests in Forest Trees*. IBD, Dehra Dun (India).

Nair KSS, Sharma JK and Varma RV. 1996. *Impact of Diseases and Insect Pest in Forest Trees*. Parker J. 2008. *Molecular Aspects of Plant Disease Resistance*. Ann. Pl. Rev.,. 34. Blackwell Publications UK.

Ross Wylie F and Martin R Speight. 2012. *Insect Pests in Tropical Forestry* (2nd Ed.). CABI

Tropical Forests.

Van der Plank JE. 1984. *Disease Resistance in Plants*. Academic Press Inc., New York.

Van der Plank JE. 1982. *Host Pathogen Interactions in Plant Disease*. Academic Press Inc., New York.

Willium M Ciesla. 2010. *Forest Entomology-A Global Perspective*. Wiley-Blackwell.

Lecture Schedule
Theory

Sr. No.	Topic	No. of Lecture (s)
1	Need for disease resistance in forest trees	1
2	Process of infection, variability in plant pathogens	3
3	Inheritance of resistance	3
4	Disease resistance mechanisms in trees	2
5	Clonal resistance	1
6	Disease resistance breeding techniques	3
7	Types of resistance techniques of isolating resistant genes	3
8	Developing disease resistant transgenic plants	2
9	History and importance of insect pest resistance	1
10	Types and mechanism of resistance	2
11	Insect-tree relationships	3
12	Basis of resistance: Induced resistance and acquired Defence mechanisms against insects	4
13	Factors affecting tree pest resistance resistance.	2
14	Breeding for insect resistance	2
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Disease progression in relation to resistance	3
2	Disease resistance in clonal plantations and seed orchards	2
3	Hypersensitivity and its mechanisms	2
4	Disease resistance screening	3
5	Screening for insect pest resistance	2
6	Chemical and morphological characterization of susceptible / resistance tree species	2
7	Defence strategies of woody plants	2
	Total	**16**

FBT 513 TREE SEED TECHNOLOGY 2+1

Objective

To impart knowledge and develop understanding about tree seed development, harvesting, processing, storage, dormancy, germination of tropical, sub-tropical and temperate species, their testing and certification.

Theory

UNIT I

Trends and development in tropical, sub-tropical and temperate forestry and their influence on seed demand. Seed problems, limiting factors in tree propagation and afforestation.

UNIT II

Ecological fruit and seed types - seasonality and periodicity of flowering and fruiting. Seed structure

and chemical composition development and maturation germination breakdown of storage products endogenous hormonal regulation effect of stimulators and inhibitors. Dormancy its causes and breakage specific problems of seeds of woody plants.

UNIT III

Determining optimal harvest maturity indices. Methods of seed collection and processing. Storage methods – loss of viability during storage. Dormancy and pre-treatment and seed testing techniques.

UNIT IV

Quality seed production technologies – Seed stand/ seed production area, pollen management in seed orchards. Seed transfer guidelines. Seed certification and legislation.

UNIT V

Factors affecting seed longevity. Pre-storage treatment. Physiological change during ageing. Viability and vigor. Storage of orthodox, recalcitrant and pre-storage intermediate seeds, Fumigation and seed treatment.

UNIT VI

Seed fortification. Seed pelleting.

Practical

Identification of forest seed. Seed sampling, Seed quality testing- purity, viability and germination, collection and processing of seeds/ fruit. Different storage methods. Pretreatment of seed. Seed fortification, seed pelleting.

Suggested Readings

Dutta M and Saini GC. 2009. .*Advances in Forestry Research in India*, Vol. XXX. *Forest Tree Improvement and Seed Technology*. International Book Distributors.

Khullar P, Thapliyal RC, Beniwal B S, Vakshasya and Sharma A. 1991. *Forest Seeds*. *ICFRE.* Lars H Schmidt. 2000. *Guide to Handling of Tropical and Subtropical Forest Seeds*. Danida Forest Seed Centre.

Mema N P. 1989. *Principles of Seed Certification and Testing.* Allied Publ. Negi S S. 2008. *Forest Tree Seeds*. International Book Distributers

Ram Prasad and Kandya RK. 1992. *Handling of Forestry Seeds in India.*Associated Publ.

Vanangamudi K. 2007. *Advances in Seed Science and Technology*, Volume IV. Agrobios (India).

Vanangamudi K. 2013. *Advances in Seed Science and Technology*, Volume III. Agrobios (India).

William RL. 1985. *A Guide to Forest Seed Handling with Reference to the Tropics.* FAO. Zobel B and Talbert J. 1984. *Applied Forest Tree Improvement.* John Wiley & Sons.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Trends in seed demand. Seed problems, limiting factors in tree propagation and afforestation	1
2	Ecological fruit and seed types - seasonality and periodicity of flowering and fruiting	3
3	Seed structure and chemical composition – development and maturation	2
4	Germination – breakdown of storage products endogenous hormonal regulation	2
5	Effect of stimulators and inhibitors dormancy – its causes and breakage	2
6	Determining optimal harvest maturity indices	2
7	Methods of seed collection and processing, storage methods loss of viability during storage	2

8	Dormancy and pre-treatment	2
9	Seed testing techniques	2
10	Qualityseedproductiontechnologiesseedstand/seedproductionarea	2
11	Pollenmanagementinseedorchards	2
12	Seedtransfer guidelines	2
13	Seedcertificationandlegislation	2
14	Factors affecting seed longevity. Pre-storage treatment. Physiological changed uringageing. Viabilityand vigor	3
15	Storage of orthodox, recalcitrant and pre-storage inter mediate seeds, Fumigation and seedtreatment	2
16	Seedfortification,seedpelleting	2
	Total	**33**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Identification of forest seed	1
2	Collection and processing of seeds/ fruit, different storage methods	2
3	Seed sampling. Seed quality testing- purity, viability and germination	7
4	Pretreatment of seed	2
5	Seed fortification	2
6	Seed pelleting	2
	Total	**16**

Course Titles with Credit Load

Ph.D. in Forest Biology and Tree Improvement

Course Code	Course Title	Credit Hrs.
Major Courses		
FBT 601*	Special Topics in Tree Improvement	2+1
FBT 602	Forest Genetics and Tree Breeding	2+0
FBT 603*	Biometrical Genetics	2+1
FBT 604	Forest Tree Reproduction	2+1
FBT 605	Molecular Genetics of Forest Trees	2+1
FBT 606	Genetics of Forest Ecosystems and Conservation Biology	3+0
FBT 607	Tree Physiology and Forest Productivity	2+1
FBT 608	Tree Seed Management	2+1
Minor Courses		
	Courses from Silviculture and Agroforestry or Forest Products and Utilization or Forest Resource Management	06
Supporting Courses		
FOR 610*	Research Methodology in Forestry	2+1
FOR 611	Research and Publication Ethics	1+1
FBT 691*	Doctoral Seminar-I	1+0
FBT 692*	Doctoral Seminar-II	1+0
	The student may choose the above mentioned Supporting Courses or other courses provided the opted courses are related to the research problem selected by the student and be mandatorily approved by the Student Advisory	
ii) Thesis Research		
FBT 699	Doctoral Research	0+75

***Compulsory Core Courses**

Course Contents

FBT 601 SPECIAL TOPICS IN TREE IMPROVEMENT 2+1

Objective

To develop understanding among students in application of Mendelian principles to forest trees and integration of physiological and molecular techniques for tree improvement programmes.

Theory

UNIT I

Mendelian concepts as applied to forest trees. Cytological and chromosomal systems of forest trees. Cytoplasmic inheritance in trees. Colchiploid and mutation breeding for forest trees.

UNIT II

Tree domestication for small-scale farmers: needs, criteria and selection methods . Choosing the right tree. Participatory rural appraisal approaches. Ethnobotanical methods. Species priority setting procedures. Value chain analysis. Participatory tree domestication approach.

UNIT III

Physiological basis of tree improvement. Pollution responses of trees. Pollen handling and hybridization techniques in forest trees. Tissue culture of trees.

UNIT IV

Molecular genetics as applied to forest trees, recent trends in tree improvement, somatic hybrids, transformation, gene sequencing. Inheritance of monoterpene composition in conifers.

UNIT V

Indirect selection for improvement of desired traits, molecular markers. Juvenile traits and their role in genetic evaluation in tree improvement programmes.

UNIT VI

Geographic variation in trees, evolution and gene flow. Exploration and conservation of gene resources of trees. Dioecism and moneocism in trees.

Practical

Cytology of pine root tips, kryotypic analysis, mutagenic treatments with colchicine and MH, tissue culture of organs and transformation experiments, resin tapping and observation of trees for menoecium and dioecium.

Suggested Readings

Ramawat KG, Merillon JM and Ahuja MR. 2014. *Tree Biotechnology*. CRC Press. Schnell RJ and Pridarshan PM. 2012. *Genomics of Tree Crops*, Springer.
White TL, Adams WT and Neale DB. 2007. *Forest Genetics*. CABI.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Introduction	1
2	Mendelian concepts as applied to forest trees	1
3	Tree domestication, selection methods, ethnobotanical methods	2

4	Value chain analysis, Participatory tree domestication approach	2
5	Cytological and chromosomal systems of forest trees	2
6	Cytoplasmic inheritance in trees	1
7	Colchiploid and mutation breeding for forest trees	2
8	Pollen handling and hybridization techniques in forest tree	1
9	Physiological basis of tree improvement	2
10	Pollution responses of trees	2
11	Tissue culture of trees	2
12	Somatic hybrids	1
13	Genetic transformation	2
14	Gene sequencing	2
15	Inheritance of monoterpene composition in conifers	1
16	Indirect selection for improvement of desired traits, molecular markers. Juvenile traits and their role in genetic evaluation in tree improvement programmes	4
17	Geographic variation in trees	1
18	Evolution and gene flow	1
19	Exploration and conservation of gene resources of trees	1
20	Dioecism and moneocism in trees	2
	Total	**33**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Cytology of softwood/harwood spps	4
2	Mutagenic treatments with colchicine and MH	3
3	Tissue culture of organs and transformation experiments	7
4	Observation of trees for monoecium and dioecium	2
	Total	**16**

FBT 602 FOREST GENETICS AND TREE BREEDING 2+0

Objective

To develop understanding among students about methodologies involved in the study of gene flow of forest tree through pollen, seed, development of hybrids and molecular breeding.

Theory

UNIT I

Taxonomy and phylogenetic studies. Assessment of genetic diversity, gene conservation, breeding populations: long term and short term, pollen collection storage, extension, theories of pollen dispersal, mating designs. Polygenic inheritance, genetics of heterosis, overcoming incompatibility, hybrid embryo rescue and studies in hybrid development in forest trees.

UNIT II

Molecular breeding- constructing molecular map. Integrating genetic, physical and molecular maps. Diversity assessment and phylogenetic analysis. Molecular tagging of genes/traits. Selected examples on marker assisted selection of qualitative and quantitative traits. Application of molecular markers and genomic tools for the genetic enhancement.

Suggested Readings

Khosla PK. 1981. *Advances in Forest Genetics*. Ambika Publ., New Delhi.

Mandal AK and Gibson GL. (Eds.). 1997. *Forest Genetics and Tree Breeding*. CBS. Nanson A. 2004. *Genetics of Forest Tree Breeding*. Agronomic Press.

Schnell RJ and Pridarshan PM. 2012. *Genomics of Tree Crops*, Springer.

Surendran C, Sehgal RN and Parmathama M. (Eds.). 2003. *A Text Book of Forest Tree Breeding*. ICAR.

Suzuki D, Gryfiths AJF, Miller JH and Lewontin RC. 1986. *An Introduction to Genetic Analysis*.

Wright JW. 1976. *Introduction to Forest Genetics*. Academic Press.

Lecture schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Taxonomy and phylogenetic studies	3
2	Assessment of genetic diversity and gene conservation	3
3	Breeding populations: long term and short term	3
4	Pollen collection storage, extension, theories of pollen dispersal	3
6	Polygenic inheritance	4
7	Genetics of heterosis	2
8	Overcoming incompatibility, hybrid embryo rescue and studies in hybrid development in forest trees	2
9.	Molecular breeding- constructing molecular map. Integrating genetic, physical and molecular maps	5
11.	Molecular tagging of genes/traits	3
12.	Application of molecular markers and genomic tools for the genetic enhancement	2
13.	Selected examples on marker assisted selection of qualitative and quantitative traits	2
	Total	**32**

FBT 603 BIOMETRICAL GENETICS 2+1

Objective

To develop understanding of principles of biometrical genetics and utility of various biometrical techniques in tree improvement programmes.

Theory

UNIT I

Concepts inquantitative genetics, quantitative inheritance, historical aspects, Galton (1869) methods for studying quantitative traits, qualitative and quantitative traits and their inheritance, property of nuclear born genes (segregation and linkages). Linkage between major gene and polygenes. Evidence that quantitative trait is inherited in Mendalian Fashion. Nilsson Ehle (1908) multiple factor hypothesis. East (1916) experiment on *Nicotiana longifera*.

UNIT II

Genetic components of continuous variation gene models (additive, dominance, epistasis) features of additive gene action, features of non-additive gene action, genetic variance in F2 population in various gene models. Important principles established by NCSU (North Carolina State University) for forest Tree Improvement, Origin of variation, estimation of hereditary parameters, variance derivation in F2

and backcrosses. Genotype X environment interaction, its measurement and significance. Concepts of heritablility and genetic advance. Random mating in forest trees, their population structure and response to selection.

UNIT III

Quantitative genetics in relation to efficient breeding methodology – partitioning of means and variances, simple scaling and joint scaling tests. Line X tester analysis and diallel analysis mating designs in tree improvement, incomplete pedigree design and complete pedigree design.

UNIT IV

Usefulness of biometrical techniques. Assessment of variability, variance analysis, metroglymph analysis, D^2. Statistic. Aids to selection correlation, path analysis, discriminant function. Aids to choice of parents: Assessment of adaptability, stability analysis, software in forest genetic analysis and their interpretation.

UNIT V

Molecular diversity analysis, methods for mapping QTL.

Practical

Genotypic and phenotypic variance in forest trees. Detection of linkage in coupling.Proof that gene and genotypic frequencies remain constant in random mating populations.Stability analysis- Eberhart and Russel Model (1966)- Perkins and Jinks Model (1971).Problems on demonstrating the effects of selection, mutation, migration and genetic drift in random mating population through graphs. Simple scaling tests. Joint scaling tests. Heritability estimation (Analysis of variance, parent offspring correlation and regression). Heritability in narrow sense estimation. Line X Tester analysis. Diallel analysis

Calculation of genotypic and phenotypic correlations. Path analysis. Discriminant function.D^2

Statistics.Principal component analysis.Diversity analysis based on RAPD/ SSR

Suggested Readings

Mather K and Jinks JL. 1971. *Biometrical Genetics*. Champman and Hall, London.

Singh RK and Chaudhary BD.1985. *Biometrical Methods in Quantitative Genetical Analysis*. Kalyani Publishers, New Delhi.

White TL, Adams WT and Neale DB. 2007. *Forest Genetics*. CABI.

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Concepts inquantitative genetics, quantitative inheritance, historical aspects	1
2	Galton (1869) methods for studying quantitative traits, qualitative and quantitative traits and their inheritance, property of nuclear born genes (segregation and linkages)	2
3	Linkage between major gene and polygenes. Evidence that quantitative trait is inherited in Mendalian Fashion. Nilsson Ehle (1908) multiple factor hypothesis. East (1916) experiment on *Nicotiana longifera*	2
4	Genetic components of continuous variation gene models (additive, dominance, epistasis) features of additive gene action, features of non-additive gene action, genetic variance in F2 population in various gene models	3
5	Important principles established by NCSU (North Carolina State University) for forest Tree Improvement, Origin of variation, estimation of hereditary parameters, variance derivation in F2 and backcrosses. Genotype X environment interaction, its measurement and significance	3
6	Concepts of heritablility and genetic advance.Random mating in forest trees, their population structure and response to selection	1

7	Quantitative genetics in relation to efficient breeding methodology – partitioning of means and variances, simple scaling and joint scaling tests	2
8	Incomplete pedigree design and complete pedigree design. Line X tester analysis and diallel analysis mating designs in tree improvement	2
9	Usefulness of biometrical techniques. Assessment of variability, variance analysis	2
10	Metroglymph analysis	2
11	D^2. Statistic	2
12	Aids to selection correlation, path analysis, discriminant function	2
13	Aids to choice of parents: Assessment of adaptability	2
14	Stability analysis	2
15	Software in forest genetic analysis and their interpretation	2
16	Molecular diversity analysis, methods for mapping QTL	2
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Genotypic and phenotypic variance in forest trees	1
2	Detection of linkage in coupling. Eberhart and Russel Model (1966)- Perkins and Jinks Model (1971	1
3	Proof that gene and genotypic frequencies remain constant in random mating populations	1
4	Stability analysis-	1
5	Problems on demonstrating the effects of selection, mutation, migration and genetic drift in random mating population through graphs	2
6	Simple scaling tests. Joint scaling tests	1
7	Heritability estimation (Analysis of variance, parent offspring correlation and regression).Heritability in narrow sense estimation	1
8	Line X Tester analysis	1
9	Diallel analysis	1
10	Calculation of genotypic and phenotypic correlations	1
11	Path analysis	1
12	Discriminant function.D^2 Statistics	1
13	Principal component analysis	1
14	Diversity analysis based on RAPD/ SSR	2
	Total	**16**

FBT 604 FOREST TREE REPRODUCTION 2+1

Objective

To develop understanding of students about phenology, phenodynamics breeding behaviour pollination biology and breeding systems in forest trees.

Theory

UNIT I

Reproductive biology of gymnosperms and angiosperms, Reproduction and population genetic structure, population dynamics. Floral morphology, floral initiation and breeding systems. Flowering manipulation. Reproductive abnormalities.

UNIT II

Pollination, biology, pollination ecology of tropical and temperate forest tree species, plant- pollination interactions. Pollinator energetic and nectar production.

UNIT III

Genetic consequences of variation in reproductive biology. Pollen biotechnology for improved production.

UNIT IV

Gene expression during pollen development Pollination efficiency of insects. Self-incompatibility.

Practical:

Phenological studies in forest trees, nectar collection and analysis, pollination trapling distances, foraging behaviour, pollinator identification and visitation.

Suggested Readings

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.*

Cláudia Inês da Silva and Helena Maura Torezan Silingardi. 2006. *Reproductive Biology of Tropical Plants*. International Commission on Tropical Biology and Natural Resources. Encyclopedia of Life Support Systems (EOLSS).

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 M and Griffin A R. 1989. *Sexual Reproduction of Tree Crops*. Academic Press.

Spencer CH, Barrett, Robert I, Colautti and Christopher G Eckert. 2007. *Plant Reproductive Systems and Evolution during Biological Invasion*. Wiley Online Library.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Reproductive biology of gymnosperms and angiosperms	2
2	Reproduction and population genetic structure, population dynamics	2
3	Floral morphology, floral initiation and breeding systems	4
4	Flowering manipulation	2
5	Reproductive abnormalities	2
6	Pollination, biology, pollination ecology of tropical and temperate forest tree species, plant-pollination interactions	5
7	Pollinator energetic and nectar production	2
8	Genetic consequences of variation in reproductive biology	2
9	Pollen biotechnology for improved production	2
10	Gene expression during pollen development	2
11	Pollination efficiency of insects	2
12	Self-incompatibility	2

	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Phenological studies in forest trees.	4
2	Pollination trapling distances.	2
3	Nectar collection and analysis.	4
4	Foraging behaviour.	3
5	Pollinator identification and visitation.	3
	Total	**16**

FBT 605 MOLECULAR GENETICS OF FOREST TREES 2+1

Objective

To develop understanding among students about molecular markers, biochemical markers, gene mapping, transgenics in forest trees.

Theory

UNIT I

Biochemical markers (Isozymes and Monoterpenes). Molecular markers – Non-PCR based (RFLP) and PCR based (RAPD, ISSR, SSR, AFLP, SNP etc.). Application in forestry – quantification of genetic diversity. Marker assisted selection. Genetic maps of selected forest trees.

UNIT II

DNA sequencing.Structural genomics. Functional genomics. Transcriptomics. Proteomics. Metabolomics.

UNIT III

Recombinant DNA Technology, Transgenics, Vectors,. Gene transfer strategies – direct and indirect. Molecular characterization of transformants. Application of transgenics in forestry.

Practical

Isolation of DNA, RNA from forest tree species, isozyme analysis, use of molecular markers and RAPD and RFLP for clonal identification. *Agrobacterium* mediated gene transfer. Preparation of linkage maps.

Suggested Readings

Brown CM, Campbell I and Preist FG. 2005. *Introduction to Biotechnology*. Panima Publishers. Chawla HS. 2004. *Introduction to Plant Biotechnology*. Kalyani Publishers.

Kole C 2007. *Genome Mapping and Molecular Breeding in Plants*. Springer. Schnell RJ and Pridarshan PM. 2012. *Genomics of Tree Crops*. Springer.

Singh BD. 2006. *Biotechnology – Expanding Horizons*. Kalyani Publishers.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Biochemical markers (Isozymes and Monoterpenes)	2
2	Molecular markers – Non-PCR based (RFLP) and PCR based (RAPD, ISSR, SSR, AFLP, SNP etc.)	5
3	Application in forestry – quantification of genetic diversity	2

4	Marker assisted selection. Genetic maps of selected forest trees	4
5	DNA sequencing	2
6	Structural genomics, functional genomics	4
7	Transcriptomics, proteomics, metabolomics	4
8	Recombinant DNA Technology, Transgenics, Vectors	4
9	Gene transfer strategies – direct and indirect	3
10	Molecular characterization of transformants. Application of transgenics in forestry	2
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Isozyme analysis	2
2	Isolation of DNA, RNA from forest tree species	2
3	Use of molecular markers and RAPD, SSR and RFLP for clonal	6
4	identification *Agrobacterium* mediated gene transfer	4
5	Preparation of linkage maps	2
	Total	**16**

FBT 606 GENETICS OF FOREST ECOSYSTEMS & CONSERVATION BIOLOGY 3+0

Objective

To make the students understand about the ecological genetics, markers and sampling in ecological genetics, genetic diversity and differentiation, gene flow and mating system, forest ecosystems, physiology of woody plants and forests as biological community.

Theory

UNIT I

What is ecological genetics, uses of ecological genetics, markers and sampling in ecological genetics, genetic diversity and differentiation, gene flow and mating system, intraspecific phylogenies and phylogeography, speciation and hybridization.

UNIT II

The ecological niche, adaptations, genetic systems, adaptive strategies, forest ecosystems, how man affects forest ecosystems manmade forest ecosystems.

UNIT III

Carbon sequestration consumption and export - carbon balance in trees – canopy photosynthesis - Transport and partitioning. Factors influencing net photosynthesis in trees. Relationship between the CO2 compensation point and carbon fixation efficiency in trees. Physiology of formation of early and late woods-resource sharing in mixed agroforestry system.

UNIT IV

Evapo-transpiration - factors affecting evapo-transpiration potential evapo-transpiration. Moisture stress - osmotic adjustment stomatal response to moisture stress water use efficiency drought tolerance.

UNIT V

Forest as biological community, Amplification of conceptual and quantitative models of variation in trees.

Changes in gene frequencies genetics and theory of selections adaptations and conservation. Gene flow and genetic drift, polymorphism. Population structure and migration.

UNIT VI

Conservation biology: Introduction, Conservation biology—past and present. Biodiversity. Defining and measuring biological diversity. Threats to biodiversity. Computing biological diversity. Biological hot spots. Social value and the role of people in conservation. Ecosystem functions and services. Habitat destruction. Habitat fragmentation and landscape changes. Over harvesting. Invasive species impacts. Climate change. Population viability analysis. Application of population ecology to conservation biology for fauna and flora. Population and conservation genetics practical examples in conservation of plants and animals. Landscape ecology and conservation practices. Conservation planning and priorities. Single and Multi species conservation strategies. Endangered species management. Restoration and species recovery planning. Community biodiversity management. Strategic species concepts (Keystone species. Indicator species. Umbrella and flagship species) concept of sustainable development.

Suggested Readings

Klaus Stern and Laurence Roche. 1974.*Genetics of Forest Ecosystems.*New York a.o. Springer- Verl.

Kozlowski TT. 1971. *Growth and Development of Trees*. Vol. I. Academic Press. Kramer PJ and Kozlowshi TT. 1979. *Physiology of Woody Plants*. Academic Press. Larcher W. 1980. *Physiological Plant Ecology*. Springer-Verlag.

Lowe A, Harris S and Ashton P. 2004. *Ecological Genetics: Design, Analysis and Application*

Oxford: Blackwell Publishing.

Raghavendra AS. 1991. *Physiology of Trees*. John Wiley & Sons.

Weathers. 2013. *Fundamentals of Ecosystem Science*. . M/s. International Books & Periodicals Supply Service, Pitampura, Delhi.

Zimmerman RH. 1972. *Juvenility and Flowering in Woody Plants: A Review*. *Hort. Science* 7(5): 447-455.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Ecological genetics, uses of ecological genetics, markers and sampling in ecological genetics	2
2	Genetic diversity and differentiation, gene flow and mating system	2
3	Intraspecific phylogenies and phylogeography, speciation and hybridization	2
4	The ecological niche, adaptations.	1
5	Genetic systems, adaptive strategies, forest ecosystems	2
6	How man affects forest ecosystems manmade forest ecosystem	1
7	Carbon sequestration consumption and export - carbon balance in trees	2
8	Canopy photosynthesis - Transport and partitioning	1
9	Factors influencing net photosynthesis in trees	1
10	Relationship between the CO_2 compensation point and carbon fixation efficiency in trees	1
11	Physiology of formation of early and late woods	2
12	Resource sharing in mixed agroforestry system	2

13	Evapo-transpiration, factors affecting evapo-transpiration, Potential evapo-transpiration	2
14	Moisture stress, osmotic adjustment, stomatal response to moisture stress	2
15	Water use efficiency, drought toleranc	1
16	Forest as biological community	1
17	Amplification of conceptual and quantitative models of variation in trees	1
18	Changes in gene frequencies, genetics and theory of selections, adaptations and conservation	1
19	Gene flow and genetic drift, polymorphism, population structure and migration	1
20	Introduction, Conservation biology, past and present	1
21	Biodiversity concepts. Measuring biological diversity. Threats to biodiversity	2
22	Computing biological diversity. Biological hot spots	1
23	Social value and the role of people in conservation	1
24	Ecosystem functions and services	1
25	Habitat destruction. Habitat fragmentation and landscape changes. Over harvesting. Invasive species impacts	2
26	Climate change. Population viability analysis	1
27	Application of population ecology to conservation biology : for fauna and flora	2
28	Population and conservation genetics: practical examples in conservation of plants and animals	1
29	Landscape ecology and conservation practices. Conservation planning and priorities	2
30	Single and Multi species conservation strategies. Endangered species management	2
31	Restoration and species recovery planning. Community biodiversity management	1
32	Strategic species concepts (keystone species, Indicator species, umbrella and flagship species)	1
33	Concept of sustainable development	1
	Total	**47**

FBT 607 TREE PHYSIOLOGY AND FOREST PRODUCTIVITY 2+1

Objective

To make the students understand the physiological factors responsible for the tree growth and how CO_2 fixation and consumption lead to growth.

Theory

UNIT I

Introduction, tree forms in relation to environmental factors mechanism responsible for differences in tree forms stand structure and micro-climate.

UNIT II

Carbon fixation by tree canopies, leaf area, interception of solar radiation and tree growth. Leaf area index and dry matter production. Radiation attenuation through canopies strategies for maximising solar energy utilization, stomatal conductance.

UNIT III

Carbon consumption and export, carbon balance in trees, canopy photosynthesis. Transport and partitioning. Factors influencing net photosynthesis in trees. Relationship between the CO_2 compensation point and carbon fixation efficiency in trees. Physiology of formation of early and late woods. Resource sharing in

mixed agroforestry system .

UNIT IV

Evapo-transpiration factors affecting evapo-transpiration. Potential evapo-transpiration. Moisture stress, osmotic adjustment stomatal response to moisture stress. Water use efficiency drought tolerance

UNIT V

Biochemical and molecular aspects, water logging, physiology of resistance to water logging. Salt and ion stress.

UNIT VI

Avoidance and tolerance mechanisms. Temperature stress, low temperature stress,physiology of resistance to frost. Heat stress, heat injury, heat avoidance and tolerance mechanism, Radiation stress, mechanism of shade tolerance, Physiological basis of pollution stress, Ozone injury Acid rain, Heavy metals.

Practical

Chlorophyll stability index. Leaf water potential by pressure bomb technique - porometry steady state porometer. Leaf temperature, transpiration rate. Stomatal resistance and conductance. Seed germination test for drought, tolerance and pre-treatment of seeds for drought tolerance. Water use efficiency. Measurement of photosynthesis.

Suggested Readings

Kozlowski TT. 1971. *Growth and Development of Trees. Vol. I*. Academic Press. Kramer PJ and Kozlowshi TT. 1979. *Physiology of Woody Plants*.Academic Press. Ksenzhek OS and Volkov AG. 1998. *Plant Energetics*. Academic Press, New York.

Lack AJ and Evans DE. 2001. *Plant Biology- Instant Notes*. Vina Books Pvt. Ltd., New Delhi. Larcher W. 2003. *Physiological Plant Ecology*. 4th edn, Springer-Verlag, Germany.

Luttge U. 2008. *Physiological Ecology of Tropical Plants*. Springer-Verlag, Germany Mandal AK and Gibson GL. 1997. *Forest Genetics and Tree Breeding.* CBS.

Raghavendra AS. 1991. *Physiology of Trees*. John Wiley & Sons.

Taiz L and Zeiger E. 2007. *Plant Physiology* 4t h Ed. Sinauer Associates Inc. Publishers, Sunderland.

Zimmerman RH. 1972. *Juvenility and Flowering in Woody Plants: A Review*. Hort. Science 7(5): 447-455.

Zimmermann MH and Brown CL. 1971. *Trees Structure and Function*. Springer Verlag.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Introduction, tree forms in relation to environmental factors mechanism responsible for differences in tree forms stand structure and micro-climate	2
2	Carbon fixation by tree canopies, leaf area, interception of solar radiation and tree growth	2
3	Leaf area index and dry matter production. Radiation attenuationthrough canopies, strategies for maximising solar energy utilisation stomatal conductance	4
4	Carbon consumption and export carbon balance in trees	2
5	Canopy photosynthesis. Transport and partitioning. Factors influencing net photosynthesis in trees. Relationship between the CO2 compensation point and carbon fixation efficiency in trees	2
6	Physiology of formation of early and late woods-Resource sharing in mixed agroforestry system	3

7	Evapo-transpiration factors affecting evapo-transpiration	2
8	Potential evapo-transpiration. Moisture stress, osmotic adjustment	2
9	Stomatal response to moisture stress, water use efficiency, drought tolerance	2
10	Biochemical and molecular aspects water logging physiology of resistance to water logging	2
11	Salt and ion stress	2
12	Avoidance and tolerance mechanisms - temperature stress – low temperature stress physiology of resistance to frost. Heat stress – heat injury, heat avoidance and tolerance mechanism	3
13	Radiation stress mechanism of shade tolerance	2
14	Physiological basis of pollution stress, Ozone injury Acid rain. Heavy metals	2
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Chlorophyll stability index	2
2	Leaf water potential by pressure bomb technique	2
3	Porometry, steady state porometer leaf temperature transpiration rate	2
4	stomatal resistance and conductance	
5	Seed germination test for drought tolerance and pre-treatment of	3
6	seeds for drought tolerance	
7	Water use efficiency	3
8	Measurement of photosynthesis	4
	Total	**16**

FBT 608 TREE SEED MANAGEMENT 2+1

Objective

To develop understanding among students in the concept of seed maturity, dormancy, stratification, seed storage and forest seed management.

Theory

UNIT I

Concepts, classification, seed fortification, use of adjuvants, diluents, stickers, encapsulation materials, dyes, chemicals, pesticides, fungicides, animal repellents, biological materials, antibiotic and growth regulators, biofertilizers, minerals salts, bioactive substances.

UNIT II

Seed infusion and involvement in synergistic factors dormancy and stratification, Physical treatment with abrasives, hot and cold temperature, radio, frequency waves, UV rays, X-rays and gamma rays.

UNIT III

Methods of application and their effects on germination, seed hardening, osmotic priming in relation to stress management.

UNIT IV

Seed pelleting, use of bio-fertilizers, mineral salts, growth regulators, hydrophilic substances, seed-coat polymers in stress management, sequences in seed inoculation.

UNIT V

Planting value determination and storage potential evaluation, aerial seeding and its implication, use of IDS for separation of viable seed from non viable seeds mid-storage correction treatment.

Practical

Influence of seed fortification with different treatments on germination and vigour of seeds. Studies on seed infusion effects on germination. Vigour and planting value. Use of physical treatment of seeds on seed germination and vigour. Seed hardening treatments and their influence on the planting value of seeds. Studies on osmotic priming on stress tolerance of seedlings. Seed pelleting studies in tree seeds. Evaluation of pelletted seeds for survival percentage both in laboratory and field. Determination of storage potential of pelleted seeds. Use of organic solvents for seed infusion and their influence on the seed quality. Standardization of IDS method to separate viable seeds from non-viable seeds in tree species. Evaluation of effectiveness of separation by IDS method by germination test, cutting test radiographic analysis. Studies on the evaluation of mid-storage correction treatments on the viability and vigour of seeds in storage by accelerated aging test.

Suggested Readings

Dutta M and Saini GC. 2009.*Advances in Forestry Research in India*, Vol. XXX. *Forest Tree Improvement and Seed Technology*. International Book Distributors.

Khullar P, Thapliyal RC, Beniwal BS, Vakshasya and Sharma A. 1991. *Forest Seeds*. *ICFRE.*

Lars H Schmidt. 2000. *Guide to Handling of Tropical and Subtropical Forest Seed*s. Danida Forest Seed Centre.

Mema NP. 1989. *Principles of Seed Certification and Testing.* Allied Publ. Negi SS. 2008. *Forest Tree Seeds*. International Book Distributers.

Ram Prasad and Kandya R K. 1992. *Handling of Forestry Seeds in India.*Associated Publ.

Vanangamudi K. 2007. *Advances in Seed Science and Technology*, Volume IV. Agrobios (India).

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Concepts, classification, seed fortification, use of adjuvants, diluents,stickers, encapsulation materials, dyes, chemicals, pesticides, fungicides, animal repellents, biological materials, antibiotic and growth regulators, biofertilizers, minerals salts, bioactive substances	3
2	Seed infusion and involvement in synergistic factors, dormancy and stratification	3
3	Physical treatment with abrasives, hot and cold temperature, radio - frequency waves, UV rays, X-rays and gamma rays	4
4	Methods of application and their effects on germination, seed hardening, osmotic priming in relation to stress management	3
5	Seed pelleting, use of bio-fertilizers, mineral salts, growth regulators,hydrophilic substances, seed-coat polymers in stress management, sequences in seed inoculation	3
6	Planting value determination and storage potential evaluation	1
7	Aerial seeding and its implication	1
8	Use of IDS for separation of viable seed from non viable seeds mid- storage correction treatment	2
	Total	**20**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Influence of seed fortification with different treatments on germination and vigour of seeds	3
2	Studies on seed infusion effects on germination.Vigour and planting value	3
3		
4	Use of physical treatment of seeds on seed germination and vigour. Seed hardening treatments and their influence on the planting value of seeds	3
5	Studies on osmotic priming on stress tolerance of seedlings. Seed pelleting studies in tree seeds. Evaluation of pelletted seeds for survival percentage both in laboratory and field. Determination of storage potential of pelleted seeds	4
6	Use of organic solvents for seed infusion and their influence on the seed quality. Standardization of IDS method to separate viable seeds from non-viable seeds in tree species. Evaluation of effectiveness of separation by IDS method by germination test, cutting test radiographic analysis. Studies on the evaluation of mid-storage correction treatments on the viability and vigour of seeds in storage by accelerated aging test	4
	Total	**17**

Forest Products and Utilization

Course Titles with Credit Load

M.Sc. in Forest Products and Utilization

Course Code	Course Title	Credit Hrs.
Major Courses		
FPU 501*	Non Wood Forest Products Management	2+1
FPU 502	Applied Wood Technology	2+1
FPU 503	Pulp and Paper Technology	2+1
FPU 504	Composite Wood Technology	2+1
FPU 505*	Forest Products Laboratory Techniques	0+2
FPU 506*	Agro-techniques of Medicinal and Aromatic Crops	2+1
FPU 507	Breeding Techniques and Improvement of Medicinal and Aromatic Crops	2+1
FPU 508	Chemistry and Processing of Medicinal and Aromatic Plants	2+1
FPU 509*	Wood Identification	0+2
FPU 510*	Chemistry of Forest Products and Industries	2+1
FPU 511	Wood Chemistry	1+1
FPU 512	Wood Physics	1+1
FPU 513	Wood Seasoning and Preservation	2+1
FPU 514	Production of Medicinal and Aromatic Crops	1+1
FPU 515	Medicinal and Aromatic Plants in Health Care Systems	2 +0
FPU 516	Pharmacognosy of Medicinal and Aromatic Plants	1+1
Minor Courses		
	Courses from Silviculture and Agroforestry or Forest Biology and Tree Improvement or Forest Resource Management	08
Supporting Courses		
FOR 511*	General Statistical Methods and Computer Applications	2+1
	Note: The student may choose the above mentioned Supporting Course or other courses provided the opted courses are related to the research problem selected by the student and be mandatorily approved by the Student Advisory committee/HOD".	

FPU 591*	I/II	Master's Seminar	1+0

ii) Thesis Research			
FPU 599		**Master's Research**	**0+30**

***Compulsory Core Courses**

Course Contents

FPU 501 NON WOOD FOREST PRODUCTS MANAGEMENT 2+1

Objective

To make

students to understand and learn about the different non wood Forest Products and their scientific extraction, processing and disposal.

Theory

UNIT I

Classification of non wood forest products like gums & resins, katha, dyes, tannins, oils, raw drugs, bamboos, canes and other products.

UNIT II

Technologies for extraction of gums, resins, katha, dyes, tannins, oils, raw drugs and other products.

UNIT III

Utilization of various non wood forest products and their scientific management for processing, value addition, marketing and disposal.

UNIT IV

Quality assessment of important products and their methods for storage. Important industries based on non wood forest products and their management.

Practical

Extraction of resins, gums, katha, dyes, tannins, oils raw drugs, bamboos, canes and other products. Value addition techniques for these products. Visit to non wood forest products based industries.

Suggested Readings

Linskens HF and Jackson JF. 1991. *Essential Oils and Waxes* (Ed.). Springer-Verlag Berlin Heidelberg.

Mathe A. 2015. *Medicinal and Aromatic Plants of the World-Scientific, Production, Commercial and Utilization Aspects.* Springer Netherlands.

Panda H. 2005. *Hand Book on Specialty Gums, Adhesive, Oils, Rosin And Derivatives, Resins, Oleoresins, Katha, Chemicals with others Natural Products*. Asia Pacific business press. Inc.

Panshin AJ, Harrer ES and Bethel JS. *Forest Products, their Sources, Production and Utilization.* Shackleton S, Shackleton C and Shanley P. 2011. *Non-Timber Forest Products in the Global Context* (Ed.). Springer, Verlag Berlin Heidelberg.

Lecture chedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Classification of non wood forest products like; gums & resins, katha, dyes, tannins, oils, raw drugs and other products	9
2	Technologies for extraction of gums, resins, katha, dyes, tannins, oils, raw drugs and other products	8
3	Utilization of various non wood forest products and their scientific management for processing, value addition and disposal	6
4	Quality assessment of important products and their methods for storage	6

5	Important industries based on non wood forest products and their management	3
	Total	**32**

Practical

Sr. No.	Topic	No. of Lecture (s)
1	Extraction of resins, gums, katha, dyes, tannins, oils, raw drugs and other products	8
2	Value addition techniques resins, gums, katha, dyes, tannins, oils, raw drugs and other products	5
3	Visit to non wood forest products based industries	3
	Total	**16**

FPU 502 APPLIED WOOD TECHNOLOGY 2+1

Objective

To acquaint students with various aspects of wood technology and their role in different applications.

Theory

UNIT I

Physical properties of wood-wood density, specific gravity and methods of their determination. Effect of growth on density of wood. Moisture content and its measurement. Effect of sound on wood resonance. Color of wood, phosphorescence, fluorescence and residual luminescence. Thermal properties-conductivity and diffusivity. Electrical properties-conductivity, dielectric constant and current resistivity. Wood permeability.

UNIT II

Mechanical properties-elastic constants, plasticity, Hook's Law, Poisson's ratio, elastic constants, modulus of elasticity, factors affecting strength properties, elastic theory of bending, shear stresses in simple beams, supported beams & cantilevers carrying concentrated and uniformly distributed loads, direct & bending safe working stresses and their evaluation.

UNIT III

Standard tests of timber specimen's-compression, tensile strength. Mechanics and Rheology of wood, abrasion, brittleness and hardness. Suitability coefficient and indices of different wood species. Vibration properties.

UNIT IV

Effect of environment on mechanical properties of wood. Effect of radiations on strength of wood.

Practical

Determination of density, specific gravity, strength, hardness, modulus of elasticity, mechanical properties, thermal conductivity, electrical resistivity and dielectric constant of important domestic and imported timber species.

Suggested Readings

Bodig J and Benjamin AJ. 1993. *Mechanics of Woods and Woods Composites.* Krieger Publish Company.

Brown HP. 1925. *An Elementary Manual on Indian Wood technology.* Central Publication Branch, Government of India, Calcutta.

Brown HP. 1985. *Manual of Indian Wood Technology*. International Books and Periodicals Supply Service, New Delhi.

Hill CAS. 2006. *Wood Modification: Chemical, Thermal and other Processes.* John Wiley and Sons

Ltd. Hoadley B. 2000. *Understanding Wood: A Craftsman's Guide to Wood Technology.* Taunton Press. Newtown, USA.

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.

Panshin AJ and De ZC. 1980. *Textbook of Wood Technology*, 4th Ed. McGraw-Hill. New York.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Physical properties of wood-wood density, specific gravity and methods of determination	4
2	Effect of growth on density of wood. Moisture content and its measurement. Effect of sound on wood resonance. Phosphorescence, fluorescence and residual luminescence	4
3	Thermal properties-conductivity and diffusivity	2
4	Electrical properties-conductivity, dielectric constant and current resistivity. Wood permeability	3
5	Mechanical properties-elastic constants, plasticity, Hook's Law, Poisson's ratio, elastic constants, modulus of elasticity, factors affecting strength properties, elastic theory of bending, shear stresses in simple beams, supported beams & cantilevers carrying concentrated and uniformly distributed leads, direct & bending safe working stresses in simple and their evaluation	8
6	Standard tests of timber specimen's-compression, tensile strength, Mechanics and Rheology of wood, abrasion, brittleness and hardness.	5
7	Suitability coefficient and indices of different wood species. Vibration properties	3
8	Effect of environment on mechanical properties of wood . Effect of radiations on strength of wood	3
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Determination of density, strength, hardness modulus of elasticity of wood and mechanical properties of important domestic and imported timber species	9
2	Determination electrical resistivity and dielectric constant of important domestic and imported timber species	7
	Total	**16**

FPU 503 PULP AND PAPER TECHNOLOGY 2+1

Objective

To acquaint the students with the resources and processes for making pulp and paper.

Theory

UNIT I

Raw material used in pulp and paper industries, characteristics and handling.

UNIT II

Pulping process, mechanical, chemical, semi-chemical and biopulping. Pulp bleaching, pulp treatment, defibering, de-knotting, brown stock washing, screening, cleaning, thickening etc.

UNIT III

Recycled fibers, supplementary pulp treatment and additives. Paper making, paper drying, reeling, external sizing, coating, calendaring, etc.

UNIT IV

Structure of paper, its characterization and measuring strength method, optional and structural properties of paper, Type of paper: coated paper, corrugated containers, printing quality of paper, ageing of paper. Rayon industry.

Practical

Visit to pulp and paper industry. Study of raw materials, techniques and pulp yield, making of paper and its quality determination.

Suggested Readings

Asuncion J. 2003. *The Complete Book of Paper Making.* Lark books, New York.

Bajpai P. 2018. *Biermann's Handbook of Pulp and Paper.* Vol. 1st:Raw material and pulp making. Elsevier Science, UK.

Biermann C. 1996. *Handbook of Pulping and Paper Making*. 2nd Ed. Academic Press San Diego, New York, Boston, London, Sydney, Tokyo, Toronito.

Britt KW. 1970. *Handbook of Pulp and Paper Technology*. 2nd Ed. Van Nostrand Reinhold Company, New York.

Lavigne JR. 1979. *Instrumentation Applications for the Pulp and Paper Industry.* Miller Freeman Publications.

Rao KP. 2007. *Pulp and Paper Technology: Technology, Testing and Applications.* CBS Publishing and Distributors, New Delhi.

Sjostrom E and Alen R (Eds). 1999. *Analytical Methods in Wood Chemistry Pulping and Paper Making.* Springer Series in Wood Science.

Viikari L and Lantto R. 2002. *Progress in Biotechnology*. Vol. 21st. Biotechnology in the pulp and paper industry. 1st Ed. ICBPPI. Elsevier Science.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Raw materials used in pulp and paper industries, characteristics and handling	6
2	Pulping process, mechanical, chemical, semi-chemical and biopulping. Pulp bleaching, pulp treatment, defibering, de-knotting, brown stock washing, screening, cleaning, thickening etc.	8
3	Recycled fibers, supplementary pulp treatment and additives. Paper making, paper drying, reeling, external sizing, coating, calendaring, etc. Structure of paper, its characterization and measuring strength method	10
4	Optional and structural properties of paper, Type of paper: coated paper, corrugated containers, printing quality of paper, ageing of paper	6
5	Rayon industry	2
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Visit to pulp and paper industry	6
2.	Study of raw materials, techniques and pulp yield, making of paper and its quality determination	10
	Total	**16**

FPU 504 COMPOSITE WOOD TECHNOLOGY 2+1

Objective

To impart knowledge regarding the scope and processes for developing composite and modified woods.

Theory

UNIT I

Introduction to wood modification, its need and scope.Chemical modification of wood (acetylation, reaction with isocyanates, acetates, ethers, epoxides, etc.) Wood impregnation and compregnation, heat stabilization, wood densification.

UNIT II

Modern trends in composite wood. Wood adhesives - types, characteristics and application.

UNIT III

Plywood, laminated wood and inorganic wood composites- their manufacture, characteristics and application.

Practical

Use of different adhesives in plywood, study of composite boards, study of anti-shrink efficiency of wood treated with different chemicals. Impregnation and compregnation of wood with chemicals.

Suggested Readings

Ansell MP. 2015.*Wood Composites*. Elsevier, Science & Technology.

Hill CAS. 2006. *Wood Modification: Chemical, Thermal and Other Processes*. John Wiley and Sons Ltd.

Pizzi A and Mittal K L. 2011. *Wood Adhesives*. CRC Press, New York.

Rowell RM. 2013. *Handbook of Wood Chemistry and Wood Composites*. 2nd Ed. CRC Press, New York.

USDA (U.S. Department of Agriculture). 1999. *Wood Handbook: Wood as an Engineered Material.* US Department of Agriculture, Forest Service. Forest Products Laboratory, Madison, WI.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1.	Introduction to wood modification, its need and scope	4
2.	Chemical modification of wood (acetylation, reaction with isocyanates, acetates, ethers, epoxides, etc.)	6
3.	Wood impregnation and compregnation, heat stabilization, wood densification	6
4.	Modern trends in composite wood	4
5.	Wood adhesives - types, characteristics and application	4

6.	Plywood, laminated wood and inorganic wood composites- their manufacture, characteristics and application	8
	Total	**32**

Practical

Sr. No.	Topic	No. of Lecture (s)
	Use of different adhesives in plywood	4
	Study of composite boards, study of anti-shrink efficiency of wood treated with different chemicals	6
	Impregnation and compregnation of wood with chemicals	6
	Total	**16**

FPU 505 FOREST PRODUCTS LABORATORY TECHNIQUES 0+2

Objective

To expose the students to the practical aspects of laboratory techniques employed in forest products.

Practical

UNIT I

Wood and non-wood product sampling, drying and storage. Estimation of extraneous components of wood. Analysis of volatile compounds.

UNIT II

Estimation of chemical composition of wood samples (hardwoods, softwood and other lignocellulosic material) and ash.

UNIT III

Separation of components by column, paper, thin layer and gas chromatography. HPLC techniques. Determination of strength properties of paper and wood composites.

Suggested Readings

Meyland BA and Butterfield BG. 1972. *Three-Dimensional Structure of Wood: A Scanning Electron Microscope Study.* Syracuse University Press.

Rowell RM. 2013. *Handbook of Wood Chemistry and Wood Composites*. 2nd Ed. CRC Press, New York.

Skaar C. 1988. *Wood-Water Relations.* Springer Series in Wood Science.

Snyder LR, Kirkland JJ and Glajch JL. 2012. *Practical HPLC Method Development.* 2nd Ed. John Wiley & Sons.

Lecture Schedule

Practical

Sr. No.	Topic	No. of Lecture (s)
1	Wood and non-wood products sampling, drying and storage	4
2	Estimation of extraneous components of wood. Analysis of volatile compounds	6
3	Estimation of chemical composition of wood samples (hardwoods, softwood and other lignocellulosic material) and ash	10
4	Separation of components by column, paper, and thin layer chromatography. HPLC techniques	6
5	Determination of strength properties of paper and wood composites	6
	Total	**32**

FPU 506 AGRO-TECHNIQUES OF MEDICINAL AND AROMATIC CROPS 2+1

Objective

To equip the student with the conventional and commercial production techniques of medicinal & aromatic plant species.

Theory

UNIT I

Importance of medicinal and aromatic plants in human health, national economy and related industries. Need of cultivation of medicinal & aromatic plants as agricultural crops. Concept of organic farming, GACP & GAP in medicinal & aromatic crops production. Quality concern in plant based drugs.

UNIT II

Introduction and importance, climate and soil requirements, cultural practices, harvesting & yield, important constituents of medicinal plants - Mulhathi, Senna, *Gloriosa superba*, *Valeriana jatamansi, Swertia chirayita,* Isabgol, *Rauwolfia serpentina, Withania sominifera,* Opium Poppy, *Aloe vera*, Satavar, *Stevia rebaudiana,* Safed Musli, Kalmegh & other important species of the region.

UNIT III

Introduction and importance, climate and soil requirements; cultural practices; harvest & yield; important constituents of aromatic plants - Citronella, Palmarosa, Mentha, Basil, Lemon grass, Rose, *Tagetes minuta*, Lavender, Rosemary, Patchouli, Geranium & other important species of the region.

Practical

Morphological identification of listed plants & their economic parts, maturity indices. Preparation and layout of nursery and field, methods of seed sowing/transplantation, cultural operations in MAP crops. Raising and harvesting of at least one crop grown in the region.

Visit to government and private Pharmaceutical units/ Institutes in adjoining areas. Visit to large scale herb growing and processing units engaged in commercial cultivation and preparation of purified phytochemical/ standardized extracts. Visit to nearby marketing/ trade centres.

Suggested Readings

Atul CK and Kapur BK. 1982. *Cultivation and Utilization Of Medicinal Plants*. RRL, CSIR, Jammu-Tawi.

Chadha KL and Gupta R. 2006. *Advances in Horticulture*. Vol. XI. Medicinal and aromatic plants. Malhotra Publishing House.

Chopra AK. 2007. *Medicinal Plants: Conservation, Cultivation and Utilization*. Daya Books. Chopra RN. Nayar SL and Chopra IC. 1956. *Glossary of Indian Medicinal Plants.* CSIR, New Delhi.

EIRI Board. 2007. *Handbook of Medicinal and Aromatic Plants: Cultivation, Utilization and Extraction Processes.* Engineers India Research Institute, New Delhi.

Gunther E. 1975. *The Essential Oils.* Robert, K Krieger Pub. Co, New York.

Khan IA and Khanum A. 2005. *Medicinal and Aromatic Plants of India; Herbal Wealth for Human Health.* 1st Ed. Ukaaz Publications.

Muralia S. 2006. *Medicinal and Aromatic Plants* 1st Ed. Neha Publishers & Distributors.

Lecture Schedule
Theory

Sr. No.	Topic	No. of Lectures (s)
1.	Importance of medicinal and aromatic plants in human health, national economy and related industries. Need of cultivation of Medicinal & aromatic plants as agricultural crops	2
2	Concept of organic farming, GACP & GAP in medicinal & aromatic crop production. Quality concern in plant based drugs	3

3.	Introduction and importance, botanical features, climate and soil requirements, cultural practices, harvesting & yield and important constituents of medicinal plants - Mulhathi, Senna, *Gloriosa superba*, *Valeriana jatamansi, Swertia chirayita,* Isabgol, *Rauwolfia serpentina, Withania somnifera,* Opium Poppy, *Aloe vera*, Satavar, *Stevia rebaudiana,* Safed Musli, Kalmegh & other important species of the region	15
4.	Introduction and importance, climate and soil requirements; cultural practices; harvest & yield; important constituents of aromatic plants - Citronella, Palmarosa, Mentha, Basil, Lemon grass, Rose, *Tagetes minuta*, Lavender, Rosemary, Patchouli, Geranium & other important species of the region	12
	Total	**32**

Practical

Sr. No.	Topic	No. of Lectures (s)
1	Morphological identification of listed plants & their economic parts, maturity indices	3
2	Preparation and layout of nursery and field, methods of seed sowing/ transplantation, cultural operations in MAP crops	4
3	Raising and harvesting of at least one crop grown in the region	3
4	Visit to government and private Pharmaceutical units/ Institutes in adjoining areas. Visit to large scale herb growing and processing units engaged in commercial cultivation and preparation of purified phytochemical/standardized extracts	4
5	Visit to nearby marketing/ trade centres	2
	Total	**16**

FPU 507 BREEDING TECHNIQUES AND IMPROVEMENT OF MEDICINAL AND AROMATIC CROPS 2+1

Objective

To acquaint with the breeding techniques and quality improvement of medicinal and aromatic crops.

UNIT I

Plant biodiversity, Major objectives of breeding of medicinal & aromatic crops. Plant introduction, domestication and germplasm conservation. Modes of pollination, male sterility, self incompatibility and apomixis. Production and maintenance of pure seeds of medicinal & aromatic plants.

UNIT II

Principles of plant breeding for self pollinated and cross pollinated crops. Selection, Hybridization-techniques & consequences. Hetersosis & inbreeding depression. Different plant breeding methods for self pollinated, cross pollinated and asexually propagated crops. Mutation and polyploidy breeding. Distinctiveness, uniformity, stability testing in medicinal & aromatic crops.

UNIT III

Breeding for quality parameters in medicinal & aromatic crops. Achievements & prospects in breeding of important medicinal and aromatic crops- *Rauvolfia serpentina, Plantago ovata, Cassia angustifolia, Ocimum spp., Withania somnifera, Valeriana spp., Opium poppy, Gloriosa superb, Andrographis paniculata, Mentha spp., Geranium, Cymbopogon spp.,* and other important crops.

UNIT IV

Legislation in conservation of medicinal and aromatic plants- IPR issues in medicinal & aromatic plants.

Practical

Identification based on morphological features; pollen viability & germination testing, stigma receptivity. Field practice in emasculation, selfing and crossing in different medicinal & aromatic crops. Determination of mode of pollination and hybridization in different medicinal & aromatic crops.

Suggested Readings

Alikhan I and Khanum A. 2008. *Role of Biotechnology in Medicinal and Aromatic Plants*. UKAZ Publishers.

Chadha KL and Gupta R. 2006. *Advances in Horticulture.* Vol. XI. Medicinal and aromatic plants. Malhotra Publishing House.

Gupta AK and Sharma M. 2008. *Reviews on Indian Medicinal Plants.* ICMR.

Gupta AK, Tandon N and Sharma M. 2008. *Quality Standards of Indian Medicinal Plants.* ICMR. Johnson CB and Franz C. 2005. *Breeding Research on Aromatic and Medicinal Plants.* International Book Distributor.

Sharma R. 2004. *Agrotechniques of Medicinal Plants.* Daya Publishing.

Singh BD. 2010. *Plant Breeding- Principles and Methods.* Kalyani Publishers.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lectures (s)
1	Plant biodiversity, Major objectives of breeding of medicinal &	3
2	Modes of pollination, male sterility, self incompatibility and apomixis. Production and maintenance of pure seeds of medicinal & aromatic plants	3
3	Principles of plant breeding for self pollinated and cross pollinated crops	3
4	Selection, Hybridization-techniques & consequences	2
5	Hetersosis & inbreeding depression	3
6	Different plant breeding methods for self pollinated, cross pollinated and asexually propagated crops	5
7	Mutation and polyploidy breeding	2
8	Distinctiveness, uniformity, stability testing in medicinal & aromatic crops	3
9	Breeding for quality parameters in medicinal & aromatic crops	2
10	Achievements & prospects in breeding of important medicinal and aromatic crops- *Rauvolfia serpentina, Plantago ovata, Cassia angustifolia, Ocimum* sp., *Withania somnifera, Valeriana* sp., *Opium poppy, Gloriosa superba, Andrographis paniculata, Mentha* sp., *Geranium, Cymbopogon* sp., and other important crops	5
11	Legislation in conservation of medicinal and aromatic plants- IPR issues in medicinal & aromatic plants	1
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Identification based on morphological features	3
2	Pollen viability & germination testing	3
3	Stigma receptivity	2
4	Field practice in emasculation	2
5	Selfing and crossing in different medicinal & aromatic crops	4

6	Determination of mode of pollination and hybridization in different medicinal & aromatic crops	2
	Total	**16**

FPU 508 CHEMISTRY AND PROCESSING OF MEDICINAL AND AROMATIC PLANTS 2+1

Objective

To understand the chemistry of phytopharmaceuticals and their processing as industrial products.

Theory

UNIT I

Organic compounds and their classification such as aliphatic, aromatic, alkaloids, steroids, terpenoids, glycosides, phenolic compounds, heterocyclic compounds and carbohydrates.

UNIT II

Primary and Secondary plant metabolites and theurapeutical uses of phytoconstituents such as anthraquinones, steroidal and triterpenoidal glycosides, phenolic compounds, lipids, alkaloids and terpenoids.

UNIT III

Basic principles and extraction techniques of different phytoconstituents. Analysis of active principles using TLC, HPLC, Gas chromatography etc. Quality standards in herbal products. Drug descriptors for medicinal and aromatic plants.

UNIT IV

Postharvest processing-drying, grading and storage. Extraction techniques of essential oils and their quality analysis.

Practical

Use of thin layer and column chromatography during extraction and purification of phytopharmaceuticals. Preparation of active constituent enriched extracts. Extraction of Essential oils and their quality evaluation, preparation of concretes and absolutes. Use of HPLC & GC in quality evaluation.

Suggested Readings

Bedi S, Singh T and Vyas SP. 2012. *A Handbook of Aromatic and Essential Oil Plants: Cultivation, Chemistry, Processing and Uses.* Agrobios (India).

Finar IL. 2002. *Organic Chemistry*. Vol. I & II. *Pearson Education* India.

Raaman N. 2006. *Phytochemical Techniques.* New India Publishing Agency, N. Delhi.

Singh MP and Panda H. 2005. *Medicinal Herbs with their Formulations.* Vol-1st. Daya Publishing House.

Singh S. 2009. *Essentials of Pharmacology*. 2nd Ed. New Age International Publisher.

Wagner H and Bladt S. 2009. *Plant Drug Analysis- A Thin Layer Chromatography Atlas.* Springer (India) Pvt. Ltd.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lectures (s)
1	Organic compounds and their classification such as aliphatic, aromatic, alkaloids, steroids, terpenoids, glycosides, phenolic compounds, heterocyclic compounds and Carbohydrates	9

2	Primary and secondary plant metabolites	4
3	Theurapeutical uses of phytoconstituents such as anthraquinones, steroidal and triterpenoidal glycosides, phenolic compounds, lipids, alkaloids and terpenoids	6
4	Basic principles and extraction techniques of different phytoconstituents. Analysis of active principles using TLC, HPLC, Gas chromatography etc. Quality standards in herbal products	4
5	Drug descriptors for medicinal and aromatic plants	2
6	Postharvest processing-drying, grading and storage	4
7	Extraction techniques of essential oils and their quality analysis	3
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Use of thin layer and column chromatography during purification of phytopharmaceuticals extraction and	3
2	Preparation of active constituent enriched extracts	3
3	Extraction of Essential oils and their quality evaluation	2
4	Preparation of concretes and absolutes	2
5	Use of HPLC & GC in quality evaluation	6
	Total	**16**

FPU 509 WOOD IDENTIFICATION 0+2

Objective

The course deals with the use of anatomical features of wood in timber identification and classification.

Practical

Planes of wood, gross features and physical characteristics of important woods, Identification of different types of cells and tissues. Anatomical studies of soft and hard woods. Anatomical studies of reaction wood. Classification of timber using dichotomous key. Modern timber identification techniques.

Suggested Readings

Agarwal VK and Upadhaya SD. 2006. *Agrotechniques of Medicinal and Aromatic Plants.* Satish Serial Publishing House.

Anoop EV. 1971. *Timber Identification Manual.* Forest Research Institute, Dehradun.

Dutta JC. 1964. *Botany for Degree Students.* Oxford University Press, Bombay-Calcutta-Madras. Govil JN, Pandey J, Shivakumar BG and Singh VK. 2004. *Crop Improvement, Production Technology, Trade Commerce.*

Lakshman HC and Inchal RF. 2012. *Indigenous Medicinal Plants and their Practical Utility.*

Meier E. 2015. *Wood Identifying and Using Hundreds of Woods Worldwide.* Wood database.

Porter T. 2004. *Wood Identification and Use.* Guild of Master Craftsman, UK.

Purkayastha SK. 1982. *Indian Woods: Their Identification Properties and Uses.* Controller of Publication.

Rao R and Juneja KDS. 1971. *A Handbook for Field Identification of Fifty Important Timbers of India.* Manager of Publications.

Vashishta PC. 1985. *A Text Book of Botany.* S. Chand Publishing Company, New Delhi.

Lecture Schedule

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Study of planes of wood,gross features and physical characteristics of important woods	6
2.	Identification of different types of cells and tissues	5
3.	Anatomical studies of soft and hard woods. Anatomical studies of reaction wood	10
4.	Classification of timber using dichotomous keys	6
5.	Modern timber identification techniques	5
	Total	**32**

FPU 510 CHEMISTRY OF FOREST PRODUCTS AND INDUSTRIES 2+1

Objective

The course will equip the students regarding forest based industries and their impact on the economy of the country. To support the studies on the role of various products such as pulp, paper, composite wood, furniture match boxes, sports, pencil making, resins & gums, katha, tannins and various types of other non-timber and wood products either produced or processed in these industries. Practicals will make them aware regarding extraction and processing methods of different forest products.

Theory

UNIT I

Importance of forest based industries in relation to Indian economy. Role of Chemistry in relation to forest products.

UNIT II

Classification and description of different forest based industries - pulp and paper, composite wood, furniture, bamboo, sports goods, pencil making, match box and splint making. Use of lesser known wood species for commercial purposes.

UNIT III

Cell wall constituents. Chemistry of cellulose, starch, hemicelluloses and lignin. Extraneous components of wood - water and organic solvent soluble.

UNIT IV

Chemical composition of oleoresin from major pine species. Structural difference among different gums (arabic, ghatti, tragacanth etc.).

UNIT V

Chemical nature and uses of volatile oils, tannins, katha and cutch and important forest based dyes and pigments.

Practical

Estimation of cell wall constituents - Hemicelluloses and lignin, Extraction of essential oils, resins and tannins. Wood pulping. Acetylation of wood. Visit to nearby forest based industries.

Suggested Readings

Bowyer JL, Shmulsky R and Haygreen JG. 2003. *Forest Products and Wood Science: An Introduction*. 4th Ed. Blackwell Publishing.

Chung and Deborah DL. 2003. *Composite Materials-Functional Materials for Modern Technologies*. Springer,Verlag London.

David AT. 2013. *Forest Products: Advanced Technologies and Economic Analyses*. Elsevier.

Eriksson KEL, Blanchette RA and Ander P. 1990. *Microbial and Enzymatic Degradation of Wood and Wood Components*. Springer,Verlag Berlin Heidelberg.

Linskens HF and Jackson JF. 1991. *Essential Oils and Waxes* (Ed.). Springer-Verlag Berlin Heidelberg.
Panda H. 2005. *Hand Book on Specialty Gums, Adhesive, Oils, Rosin And Derivatives, Resins, Oleoresins, Katha, Chemicals with Others Natural Products*. Asia Pacific business press. Inc.

Rojas OJ. 2016. *Cellulose Chemistry and Properties: Fibers, Nanocelluloses and Advanced Materials (Ed.).* Springer International Publishing.

Rowell RM. 2013. *Hand Book of Wood Chemistry and Wood Composites*. CRC press, Taylor and Francis group.

Shackleton S, Shackleton C and Shanley P. 2011. *Non-Timber Forest Products in the Global Context (Ed.)*. Springer, Verlag Berlin Heidelberg.

Sharma LC. 2012. *Development of Forests and Forest Based Industries*. M/s Bishen Singh Mahendra Pal Singh.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1.	Importance of forest based industries in relation to Indian economy	1
2.	Role of chemistry in relation to forest products	1
3.	Classification and description of different forest based industries - pulp & paper and composite wood	6
4.	Classification and description of different forest based industries like; Furniture, bamboo, sports goods, pencil making, match box and splint making	5
5.	Use of lesser known wood species for commercial purposes	2
6.	Cell wall constituents. Chemistry of cellulose, starch, hemicelluloses and lignin	4
7.	Extraneous components of wood - water and organic solvent soluble	2
8.	Chemical composition of oleoresin from major pine species	3
9.	Structural difference among different gums (arabic, ghatti, tragacanth etc.)	2
10.	Chemical nature and uses of volatile oils, tannins, katha and cutch	3
11.	Chemical nature and uses of important forest based dyes and pigments	3
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Estimation of cell wall contents - Hollocellulose and lignin	5
2	Extraction of essential oils	2
3	Extraction of resins & tannins	3
4	Wood pulping	2
5	Acetylation of wood	2
6	Visit to nearby forest based industries	2
	Total	**16**

FPU 511 WOOD CHEMISTRY 1+1

Objective

To impart knowledge about the chemical properties of wood, cell wall constituents and wood extractions.

Theory

UNIT I

Chemical composition of wood: Cell wall constituents- cellulose, lignin, hemicellulose, peptic substances, etc.

UNIT II

Volatile oils and extractives, cellulose derivatives and their applications.

UNIT III

Hydrolysis & fermentation of lignocellulosic materials. Pyrolysis & gasification of wood.

Practical

Extraction of cellulose, hemicellulose, lignin, extractives and ash content of wood.

Suggested Readings

Coppen JJW. 1995. *Gums, Resin and Latex of Plant Origin.* Food and Agriculture Organizations, Rome.

Rowe JW. 1989. *Natural Products of Woody Plants.* Springer Series in Wood Science.

Rowell RM. 1984. *The Chemistry of Solid Wood (Advances in Chemistry Series)*. American Chemical Society.

Rowell RM. 2013. *Handbook of Wood Chemistry and Wood Composites.* 2nd Ed. CRC Press. Singh A. 1967. *Plant Physiology.* Readers in Botany, Allahabad University.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1.	Chemical composition of wood: Cell wall constituents- cellulose, lignin, hemicellulose, peptic substances, etc.	5
2.	Volatile oils and extractives, cellulose derivatives and their applications	4
3.	Hydrolysis & fermentation of lignocellulosic materials	4
4.	Pyrolysis & gasification of wood	3
	Total	**16**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Extraction of cellulose	3
2	Extraction of Hemicellulose	3
3	Extraction of lignin	4
4	Extraction of wood extractives	3
5	Extraction of ash content of wood	3
	Total	**16**

FPU 512 WOOD PHYSICS 1+1

Objective

To acquaint with the physical characteristics and strength properties of wood.

Theory

UNIT I

Wood density, thermal, electrical and acoustic properties of wood. Mechanics and Rheology of wood, elasticity, plasticity and creep (tensile compression and bending strength)

UNIT II

Toughness, torsion, shear, hardness and abrasion strength. Acoustic and acousto-ultrasonics based non-destructive evaluation technique.

Practical

Determination of wood density, study of thermal, electrical and acoustic properties of wood. Determination of tensile and bending properties of wood.

Suggested Readings

Brown HP. 1925. *An Elementary Manual on Indian Wood Technology.* Central Publication Branch Government of India.

Dutta AC. 1964. *Botany for Degree Students*. Oxford University Press.

Franz FP, Kollmann and Wilfred AJC. 1968. *Principle of Wood Science and Technology*. Vol I. Solid wood. George Allen and Unwin Ltd London, Springer-Verlag, Berlin, Heidelberg.

Franz FP, Kollmann, Kuwnzi E and Stamm AJ. 1975. *Principle of Wood Science and Technology.*

Wood based material. Vol. II Springer-Verlag, Berlin, Heidelberg.

Meyland BA and Butterfield BG (Eds). 1972. *Three-Dimensional Structure of Wood: A Scanning Electron Microscope Study.* Syracuse University Press.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Wood density, thermal, electrical and acoustic properties of wood.	4
2	Mechanics and Rheology of wood, elasticity, plasticity and creep (tensile compression and bending strength)	5
3	Toughness, torsion, shear, hardness and abrasion strength	4
4	Acoustic and acousto-ultrasonics based non-destructive evaluation technique	3
	Total	**16**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Determination of wood density, study of thermal, electrical and acoustic properties of wood	7
2	Study of thermal, electrical and acoustic properties of wood	5
3	Determination of tensile and bending properties of wood	4
	Total	**16**

FPU 513 WOOD SEASONING AND PRESERVATION 2+1

Objective

To understand the importance of wood seasoning and preservation for utilizing secondary timber for multipurpose use.

Theory

UNIT I

Wood water relationship, absorption behaviour and wood drying, Refractory and non refractory behaviour of wood, Wood seasoning, types- air, kiln and special seasoning methods like steaming, chemical, high temperature drying, vacuum drying and water conditioning.

UNIT II

Defects of timber- natural, seasoning defects, defects due to external agencies, machining defects. Effect of defects on utilization.

UNIT III

Detection and diagnosis of discolouration and decay in wood: decaying agencies- fungi, insects, borer, etc.

UNIT IV

Wood preservation: preservatives and treatment processes. Advantages and safety concern of wood preservatives, fire retardants. Graveyard test and anti-fungal activity of wood. Bio- preservation.

Practical

Determination of moisture content and swelling coefficients of different woods. Comparative studies on air and kiln dried woods. Analysis of decayed wood for physical and chemical parameters. Treatment of wood with different types of preservatives. Graveyard test.

Suggested Readings

FAO. 2007. *Wood Preservation Manual*. International Book Distributor.

Hunt GM. 1967. *Wood Preservation* 3rd Ed. Mc GRAW-HILL Book Company. Pandey CN and Jain VK. 1992. *Wood Seasoning Technology*. FRI, Dehradun.

Purushotham A, Pande JN and Jadhav. 1959. *Wood Preservation In India.* Manager of Publications.

Winn W. 1919. *Timbers and their Uses*. London George Rotledge & Sons Ltd.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Wood water relationship, absorption behaviour and wood drying	4
2	Refractory and non refractory behaviour of wood	4
3	Wood seasoning, types- air, kiln and special seasoning methods like steaming, chemical, high temperature drying, vacuum drying and water conditioning	6
4	Defects of timber- natural, seasoning defects, defects due to external agencies, machining defects	4
5	Effect of defects on utilization	2
6	Detection and diagnosis of discolouration and decay in wood: decaying agencies- fungi, insects, borer, etc.	4
7	Wood preservation: preservatives and treatment processes	2
8	Advantages and safety concern of wood preservatives, fire retardants	2
9	Graveyard test and anti-fungal activity of wood. Bio-preservation	4
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Determination of moisture content and swelling coefficients of different woods	3
2	Comparative studies on air and kiln dried woods	3
3	Analysis of decayed wood for physical and chemical parameters	4
4	Treatment of wood with different types of preservatives. Graveyard test	6

	Total	**16**

FPU 514 PRODUCTION OF MEDICINAL AND AROMATIC CROPS 1+1

Objective

To acquaint the students with the plant production techniques.

Theory

UNIT I

Modes of reproduction in MAP crops and their relevance in maintaining genetic purity of crops. Concept of quality seed production & maintenance.

UNIT II

Soil fertility, essential nutrient elements- functions, deficiency symptoms, availability and factors affecting their availability. Soil micro-organisms & their role in organic matter decomposition. Importance of pH and C:N ratio in plant nutrition. Concept of bio-fertlizers and their potential for use in medicinal & aromatic crops.

UNIT III

Essentials of nursery production, criteria of site selection, and types of nursery, establishment of a model nursery. Nursery raising of medicinal plants. Tissue culture technique and *in vitro* propagation of important MAPs.

UNIT IV

Plant protection measures in medicinal & aromatic crops, Quality parameters of seedlings and nursery stock.

Practical

Asexual /vegetative reproduction techniques- cutting, budding, layering etc. Methods of seed collection and storage techniques. *In vitro*-propagation techniques. Determination of pH, organic matter & N,P,K from soil.

Suggested Readings

Atul CK and Kapur BK. 1982. *Cultivation and Utilization of Medicinal Plants.* RRL, CSIR, Jammu-Tawi.

Chopra AK. 2007. *Medicinal Plants: Conservation, Cultivation and Utilization.* Daya Books. Chopra RN. Nayar SL and Chopra IC. 1956. *Glossary of Indian Medicinal Plants*. CSIR, New Delhi.

EIRI Board. 2007. *Handbook of Medicinal and Aromatic Plants: Cultivation, Utilization and Extraction Processes.* Engineers India Research Institute, New Delhi.

Gunther E. 1975. *The Essential Oils*. Robert, K Krieger Pub. Co, New York.

Khan IA and Khanum A. 2005. *Medicinal and Aromatic Plants of India; Herbal Wealth for Human Health.* 1st Ed. Ukaaz Publications.

Muralia S. 2006. *Medicinal and Aromatic Plants* 1st Ed. Neha Publishers & Distributors.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Modes of reproduction in crop plants and their relevance in maintaining genetic purity of crops. Concept of quality seed production & maintenance	2
2	Soil fertility, essential nutrient elements- functions, deficiency symptoms availability and factors affecting their availability. Soil micro-organisms & their role in organic matter decomposition. Importance of pH and C:N ratio in plant nutrition. Concept of bio- fertlizers and their potential for use in medicinal & aromatic crops	5

3	Essentials of nursery production, criteria of site selection, and types of nursery, establishment of a model nursery.Nursery raising of medicinal plants. Mode of plant propagation techniques. Tissue culture technique and *in vitro* propagation of important MAPs	6
4	Plant protection measures in medicinal & aromatic crops, Quality parameters of seedlings and nursery stock	3
	Total	**16**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Asexual /vegetative reproduction techniques-cutting, budding, layering etc.	5
2	Methods of seed collection and storage techniques	2
3	*In vitro*-propagation techniques	3
4	Determination of pH, Organic matter & N,P,K from soil	6
	Total	**16**

FPU 515 MEDICINAL AND AROMATIC PLANTS IN HEALTH CARE SYSTEMS 2+0

Objective

To acquaint the student with the importance of plants used in modern and AYUSH methods of treatment.

Theory

UNIT I

Concept of Health Care systems

UNIT II

Brief introduction to Ayurveda, Unani, Sidha, Homeopathy, allopathy, naturopathy, electrohomoeopathy, etc.

UNIT III

Important medicinal plants used in treating various diseases in modern and complementary systems.

UNIT IV

Biological activity of selected medicinal plants. Methods of preparing poultices, decoctions, powders, tinctures, active content rich extracts.

Suggested Readings

Atul CK and Kapur BK. 1982. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu-Tawi.

Chopra AK. 2007. M*edicinal Plants: Conservation, Cultivation and Utilization.* Daya Books. Chopra RN. Nayar SL and Chopra IC. 1956. *Glossary of Indian Medicinal Plants*. CSIR, New Delhi.

Cunningham A. 2014. *Applied Ethnobotany: "People, Wild Plant Use and Conservation*". Taylor & Francis.

Gunther E. 1975. *The Essential Oils.* Robert, K Krieger Pub. Co, New York.

Jain SK. 1968. *Medicinal Plants.* National book trust, New Delhi. Oxford & IBH, New Delhi. Khan IA and Khanum A. 2005. *Medicinal and Aromatic Plants of India; Herbal Wealth for Human Health.* 1st Ed. Ukaaz Publications.

Maheshwari JK. 2000. *Ethnobotany and Medicinal Plants of Indian Subcontinent.* Scientific Publishers,Jodhpur, India.

Muralia S. 2006. *Medicinal and Aromatic Plants* 1st Ed. Neha Publishers & Distributors.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Concept of Health Care systems	2
2	Brief introduction to Ayurveda, Unani, Sidha, Homeopathy, allopathy, naturopathy, electrohomoeopathy, etc.	10
3	Important medicinal plants used in treating various diseases in modern and complementary systems.	6
4	Biological activity of selected medicinal plants.	6
5	Methods of preparing poultices, decoctions, powders, tinctures, active content rich extracts	8
	Total	**32**

FPU 516 PHARMACOGNOSY OF MEDICINAL AND AROMATIC PLANTS 1+1

Objective

To develop understanding about microscopical, macroscopical and chemical methods of drug identification.

Theory

UNIT I

History and scope of pharmacognosy, Pharmaceutical products. Classification of natural drugs. Chemical nature of drugs. Pharmacognostic analysis of drug plants based on botanical, chemical and histological features.

UNIT II

Evaluation based on pharmacopoeial standards for both single drugs and compound formulations most commonly used in different systems of medicines.

UNIT III

Pharmacognostic features of Sarpagandha, Jatamansi, Ashwagandha, Turmeric, Punarnava, *Ephedra, Gymnema*, Senna, Amla, Gokhru, Isabgol, Black pepper, Banafsha, Arjun or any other commercially species specific to the region.

Practical

Identification of drugs by morphological characters. Physical and chemical tests for evaluation of drugs. Gross anatomical studies of Ginger, Ashwagandha, Senna, *Gentiana*, Kalmegh, Sarpagandha, Mulhathi, *Aconitum* species or any other important species relevant to the region.

Suggested Readings

Atul CK and Kapur BK. 1982.*Cultivation and Utilization of Medicinal Plants*.RRL, CSIR, Jammu-Tawi. Chopra AK. 2007. *Medicinal Plants: Conservation, Cultivation and Utilization*. Daya Books.

Chopra RN, Nayar SL and Chopra IC. 1956. *Glossary of Indian Medicinal Plants*. CSIR, New Delhi. Cunningham A. 2014. *Applied Ethnobotany: "People, Wild Plant Use and Conservation*". Taylor & Francis.

Cupp J and Tracy TS. 2003. Dietary Supplements: Toxicology and Clinical Pharmacology. Humana Press. Gunther E. 1975. *The Essential Oils*. Robert, K Krieger Pub. Co, New York.

Gupta K, Tandon N and Sharma M. 2008. *Quality Standards of Indian Medicinal Plants*. Jain SK. 1968. *Medicinal Plants*. National book trust, New Delhi. Oxford & IBH, New Delhi.

Khan IA and Khanum A. 2005. *Medicinal and Aromatic Plants of India; Herbal Wealth for Human Health.* 1st Ed. Ukaaz Publications.

Maheshwari JK. 2000. *Ethnobotany and Medicinal Plants of Indian Subcontinent*. Scientific Publishers,Jodhpur, India.

Muralia S. 2006. *Medicinal and Aromatic Plants*. 1st Ed. Neha Publishers & Distributors.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	History and scope of pharmacognosy	1
2	Pharmaceutical products. Classification of natural drugs. Chemical nature of drugs	3
3	Pharmacognostic analysis of drug plants based on botanical, chemical and histological features	4
4	Evaluation based on pharmacopoeial standards for both single drugs and compound formulations most commonly used in different systems of medicines	3
5	Pharmacognostic features of Sarpagandha, Jatamansi, Ashwagandha, Turmeric, Punarnava, Ephedra, Gymnema, Senna, Amla, Gokhru, Isabgol, Black pepper, Banafsha, Arjun or any other commercially species specific to the region	5
	Total	**16**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Identification of drugs by morphological characters	3
2	Physical and chemical tests for evaluation of drugs	6
3	Gross anatomical studies of Ginger, Ashwagandha, Senna, Gentiana, Kalmegh, Sarpagandha, Mulhathi, *Aconitum* species or any other important species relevant to the region	7
	Total	**16**

Course Titles with Credit Load

Ph.D. in Forest Products and Utilization

Course Code	Course Title	Credit Hrs.
Major Courses		
FPU 601*	Developments in Wood and Non-Wood Forest Products	3+0
FPU 602	Energy and Chemicals from Wood	2+0
FPU 603	Wood and Wood Technology	2+1
FPU 604 *	Analytical Techniques in Forest Products	1+2
FPU 605	Chemistry of Medicinal and Aromatic Plants	2+1
FPU 606	Processing Technology of Forest Products	2+1
FPU 607	Value Addition and Marketing of Forest Products	2+1
FPU 608	Modern Trends in Wood Modification	2+1
FPU 609	Development in Pulp and Paper Technology	2+0
FPU 610	Application of Traditional Knowledge	2+0
FPU 611	Production of Quality Planting Material of Medicinal and Aromatic Plants	2+1
FPU 612	Processing Technology of Medicinal & Aromatic Plants	2+1
FPU 613	Biosynthesis of Secondary Metabolites	3+0
FPU 614	Value Additions and Marketing of Medicinal & Aromatic Plants	2+1
FPU 691*	Doctoral Seminar-I	1+0
FPU 692*	Doctoral Seminar-II	1+0
Minor Courses		
	Courses from Silviculture and Agroforestry or Forest Biology and Tree Improvement or Forest Resource Management	06
Supporting Courses		
FOR 610*	Research Methodology in Forestry	2+1
FOR 611	Research and Publication Ethics	1+1
	Note: The student may choose the above mentioned Supporting Course or other courses provided the opted courses are related to the research problem selected by the student and be mandatorily approved by the Student Advisory committee/HOD".	
ii) Thesis Research		
FPU 699	Doctoral Research	0+75

***Compulsory Core Courses**

Course Contents

FPU 601 DEVELOPMENTS IN WOOD AND NON-WOOD FOREST PRODUCTS 3+0

Objective

To acquaint the students regarding updated and advance technology of timber mechanics, wood derivatives, export and import potential of non timber forest produce and computer applications in various forest products.

Theory

UNIT I

Mechanics of wood and wood composites, Application of orthotropic and non-linear constitutive relations, Laminate theory and failure criterion in the prediction of mechanical properties of solid woods; Wood-polymer; Hybrid composite processing.

UNIT II

Principles of industrial wood processes, products derived from wood by chemical processes and value added wood products, properties of construction, Wood polymers and surface chemistry, fundamentals of adhesion and fracture in adhesively bonded wood, adhesive systems used for wood with emphasis in wood based composites.

UNIT III

Methods of extraction, chemistry, processing, import and export potential of gums, resins, tannins, dyes, essential oils, fixed oils, cutch and katha, drugs, spices, poisons, insecticides, pesticides, wild edible fruits, etc.

UNIT IV

Computer application system in forest products, Use of information technologies to integrate material, quality and market fluctuations.

Suggested Readings

Arnason JT, Rachel M and Romeo JT. 1995. *Phytochemistry of Medicinal Plants*. Springer, US. Bowyer JL, Shmulsky R and Haygreen JG. 2003. *Forest Products and Wood Science: An Introduction. 4th Ed.* Blackwell Publishing.

Chung and Deborah DL. 2003. *Composite Materials-Functional Materials for Modern Technologies*. Springer,Verlag London.

David AT. 2013. *Forest Products: Advanced Technologies and Economic Analyses*. Elsevier. Linskens HF and Jackson JF. 1991. *Essential Oils and Waxes (Ed.).* Springer-Verlag Berlin Heidelberg.

Mathe A. 2015. *Medicinal and Aromatic Plants of the World-Scientific, Production, Commercial and Utilization Aspects.* Springer Netherlands.

Panda H. 2005. *Hand Book on Specialty Gums, Adhesive, Oils, Rosin and Derivatives, Resins, Oleoresins, Katha, Chemicals with others Natural Products*. Asia Pacific business press. Inc.

Rojas OJ. 2016. *Cellulose Chemistry and Properties: Fibers, Nanocelluloses And Advanced Materials (Ed.).* Springer International Publishing.

Rowell RM. *Hand Book of Wood Chemistry and Wood Composites*. 2013. CRC press, Taylor and Francis group.

Shackleton S, Shackleton C and Shanley P. 2011. *Non-Timber Forest Products in the Global Context (Ed.)*. Springer, Verlag Berlin Heidelberg.

Sharma LC. 2012. *Development of Forests and Forest Based Industries*. M/s Bishen Singh Mahendra Pal

Singh.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Mechanics of wood and wood composites	4
2	Application of orthotropic and non-linear constitutive relations	2
3	Laminate theory and failure criterion in the prediction of mechanical properties of solid woods	3
4	Wood-polymer; Hybrid composite processing	4
5	Principles of industrial wood processes, products derived from wood by chemical processes and value added wood products, properties of construction	6
6	Wood polymers and surface chemistry	4
7	Fundamentals of adhesion and fracture in adhesively bonded wood, adhesive systems used for wood with emphasis in wood based composites	3
8	Methods of extraction, chemistry & processing of gums, resins, tannins, dyes, essential oils, fixed oils, cutch and katha, drugs, spices, poisons, insecticides, pesticides, wild edible fruits, etc.	8
9	Import and export potential of gums, resins, tannins, dyes, essential oils, fixed oils, cutch and katha, drugs, spices, poisons, insecticides, pesticides, wild edible fruits, etc.	7
10	Computer application system in forest products	2
11	Use of information technologies to integrate material, quality and market fluctuations	2
	Total	**45**

FPU 602 ENERGY AND CHEMICALS FROM WOOD 2+0

Objective

To make students conversant with wood as a source of energy and utilization of wood residues and chemicals for different purposes.

Theory

UNIT I

Energy and its measurements. Wood as sources of energy and its comparison with other sources. Criteria for evaluation of different fuel wood species for energy.

UNIT II

Utilization of wood waste material as fuel. Gasification, pyrolysis and briquetting of lignocellulosic material. Production of chemicals from forest biomass cellulose, lignin and hemicelluloses. Important wood extractives

UNIT III

Wood refinery techniques. Chemicals produced as by product in pulp industry.

UNIT IV

Destructive distillation of wood. Future of wood chemical industry.

Suggested Readings

Dimitris SA. 2007. *Materials, Chemicals, and Energy from Forest Biomass*. American Chemical Society.

Klass DL. 1998. *Biomass for Renewable Energy, Fuels and Chemicals.* Academic Press. Rowell RM. 2013.

Handbook of Wood Chemistry and Wood Composites. 2nd Ed. CRC Press.

Sjostrom E. 1993. *Wood Chemistry: Fundamentals and Applications*. 2nd Ed. Gulf Professional Publishing, Texas.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Energy and its measurements	2
2	Wood as sources of energy and its comparison with other sources	3
3	Criteria for evaluation of different fuel wood species for energy	3
4	Utilization of wood waste material as fuel	4
5	Gasification, pyrolysis and briquetting of lignocellulosic material	3
6	Production of chemicals from forest biomass cellulose, lignin andhemicelluloses. Important wood extractives	6
7	Wood refinery techniques	4
8	Chemicals produced as by product in pulp industry	3
9	Destructive distillation of wood. Future of wood chemical industry	4
	Total	**32**

FPU 603 WOOD AND WOOD TECHNOLOGY 2+1

Objective

To develop understanding of students about advances in wood technology

Theory

UNIT I

Ultrastructure and composition of softwoods and hardwoods.

UNIT II

Transverse, volumetric and longitudinal shrinkages in wood

UNIT III

Biopulping, enzyme pulp bleaching, biotechnological production of wood composites, bioremediation of wood treated with preservatives, bioactive wood polymer composites, non- conventional wood bonding, wood degradation by chemicals, treatment of pulp effluents.

Practical

Study of major cell types of softwoods and hardwoods. Cell inclusions. Shrinkage and swelling of wood. Determination of anti-shrink efficiency of treated wood. Pulping, pulp yield and bleaching. **Suggested Readings**

Bowyer JL Shmulsky R and Haygreen JG. 2010. *Forest Products and Wood Science: An Introduction.* 4th Ed. Blackwell Publishing.

David A and Talliman. 1978. *Wood as an Energy Resource*. Academic Press. Hills WE. 1982. *Heartwood and Tree Exudates.* Springer Verlag.

Rowell RM. 2013. *Handbook of Wood Chemistry and Wood Composites.* 2nd Ed. CRC Press,Taylor and Francis Group.

Shmulsky RP and David. 2011. *Forest Products and Wood Science: An Introduction*. 6th Ed. Wiley, Blackwell.

Sjostrom E. 1993. *Wood Chemistry: Fundamentals and Applications*. 2nd Ed. Gulf Professional Publishing.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Ultrastructure and composition of softwoods and hardwoods	6
2	Transverse, volumetric and longitudinal shrinkages in wood	6
3	Biopulping, enzyme pulp bleaching	4
4	Biotechnological production of wood composites	4
5	Bioremediation of wood treated with preservatives, bioactive wood polymer composites, non-conventional wood bonding	8
6	Wood degradation by chemicals, treatment of pulp effluents	4
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Study of major cell types of softwoods and hardwoods	5
2.	Cell inclusions. Shrinkage and swelling of wood	5
3.	Determination of anti-shrink efficiency of treated wood. Pulping, pulp yield and bleaching	6
	Total	**16**

FPU 604 ANALYTICAL TECHNIQUES IN FOREST PRODUCTS 1+2

Objective

To develop understanding of students about advances in research methods

Theory

UNIT I

Concept of spectroscopy, electromagnetic radiation, Beer-Lambert Law of electromagnetic radiation. Chemical analysis of spectrophotometery. Different spectrophotometric methods in chemical analysis. Principle and utilization of different instruments based on spectrophotomeric methods- atomic absorption, spectrophotometer, IR, UV, NMR, Mass spectrophotometer etc. Chromatography and various chromatographic techniques in chemical analysis of plant samples.

Principle and utilization of various chromatographic techniques and instruments- TLC, HPLC, Gas chromatography etc.

UNIT II

Principle and utilization of CHN analyzer. Physico-chemical analysis of pulp and Paper.

Practical

Estimation of volatile and non volatile chemical constituents of plants through various techniques and instruments. Estimation of different elements in plant samples. Chemical analysis of pulp. Determination of physico-chemical analysis of pulp and Paper.

Preparation of research project. Writing of research report.

Suggested Readings

Harborne JB. 1998. *Phyto-Chemical Method*s. 3rd Ed. Springer Publication, New York.

Moore WE and Johnson DB. 1967. *Procedure for Chemical Analysis of Wood and Wood Products.*

Forest Products Laboratory, Forest Service US Dept of Agriculture.

Raaman N. 2006. *Phytochemical Techniques*. New India Publishing Agency, New Delhi. Rao KP. 2003. *Pulp and Technology*. CBS Publishing and Distributors, New Delhi.

Rowell RM. 2013. *Handbook of Wood Chemistry and Wood Composites*. 2nd Ed. CRC Press, New York.

Rydholm SA. 1965. *Pulping Process*. Inter-science Publishers.

Snyder LR, Kirkland JJ and Glajch JL. 1997. *Practical HPLC Method Development*. 2nd Ed. John Wiley & Sons.

Wilde KD and Engewald W. 2014. *Practical Gas Chromatography: A Comprehensive Reference.*

Springer, Berlin.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Concept of spectroscopy, electromagnetic radiation, Beer-Lambert Law of electromagnetic radiation. Chemical analysis of spectrophotometery. Different spectrophotometric methods in chemical analysis.	3
2	Different spectrophotometric methods in chemical analysis. Principle and utilization of different instruments based on spectrophotomeric methods- atomic absorption, spectrophotometer, IR, UV, NMR, Mass spectrophotometer etc.	5
3	Chromatography and various chromatographic techniques in chemical analysis of plant samples. Principle and utilization of various chromatographic techniques and instruments- TLC, HPLC, Gas chromatography etc.	3
4	Principle and utilization of CHN analyzer	2
5	Determination of physico-chemical analysis of pulp and Paper	3
	Total	**16**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Estimation of volatile and non volatile chemical constituents of plants through various techniques and instruments	8
2	Estimation of different elements in plant samples	4
3	Determination of physico-chemical analysis of pulp and Paper	6
	Preparation of research project. Writing of research report	14
	Total	**32**

FPU 605 CHEMISTRY OF MEDICINAL AND AROMATIC PLANTS 2+1

Objective

To expose the students on different aspects related to medicinal plants research and its application.

Theory

UNIT I

Detail study of biosynthetic pathways of terpenoides, steroids, alkaloids, phenolic compounds and amino acids

UNIT II

Chemical studies of important insecticidal compounds of plant origin. Chemical conversion of some plant products to useful drugs.

UNIT III

Nature of postharvest degradation of active principles.

Practical:

Extraction, purification, separation and structural determination of some important active principles of plants by various physical and chemical techniques. Structural determination of some important active principles of plants by various physical and chemical techniques.

Suggested Readings

Chauhan NS. 1999. *Medicinal and Aromatic Plants ff Himachal Pradesh*. Indus Publishing. Mathe A. 2015. *Medicinal and Aromatic Plants of the World: Scientific, Production, Commercial and Utilization Aspects.* Springer.

Zohara Y and Bachrach U. 2005. *Handbook of Medicinal Plants.* CRC Press.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Detail study of biosynthetic pathways of terpenoides, steroids, alkaloids, phenolic compounds and amino acids	10
2	Chemical studies of important insecticidal compounds of plant origin	6
3	Chemical conversion of some plant products to useful drugs	8
4	Nature of postharvest degradation of active principles	8
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Extraction, purification and separation of some important active principles of plants by various physical and chemical techniques	9
2	Structural determination of some important active principles of plants by various physical and chemical techniques	7
	Total	**16**

FPU 606 PROCESSING TECHNOLOGY OF FOREST PRODUCTS 2+1

Objective

To develop understanding of students about nutritional and post harvest aspects

Theory

UNIT I

Identification of harvesting period based on active content of drugs. Harvesting method of underground parts, leaves, stem, bark, wood, fruits, flowers etc.

UNIT II

Processing of harvested crops of various forest products (*e.g.* Gums, Resin, Katha, Cutch, Tans, Dyes and fixed oil). Storage and value addition. Deterioration degradation of active principles during storage and their control.

UNIT III

Isolation of major bioactive compounds. Preparation of active content enriched extracts.

UNIT IV

Latest methods of extraction of volatile and fixed oil.

Practical

Harvesting, drying, grading and packaging of various forest products. Assessment of deterioration of active principles during storage and their control. Preparation of active content enriched extracts of important forest products.

Suggested Readings

Bedi S, Singh T and Vyas SP. 2012. *A Handbook ff Aromatic and Essential Oil Plants: Cultivation, Chemistry, Processing and Uses.* Agrobios (India).

Dawn CPA, Annamalai M and Naik R. 2016. *Leafy Medicinal Herbs: Botany, Chemistry, Postharvest Technology and Uses.* CABI.

Serdar O and Milan M. 2014. *Medicinal and Aromatic Crops: Harvesting, Drying and Processing.*

CRC Press.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Identification of harvesting period based on active content of drugs	3
2	Harvesting method of underground parts, leaves, stem, bark, wood, fruits, flowers etc.	4
3	Processing of harvested crops of various forest products (*e.g.* Gums, Resin, Katha, Cutch, Tans, Dyes and fixed oil)	5
4	Storage and value addition	4
5	Deterioration degradation of active principles during storage and their control	4
6	Isolation of major bioactive compounds	5
7	Preparation of active content enriched extracts	4
8	Latest methods of extraction of volatile and fixed oil	3
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Harvesting, drying, grading and packaging of various forest products.	5
2.	Assessment of deterioration of active principles during storage and their control	5
3.	Preparation of active content enriched extracts of important forest products	6
	Total	**16**

FPU 607 VALUE ADDITIONS AND MARKETING OF FOREST PRODUCTS 2+1

Objective

This course will educate students, methods of harvesting of yieldable plant/plant parts of herb shrub, trees, etc. to increase the value of product, post harvest technology and will make them aware about instruments/ equipments used to extract essential oil and also operation of machines for preparation of tablets, mixture, tinctures etc.

Theory

UNIT I

Value addition - concepts and procedures. Drying and grading of various forest products. Preparation of powders, aqueous and alcoholic extracts essences etc. Preparation of tablets, mixtures, balms, ointments, etc. Bulk storage and packaging.

UNIT II

Basic and advanced concepts of trade and marketing, marketing under disorganized and organized sector. Village and regional markets, state, national and international market of forest products. Internet marketing practices for latest market value and other pattern of fluctuations for high value forest products. Concept of e-market and quality standards. Constraint in sale and procurement.

Practical

Visit to nearby pharmaceutical concern for understanding value addition processes. Visit to local market and data collection of sale and sale procedure - organized and unorganized. Internet surfing for latest market value of high value forest products.

Suggested Readings

Govil JN, Arunachalam C and Singh VK. 2006. *Recent Progress in Medicinal Plants.* Volume11: drug development from molecules. Studium Press LLC.

Sharma AK and Singh VK, Govil JN and Goyal NK. 2006. *Recent Progress in Medicinal Plants.*

Volume 12: Globalization Of Herbal Health. Studium Press LLC.

Singh MP and Somadey. 2015. *Indian Medicinal Plants*. Satish Serial Publishing House.

Singh VK, Govil JN and Singh G. 2002. *Ethnomedicine and Pharmacognosy.* Science Technology, Publishing LLC.

Syamal MM. 2008. *Production Technology of Medicinal & Aromatic Plants*. IBDC Publishers.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Value addition - concepts and procedures	3
2	Preparation of powders, aqueous and alcoholic extracts, essences etc.	5
3	Preparation of tablets, mixtures, balms, ointments, etc. Bulk storage and packaging	6
4	Basic and advanced concepts of trade and marketing, marketing underdisorganized and organized sector	5
5	Village and regional markets, state, national and international market of herbs and herbal forest products	5
6	Internet marketing practices for latest market value and other pattern of fluctuations for high value forest products	6
7	Concept of e-market and quality standards	2
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Visit to nearby pharmaceutical concern for understanding value addition processes	**6**

2	Visit to local market and data collection of sale and sale procedure organized and unorganized. Internet surfing for latest market value of high value forest products	10
	Total	**16**

FPU 608 MODERN TRENDS IN WOOD MODIFICATION 2+1

Objective

To develop understanding of students about advances in wood modification.

Theory UNIT I

Engineered wood products. Wood polymer hybrid composites. Stabilization of wood preservatives.

UNIT II

Testing of biological performance of modified wood products. Degradation of cellular structure of wood during use.

UNIT III

Environmental issues related to wood modification.

Practical

Different preservative treatments of wood. Chemical modification of wood. Testing of biological performance of modified wood. Treated wood finishing.

Suggested Readings

Ansell MP. 2015. *Wood Composites.* Elsevier-Science-Technology.

FAO. 2007. *Wood Preservation Manual.* International Book Distributor, Dehradun.

Hill CAS. 2006. *Wood Modification: Chemical, Thermal and Other Processes*. John Wiley and Sons Ltd.

Pizzi A and Mittal KL. 2011. *Wood Adhesives*. CRC Press.

Rowell RM. 2013. *Handbook of Wood Chemistry and Wood Composites*. 2nd Ed. CRC Press. USDA. 1999. *Wood Handbook - Wood as an Engineered Material.* US Department of Agriculture, Forest Service. Forest Products Laboratory, Madison.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1.	Engineered wood products	5
2.	Wood polymer hybrid composites	7
3.	Stabilization of wood preservatives	5
4.	Testing of biological performance of modified wood products	6
5.	Degradation of cellular structure of wood during use	5
6.	Environmental issues related to wood modification	4
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Different preservative treatments of wood	5
2.	Chemical modification of wood	5

3.	Testing of biological performance of modified wood. Treat wooded finishing	6
	Total	**16**

FPU 609 DEVELOPMENT IN PULP AND PAPER TECHNOLOGY 2+0

Objective

To impart advanced knowledge related to different aspects of pulp and paper technology.

Theory

UNIT I

Historical development of the pulp and paper industry. Chemistry of fibrous raw material - raw material preparation.

UNIT II

Advances in pulping processes for softwood, hardwoods and other fibrous material. Recent trends in Bio-pulping, Chorine free bleaching, organo solve pulping.

UNIT III

Nenotechnology in pulp and paper making. Substitution of wood with recycled fibers.

UNIT IV

Reduction in water utilization and effluent discharge.

Suggested Readings

Rowell RM. 2013. *Handbook of Wood Chemistry and Wood Composites*. 2nd Ed. CRC Press.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Historical development of the pulp and paper industry	3
2	Chemistry of fibrous raw material - raw material preparation	4
3	Advances in pulping processes for softwood, hardwoods and other fibrous material	6
4	Recent trends in Bio-pulping, Chorine free bleaching, organo solve pulping	7
5	Nenotechnology in pulp and paper making	4
6	Substation of wood with recycled fibers	4
7	Reduction in water utilization and effluent discharge	4
	Total	**32**

FPU 610 APPLICATION OF TRADITIONAL KNOWLEDGE 2+0

Objective

To develop understanding of students about application of traditional knowledge.

Theory

UNIT I

Traditional remedies for treating specific diseases like cardiovascular disease, mental disorders, rheumatic arthritis, diabetes, cough and asthma, fatigue, liver diseases, kidney and bladder stones, wounds stomach

disorders etc. Traditional therapies *vis-a-vis* modern therapies.

UNIT II

Scientific validation of traditional systems of medicines/ remedies - case studies. Important herbs used in traditional medicines. Integration of herbal remedies with allopathic system of medicine. Allopathic drugs based on medicines herbs.

UNIT III

National and international research and other institutions involved in scientific validation of traditional knowledge eg. CDRI, CIMAP, RRL's, CCRAS, WHO etc., their role and major achievements.

UNIT IV

Composition of major herbal formulations e.g. Chavanprash, Vasavaleha, Arjunarishta, Pachakchurna etc. Major herbal pharmaceutical companies and their products like Dabur, Zandhu, Baidyanath, Himalayan Drug Company, Charak Pharmaceuticals etc. Role of local health traditions in primary health care.

Suggested Readings

Alikhan I and Khanum A. 2008. *Role of Biotechnology in Medicinal and Aromatic Plants*. UKAZ Publishers.

Chadha KL and Gupta R. 2006. *Advances in Horticulture*. Vol. XI. Medicinal and aromatic plants. Malhotra Publ. House.

Gupta AK and Sharma M. 2008. *Reviews on Indian Medicinal Plants*. ICMR.

Johnson CB and Franz C. 2005. *Breeding Research on Aromatic and Medicinal Plants.*

International Book Distr.

Sharma R. 2004. *Agrotechniques of Medicinal Plants*. Daya Publ.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Traditional remedies for treating specific diseases like cardiovascular disease, mental disorders, rheumatic arthritis, diabetes, cough and asthma, fatigue, liver diseases, kidney and bladder stones, wounds stomach disorders etc.	5
2	Traditional therapies *vis-a-vis* modern therapies	3
3	Scientific validation of traditional systems of medicines/ remedies - case studies	4
4	Important herbs used in traditional medicines. Integration of herbal remedies with allopathic system of medicine	4
5	Allopathic drugs based on medicines herbs	2
6	National and international research and other institutions involved in scientific validation of traditional knowledge eg. CDRI, CIMAP, RRL's, CCRAS, WHO etc., their role and major achievements	3
7	Composition of major herbal formulations e.g. Chavanprash, Vasavaleha, Arjunarishta, Pachakchurna etc.	4
8	Major herbal pharmaceutical companies and their products like Dabur, Zandhu, Baidyanath, Himalayan Drug Company, Charak Pharmaceuticals etc.	5
9	Role of local health traditions in primary health care	2
	Total	**32**

FPU 611 PRODUCTION OF QUALITY PLANTING MATERIAL OF MEDICINAL AND AROMATIC PLANTS 2+1

Objective

To develop understanding of students about production of quality planting material.

Theory

UNIT I

Concept of quality in the context of medicinal and aromatic plants. Quality parameters of different medicinal and aromatic plants.

UNIT II

Role of genotype and environment in affecting quality. Selection and development of hybrids in medicinal and aromatic plants.

UNIT III

Breeders seed, foundation seed and certified seed. Marker assisted breeding. Authentication of nursery produce for quality parameters. Different approaches including biotechnological tools for production of quality planting material.

Practical

Production of inbred seed of commercially important species. Selection of superior genotypes on the basis of agronomical characters from an existing population of medicinal and aromatic plants. Evaluation of germplasm for yield attributes.

Suggested Readings

Alikhan I and Khanum A. 2008. *Role of Biotechnology in Medicinal and Aromatic Plants*. UKAZ Publishers.

Chadha KL and Gupta R. 2006. *Advances in Horticulture*. Vol. XI. Medicinal and aromatic plants. Malhotra Publ. House.

Gupta AK and Sharma M. 2008. *Reviews on Indian Medicinal Plants*. ICMR.

Gupta AK, Tandon N and Sharma M. 2008. *Quality Standards of Indian Medicinal Plants.* Johnson CB and Franz C. 2005. *Breeding Research on Aromatic And Medicinal Plants.* International Book Distr.

Sharma R. 2004. *Agrotechniques of Medicinal Plants.* Daya Publications.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1.	Concept of quality in the context of medicinal and aromatic plants	2
2.	Quality parameters of different medicinal and aromatic plants	7
3.	Role of genotype and environment in affecting quality	4
4.	Selection and development of hybrids in medicinal and aromatic plants. Breeders seed, foundation seed and certified seed	6
5.	Marker assisted breeding	3
6.	Authentication of nursery produce for quality parameters	5
7.	Different approaches including biotechnological tools for production of quality planting material	5
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Production of inbred seed of commercially important species	5
2.	Selection of superior genotypes on the basis of agronomical characters from an existing population of medicinal and aromatic plants	6

3.	Evaluation of germplasm for yield attributes	5
	Total	**16**

FPU 612 PROCESSING TECHNOLOGY OF MEDICINAL & AROMATIC PLANTS 2+1

Objective

To develop understanding of students about nutritional and post harvest aspects of medicinal and aromatic plants.

Theory

UNIT I

Identification of maturity indices and harvesting period based on active content. Harvesting method of underground parts, leaves, stem, bark, fruits, flowers etc.

UNIT II

Processing of harvested crops of medicinal and aromatic plants. Storage and value addition. Deterioration/ degradation of active principles during storage and their control.

UNIT III

Isolation of major bioactive compounds from medicinal plants, preparation of active content enriched extracts.

UNIT IV

Advances in extraction of essential oil.

Practical

Harvesting, drying, garbling, grading and packaging of medicinal and aromatic plants. Assessment of deterioration of active principles during storage and their control. Preparation of active content enriched extracts of important medicinal plants.

Suggested Readings

Alikhan I and Khanum A. 2008. *Role of Biotechnology in Medicinal and Aromatic Plants*. UKAZ Publishers.

Chadha KL and Gupta R. 2006. *Advances in Horticulture.* Vol. XI. Medicinal and aromatic plants. Malhotra Publ. House.

Gupta AK and Sharma M. 2008. *Reviews on Indian Medicinal Plants*. ICMR.

Gupta AK, Tandon N and Sharma M. 2008. *Quality Standards ff Indian Medicinal Plants*. Mann J 1994. *Chemical Aspects ff Biosynthesis*. Oxford Chemistry Primers.

Sharma R. 2004. *Agrotechniques ff Medicinal Plants*. Daya Publ.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Identification of maturity indices and harvesting period based on active content	4
2	Harvesting method of underground parts, leaves, stem, bark, fruits, flowers etc.	4
3	Processing of harvested crops of medicinal and aromatic plants	5
4	Storage and value addition.	4
5	Deterioration/ degradation of active principles during storage and their control	3
6	Isolation of major bioactive compounds from medicinal plants, preparation of active content enriched extracts	8
7	Advances in extraction of essential oil	4

	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Harvesting, drying, garbling, grading and packaging of medicinal and aromatic plants	5
2	Assessment of deterioration of active principles during storage and their control	6
3	Preparation of active content enriched extracts of important medicinal plants	5
	Total	**16**

FPU 613 BIOSYNTHESIS OF SECONDARY METABOLITES 3+0

Objective

To develop understanding of students about biosynthesis of secondary metabolites.

Theory

UNIT I

Primary and secondary metabolites. Building blocks for secondary metabolites. Common reactions involved in the biosynthesis of secondary metabolites. Effect of environmental factors on production of secondary metabolites.

UNIT II

Biosynthetic pathways of terpenoids (mono, sesqui, di, tri and tetraterpenoids) and steroids.

UNIT III

Biosynthesis of alkaloids of phenylethylamine. Pyrrolidine piperidine, pyrrolidine - pyridine, tropane, quinoline, isoquinoline and phenanthrene groups.

UNIT IV

Biosynthesis of flavonoids, lignans (podophyllotoxin) and Vitamins E & K.

Suggested Readings

Alikhan I and Khanum A. 2008. *Role of Biotechnology in Medicinal and Aromatic Plants*. UKAZ Publishers.

Chadha KL and Gupta R. 2006. *Advances in Horticulture*. Vol. XI. Medicinal and aromatic plants. Malhotra Publ. House.

Gupta K and Sharma M. 2008. *Reviews on Indian Medicinal Plants*. ICMR.

Gupta AK, Tandon N and Sharma M. 2008. *Quality Standards of Indian Medicinal Plants.*

Mann J 1994. *Chemical Aspects of Biosynthesis*. Oxford Chemistry Primers. Sharma R. 2004. *Agrotechniques of Medicinal Plants.* Daya Publ.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Primary and secondary metabolites	4
2	Building blocks for secondary metabolites	4
3	Common reactions involved in the biosynthesis of secondary metabolites	7
4	Effect of environmental factors on production of secondary metabolites	4
5	Biosynthetic pathways of terpenoids (mono, sesqui, di, tri and tetraterpenoids) and steroids	8
6	Biosynthesis of alkaloids of phenylethylamine. Pyrrolidine piperidine,	10
7	pyrrolidine - pyridine, tropane, quinoline, isoquinoline and phenanthrene groups	

8	Biosynthesis of flavonoids, lignans (podophyllotoxin) and Vitamins E & K		8
		Total	**45**

FPU 614 VALUE ADDITIONS AND MARKETING OF MEDICINAL & AROMATIC PLANTS 2+1

Objective

This course will educate students, methods of harvesting of yieldable plant/plant parts of herb, shrub, trees, climber, lianas and ephipytes. To increase the value of product, post harvest technology will be known to them, practical classes will make them aware about instruments/ equipments used to extract essential oil and also operation of machines for preparation of tablets, mixture, tinctures etc.

Theory

UNIT I

Value addition for higher economic returns. Concepts and procedures. Preparation of powders, aqueous and alcoholic extracts, essences etc. Preparation of tablets, mixtures, balms, ointments, etc. Bulk storage and packaging of medicinal and aromatic plants.

UNIT II

Basic and advanced concepts of trade and marketing, marketing under disorganized and organized sector. Village and regional markets, state, national and international market of herbs and herbal products. Internet marketing practices for latest market value and other pattern of fluctuations for high value medicinal and aromatic plants/plant parts and products. Concept of e-market and quality standards. Constraint in sale and procurement.

Practical

Visit to nearby pharmaceutical concern for understanding value addition processes. Visit to local market and data collection on sale and sale procedure - organized and unorganized. Internet surfing for latest market value of high value of medicinal and aromatic plants.

Suggested Readings

Alikhan I and Khanum A. 2008. *Role of Biotechnology in Medicinal and Aromatic Plants*. UKAZ Publishers.

Chadha KL and Gupta R. 2006. *Advances in Horticulture*. Vol. XI. Medicinal and aromatic plants. Malhotra Publ. House.

Gupta K and Sharma M. 2008. *Reviews on Indian Medicinal Plants*. ICMR.

Gupta AK, Tandon N and Sharma M. 2008. *Quality Standards of Indian Medicinal Plants.*

Mann J 1994. *Chemical Aspects of Biosynthesis*. Oxford Chemistry Primers. Sharma R. 2004. *Agrotechniques of Medicinal Plants.* Daya Publ.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Value addition for higher economic returns. Concepts and procedures	4
2	Preparation of powders, aqueous and alcoholic extracts, essences etc.	5
3	Preparation of tablets, mixtures, balms, ointments, etc. Bulk storage and packaging of medicinal and aromatic plants	5
4	Basic and advanced concepts of trade and marketing, marketing under disorganized and organized sector	5
5	Village and regional markets, state, national and international market of herbs and herbal products	5

6	Internet marketing practices for latest market value and other pattern of fluctuations for high value medicinal and aromatic plants/plant parts and products	6
7	Concept of e-market and quality standards	2
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Visit to nearby pharmaceutical concern for understanding value addition processes	6
2	Visit to local market and data collection on sale and sale procedure - organized and unorganized. Internet surfing for latest market value of high value of medicinal and aromatic plants	10
	Total	**16**

Forest Resource Management

Course Titles with Credit Load
M.Sc. in Forest Resource Management

Course Code	Course Title	Credit Hrs.
Major Courses		
FRM 501*	Forest Biometry and Management	2+1
FRM 502	Ecology and Management of Forest Soils	2+1
FRM 503*	Remote Sensing and Geographical Information System in Forest Resource Management	2+1
FRM 504	Land Use Planning and Watershed Management	2+1
FRM 505*	Forest Resource Economics	1+1
FRM 506*	Forest Ecosystem Services and Valuation	2+1
FRM 507	Environmental Impact Assessment and Auditing	1+1
FRM 508*	Forest Policy, law and International Conventions	2+0
FRM 509	Global Climate Change Impact, Mitigation and Adaptation	2+0
FRM 510*	Participatory Approaches in Forest Resource Management	1+1
FRM 511	Management of Tree Insect-Pests and Diseases	2+1
FRM 512	Forest Ecology, Biodiversity and Management	2+1
Minor Courses		
	Courses from Silviculture and Agroforestry or Forest Biology and Tree Improvement or Forest Products and Utilization	08
Supporting Courses		
FOR 511*	General Statistical Methods and Computer Applications	2+1
	Note: The student may choose the above mentioned Supporting Course or other courses provided the opted courses are related to the research problem selected by the student and be mandatorily approved by the Student Advisory committee/HOD".	

FRM 591*	Master's Seminar	1+0
ii) Thesis Research		
FRM 599	Master's Research	0+30

*Compulsory Core Courses

Course Contents

FRM 501 FOREST BIOMETRY AND MANAGEMENT 2+1

Objective

To provide knowledge about forest management, ecosystem management, site quality evaluation, stand density and forest valuation, tree measurements, forest inventory and yield concepts Theory

UNIT I

Measurement of tree parameters. Estimation of volume, growth and yield of individual tree and forest stands. Preparation of volume tables and its application, yield and stand tables.

UNIT II

Forest inventory, Sampling methods adopted in forestry, Use of GPS in forest inventory. Measurement of stand density. Simulation techniques.

UNIT III

Principles of forest management; scope and object of forest management, ecosystem management, development of forest management in India. Site quality evaluation and importance. Stand density measurement.

UNIT IV

Forest valuation and appraisal in regulated forests.

UNIT V

Growth and yield prediction models – their preparation and applications.

Practical

Calculations of volume of felled as well as standing trees, Volume table preparation, Application of sampling procedures, Handling of GPS, Preparation of yield and stand table.

Suggested Readings

Chaturvedi AN and Khanna LS. 1994. *Forest Menstruation*. International Book Distributor. Davis LS and Johnson KN.2005. *Forest Management.* Waveland Press.

Husch B, Miller CI and Beers TW. 2003.*Forest Menstruation*. John Wiley.

John AK, Ducey MJ, Beers TW and Husch B. 2017. *Forest Mensuration*. Wiley Blackwel. Laar A. Van and Akca A. 2007. *Forest Mensuration*. Springer, Netherlands.

Loctsch I and Haller KE . 1964. *Forest Inventory* Vol. and Vol II . BLV Verlagsgesellschaft, München, Germany.

Michacl S Philip. 1994. *Measuring Forests and Trees.* CAB International. Prodan M. 1968. *Forest Biometrics*. Pergamn Press.

Ram Parkash 1983. *Forest Surveying*. International Book Distr.

Sharpe GW, Hendee CW and Sharpe WE. 1986. *Introduction to Forestry*. McGraw-Hill.

Simmons CE. 1980. *A Manual of Forest Mensuration*. Bishen Singh Mahender Pal Singh, Dehradun

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Measurement of tree parameters. Estimation of volume, growth and yield of individual tree and forest stands	2

2	Preparation of volume tables and their application	2
3	Preparations of Yield and stand tables, their application	2
4	Forest Inventory, Sampling methods adopted in Forestry, Kinds of enumeration, Kinds of sampling Advantages of sampling, Sampling design, Sampling Intensity and Sampling errors Use of aerial Photography in Forest Inventory	5
5	Use of GPS in Inventory	2
6	Principles of forest management, scope and object of forest management	2
7	Ecosystem management, development of forest management in India Site quality evaluation and importance: Site Index, Methods of site quality evaluation, Methods of determining past growth of stands Canopy Density, Crown Competition Factor	2
8	Stand Density Measurement : Measure of stand density, Absolute measures of stand density, Stand density index, Stand density versus stocking	4
9	Forest Valuation and appraisal in regulated forests	3
10	Growth and yield prediction models- their preparation and applications	4
11	Simulation techniques	2
	Total	**36**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Calculations of volume of felled as well as standing trees	3
2	Volume table preparation	4
3	Application of sampling procedures	3
4	Handling of GPS	2
5	Preparation of yield and stand table	4
	Total	**16**

FRM 502 ECOLOGY AND MANAGEMENT OF FOREST SOILS 2+1

Objective

To impart information on the soil types and properties of soils under different forest ecosystems, chemical and biological dimensions of soil fertility, and forest soil fertility evaluation and management.**Theory**

UNIT I

Forest soils – distinguishing features, soil forming processes and its factors. soils and vegetation development, physical and chemical properties- Types and properties of soils under different forest ecosystems.

UNIT II

Forest floor - Organic horizons- litter dynamics- humus – types- organic matter decomposition- mineralization and immobilization of organic matter- nutrient cycling significance of C:N ratio, soil pH.

UNIT III

Forest soil biology - soil fauna - nitrogen fixation - rhizobium-tree legume symbiosis *Frankia* x non-legume symbiosis, nitrification and denitrification in forest ecosystems. Micorrhizal associations in forest soils.

UNIT IV

Nursery soils, problem soils, mineral nutrition, acidic deposition effects, fire effects and management interventions of forest soils. Soil fertility and its evaluation.

Practical

Study of the soil profile, mechanical analysis, determination of pH, organic C, CEC and available, micro and

macro nutrients, manurial schedules for different soils.

Suggested Readings

Brady NC and Weil RR. 2007. *The Nature and Properties of Soils.* 14th Ed., Prentice

Fisher RF and Binkley D. 2000. *Ecology and Management of Forest Soils*. John Wiley & Sons, Inc. New York.

Hall, New Jersey.

Stevenson FJ and cole MA. 1999. *Cycles of soil; Carbon, Nitrogen, Phosphorus, Sulphur, micronutrients.* John Wiley & Sons Inc. New York.

Tisdale LS, Nelson LW and Beaton JD. 1985. *Soil Fertility and Fertilizers*. Macmillan Publishing Company, New York.

Troeh FR and Thompson LM. 2005. *Soils and Soil Ferility*. Black well.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Forest soils – distinguishing features - soils and vegetation development	3
2	Physical and chemical properties- Types and properties of soils under different forest ecosystems	3
3	Forest floor : Organic horizons and litter dynamics	3
4	Humus – types- organic matter decomposition-mineralization and	4
5	immobilization of organic matter Nutrient cycling, significance of C:N ratio, soil pH	3
6	Forest soil biology, soil fauna, nitrogen fixation. Rhizobium-tree legume symbiosis. *Frankia* x non-legume symbiosis	4
7	Nitrification and denitrification in forest ecosystems. Micorrhizal associations in forest soils	3
8	Nursery soils, problem soils, mineral nutrition, acidic deposition effects	5
9	Effect of forest fire and management interventions of forest soils	4
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Study of the soil profile	1
2	Mechanical analysis of soil	3
3	Determination ofpH, EC, organic carbon	2
4	Determination ofCEC	2
5	Determination of availableN, P, K, Ca, Mg and S	3
6	Determination of micro-nutrients-Cu, Zn, Mn and Fe	2
7	Manurial schedules for different soils	3
	Total	**16**

FRM 503 REMOTE SENSING AND GEOGRAPHICALINFORMATION SYSTEM IN FOREST RESOURCE MANAGEMENT 2+1

Objective

To impart practical knowledge to the students on geomatics and its application in natural resource management

Theory

UNIT I

Remote sensing: Introduction, definition, brief history and fundamental principle of RS. 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

UNIT II

Geo-referencing of topo-sheets and satellite imageries, Satellite Image Interpretation, Digital Image Processing (DIP)-image registration, image enhancement, classification, supervised and unsupervised classification

UNIT III

RS software, free and open source software for remote sensing Application of Remote Sensing in forest resource management-land-use and land cover mapping, vegetation mapping and change detection, forest biomass and carbon mapping and monitoring, forest damage as assessment (pests and diseases ,mining, fire), forest fire risk zonation and mapping, Watershed delineation and mapping, wildlife habitat assessment etc.

UNIT IV:

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. Free and open source software in GIS, Global Positioning System.

Practical

Thematic layers build up, overlaying and their integration using ERDAS and Arc GIS software package Interpretation of satellite data and digital image processing. Preparationof thematic maps. Preparation forest biomass and carbon map, fire affected areas assessment, preparation of change detection map, classification of LULC using ERDAS and Arc GIS 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.Agncy, New Delhi.

Gurugnanam 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.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Remote sensing: Introduction, definition, brief history, fundamental principle of RS, Stages of RS, Classification of RS: Active and Passive RS- based on source of energy and wavelength; Aerial and space remote sensing, Merits and limitations of RS.Recent developments in geomatics. Different satellite missions of India and abroad	6
2	Remote sensing platforms-ground aerial and space platforms, satellite orbits, Resolution- spatial, spectral, radiometric and temporal; Scanning systems- whisk broom and push broom scanners; Sensor system- MSS, ETM, MSS, LISS etc.	6
3	Image analysis: Definition, visual image analysis, digital image analysis, elements of image analysis and steps in digital image processing. Agencies involved in remote sensing	4
4	Application of RS in forestry: Vegetation cover classification and mapping-NDVI, SAVI, EVI, status and monitoring, species identification, social and agro-forestry applications, growing stock estimation, biodiversity characterization, wildlife habitat suitability mapping, biomass and carbon mapping etc.	6
5	Geoinformatics and GIS meaning, objectives, elements of GIS- software, hardware, data ware, human ware, processes involved in GIS, Raster data, vector data, thematic overlay building. Application of GIS to forestry	5
6	GPS: Global Positioning System-meaning, principles, applications, GNSS, IRNS, GAGAN etc.	3
	Total	**30**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Thematic layers build up, overlaying and their integration using ERDAS and ArcGIS SoftwarepackageArcGISsoftware	4
2	Interpretationofsatellitedataanddigitalimageprocessing	4
3	Preparationof thematic maps	3
4	Preparation forest biomass and carbon map, fire affected areas assessment, preparation of change detection map, classification of LULC using ERDAS and ArcGIS softwares	5
	Total	**16**

FRM 504 LAND USE PLANNING AND WATERSHED MANAGEMENT 2+1

Objective

To develop understanding of students about land use planning and watershed management. Developing sustainable agroforestry systems/techniques in watershed.

Theory

UNIT I

Land use Planning: Concepts and techniques; Agro-ecological regions/ sub-regions of India; factors affecting land use; soil and land use survey through remote sensing techniques.

UNIT II

Interpretation of soil resource map for land use planning; land evaluation methods and soil-site suitability evaluation for different crops.

UNIT III

Watershed management concept- objectives, characterization, planning, execution, community participation and evaluation.

UNIT IV

Developing economically and ecologically sustainable agroforestry systems for watersheds; water harvesting and its efficient use; rehabilitation of watersheds. Suitable tree planting techniques in watersheds. Suitable trees/shrubs and grasses for watershed for different agro-climatic regions.

UNIT V

Watershed management cases studies. Drought and flood mapping and its relevance in designing sustainable cropping systems.

Practical

Study of Agro-ecological regions/ sub-regions of India; soil and land use survey through remote sensing technique.Interpretation of soil resource map for land use planning; land evaluation methods and soil-site suitability evaluation for different crops. Watershed characterisation, planning, execution, community participation and evaluation.Suitable tree planting techniques in watersheds. Suitable trees/shrubs and grasses for watershed for different agro-climatic regions.

Watershed management cases studies. Drought and Flood mapping and its relevance in designing sustainable cropping systems.

Suggested Readings

Michael AM and Ojha TP. 1966. *Principles of Agricultural Engineering*, Jain Brothers, Jodhpur. Michael AM. 2008. *Irrigation Theory and Practice*. Vikas Publishing House Pvt Ltd.

Murthy JVS. 1998. *Watershed Management*. New Age International, New Delhi.

Murthy VVN.1985. *Land and water management engineering*. Kalyani Publishers, New Delhi. Narayana DVV, G Sastry and US Patnaik. 1997. *Watershed Management*. Indian Council of Agricultural Research, New Delhi.

Narayana DVV. 1993. *Soil and Water Conservation Research in India*, ICAR, New Delhi.

Singh G*et al*. 1988. *Manual of Soil and Water Conservation*. Oxford IBH Publishing Co. New Delhi.

Subramanya K. 2006. *Engineering Hydrology*, Tata McGraw Hill publication.

USDA 1961. *A Manual on Conservation of Soil and Water*. Oxford and IBH Publishing Company.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Land use Planning: concepts and techniques; Agro-ecological regions/ sub-regions of India	3
2	Factors affecting land use; soil and land use survey through remote sensing technique	3
3	Interpretation of soil resource map for land use planning	2
4	Land evaluation methods and soil-site suitability evaluation for different crops	4

5	Watershed management concept- objectives, characterization, planning, execution, community participation and evaluation	5
6	Developing economically and ecologically sustainable agroforestry systems for watersheds; water harvesting and its efficient use; rehabilitation of watersheds	4
7	Suitable tree planting techniques in watersheds	2
8	Suitable trees/shrubs and grasses for watersheds for different agroclimatic regions	2
9	Watershed management cases studies	4
10	Drought and flood mapping and its relevance in designing sustainable cropping systems	3
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Study of Agro-ecological regions/ sub-regions of India	2
2	Soil and land use survey through remote sensing technique	2
3	Interpretation of soil resource map for land use planning; land evaluation methods and soil-site suitability evaluation for different crops	3
4	Watershed characterisation, planning, execution, community participation and evaluation.Suitable tree planting techniques in watersheds	3
5	Suitable trees/shrubs and grasses for watershed for different agro- climatic regions Watershed management cases studies	3
6	Drought and Flood mapping and its relevance in designing sustainable cropping systems	3
	Total	**16**

FRM 505 FOREST RESOURCE ECONOMICS 1+1

Objective

To develop understanding of students about forest resource management and economics management decisions, forest and environmental resource accounting.

Theory

UNIT I

Principles of microeconomics and its application in forest resource management. Demand, supply and marketing of forest products. Theory of capital and application in forest resource management. **UNIT II**

Domestic and international trade in forest products. Impact of soicio-economic variables on forest appraisal and management decisions. Externalities and property rights. Knowledge about risk and uncertainty in forest resource management

UNIT III

Natural and environmental resource accounting –methods and implications. Application of operational research tools in evaluating forest management alternatives in public and private forest planning and valuation.

Practical

Exercises on estimation of demand and supply functions; biodiversity valuation, valuation of non- marketed forest products. Exercises on financial and economic appraisal of forestry projects. Exercises on marketing

of forest products and international trade competitiveness. Computer applications for using programming techniques in evaluating forest management alternatives.

Suggested Readings

FAO. 1986. *Guidelines to Practical Project Appraisal*. Natraj Publ.

Kerr JM, Marothia DK, Singh K, Ramaswamy C and Beritley WR. 1997. *Natural Resource Economics : Theory and Applications in India*. Oxford and IBH.

Nautiyal JC. 1988. *Forest Economics – Principles and Applications*. Natraj Publications, Dehradun.

Sharma LC. 1980. *Forest Economics, Planning and Management*. International Book Distributors, Dehradun.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Principles of microeconomics and its application in forest resource management	3
2	Demand, supply and marketing of forest products. Theory of capital and application in forest resource management	4
3	Domestic and international trade in forest products	1
4	Impact of soicio-economic variables on forest appraisal and management decisions. Externalities and property rights	3
5	Forest and environmental resource accounting –methods and implications.	3
6	Application of operational research tools in evaluating forest management alternatives in public and private forest planning and valuation	3
	Total	**17**

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Exercises on estimation of demand and supply functions	4
2.	Biodiversity valuation, valuation of non-marketed forest products	3
3.	Exercises on financial and economic appraisal of forestry projects Exercises on marketing of forest products and international trade competitiveness	6
4.	Computer applications for using programming techniques in evaluating forest management alternatives	3
	Total	**16**

FRM 506 FOREST ECOSYSTEM SERVICES AND VALUATION 2+1

Objective

To impart knowledge ecosystem services, natural capital, natures contribution to people, global science perception on ecosystem services, quantification and valuation tools, governance, challenges and policy issues. To develop an understanding of students on the concepts of Ecological-Economics and importance of Green Economy.

Theory

UNIT I

Ecosystem Services (ES) basics, importance, history of ES and natural capital, classification of ES-provisioning, regulating, supporting and cultural services and their status and changes, drivers of change of ecosystem services, international conventions and charters on ES-Inter- governamental Science Policy

Platform on Biodiversity and Ecosystem Services (IPBES) and Millennium Ecosystem Services (MEA) Assessment– an overview. Linkages among biodiversity, ecosystem services and human well being.

UNIT II

Quantification of Ecosystem Services-direct and indirect approaches. Ecological Economics: Valuation of ES, need for valuation. Use values and Non-Use values- direct value, indirect value, optional value, bequest value, existence value. Valuation methods-Market price based approach such as stumpage value method, productivity and cost based approaches such as replacement cost method and surrogate market and stated preference approaches such as stumpage value method, Hedonic Pricing Method, Contingent Valuation Method, Travel Cost Method etc., Case studies in India and abroad. Challenges in valuation of ES. Management tools for embedding ecosystem services perspective.

UNIT III

Governance and policy issues in ecosystem services, Payment for ecosystem services (PES), mechanisms of benefit sharing, eco-certification, Geographic Indications, Forest Stewardship Council, Landscape labelling. National and International initiatives in PES and on-going programs.

Practical

IPBES and MEA assessment. Valuation methods- direct and indirect. Case studies of PES in India and Abroad. Case studies on certification and geographical indications, FSC.

Suggested Readings:

Alavalapati JRR, Shrestha RK, Stainback GA and Matta JR. 2004. *Agroforestry development: An environmental economic perspective.* Agroforestry Systems.

Huxley P. 1999. *Tropical Agroforestry*. Blackwell.

Jain SK and Singh P. 2000. *Economic Analysis of Industrial Agroforestry: Poplar (Populus deltoides) in Uttar Pradesh (India).* Agroforestry Systems.

Jeffers JNR. 1978. *An Introduction to System Analysis with Ecological Application*. Edward Arnold.

Jose S. 2009. *Agroforestry for Ecosystem Services and Environmental Benefits: an Overview*. Agroforestry Systems.

Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer, Netherlands.

Paulo ELD and Nunes. 2014. *Handbook on the Economics of Ecosystem and Biodiversity*. E-book. Sander J, Nicolas D and Hans K. 2014. *Ecosystem Services: Global Issues and Local Practices*. First Edition. Elsevier Publications.

Schroth G, Sinclair F. 2003. *Tree Crops and Soil Fertility: Concepts and Research Methods*, CABI, Wallingford, UK.

Young A. 1997. *Agroforestry for Soil Management*. 2nd ed. CABI, Wallingofrd, UK.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Ecosystem Services (ES) basics, importance, history of ES and natural capital, classification of ES-provisioning, regulating, supporting and cultural services	3
2	Status and changes of ecosystem services, drivers of change of ecosystem services	2
3	International conventions and charters on ES-Inter- governmentalScience Policy Platform on Biodiversity and Ecosystem Services (IPBES) and Millennium Ecosystem Services (MEA) Assessment– an overview	3
4	Linkages among biodiversity, ecosystem services and human well being	2

5	Quantification of Ecosystem Services-direct and indirect approaches. Ecological Economics: Valuation of ES, need for valuation	4
6	Use values and Non-Use values- direct value, indirect value, optional value, bequest value, existence value	2
7	Valuation methods-Market price based approach such as stumpage value method, productivity and cost based approaches such as replacement cost method and surrogate market and stated preference approaches such as stumpage value method, Hedonic Pricing Method, Contingent Valuation Method, Travel Cost Method etc.	6
8	Case studies of valuation of ES in India and abroad. Challenges in valuation of ES	2
9	Governance and policy issues in ecosystem services	2
10	Payment for ecosystem services (PES), mechanisms of benefit sharing, eco-certification, Geographic Indications, Forest Stewardship Council, Landscape labelling	3
11	National and International initiatives in PES and on-going programs	3
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	IPBES and MEA assessment	3
2	Valuation methods- direct and indirect	3
3	Case studies of PES in India and Abroad	4
4	Case studies on certification and geographical indications, FSC	4
	Total	**16**

FRM 507 ENVIRONMENTAL IMPACT ASSESSMENT AND AUDITING 1+1

Objective

To provide a detailed knowledge on the environmental inmpact assessment and its importance. Also this course enables the students to know salient features of EIA legislation and other statutory obligations.

Theory

UNIT I

Origin of EIA and historical perspective, scope and purpose of EIA; Key merits of environmental assessment in regulating the state of environment. Global experience in EIA; Comparative review of EIA systems in different countries and regions. Salient features of EIA legislation and other statutory obligations. · Environmental decision making in India Environmental clearance procedures and national requirements.

UNIT II

Flow charts showing key steps; Methodological approaches and tools for key stages in the process: Screening (classification of developments and stage to determine the level of EIA, exclusion and inclusion lists of projects, different approaches to screening) Scoping (scoping steps, guidance and tools, and stakeholder involvement), Impact prediction and evaluation (approach for baseline development and methods of impact identification-checklists, Matrices, Networks)

UNIT III

Introduction to various impact assessment methods: checklist, matrices, networks, indices and weight

scaling techniques and their scope and limitations · Prediction and assessment of impact on the land, air, water, noise, biological and socioeconomic environments Mitigation: definitions and hierarchy of measures including avoidance, reduction, rectification and compensation enhancement approaches, principles and concepts of offsets, type of offsets

UNIT IV

EIA administration and practice. Cost and benefits of evaluation of EIA; understanding strengths and limitation of EIA. EIA standards; risk assessment; potential impact to water and air pollution. **Practical**

Flow charts showing key steps; Methodological approaches and tools for key stages in the process: Screening (classification of developments and stage to determine the level of EIA, exclusion and inclusion lists of projects, different approaches to screening) Scoping (scoping steps, guidance and tools, and stakeholder involvement), Impact prediction and evaluation (approach for baseline development and methods of impact identification-checklists, Matrices, Networks), EIA of development projects, EIA of restored mine lands, Undertaking an EIA: case studies for agro- industries.

Suggested Readings

AK Shrivastava. 2003. *Environment Auditing*. APH Publishing. Anjanayulu Y. 2002. *EIA Methodologies*. BSP BS publication

Lawrence and Dravid P. 2003. *EIA Practical Solutions to Recurrent problems.*

Morgan RK. 1988. EIA- *A methodological Perspective*. Kluwer Academic Publishers.

Patnaik and Naba Kumar. 2000. *Environmental Audit-A Perspective, Environment Management and Audit*, Deep and Deep Publication Pvt. Ltd., New Delhi.

Pramanik AK. 2002. *Environmental Audit and Indian Scenario, Environmental Accounting and Reporting*, Deep and Deep Publications Pvt. Ltd., New Delhi.

Selvam M. 2002. *The Need for an Environmental Audit, Environmental Accounting and Reporting*, Deep and Deep Publications Pvt. Ltd., New Delhi.

Smith LG. 1993. *Impact Assessment and Sustainable Resource Management*, John Wiley & Sons. New York.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Origin of EIA and historical perspective, scope and purpose of EIA. Key merits of environmental assessment in regulating the state of environment	1
2	Global experience in EIA; Comparative review of EIA systems in different countries and regions. Salient features of EIA legislation and other statutory obligations	2
3	Environmental decision making in India Environmental clearance procedures and national requirements	2
4	Flow charts showing key steps; Methodological approaches and tools for key stages in the process: Screening (classification of developments and stage to determine the level of EIA, exclusion and inclusion lists of projects, different approaches to screening	2
5	Scoping (scoping steps, guidance and tools, and stakeholder involvement), Impact prediction and evaluation (approach for baseline development and methods of impact identification- checklists, Matrices, Networks)	2
6	Introduction to various impact assessment methods: checklist, matrices, networks, indices and weight scaling techniques and their scope and limitations	2

7	Prediction and assessment of impact on the land, air, water, noise, biological and socioeconomic environments	2
8	Mitigation: definitions and hierarchy of measures including avoidance, reduction, rectification and compensation enhancement approaches	2
9	Principles and concepts of offsets, type of offsets	2
	Total	**17**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Flow charts showing key steps; Methodological approaches and tools for key stages in the process: Screening (classification of developments and stage to determine the level of EIA, exclusion and inclusion lists of projects, different approaches to screening) Scoping (scoping steps, guidance and tools, and stakeholder involvement)	8
2	Impact prediction and evaluation (approach for baseline development and methods of impact identification-checklists, Matrices, Networks), EIA of development projects, EIA of restored mine lands, Undertaking an EIA: case studies for agro-industries	8
	Total	**16**

FRM 508 FOREST POLICY, LAW AND INTERNATIONAL CONVENTIONS 2+0

Objective

To develop understanding of students about forest policy and laws and international conventions

Theory

UNIT I

Forest policy – Relevance and scope; National Forest Policy – 1894, 1952 and 1988

UNIT II

Forest laws; Indian Forest Act –1927, general provision and detailed study; Forest Conservation Act 1980, Wildlife Protect Act 1972 Important Forest Rules and Guidelines. ; Indian evidence act applied to forestry matters, Legal definitions;objectives of species forest laws

UNIT III

History of environmental policy in India. Constitutional and legislative provisions— constitutional provisions and the environment, Environmental protection and fundamental rights, Digest of environmental *legislation*(Interpretation of environmental statutes, Environmental protection Act 1986; Biodiversity Act, 2002, Schedules tribes (Recognition of forest rights), Act, 2007. Judicial remedies & procedures, public interest litigations, Intellectual Property Rights (Patents , Copy rights, Trade mark, Trade secrets),freedom of information, and right to know.

UNIT IV

Important case studies and landmark judgments. Case studies of different forests divisions/areas of India. International conventions of forestry issue. e.g. Role of internationaltreaties like CITES, IUCN, RAMSER, CBD etc.

Suggested Readings

Divan S andRosencranz 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.The Biodiversity Act,2002.

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

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Forest policy – Relevance and scope,National Forest Policy – 1894, 1952 and 1988	2
2	Forest laws; Indian Forest Act –1927, general provision and detailed study	3
3	Forest Conservation Act 1980	2
4	Wildlife Protect Act 1972	2
5	Important Forest Rules and Guidelines. ; Indian evidence act applied to forestry matters, Legal definitions ;objectives of species forest laws	2
6	History of environmental policy in India	1
7	Constitutional and legislative provisions—constitutional provisions and the environment,	2
8	Environmental protection and fundamental rights, Digest of environmental *legislation*(Interpretation of environmental statutes,	2
9	Environmental protection Act 1986	2
10	Biodiversity Act, 2002	2
11	Schedules tribes (Recognition of forest rights), Act,2007	1
12	Judicial remedies & procedures, public interest litigations, Intellectual Property Rights (Patents, Copy rights, Trademark, Trade secrets),freedom of information, and right to know	4
13	Important case studies and landmark judgments. Case studies of different forests divisions/areas of India	3
14	International conventions of forestry issue. e.g. Role of internationaltreaties like CITES, IUCN, RAMSER, CBD etc.	3
	Total	**32**

FRM 509 GLOBAL CLIMATE CHANGE IMPACTMITIGATION AND ADAPTATION 2+0

Objective

To impart knowledge on climate change and different mitigation and adaptation strategies and also on international initiatives on climate change.

Theory

UNIT I

Definition and concept of climate change and variability; global warming and dimming; science and politics of climate change and international conventions; evidence, scenario and causes of climate change. Greenhouse gases and mechanism of their production and emission from various agro-ecosystems, source and sinks of GHG; warming potential and contribution of greenhouse gases to global warming, greenhouse effect; monitoring of greenhouse gases

UNIT II

Impact assessment of rise in atmospheric temperature and CO_2 on growth, physiological processes, productivity and quality of different vegetation types, soil health, water availability, insect pest dynamics, crop production, milk and inland and marine fish production; climate change and loss of biodiversity; spatial and temporal changes in forest and plantation productivity and agricultural production in context of climate change.

UNIT III

Adaptation and mitigation options to climate change; carbon sequestration; modeling climate change and its impact on forests. International summit, conferences, protocols and negotiations on climate change; clean development mechanism; carbon trading, credits, footprints and govt. strategies and policies on climate change management.

UNIT IV

Recent techniques for assessing the impact of high temperature on tree species and crops, recent techniques for assessing the impact of CO_2 fertilization on productivity, recent techniques for assessing the impact of elevated CO_2 on tree species.

Suggested Readings

Climate Change: Challenges To Sustainable Development in India. 2008. Research UNIT (Larrdis) Rajya Sabha Secretariat, New Delhi.

Greenhouse Gas Emission from Agricultural System, Published by IPCC- USEPA *Climate change and global crop productivit*y Ed. by K R Reddy and HF Hodges CABI Publishing.

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.

John Houghton. *Global Warming* (4th), Cambridge Press.

Robert M, Clausen and Henry L Gholz. *Carbon and Forest Management*. School of Forest Resources and Conservation. University of Florida, Gainesville, FL 32611, USA.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Definition and concept of climate change and variability; global warming and dimming	2
2	Science and politics of climate change and international conventions; evidence, scenario and causes of climate change. Greenhouse gases and mechanism of their production and emission from various agro- ecosystems, source and sinks of GHG	4
3	Warming potential and contribution of greenhouse gases to global warming, greenhouse effect; monitoring of greenhouse gases	4
4	Impact assessment of rise in atmospheric temperature and CO_2 on growth, physiological processes, productivity and quality of different forest types, soil health, water availability, insect pest dynamics, crop- weed competition, milk and inland and marine fish production	4
5	Climate change and loss of biodiversity; spatial and temporal changes in forest and plantation productivity and agricultural production in context of climate change	3

6	Adaptation and mitigation options to climate change; carbon sequestration; modeling climate change and its impact on forests	4
7	International summit, conferences, protocols and negotiations on climate change; clean development mechanism; carbon trading, credits, footprints	3
8	Government strategies and policies on climate change management	3
9	Recent techniques for assessing the impact of high temperature on tree species and crops, recent techniques for assessing the impact of CO_2 fertilization on productivity, recent techniques for assessing the impact of elevated CO_2 on tree species	5
	Total	**32**

FRM 510 PARTICIPATORY APPROACHES IN FOREST RESOURCE MANAGEMENT 1+1

Objective

To inculcate knowledge and skills in students to employ participatory tools and techniques for effective planning, implementation, monitoring and evaluation of forestry projects, to efficiently carry out forest resource management and to effectively resolve conflicts by adopting participatory techniques.

Theory

UNIT I

Participatory approaches- Participatory planning- Participatory data collection, research and project preparation; Participatory implementation- group approaches for implementation of projects and programmes; Participatory monitoring; Participatory evaluation- Concurrent and ex- post evaluation; Peoples' participation- community mobilization

UNIT II

Concept of Social Research, Traditional methods of doing research, Action Research and Participatory Research. Scope and importance of Qualitative Data. Construction and Methods of Data Collection. Different types of Sampling. Interview Techniques. Qualitative methods- Sociometry, Case Studies, observation, coding and content analysis

UNIT III

Participatory Methods of Data Collection-Concept and Need of Data, Information, Appraisal; Various methods of Data Collection, Interpretation of Qualitative and Quantitative Data. Origin of Participatory Methods, FSA, Rapid Rural Appraisal.Key informants, selection of key informants.Semi-structured interviews, Question guide/checklist and other relevant methods and their applications in forestry and natural resource management.

UNIT IV

Objectives of PRA.The Logic and merits of the PRA.Challenges/constraints of PRA. Major methods of PRA. The fundamental concepts of PRA. Principles of PRA. Operational guidelines for organizing PRA at village level. PRA & PLA – Concept, Methods, Tools, Interpretation and Techniques. Other relevant participatory approaches like RRA, PANR etc.. Emerging tools used for PRA (ICT, GIS, GPS etc.)

Practical

Visit to selected forest areas to undertake and understand various participatory research methods including participatory rural appraisal techniques like social mapping, resource mapping, Venn diagrams, transect walk, time lines etc.

Suggested Readings

CR Kothari. 1992. *Research Methodology- Methods & Techniques*. Wiley Eastern Limited New Delhi.

N Narayanasamy. 2008. *Participatory Rural Appraisal: Principles, Methods and Application*. Robert C. 1981. *Rapid Rural Appraisal Rationale and Repertoire*. IDS Discussion Paper, No. 155, IDS, Sussex.

VE Sabarathnam. 2002. *R/R/PRA for Agriculture*.Vamsaravath Publishers, Hyderabad.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Participatory approaches- Participatory planning- Participatory data collection, research and project preparation	2
2	Participatory implementation- group approaches for implementation of projects and programmes; Participatory monitoring; Participatory evaluation- Concurrent and ex-post evaluation; Peoples' participation- community mobilization	2
3	Concept of Social Research, Traditional methods of doing research, Action Research and Participatory Research	2
4	Impact assessment of rise in atmospheric temperature and CO2 on growth, physiological processes, productivity and quality of different forest types, soil health, water availability, insect pest dynamics, crop-weed competition, milk and inland and marine fish production	2
5	Scope and importance of qualitative data. Construction and Methods of Data Collection. Different types of Sampling	2
6	Interview Techniques. Qualitative methods-Sociometry, Case Studies, observation, coding and content analysis	2
7	Participatory Methods of Data Collection-Concept and Need of Data, Information, Appraisal; Various methods of Data Collection, Interpretation of Data Qualitative and Quantitative	2
8	Origin of Participatory Methods, FSA, Rapid Rural Appraisal. Keyinformants, selection of key informants. Semi-structured interviews, Question guide/checklist and other relevant methods and their applications in forestry and natural resource management	2
9	Objectives of PRA. The Logic and merits of thePRA. Challenges/constraints of PRA. Major methods of PRA. The fundamental concepts of PRA. Principles of PRA	2
10	Operational guidelines for organizing PRA at village level. PRA & PLA Concept, Methods, Tools, Interpretation and Techniques.	1
11	Other relevant participatory approaches like RRA, PANR etc.. Emerging tools used for PRA (ICT, GIS, GPS etc.)	1
	Total	**18**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Visit to selected forest areas to undertake and understand various participatory research methods	8
2	Including participatory rural appraisal techniques like social mapping, resource mapping, Venn diagrams, transect walk, time lines etc.	8
	Total	**16**

FRM 511 MANAGEMENT OF TREE INSECT PESTS AND DISEASES 2+1

Objective

To provide and understanding to the students on management of insect pests and diseases and aspects

related to INM.

Theory

UNIT I

Principles and methods of integrated pests management; Insect attractants and repellents; male sterility techniques.

UNIT II

Important insect pests of nurseries, plantations, avenue trees and their management. Insect pests of seeds of forest trees and their management.

UNIT III

Principles of tree disease. management; Integrated forest protection; development of disease management system.Integrated pest management

UNIT IV

Important diseases of nurseries, plantations and avenue trees and their management, Mycoflora of seeds and their management.

Practical

Collection and identification of insect pests and non-insect pests. Inspection and collection of insect damaged plant specimens. Preparations of different pesticides. Application of pesticides, pesticide application method.

Collection, preservation and identification of tree diseases, forest nursery and plantation, Isolation and characterization of tree pathogens; preparation of fungicidal solutions; *In vitro* efficacy and *In vivo* efficacy assessments.

Suggested Readings

Agrios GN. 2005. *Plant Pathology.* Elsevier Acad. Press. Singapore.

Butin H. 1995. *Tree Diseases and Disorders*. Oxford Univ. Press, New York.

Evane JW. 1989. *Insect Pest and their Control*. Samir BooK Center, New Delhi (India).

Gonthia P and Nicolotti G. 2013. *Infectious Forest Diseases*. CABI, UK. Guy Watson., 2013, Tree Pests and Diseases.

Pathak H, Maru S, Satya HN and Silawat SC. 2015. *Fungal Diseases of Trees in Forest Nurseries of Indore, India.* J Plant Pathol Microb.

Sinclair W and Howard HL. 2005. *Diseases of Trees and Shrubs*.

Speight MR. 2000. *Insect Pest in Tropical Forestry.* Rose Willey Publications.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Concepts and terminologies in forest entomology	1
2	Insect pest induced loss assessments in different forest nursery seedlings	2
3	Insect pest induced loss assessments in different forest plantations	2
4	Principles of integrated pest management	2
5	Insect attractants and repellents, male sterility techniques	2
6	Important insect pests of nurseries	1
7	Important insect pests of plantation trees, avenue trees and their management	3
8	Insect pests of seeds of forest trees and their management.	1

9	Concepts and terminologies forest pathology	2
10	Disease induced loss assessments in different forest nursery seedlings and plantations	2
11	Principle methods of tree disease management	2
12	Integrated forest protection	2
13	Development of disease management system	2
14	Important diseases of forest nurseries and their management	3
15	Important diseases of forest plantations and avenue trees and their management	3
16	Mycoflora of seeds and their management	2
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Collection and identification of insect pests and non-insect pests	2
2	Inspection and collection of insect damaged plant specimens	3
3	Preparations of different pesticides. Application of pesticides	3
4	Collection, preservation and identification of tree diseases, forest nursery and plantation	3
6	Isolation and characterization of tree pathogens	2
7	Preparation of fungicidal solutions; *In vitro* efficacy and *In vivo* efficacy assessments	3
	Total	**16**

FRM 512 FOREST ECOLOGY, BIODIVERSITY AND MANAGEMENT 2+1

Objective

This course would enable the students to understand the aspects related to forest ecosystem and its dynamics. As well it provides the knowledge on biodiversity conservation in natural forests and agro-ecosystems, policy issues, IPR etc.

Theory

UNIT I

Introduction to forest ecology, forest population, forest community dynamics, forest community structure and analysis, forest productivity on a global scale, ecology of forest landscapes spatial heterogeneity; Hierarchy issues in ecology.

UNIT II

Biodiversity-an overview; genetic, species and ecosystem diversity; determinants of biodiversity. Higher plant diversity, species richness and endemism. Managing plant genetic resources: Basic science issues - genetic vulnerability and crop diversity, crop diversity-institutional responses, in situ conservation of genetic resources, the science of collecting,utilizing and managing genetic resources, the science of managing genetic resources, using genetic resources, biotechnology and germplasm conservation etc.

UNIT III

Complementary strategies for plant biodiversity conservation. In situ conservation of wild species in nature reserves, in situ conservation components, factors influencing conservation value, national plan for in situ conservation. In situ conservation of Forest and agro-biodiversity on-farm: importance of on-farm conservation initiatives, overview of the types of information necessary in the design of an on-farm conservation programme.

UNIT IV

Managing plant genetic resources: policy issues (exchange of genetic resources: quarantine, IPR; genetic resources: assessing economic value; conflicts over ownership, management and use; national and international treaties/legislations: CBD, IT-PGRFA, GPA, PVP&FR Act, Biodiversity Act etc.). International instruments concerning agro-biodiversity, Agenda 21, convention on biological diversity (CBD), FAO and global system of PGR, the International Treaty on Plant Genetic Resources for food and agriculture (ITPGR), Global Plan of Action, TRIPS agreement and IPR protection of life forms.

Practical

Study of forest community structure and its successional status, Estimation of productivity of forest ecosystem, Trip to different regions of the state to study forest vegetation, Collection and preservation of specimen, Methods of vegetation analysis, Measurement of biomass and productivity, Quantification of litter production and decomposition, Visit to national parks, wildlife sanctuaries, botanical gardens and arboreta.

Suggested Readings

Bonneuil, Christophe and Jean-Baptiste F. *The Shock of the Anthropocene: The Earth, History and Us. London* ; Brooklyn, NY: Verso, 2016. (Chapter 1: Welcome to the Anthropocene).

Brush SB. 1999. *Genes in the Field: On-farm Conservation of Crop Diversity*. Lewis Publishers, Boca Raton, Florida, USA.

Chandna R C. 2002: *Environmental Geography*, Kalyani, Ludhiana.

Cunninghum WP and Cunninghum MA. 2004: *Principles of Environmental Science: Inquiry and Applications*, Tata Macgraw Hill, New Delhi.

Engels JMM. 1995. *In Situ Conservation and Sustainable Use of Plant Genetic Resources For Food and Agriculture in Developing Countries*. IPGRI/DSE.

Jarvis D, Staphit B and Sears L. 2000. *Conserving Agricultural Biodiversity in Situ: A Scientific Basis for Sustainable Agriculture*. IPGRI, Rome, Italy.

Maxted N, Ford-Lloyd BV and Hawkes JG. 1997. *Plant Genetic Conservation: The In Situ Approach.* Chapman & Hall, London.

Wood D and Lenne J. 1999. *Agrobiodiversity: Characterisation, Utilization and Management*. CAB International, Wallingford.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Introduction to forest ecology, forest population, forest community dynamics, forest community structure and analysis	2
2	Forest productivity on a global scale, ecology of forest landscapes spatial heterogeneity; Hierarchy issues in ecology	2
3	Biodiversity-an overview; genetic, species and ecosystem diversity; determinants of biodiversity. Higher plant diversity, species richness and endemism	2
4	Managing plant genetic resources: Basic science issues - genetic vulnerability and crop diversity, crop diversity-institutional responses, in situ conservation of genetic resources	3
5	The science of collecting genetic resources, the science of managing genetic resources, using genetic resources	2

6	Biotechnology and germplasm conservation Complementary strategies for plant biodiversity conservation. In situ	1
7	conservation of wild species in nature reserves, in situ conservation components, factors influencing conservation value, national plan for in situ conservation	
8	In situ conservation of Forest and agro-biodiversity on-farm: importance of on-farm conservation initiatives, overview of the types of information necessary in the design of an on-farm conservation programme	4
9	Managing plant genetic resources: policy issues (exchange of genetic resources: quarantine, IPR; genetic resources: assessing economic value; conflicts over ownership, management and use	4
10	National and international treaties/legislations: CBD, IT-PGRFA, GPA, PVP&FR Act, Biodiversity Act etc.)	4
11	International instruments concerning agro-biodiversity, Agenda 21, convention on biological diversity (CBD), FAO and global system of PGR, the International Treaty on Plant Genetic Resources for food and agriculture (ITPGR), Global Plan of Action, TRIPS agreement and IPR protection of life forms	4
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Study of forest community structure and its successional status	2
2	Estimation of productivity of forest ecosystem	2
3	Trip to different regions of the state to study forest vegetation, Collection and preservation of specimen	4
4	Methods of vegetation analysis, Measurement of biomass and productivity	3
5	Quantification of litter production and decomposition	2
6	Visit to national parks, wildlife sanctuaries, botanical gardens and arboreta	3
	Total	16

Course Titles with Credit Load
Ph.D. in Forest Resource Management

Course Code	Course Title	Credit Hrs.
Major Courses		
FRM 601*	Forest Management	2+1
FRM 602	Forest Economic Analysis	2+1
FRM 603	Climate Change and Forestry	1+1
FRM 604	Geo-informatics in Forest Resource Management	2+1
FRM 605*	Environmental Impact Analysis and Assessment	2+1
FRM 606	Forest Soil Management	2+1
FRM 607	Environmental Modelling and Biostatistics	2+0
FRM 608	Approaches in Forest Resource Assessment	1+1
FRM 609	Forest Hydrology and Watershed Management	2+1
FRM 610	Operational Research and Forest Modeling	1+1
FRM 691*	Doctoral Seminar-I	1+0
FRM 692*	Doctoral Seminar-II	1+0
Minor Courses		
	Courses from Silviculture and Agroforestry or Forest Biology and Tree Improvement or Forest Products and Utilization	06
Supporting Courses		
FOR 610*	Research Methodology in Forestry	2+1
FOR 611	Research and Publication Ethics	1+1
	Note: The student may choose the above mentioned Supporting Course or other courses provided the opted courses are related to the research problem selected by the student and be mandatorily approved by the Student Advisory committee/HOD".	
ii) Thesis Research		
FRM 699	Doctoral Research	0+75

***Compulsory Core Courses**

Course Contents

FRM 601 **FOREST MANAGEMENT** **2+1**

Objective

To provide the recent knowledge on management of Indian forests, different methods of yield regulation in regular and irregular forests and forest evaluation and appraisal in regulated forests. **Theory**

UNIT I

Evolution of Indian forest management system and current approaches of forest management. Goal-Dimension matrix in forest management and its application to natural forest and plantations. Case studies in relation of even and uneven aged stands. Project planning, classical approaches to yield regulation in forest management,salient feature and strategies.

UNIT II

Operational research methods in forest management and application; use of operational research methods in forest planning models; emphasis on algorithms, problem formulation and interpretation of results.

UNIT III

Simulation modeling of forest operations processing facilities; principles and methodology for performing simulation experiments; emphasis on building, running and analyzing simulation based models applicable to forest operations and wood products processing. Application of programming-linear and dynamic, network analysis, PERT (program evaluation and review technique) and CPM (Critical path method), inventory models.

UNIT IV

Working plans and working schemes, their role in nature conservation, biodiversity and other dimensions and control.Free and open source software.

Practical

Application of above techniques through a case analysis using forest inventories. Application and use of operational research methods in forest planning models. Simulation modeling of forest operations and processing facilities.

Suggested Readings

Arunachdam A and Kha ML 2001. *Sustainable Management of Forest in India*, IBD, Dehradun. Bentley J and Recknagel AB. 1995. *Forest Management*. International book distributors, Dehra Dun.

Davis *et al*. 2005. *Forest Management*, IV Edition. Waveland Press Inc, USA. Innes JL. 1993. *Forest Health-Its Assessment and Status*, CAB international, U.K.

Pulparambil J. 2002. *Forest Management – An HRD Approach*. Uppal Publishing House, New Delhi.

Raison RJ, Brown AJ and Flimn PW. 2003. *Criteria and Indicators for Sustainable Forest Management.* CAB Publications, UK.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Principles of forest management; scope and objectives of forest management, ecosystem management, development of forest management in India	3
2	Case studies in relation of even and uneven aged stands. Project planning	3
3	Site quality evaluation and importance. Stand density	2

4	Classical approaches to yield regulation in forest management, salient feature and strategies, Basis of yield regulation. Methods of yield regulation. Examples in relation to Indian forests	5
5	Forest evaluation and appraisal in regulated forests. Operational research methods in forest management and application	3
6	Application of operational research methods in forest planning models; emphasis on algorithms, problem formulation and interpretation of results	3
7	Simulation modeling of forest operations processing facilities; principles and methodology for performing simulation experiments; emphasis on building, running and analyzing simulation based models applicable to forest operations and wood products processing	4
8	Application of programming-linear and dynamic, network analysis, PERT (program evaluation and review technique) and CPM (Critical path method), inventory models	3
9	Working plans and working schemes, their role in nature conservation, biodiversity and other dimensions and control	3
10	Preparation of working plan, different types of map, steps in working plan preparation. Difference between management plan, working plan, microplan	3
	Total	**30**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Application of above techniques through a case analysis using forest inventories	5
2	Application and use of operational research methods in forest planning models.	5
3	Simulation modeling of forest operations and processing facilities.	6
	Total	**16**

FRM 602 FOREST ECONOMIC ANALYSIS 2+1

Objective

Is to provide different aspects forest economics, Issues and dynamics of domestic and international demand and supply of forestry products

Theory

UNIT I

Use of theoretical frameworks of consumer behavior, market equilibrium, efficiency of perfect and imperfect competition, game theory, and social welfare functions in decision making about optimization of forest resources; Issues and dynamics of domestic and international demand and supply of forestry products

UNIT II

Models of optimal resource use – Applications of dynamic programming and optimal control – Optimal management of forestry resources – Logistic growth – Maximum sustainable yield – Optimal harvest rule – Regulated and unregulated common property. Economics of Forest Resource – optimal harvesting of single rotation and multiple rotation forests.

UNIT III

National income accounting – estimation and methods - Issues and methodologies in green accounting.

UNIT IV

Valuation of forestry goods and services – Direct valuation methods – Indirect valuation methods. Environmental pollution as a case of common property management- Policy initiatives for improving the management of common property resources and environmental conservation. Environmental regulation and policies - market based instruments – economic instruments – pollution charges, taxes, tradable permits.

Practical

Efficiency of perfect and imperfect competition - consumer surplus analysis. Game theory - social welfare function. Derivation of the fundamental equation of renewable resources - Estimation of growth curves and stock dynamics for forestry resources. Simple two period problem of optimal resource use – optimal rotation. National income accounting - methods Environmental Resource Accounting - Green GDP. Direct valuation methods – Indirect valuation methods. Criteria for evaluating the environment related projects and review of Environmental impact Assessment (EIA) techniques. Practical considerations and comparison of instruments of environmental policy – pollution control methodologies.

Suggested Readings

Tom Totenberg and Lynne Lewis. 2009. *Environmental and Natural Resource Economics* Pearson - Addision Wesley publication, 9th edition.

Lecture Schedule
Theory

Sr. No.	Topic	No. of Lecture (s)
1	Use of theoretical frameworks of consumer behavior, equilibrium, efficiency of perfect and im-perfect competition	market 3
2	Game theory, and social welfare functions in decision making about optimization of forest resources	3
3	Issues and dynamics of domestic and international demand and supply of forestry products	3
4	Models of optimal resource use – Applications of dynamic programming and optimal control – Optimal management of forestry resources – Logistic growth – Maximum sustainable yield – Optimal harvest rule	4
5	Regulated and unregulated common property	2
6	Economics of Forest Resource – optimal harvesting of single rotation and multiple rotation forests	3
7	National income accounting – estimation and methods - Issues and methodologies in green accounting	3
8	Valuation of forestry goods and services – Direct valuation methods – Indirect valuation methods	4
9	Environmental pollution as a case of common property management- Policy initiatives for improving the management of common property resources and environmental conservation	4
10	Environmental regulation and policies - market based instruments – economic instruments – pollution charges, taxes, tradable permits	4
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Efficiency of perfect and imperfect competition - consumer surplus analysis. Game theory - social welfare function	3
2	Derivation of the fundamental equation of renewable resources - Estimation of growth curves and stock dynamics for forestry resources. Simple two period problem of optimal resource use – optimal rotation.	4
3	National income accounting - methods Environmental Resource Accounting - Green GDP	2
4	valuation methods – Indirect valuation methods. Criteria for evaluating the environment related projects and review of Environmental impact Assessment (EIA) techniques	4
5	Direct Practical considerations and comparison of instruments of environmental policy – pollution control methodologies	3
	Total	**16**

FRM 603 CLIMATE CHANGE AND FORESTRY 1+1

Objective

To develop an understanding among the students on the recent aspects of climate change, mitigation and adaptation options and the current national and international initiatives to tackle climate change.

Theory

UNIT I

History of climate change, Institutional developments towards climate change. Recent developments in global climate changes: Changes in source and sinks of carbon in the last few decades. Global warming potentials of major GHG's.

UNIT II

Effect of climate change on: Ocean, Soil, Forest, Biodiversity, Agriculture & Livelihood and relevant mitigation measures to address these issues. Climate change, Economic development and energy conservation dilemma. Role of alternate energy sources and its current status towards offsetting fossil fuel use. Carbon Footprint: concepts, methods of assessment, applications and its uses in different fields with special reference to Agriculture. Role of agroforestry strategies to increase terrestrial carbon sinks. Global dimming; role of aerosols in global dimming and implications to solar energy constant.

UNIT III

Policy issues: Kyoto protocol, carbon trading mechanisms, Montreal agreement, Marrakesh Accord, REDD, REDD+ and other recent international agreements and negotiations to address the climate change issues. Other Climatic aberrations and its relationship to climate change: Ozone depletion, ENSO etc. India's stand on climate change: Recent developments in the strategies; Green India Mission, CAMPA, Millennium goal and other policy initiatives to mitigate climate change.

Practical

Atmospheric CO_2 measurement methods. Soil Carbon assessment, Soil carbon dynamics. Atmospheric CO_2 flux measurements. Exposing plants to elevated CO_2 concentration. FACE and FATE experiments, Open top chambers and its importance in understanding the effect of increased CO_2 concentration and plant growth. Differential responses of species to elevated CO_2 concentrations. Diurnal plant response t light, temperature and CO_2 concentration. Methods of flux measurements, practical on carbon footprint measurement.

Suggested Readings

Houghton John. 2009. *Global Warming* (Fourth edition). Cambridge Press.

J Jager and HL Ferguson. 2007. IPCC Assessment Report . *Climate Change Journal Climate Change: Source, Impact and Policy*, Proceeding of 2nd World Climate Conference. Cambridge University Press, 1993.

Parry, Martin L, Canziani, Osvaldo F, Palutikof, Jean P, Van der Linden, Paul J and Hanson, Clair E. 2007. IPCC. Cambridge University Press, Cambridge, United Kingdom.

Reddy KR and Hodges HF. 2000. *Climate Change and Global Crop Productivity.* CABI Publishing. Robert M, Clausen and Henry L Gholz. *Carbon and Forest Management*. School of Forest Resources and Conservation. University of Florida, Gainesville, FL 32611, USA.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	History of climate change, Institutional developments towards climate change	1
2	Recent developments in global climate changes: Changes in source and sinks of carbon in the last few decades	1
3	Global warming potentials of major GHG's	1
4	Effect of climate change on: Ocean, Soil, Forest, Biodiversity, Agriculture & Livelihood and relevant mitigation measures to address these issues	2
5	Climate change, Economic development and energy conservation dilemma. Role of alternate energy sources and its current status towards offsetting fossil fuel use	2
6	Carbon Footprint: concepts, methods of assessment, applications and its uses in different fields with special reference to Agriculture. Role of agroforestry strategies to increase terrestrial carbon sinks	2
7	Global dimming: role of aerosols in global dimming and implications to solar energy constant	2
8	Policy issues: Kyoto protocol, carbon trading mechanisms, Montreal agreement, Marrakesh Accord, REDD, REDD+ and other recent international agreements and negotiations to address the climate change issues	2
9	Other Climatic aberrations and its relationship to climate change: Ozone depletion, ENSO etc.	2
10	India's stand on climate change: Recent developments in the strategies; Green India Mission, CAMPA, Millennium goal and other policy initiatives to mitigate climate change	2
	Total	**16**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Atmospheric CO_2 measurement methods	2
2	Soil Carbon assessment, Soil carbon dynamics	3
3	Atmospheric CO_2 flux measurements. Exposing plants to elevated CO_2 concentration	3
4	FACE and FATE experiments, Open top chambers and its importance in understanding the effect of increased CO_2 concentration and plant growth	3
5	Differential responses of species to elevated CO_2 concentrations. Diurnal plant response to light, temperature and CO_2 concentration	4
	Total	**16**

FRM 604 GEO-INFORMATICS IN FOREST RESOURCE MANAGEMENT 2+1

Objective

Is to develop and understanding among the students on basics of geomatics and its application for sustainable management of natural resources.

Theory

UNIT I

Brief introduction to Remote sensing and GIS, types of remote sensing, aerial photography, scale, process of aerial photography. Platforms, orbit and sensors, types of sensors: ground based, air borne and space borne; geostationary satellite and polar orbiting satellite.

UNIT II

Data structure, type and model: Raster and Vector data structure, vector data type, point, line and polygon. Data hierarchical models and overlays. Spatial analysis of vector based and raster based data in the software. Digital elevation models, Global positioning system and differential GPS.

UNIT III

Optical, thermal and microwave remote sensing, LiDAR remote sensing. Satellite image interpretation and recognisation elements: tone, color, texture, pattern, shape, size and associated features.Introduction of ERDAS, Arc GIS and PolSar-Pro, ENVI softwares, Digital image processing, image rectification, geometric corrections, Image enhancement techniques, Digital image classification, supervised and unsupervised classification. Free and open source software

UNIT IV

Applications of Multispectral, Hyperspectral, thermal and microwave remote sensing. Case studies on application of remote sensing and GIS in natural resource management.

Practical

Spectral characteristics of vegetation, water and soil; Study of Topo-sheets, Forest watershed delineation using GPS, Satellite remote sensing; Study of satellite imageries; Digital image interpretation, Digital image processing in ERDAS software, image classification in ERDAS, preparation of thematic maps in Arc GIS, Watershed delineation and clipping using ERDAS and Arc GIS. Mapping of forest with PolSarPro software, Biomass estimation using RS techniques.

Suggested Readings

Campbell JB. 2002. *Introduction to Remote Sensing*-Third edition. Taylor and Francis, London. Environment System Research Institute. 1999. *GIS for Everyone*. Redlands, CA:ESRI.

Jackson MJ. 1992. *Integrated Geographical Information Systems*. International Journal of Remote Sensing, 13(6-7): 1343-1351.

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.

Obi Reddy, GP and Sarkar D. 2012. *RS and GIS in Digital Terrain Analysis and Soil Landscape Modelling*. NBSS & LUP, Nagpur.

Prithvish Nag. 1995. *Digital Remote Sensing*. IBD, Dehradun.

Surender Singh and Patel. 1999. *Principles of Remote Sensing*. Scientific Publishers, Jodhpur, India.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Brief introduction to Remote sensing and GIS, types of remote sensing, aerial photography, scale, process of aerial photography	3
2	Platforms, orbit and sensors, types of sensors: ground based, air borne and space borne; geostationary satellite and polar orbiting satellite	3
3	Data structure, type and model: Raster and Vector data structure, vector data type, point, line and polygon. Data hierarchical models and overlays	4
4	Spatial analysis of vector based and raster based data in the software. Digital elevation models, Global positioning system and differential GPS	4
5	Optical, thermal and microwave remote sensing, LiDAR remote sensing. Satellite image interpretation and recognisation elements: tone, color, texture, pattern, shape, size and associated features	4
6	Introduction of ERDAS, Arc GIS and PolSar-Pro, ENVI softwares, Digital image processing, image rectification, geometric corrections, Image enhancement techniques, Digital image classification, supervised and unsupervised classification	6
7	Applications of Multispectral, Hyperspectral, thermal and microwave remote sensing	4
8	Case studies on application of remote sensing and GIS in natural resource management	4
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Spectral characteristics of vegetation, water and soil;	3
2.	Study of Topo-sheets, Forest watershed delineation using GPS, Satellite remote sensing	3
3.	Study of satellite imageries; Digital image interpretation, Digital image processing in ERDAS software, image classification in ERDAS	4
4.	Preparation of thematic maps in Arc GIS, Watershed delineation and clipping using ERDAS and Arc GIS	3
5.	Mapping of forest with PolSarPro software, Biomass estimation using RS techniques	3
	Total	**16**

FRM 605 ENVIRONMENTAL IMPACT ANALYSIS AND ASSESSMENT 2+1

Objective

To impart the knowledge on nature and principles of EA; Procedure and monitoring of EA results; Developing, conducting and evaluating an EA. Report Writing; EIA/EA Project Report; EIA/EA Review and Decision Making Process; Environmental Management Plan.

Theory

UNIT I

EIA Functions, development and environmental degradation. International and National Laws. EIA steps. Social Impact Analysis. The Convention on Environmental Impact Assessment in a local context -

Objective and scope, Obligation to notify and consult, Public participation, Content of EIA documentation, Implementation and Compliance. Protocol on Strategic Environmental Assessment- Objective, Key provisions.

UNIT II

Nature and principles of EA; Procedure and monitoring of EA results; Developing, conducting and evaluating an EA. Report Writing; EIA/EA Project Report; EIA/EA Review and Decision Making Process; Environmental Management Plan.

UNIT III

Methods of EIA – Check Lists – Matrices – Networks – Cost-Benefit Analysis. Assessment of Impact on Land, Water, Air, Social & Cultural Activities and on Flora & Fauna- Mathematical Models- Public Participation.

UNIT IV

Plan For Mitigation Of Adverse Impact On Environment – Options For Mitigation of Impact on Water, Air, Land And on Flora & Fauna – Addressing The Issues Related To The Project Affected People. Post Project Monitoring.

Practicals:

Environmental auditing - History of environmental auditing. Introduction to the types of environmental audit. Analyze proposed development project plans for possible environmental effects and prepare appropriate initial studies. Utilize EIA documents for policy development, project planning or for legal or political action planning. Preparation of EIA, case studies on EIA.

Suggested Readings

Anjanayulu Y. 2002. *EIA Methodlogies*. BSP BS publication.

Brady J. 2011. *The response of organizations*. In: Brady J, Ebbage A, Lunn R (eds.)

Environmental Management in Organizations: The IEMA Handbook, 2nd edn. Earthscan, London, pp. 251–260.

Humphrey N and Hadley M. 2000. *Environmental Auditing*. Palladian Law Publishing Ltd, Lawrence and Dravid P. 2003. *EIA Practical Solutions to Recrurrent Problems.*

Morgan RK. 1988. EIA- *A Methodological Perspective* Kluwer Academic Publishers.

Smith LG. 1993. *Impact Assessment and Sustainable Resource Management*. John Wiley & Sons. New York.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	EIA Functions, development and environmental degradation. International and National Laws. EIA steps. Social Impact Analysis	3
2	The Convention on Environmental Impact Assessment in a local context - Objective and scope, Obligation to notify and consult, Public participation	3
3	Content of EIA documentation, Implementation and Compliance. Protocol on Strategic Environmental Assessment- Objective, Key provisions	4
4	Nature and principles of EA; Procedure and monitoring of EA results; Developing, conducting and evaluating an EA	4
5	Report Writing; EIA/EA Project Report; EIA/EA Review and Decision Making Process; Environmental Management Plan	4
6	Methods of EIA – Check Lists – Matrices – Networks – Cost-Benefit Analysis. Assessment of Impact on Land, Water, Air, Social & Cultural	4

7	Activities and on Flora & Fauna- Mathematical Models- Public Participation	3
8	Plan For Mitigation Of Adverse Impact On Environment	1
9	Options For Mitigation of Impact on Water, Air, Land And on Flora & Fauna	3
10	Addressing The Issues Related To The Project Affected People. Post Project Monitoring	3
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Environmental auditing - History of environmental auditing	4
2	Introduction to the types of environmental audit	4
3	Analyze proposed development project plans for possible environmental effects and prepare appropriate initial studies	4
4	Utilize EIA documents for policy development, project planning or for legal or political action planning	4
	Total	**16**

FRM 606 FOREST SOIL MANAGEMENT 2+1

Objective

To acquire knowledge on advances in forest soil management. Hydrology of forest plantation. Stand development and soil productivity. Harvest removal and nutrient budgeting.

Theory

UNIT I

Soils and their management for plantation forestry : Soils of the tropics, Soil requirements for plantation forestry, physical properties of major soils of India, soil erosion and erodibility, Erosion control.

UNIT II

Dynamics of nutrient supply in plantation soils: variability of nutrient stores in forest soils, changes in nutrient content, nutrient losses and their assessment, nutrient gains, Nutrient transformation in soils. Nitrogen fixation in Tropical forest Plantations: N fixation process, species, rates of N fixation, factors influencing N fixation; Nutrient cycling - comparison of plantation productivity - case studies.

UNIT III

Organic matter: Decomposition and mineralization; Litter accumulation, litter decomposition, effect of litter on soil, Interpretation of accumulation, decay and mineralisation processes, management of litter and soil organic matter in forest plantations. Soil and stand management for short rotation plantations; Water availability, Nutrient supply, uptake and tree growth, constraints on production, nutrient amendments and correction of nutrient deficiency.

UNIT IV

Nutritional factors controlling stand growth. Reforestation of salt affected, acid soils and coastal soils. Effects of fire on soils: Types of fires, effects of fire on soil properties, effects of fire on air and water quality.

UNIT V

Management and long term soil productivity - soil compaction and erosion - Harvest removal and nutrient Budgeting - Harvest effect on water quality - strategies for future management.

Practical

Nutrient budgeting for different plantation systems, Quantification of physical and chemical soil constraints in plantation and Agroforestry systems, Evolving new strategies for development.

Suggested Readings

Binkley D and R Fisher 2012. *Ecology and Management of Forest Soils* (4th Edition), John Wiley & Sons Singapore Pte. Ltd., Singapore.

Brady NC and Weil RR. 2010. *Elements of the Nature and Properties of Soils* (3rd Edition.), Pearson Education, New Delhi.

Das DK. 2011. *Introductory Soil Science* (3rd Edition), Kalyani publisher, Ludhiana (India). Gupta PK. 2009. *Soil, Plant, Water and Fertilizer Analysis* (2nd Edition), AGROBIOS, Jodhpur (India).

ISSS. 2002. *Fundamentals of Soil Science*. Indian Society of Soil Science, IARI, New Delhi.

J Benton Jones Jr. 2012. *Plant Nutrition and Soil Fertility Manual* (2nd Edition), CRC Press, USA. Jackson ML. 2012. *Soil Chemical Analysis: Advanced Course*, Scientific Publisher.

Jaiswal PC. 2006. *Soil, Plant and Water Analysis* (2nd Edition), Kalyani Publishers, Ludhiana. Khan TO. 2013. *Forest Soils: Properties and Management,* Springer International Publishing, Switzerland.

Mengel *et al*. 2001 *Principles of Plant Nutrition* (5th Edition), Springer.

Pritchett and Fisher RF 1987. *Properties and Management of Forest Soils*. John Wiley, New York.

Reddy MV. 2001. *Management of Tropical Plantation Forests and Their Soil Litter System- Litter, Biota and Soil Nutrient Dynamics*, Science Publishers, U. S.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Soils and their management for plantation forestry : Soils of India	2
2	Soil requirements for plantation forestry, physical properties of major soils of India, soil erosion and erodibility, erosion control	3
3	Dynamics of nutrient supply in plantation soils: variability of nutrient stores in forest soils, changes in nutrient content	1
4	Nutrient losses and their assessment, nutrient gains, nutrient transformation in soils	2
5	Nitrogen fixation in tropical forest plantations: N fixation process, species, rates of N fixation, factors influencing N fixation	2
6	Nutrient cycling - comparison of plantation productivity - case studies	2
7	Hydrology of forest plantations: Forest hydrological cycle; The role of hydrological modelling in plantation management	2
8	Organic matter: decomposition and mineralization; Litter accumulation and decomposition, effect of litter on soil, Interpretation of accumulation, decay and mineralisation processes	3
9	Management of litter and soil organic matter in forest plantations	2
10	Soil and stand management for short rotation plantations	1
11	Water availability, Nutrient supply, uptake and tree growth, constraints on production, nutrient amendments and correction of nutrient deficiency	3
12	Nutritional factors controlling stand growth	1
13	Reforestation of salt affected and acid soils, coastal soils	2
14	Effects of fire on soils: types of fires, effects of fire on soil properties, effects of fire on air and water quality	2
15	Management and long term soil productivity – soil compaction and erosion	2
16	Harvest removal and nutrient budgeting – harvest effect on water quality – strategies for future management	2
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Nutrient budgeting for different plantation systems	4
2	Quantification of physical and chemical soil constraints in plantation and Agroforestry systems	6
3	Evolving new strategies for development	6
	Total	**16**

FRM 607 ENVIRONMENTAL MODELING AND BIOSTATISTICS 2+0

Objective

To acquire knowledge on different environmental modeling approaches, sensitivity analysis and various statistical tools.

Theory

UNIT I

Modeling for environmental sciences and management. Types of models. Causal diagrams, System Dynamics, Introduction to modelling software package, Population modelling, Modeling of material flows through the systems (pollutants transfer, etc). Modeling of cycles in nature (carbon cycle, etc)

UNIT II

Environmental modelling: scope and problem definition, goals and objectives, definition; modelling approaches– deterministic, stochastic and the physical approach; applications of environmental models; the model building process. Types of Model - Physical models, Conceptual models, Mathematical Models.

UNIT III

Sensitivity analysis. Extinction risk. Multi-species population dynamics - Decision trees and Spatial models. Population Dynamics Predator-Prey (Lotka-Volterra methods) Model Builder in ArcGIS GIS Data for environmental models. GIS functions in environmental models. Model validation. Physical environmental models. Human (cultural, social, economic, etc.) environmental models

UNIT IV

Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing; Resampling techniques – Bootstrapping and Jack Knifing; Markov Models. Hidden Markov Models, Bayesian estimation and Gibbs sampling. Statistical fundamentals are reviewed and expanded upon with multi variable regression analysis of Variance (ANOVA).

Suggested Readings

Clarke K *et. al*. 2001. Geographic Information Systems and Environmental Modeling. Prentice Hall.

DeMers M. 2002. *GIS Modeling in Raster*. Wiley.

Goodchild *et. al.* 1996. *GIS and Environmental Modeling: Progress and Research Issues*. GIS world, Inc.

Hooman R and Lukas KB. 2005. *Bioinformatics Basics: Applications in Biological Science And Medicine.* John Wiley.

Hooman Rashidi, Lukas K and Buehler. 2005. *Bioinformatics Basics: Applications in Biological Science and Medicine.* Taylor & Francis.

Maguire Batty and Goodchild. 2005. *GIS, Spatial Analysis, and Modeling*. ESRI Press.

Nirmal khandan N. 2001. *Modelling Tools for Environmental Engineers and Scientists*, CRC Press, Boca Raton, Florida.

Rosner B. 2006. *Fundamentals of Biostatistics,* ed. 6,. Duxbury Press. USA.

Smith J and Smith P. 2007. *Introduction to Environmental Modelling*. Oxford: Oxford University Press.
Whitlock MC and Schluter D. 2009. *The Analysis of Biological Data.* Roberts and Company Publishers.
Zar JH. 2010. *Biostatistical Analysis.* 5th Edition. Pearson Education International.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Modeling for environmental sciences and management. Types of models. Causal diagrams, System Dynamics	3
2	Introduction to modelling software package, Population modelling, Modeling of material flows through the systems (pollutants transfer, etc). Modeling of cycles in nature (carbon cycle, etc)	3
3	Environmental modelling: scope and problem definition, goals and objectives, definition; modelling approaches– deterministic, tochastic and the physical approach	4
4	Applications of environmental models; the model building process. Types of Model - Physical models, Conceptual models, Mathematical Models	3
5	Sensitivity analysis. Extinction risk. Multi-species population dynamics- Decision trees and Spatial models	2
6	Population Dynamics Predator-Prey (Lotka-Volterra methods) Model Builder in Arc GIS	2
7	GIS Data for environmental models. GIS functions in environmental models	2
8	Model validation. Physical environmental models. Human (cultural, social, economic, etc.) environmental models	2
9	Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing	4
10	Re-sampling techniques – Boot strapping and Jack Knifing; Markov Models. Hidden Markov Models, Bayesian estimation and Gibbs sampling. Statistical fundamentals are reviewed and expanded upon with multi variable regression analysis of Variance (ANOVA)	4
	Total	**29**

FRM 608 APPROACHES IN FOREST RESOURCE ASSESSMENT 1+1

Objective

To inculcate knowledge and skills in students to employ participatory tools and techniques for effective planning, implementation, monitoring and evaluation of forestry projects, to efficiently carry out forest resource management and to effectively resolve conflicts by adopting participatory techniques.

Theory UNIT I

Participatory extension – Importance, key features, principles and process of participatory approaches; Different participatory approaches (RRA, PRA, PLA, AEA, PALM, PAR,PAME, ESRE, FPR) and successful models.

UNIT II

Participatory tools and techniques. Space Related Methods : village map and village forest map (social & resource),mobility services and opportunities map and transect; Time related methods : time line, trend analysis, seasonal diagram. Daily activity schedule, dream map; Relation oriented methods :cause and effect

diagram (problem tree), impact – diagram, well being ranking method, Venn diagram, matrix ranking, livelihood analysis after and before implementation of Watershed Programmes.

UNIT III

Preparation of action plans, concept and action plan preparation; Participatory technology development and dissemination; Participatory planning and management, phases and steps in planning and implementation aspects; Process monitoring, participatory evaluation.

Practical

Visit to selected forest areas to undertake and understand various participatory research methods including participatory rural appraisal techniques like social mapping, resource mapping, Venn diagrams, transect walk, time lines etc.

Suggested Readings

Kothari CR. 1992. *Research Methodology- Methods & Techniques* Wiley Eastern Limited New Delhi.

Robert Chambers. 1981. "*Rapid Rural Appraisal" "Rationale and Repertoire*", IDS Discussion Paper, No. 155, IDS, Sussex.

Sabarathnam VE. 2002. *R/R/PRA for Agriculture.* Vamsaravath Publishers, Hyderabad.

N. Narayanasamy. 2008. *Participatory Rural Appraisal: Principles, Methods and Application*.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Participatory extension – Importance, key features, principles and process of participatory approaches	2
2	Different participatory approaches (RRA, PRA, PLA, AEA, PALM, PAR, PAME, ESRE, FPR) and successful models	2
3	Participatory tools and techniques. Space Related Methods: village map and village forest map (social & resource), mobility services and opportunities map and transect	2
4	Time related methods: time line, trend analysis, seasonal diagram. Daily activity schedule, dream map	2
5	Relation oriented methods: cause and effect diagram (problem tree), impact – diagram, well being ranking method, Venn diagram, matrix ranking	2
6	Livelihood analysis after and before implementation of Watershed Programmes	1
7	Preparation of action plans, concept and action plan preparation	1
8	Participatory technology development and dissemination	2
9	Participatory planning and management, phases and steps in planning and implementation aspects; Process monitoring, participatory evaluation	2
	Total	**16**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Visit to selected forest areas to undertake and understand various participatory research methods	8
2	Including participatory rural appraisal techniques like social mapping, resource mapping, Venn diagrams, transect walk, time lines etc.	8
	Total	**16**

FRM 609 FOREST HYDROLOGY AND WATERSHED MANAGEMENT 2+1

Objective

To impart knowledge and understanding among the students on various aspects of hydrology and watershed management and different government schemes on watershed management.

Theory

UNIT I

Introduction to watershed hydrology, its management and agricultural sustainability issues; need of integrated watershed management in India; delineation of watersheds. Hydrology of watershed systems; estimation of surface runoff and sediment yields; effect of precipitation and hydro- climatic conditions on watershed systems; watershed erosion processes and their prevention; instrumentation and measurement of watershed management indicators.

UNIT II

Use of GPS, GIS, RS and Decision Support Systems (DSS) in watershed management; technologies for rain-fed farming; socio-economic evaluation of the watershed management projects. Peoples' participation and livelihood analysis; cropping system and resource conservation techniques in watersheds.

UNIT III

Heuristics and indigenous technical knowledge (ITKs) in watershed management; watershedassociations and groups in villages of India; Government policies, acts and schemes on watershed management

UNIT IV

Mathematical modelling of hydrologic processes-precipitation, infiltration, evapo-transpiration, run-off, soil water balance. Watershed modeling. Frequency analysis for design of hydrologic systems; time series analysis for hydrologic design and forecasting.

Practical

Rain water budgeting – run off and soil loss, infiltration, soil moisture, deep percolation and ground water recharge, rainfall measurement hydrographs. Techniques for measuring subsurface flow on hill slopes. Field study of hill slope flow processes. Survey of watershed, Preparation of micro-plan and planning of watershed for effective implementation. Preparation of contour maps, Estimation of earth work, Design of check dams, Acquaintance with water lifting devices, Use of measurement, Conveyance and control structures. Watershed delineation using GIS techniques.

Suggested Readings

Chow VT, David M and Mays LW. 1988. *Applied Hydrology*. McGraw Hill. Ghanshyan Das. 2000. *Hydrology and Soil Conservation Engineering*. Prentice Hall.

Isobel W Heathcote. 1998. *Integrated Watershed Management: Principles and Practice*. Wiley Publ.

Kenneth N Brooks, Peter F Ffolliott, Hans M Gregersen, Leonard F DeBano. 1991. *Hydrology and the Management of Watersheds.* Wiley-Blackwell.

Tideman EM. 1996. *Watershed Management*. Omega Scientific Publ.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Introduction to watershed hydrology, its management and agricultural sustainability issues; need of integrated watershed management in India; delineation of watersheds	4
2	Hydrology of watershed systems; estimation of surface runoff and sediment yields	3
3	Effect of precipitation and hydro-climatic conditions on watershed systems; watershed erosion processes and its prevention	3
4	Instrumentation and measurement of watershed management indicators.	1

5	Use of GPS, GIS, RS and Decision Support Systems (DSS) in watershed management; technologies for rain-fed farming; socio-economic evaluation of the watershed management projects	4
6	Peoples' participation and livelihood analysis; cropping system and resource conservation techniques in watersheds	3
7	Heuristics and indigenous technical knowledge (ITKs) in watershed management; watershedassociations and groups in villages of India	3
8	Government policies, acts and schemes on watershed management	2
9	Mathematical modelling of hydrologic processes-precipitation, infiltration, evapo-transpiration, run-off, soil water balance	3
10	Watershed modeling	3
11	Frequency analysis for design of hydrologic systems; time series analysis for hydrologic design and forecasting	3
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Rain water budgeting – run off and soil loss, infiltration, soil moisture, deep percolation and ground water recharge, rainfall measurements hydrograph	4
2	Techniques for measuring subsurface flow on hill slopes. Field study of hill slope flow processes	3
3	Survey of watershed, Preparation of micro-plan and planning of watershed for effective implementation	3
4	Preparation of contour maps, Estimation of earth work, Design of check dams, Acquaintance with water lifting devices, Use of measurement, Conveyance and control structures	4
5	Watershed delineation using GIS techniques	2
	Total	**16**

FRM 610 OPERATIONAL RESEARCH AND FOREST MODELING 1+1

Objective

To provide different techniques and skills used in forest research, yield response models and their applications in forestry.

Theory

UNIT I

Introduction to Operations Research-definitions- applications in forest science and management- Project Planning- Project Cycle-Project Evaluation tools-Log Frame Approach-Participatory Rural Appraisal - PERT -CPM- Advantages and Limitations, Application in Forestry Sector.

UNIT II

Systems – Definitions – Components of a system – Modeling approach – Different kinds of models – their classification and properties – Simulation – Elements and basic concepts – Deterministic simulation – state variables, rate variables and drying variables – Feedback models and their solutions.

UNIT III

Growth of biological populations – measurement of growth rate – population growth models – Discrete one species models – Exponential – Logistic – Gempertz and Mitcherlich– Richards Function Properties of models and estimation to biological data. Two species models – Predator and Prey models. 1569

UNIT IV

Yield response models in single and multiple inputs – Quadratic – Square root –Estimating physical and

Economic optimum Optimization of resources under constraints – Linear and non- linear programming – Formulation and their applications in Forestry.

Practical

Practicing Log Frame Approach(LFA-Participatory Rural Appraisal- PERT -CPM- Problems in Mathematical model – their classification and properties – Simulation – Examples – Growth Models – Linear – Exponential – Logistic – Richards – Gempertz and Mitcherlich – Predator and Prey models. Problems in Yield response models in single and multiple inputs – Quadratic – Square root — Quadratic and square response models for several inputs – Estimating physical and Economic optimum. - Formulation of L.P.P – Graphical method – Simplex method - Duality in L.P.P.

Suggested Reading

Ranganathan CR. 2006. *A First Course in Mathematical Models of population Growth with MATLAB Programs*, Associated Publishing Company, New Delhi.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Introduction to Operations Research-definitions- applications in forest science and management	1
2	Project Planning- Project Cycle-Project Evaluation tools-Log Frame Approach-Participatory Rural Appraisal - PERT -CPM- Advantages and Limitations, Application in Forestry Sector	2
3	Systems – Definitions – Components of a system – Modeling approach	1
4	Different kinds of models – their classification and properties –Simulation – Elements and basic concepts – Deterministic simulation – state variables, rate variables and drying variables – Feedback models and their solutions	3
5	Growth of biological populations – measurement of growth rate –population growth models	2
6	Discrete one species models – Exponential – Logistic – Gempertz and Mitcherlich– Richards Function Properties of models and estimation to biological data	2
7	Two species models – Predator and Prey models	1
8	Yield response models in single and multiple inputs	1
9	Quadratic – Square root –Estimating physical and Economic optimum Optimization of resources under constraints	2
10	Linear and non-linear programming – Formulation and their applications in Forestry	1
	Total	**16**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Practicing Log Frame Approach(LFA-Participatory Rural Appraisal- PERT -CPM- Problems in Mathematical model – their classification and properties	6
2	Simulation – Examples – Growth Models – Linear – Exponential – Logistic – Richards – Gempertz and Mitcherlich – Predator and Prey models	4
3	Problems in Yield response models in single and multiple inputs – Quadratic – Square root — Quadratic and square response models for several inputs – Estimating physical and Economic optimum	4
4	Formulation of L.P.P – Graphical method – Simplex method - Duality in L.P.P.	3
	Total	**16**

Silviculture and Agroforestry

Course Titles with Credit Load
M.Sc. in Silviculture and Agroforestry

Course Code	Course Title	Credit Hrs.
Major Courses		
SAF 501*	Silviculture	2 + 1
SAF 502*	Forest Biometry	1 + 1
SAF 503*	Silvicultural Practices	1 + 1
SAF 504*	Agroforestry Systems	2 + 1
SAF 505*	Interactions in Agroforestry Systems	1 + 1
SAF 506	Modern Nursery Technologies	1 + 1
SAF 507	Plantation Forestry	2 + 1
SAF 508	Industrial Agroforestry	1 + 1
SAF 509	Climate Change and Conservation Silviculture	2 + 0
SAF 510	Trees and Shrubs for Agroforestry	1 + 1
SAF 511	Economics of Agroforestry Systems	2 + 1
SAF 512	Tree Seed Technology	2 + 1
SAF 513	Nutrient and Weed Management in Production Forestry	1 + 1
SAF 514	Crops and Live Stock Management in Agroforestry	2+0
Minor Courses		
	Courses from Forest Biology and Tree Improvement or Forest Products and Utilization & Forest Resource Management	08
Supporting Courses		
FOR 511*	General Statistical Methods and Computer Applications	2+1
	Note: The student may choose the above mentioned Supporting Course or other courses provided the opted courses are related to the research problem selected by the student and be mandatorily approved by the Student Advisory committee/HOD".	

SAF 591*	**Master's Seminar**	**1+0**
ii) Thesis Research		
SAF 599	**Master's Research**	**0+30**

***Compulsory Core Course**

Course Contents

SAF 501 SILVICULTURE 2+1

Objective

To understand stand growth, development and provide knowledge regarding the application of silvicultural principles for the production and protection benefits from the forests.

Theory

UNIT I

Forest ecosystems- Introduction to tropical/temperate silviculture. Role of silviculture in forest and wild land management, major forest formations-classification, distribution, composition and structure. Vegetation dynamics- species richness-diversity indices. Vegetation forms of India and their productivity. Vegetation forms of the world.

Forest ecosystem- structure and functioning, community development, competitive interactions in forest communities, forest succession, concepts and models of succession-Connell-Slatyer models, climax theories, tolerance.

UNIT II

Ecophysiology of tree growth- effect of radiation and water relationship, mineral nutrients and temperature. Forest stand development - stand development, even-aged and uneven-aged stands, age and site quality. Tree architecture and its role in stand management.

UNIT III

Stand density determination-stand density indices-stand density management- density management diagram, silvicultural treatments involved- thinning as a stand management tool, objectives of thinning, effects on growth and yield, thinning effect on economic yield of stands. Forest site quality evaluation-direct and indirect methods. Tending operations.

UNIT IV

Treatment analysis-silvicultural regimes- factors influencing choice of regimes, use of system analysis to determine regimes, models for evaluating silvicultural alternatives, development of silvicultural regimes to suit management objectives, optimum management strategies, silvicultural prescriptions for maximum production regime.

Practical

Visit to forest areas to study forest composition, classification, factors of locality, site quality, form and growth of forest trees- study plant succession- study stand density, changes on productivity- thinning effects.

Suggested Readings

Daniel TW, Helms JA and Baker FS. 1979. *Principles of Silviculture.* McGraw-Hill Book Company.

Julius E. 1992. *Plantation Forestry in the Tropics*. Oxford University Press.

Khanna LS. 1996. *Principle and Practice of Silviculture*. International Book Distributors. Khanna LS. 2015. *Theory and Practice of Indian Silviculture Systems*. Bio-Green Publisher. Lamprecht. 1986. *Silviculture in the Tropics*.Verlag Paul Parey, Hamburg und Berlin.

Nyland RD, Laura S, Kenefic, Kimberly K, Bohn and Susan LS. 2016 *Silviculture: Concepts and Applications* (III edition), Kindle Edition, USA.

Pascal. 1988. *Wet Evergreen Forests of the Western Ghats.*

Shepherd KR. 1986. *Plantation Silviculture.* Springer.

Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. *The Practices of Silviculture- Applied Forest Ecology*. John Wiley & Sons.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture(s)
1	Forest ecosystems- Introduction to tropical/temperate silviculture	01
2	Role of silviculture in forest and wild land management, major forest formations-classification, distribution, composition and structure	02
3	Vegetation dynamics- species richness-diversity indices, various concepts	02
	Vegetation forms of India and their productivity	01
4	Forest ecosystem- structure and functioning, community development, competitive interactions in forest communities	03
5	Forest succession, concepts and models of succession-Connell-Slatyer models, climax theories, tolerance	03
6	Ecophysiology of tree growth- effect of radiation and water relationship, mineral nutrients and temperature	02
7	Forest stand development - stand development, even-aged and uneven-aged stands, age and site quality	02
8	Tree architecture and its role in stand management	02
9	Silvicultural treatments involved- thinning as a stand management tool, objectives of thinning, effects on growth and yield, thinning effect on economic yield of stands	03
10	Forest site quality evaluation-direct and indirect methods	02
11	Treatment analysis-silvicultural regimes- factors influencing choice of regimes, use of system analysis to determine regimes	03
12	Models for evaluating silvicultural alternatives	02
13	Development of silvicultural regimes to suit management objectives	02
14	Optimum management strategies: silvicultural prescriptions for maximum production regime	02
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Visit to different foreststo study forest composition and classification	4
2	To study the effect of locality factor and determination of site quality inthe different forests	4
3	To study the plant sucession in different types of forests	2
4	To study the stand form, growth and stand density in major forest of the locality	2
5	To carry out the productivity studies in different forests	2
6	To study the impact of thinning in different periodic blocks/selection forest	2
	Total	**16**

SAF 502 **FOREST BIOMETRY** **1+1**

Objective

To develop understanding of students about tree and stand measurements, forest inventory and yield concepts.

Theory

UNIT I

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

UNIT II

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

UNIT III

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

Calculations of volume of felled as well as standing trees. Volume table preparation. Application of different sampling methods. Preparation of yield and stand table. Quantification of regeneration and stand establishment. Measurement of crown density and crown ratios. Crown profiling of trees and stand. Dendrochronological studies. Measurement of tree parameters (Height, DBH and crown spread).

Suggested Readings

Chaturvedi AN and Khanna LS. 1994. *Forest Mensuratio*n. International Book Distributor. Ram Parkash 1983. *Forest Surveyin*g. International Book Distributor.

Sharpe GW, Hendee CW and Sharpe WE. 1986. *Introduction to Forestr*y. McGraw-Hill. Simmons CE. 1980. *A Manual of Forest Mensuratio*n. Bishen Singh Mahender Pal Singh, Dehradun.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1.	Measurement of tree parameters	01
2.	Determination of tree age and dendrochronology for growth history and climate change studies	01
3.	Estimation of volume, growth and yield of individual tree and forest stands	02
4.	Preparation of volume tables	02
5.	Application of yield and stand tables	02
6.	Forest inventory, sampling methods adopted in forestry	02
7.	Use of GIS in forest inventory	01
8.	Quantification of regeneration and stand establishment	02
9.	Measurement of crown density and crown ratios	01
10.	Simulation techniques	01
11.	Growth and yield prediction models – their preparation and applications	01
	Total	**16**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Calculations of volume of felled as well as standing trees. Preparation of yield and stand table. Crown profiling of trees and stand Dendrochronological studies	5
2	Volume table preparation. Application of different sampling methods	3
3	Quantification of regeneration and stand establishment	2
4	Measurement of crown density and crown ratios	2
5	Crown profiling of trees and stand Dendrochronological studies	2
	Total	**16**

SAF 503 SILVICULTURAL PRACTICES 1+1

Objective

To acquaint the students with the advanced silvicultural practices in forestry with particular reference to commercial and short rotation forestry.

Theory

UNIT I

Sivilculture under changing context of forestry- sivilculture and ecosystem management, stand dynamics, silvicultural practices for pure and mixed stand, even aged and uneven aged stand – silvicultural practices for changing climatic conditions.

UNIT II

Silvicultural practices for natural and artificial regeneration – Ecology of regeneration, forest site management- enrichment of site – quality classes and site index models – stand density – spacing and tree growth – forest vegetation management – techniques for early stand growth- tending operations. Biomass allocation: belowground and aboveground. Changing trends in adoption of silvicultural systems.

UNIT III

Stand development – stages- crown dynamics, Crown Competition factor, Maximum crown area, thinning - pruning – response of trees and impact on wood quality, salvage cutting – improvement felling and enrichment planting – management of weeds, Invasive weeds in forests, Silvicultural practices for short rotation forestry- coppice forestry, Continuous cover forestry.

UNIT IV

Site specific selection of tree species. Precision silviculture –silvicultural practices for important fast growing trees and bamboos of India- *Populus species*, *Neolamarkia cadamba*, *Eucalyptus sp., Casuarina sp.,Tectona grandis*, *Melia dubia*, *Dalbergia sissoo, Gmelina arborea, Leucaena leucocephala, Ailanthus excelsa, Azadirachta indica, Swietenia macrophylla, Dendrocalamus* sp., *Bambusa* sp., - Mechanization of silvicultural practices.

Practical

Visit to different forest sites to study the influence of site factors on composition, Determination of site quality; Studies on stand structure and composition of different forest types; Practicing pruning and its impact on wood quality; Characterizing methods of thinning; Working out intensity of thinning; Study of stand densities in natural forest stand and plantation stand, Afforestation techniques, Wood management techniques for forest tree crops. Planning and designing a tree planting programme. Exercise on precision silviculture practices. Exercise on mechanized silvicultural practices.

Suggested Readings

Daniel TW, Helms JA and Baker FS. 1979. *Principles of Silviculture.* McGraw-Hill Book Company. Julius E. 1992. *Plantation Forestry in the Tropics*. Oxford University Press.

Khanna LS. 1996. *Principle and Practice of Silviculture*. International Book Distributors. Khanna LS. 2015. *Theory and Practice of Indian Silviculture Systems.* Bio-Green Publisher. Lamprecht. 1986. *Silviculture in the Tropics*-Verlag Paul Parey, Hamburg und Berlin.

Nyland RD, Laura S, Kenefic, Kimberly K, Bohn and Susan LS. 2016 *Silviculture: Concepts and Applications* (III edition), Kindle Edition, USA.

Shepherd KR. 1986. *Plantation Silviculture.* Springer.

Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. *The Practices of Silviculture- Applied Forest Ecology*. John Wiley & Sons.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Sivilculture under changing context of forestry- sivilculture and ecosystem management stand dynamics	01
2	Silvicultural practices for pure and mixed stand, even aged and uneven aged stand	01
3	Silvicultural practices for changing climatic conditions	01
4	Silvicultural practices for natural and artificial regeneration	01
5	Ecology of regeneration Forest site management- enrichment of site –quality classes	01
6	Site index models – stand density – spacing and tree growth – forest vegetation management – techniques for early stand growth- tending operations	02
7	Biomass allocation: belowground and aboveground	01
8	Changing trends in adoption of silvicultural systems	01
9	Stand development – stages- crown dynamics,site specific selection of tree species. Precision silviculture	01
10	Crown Competition factor, Maximum crown area	01
11	Thinning-pruning – response of trees and impact on wood quality, salvage cutting – improvement felling and enrichment planting	01
12	Management of weeds, Invasive weeds in forest. Mechanization of silvicultural practices.	01
13	Silvicultural practices for short rotation forestry- coppice forestry, Continuous cover forestry	01
14	Precision silvicultural practices for important fast growing trees and bamboos of India- *Populus species*, *Neolamarkia cadamba*, *Eucalyptus* sp., *Casuarina* sp*., Tectona grandis*, *Melia dubia*, *Dalbergia sissoo, Gmelina arborea, Leucaena leucocephala, Ailanthus excelsa, Azadirachta indica, Swetenia macrophylla, Dendrocalamus* sp. and *Bambusa* sp.	03
	Total	**17**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Visit to different forest sites to study the influence of site factors on composition, Determination of site quality; Studies on stand structure and composition of different forest types	3
2	Practicing pruning and its impact on wood quality; Characterizing methods of thinning; Working out intensity of thinning	3
3	Study of stand densities in natural forest stand and plantation stand, Afforestation techniques	3
4	Wood management techniques for forest tree crops	2
5	Planning and designing a tree planting programme	2
6	Exercise on precision silviculture practices. Exercise on mechanized silvicultural practices	3
	Total	**16**

SAF 504 AGROFORESTRY SYSTEMS 2+1

Objective

To impart knowledge on the concept of agroforestry as a sustainable land use including diagnosis and design methodologies; overview of agroforestry and case studies.

Theory

UNIT I

Agroforestry: objectives, importance, potentials and limitations for implementations. Land capability classification and land evaluation. Basis of classification of agroforestry systems and principles, indigenous *vs.* exotic, intraspecific variations, crown architecture of tropical/temperate trees. Ideotype concept for selection of multipurpose trees. Nitrogen fixing trees. Overview and case studies of different agroforestry systems.

UNIT II

Structural and functional attributes of agroforestry systems, shifting cultivation, taungya system, multiple and mixed cropping, alley cropping, silvopastoral systems, shelter-belts and windbreaks, energy plantations and home gardens. Apiculture and Lac cultivation.

UNIT III

Role of trees in soil productivity and conservation– micro-site enrichment- litter and fine root dynamics, Nitrogen fixation and nutrient pumping. Soil productivity and management in agroforestry.

UNIT IV

Community forestry and social forestry, linear strip plantations.

UNIT V

Trends in agroforestry systems research and development, Diagnosis and Design –PRA-RRA tools in agroforestry problem diagnosis.

UNIT VI

Climate Change mitigation and adaptation through agroforestry- climate negotiations- LULUCF-agroforestry options.

Practical

Survey and analysis of land use systems in the adjoining areas. Study of tree crown architecture. Design and plan of suitable models for improvement. PRA-RRA tools in agroforestry problem diagnosis.

Suggested Readings

Buck LE, Lassoie, Fernandes ECM 1999. .*Agroforestry in Sustainable Agri. Systems*. CRC Press. Kumar BM and Nair PKR. 2006. *Tropical Homegardens: A Time-Tested Example of Sustainable Agroforestry.* Springer publication.

Kumar BM and Nair PKR. 2013. *Carbon Sequestration Potential of Agroforestry Systems: Opportunities and Challenges (Advances in Agroforestry*). Springer publication.

Nair PKR and Latt 1998. *Directions in Tropical Agroforestry Research*. Kluwer. Nair PKR, Rai MR and Buck LE. 2004. *New Vistas in Agroforestry*. Kluwer Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer Academic Pub.

Ong CK and Huxley PK. 1996. *Tree Crop Interactions – A Physiological Approach*. ICRAF. Peter Huxley. 1999. *Multiple Cropping with Woody and Non-Woody Plants*. John Wiley and Sons Ltd, Oxford, United Kingdom.

Tejwani KG. 1994. *Agroforestry in India*. Oxford & IBH Publishing Co. Pvt Ltd.

Thampan PK. 1993. *Trees and Tree Farming*. Peekay Tree Crops Development Foundation. Young A. 1997. *Agroforestry for Soil Management*. CABI.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Agroforestry: objectives, importance, potentials and limitations for implementations	02
2	Land capability classification and land evaluation	02
3	Basis of classification of agroforestry systems and principles	01
4	Indigenous vs. exotic, intraspecific variations, crown architecture of tropical/ temperate trees	02
5	Ideotype concept for selection of multipurpose trees, N fixing trees	01
6	Overview and case studies of different agroforestry systems	04
7	Structural and functional attributes of agroforestry systems, shifting cultivation, taungya system, multiple and mixed cropping, alley cropping, silvopastoral systems, shelter-belts and windbreaks, energy plantations and homegardens	06
8	Role of trees in soil productivity and conservation-micro-site	04
9	enrichment- litter and fine root dynamics, N fixation and nutrient pumping	02
10	Soil productivity and management in agroforestry	02
11	Community forestry and social forestry, linear strip plantations	01
12	Trends in agroforestry systems research and development Diagnosis and Design –PRA-RRA tools in agroforestry problem diagnosis	02
13	Climate Change mitigation and Adaptation through agroforestry- climate negotiations- LULUCF- agroforestry options	03
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Survey and analysis of land use systems in the adjoining areas	5
2	Study of tree crown architecture	3
3	Design and plan of suitable models for improvement	4
4	PRA-RRA tools in agroforestry problem diagnosis	4
	Total	**16**

SAF 505 INTERACTIONS IN AGROFORESTRY SYSTEMS 1+1

Objective

To impart knowledge to the students regarding tree-crop interaction,their quantification and techniques to neutralize the negative tree- crop interactions.

Theory

UNIT I

Tree-crop interphase- biological factors affecting form and function in woody and non-woody plant mixtures. Nature and types of interactions- positive and negative, aboveground and belowground interactions-competition, complementarity in resource sharing. Supplementry interaction of trees.

UNIT II

Method for quantifying interactions, principles of resource capture and utilization of light and water, nutrition and space. Tree-soil-crop interactions- nitrogen fixing trees interactions in agroforestry. Allelopathy. Use of radioisotopes in tree-crop interaction studies. Root distribution of trees and crops-competition and/orcomplementarity. Animal-tree-crop interaction.

UNIT III

Management options to neutralize negative (competitive) interactions, tree husbandry practices for alleviating competition- tree density manipulation, pruning, mixture of trees and herbaceous crops.

Practical

Different methods for quantifying interactions. Studies on allelopathy. Effect, microclimate modifications, different plant mixtures, tree-soil-crop interactions. Estimation of Land Equivalent Ratio, Estimation of competition indices,Measurement and interpretation of light interception in agroforestry systems, Interpretation of yield responses to shelter, soil water and drainage measurement, transpiration measurement, quantifying root distribution.

Suggested Readings

Avery MA, Cannel MGR and Ong CK. 2005. *Biophysical Research for Asian Agroforestry*. Oxford and IBH Publishing Co. Pvt. Ltd.

Mac Dicken, KG and Vergara NT. 1989. *Agroforestry-classification and Management.*

Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer Academic Pub.

Ong CK and P Huxley. 2002. *Tree-Crop Interactions- A Physiological approach*, CAB International. Patra AK. 2013. *Agroforestry-Principles and Practices*. New India Publishing AGENCY, New Delhi (India).

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)

1	Tree-crop interphase- biological factors affecting form and function in woody and non-woody plant mixtures	02
2	Nature and types of interactions- positive and negative, aboveground and belowground interactions- competition, complementarity in resource sharing	02
3	Methodforquantifyinginteractions	01
4	Principlesof resource capture and utilization of light and water, nutrition and space	02
5	Tree-soil-crop interactions- nitrogen fixing trees interactions in agroforestry systems	02
6	Allelopathy. Use of radioisotopes in tree-crop interaction studies	02
7	Root distribution of trees and crops-competition and/orcomplementarity	02
8	Animal-tree-crop interaction	01
9	Management options to neutralize negative interactions - management of competitive interactions in agroforestry, tree husbandry	01
10	Practices for alleviating competition- tree density manipulation, pruning, mixture of trees and herbaceous crops	02
	Total	**17**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Different methods for quantifying interactions	2
2	Studies on allelopathy	2
3	Effect, microclimate modifications, different plant mixtures, tree- soil-crop interactions	4
4	Estimation of Land EquivalentRatio, Estimation of competition indices, Measurement and interpretation of light interception in agroforestry systems	4
5	Interpretation of yield responses to shelter, soil water and drainage emeasurement, transpiration measurement, quantifying root distribution	4
	Total	**16**

SAF 506 MODERN NURSERY TECHNOLOGIES 1+1

Objective

To impart knowledge and develop understanding about modern nursery techniques for mass production of quality planting stock using sexual and asexual propagation techniques.

Theory

UNIT I

Introduction and importance of nursery. Types of nurseries-temporary and permanent, bare root, containerized and clonal nursery. Bare root nursery- nursery soil and water management, bed preparation, pre-sowing seed treatments, seed sowing and intermediate operations *viz.,* pricking, watering, fertilization, weeding and hoeing.

UNIT II

Physiology and nursery environment interaction affecting seedling growth. Root culturing techniques. Containerized nursery - type and size of containers including root trainers, selection of growing medium. Types of green house and mist chamber for propagation.

UNIT III

Vegetative propagation - importance, selection of superior genotypes, Advanced methods of propagation, containers, growing media, fertilizers, sanitation and management in vegetative propagation. Special requirement for clonal propagation. Propagation Structures and Management.

UNIT IV

Clonal propagation: miniclonal and micro cuttings technology. Vegetative propagation of bamboos and canes. Factors affecting rooting of cuttings. Lifting windows. Important forest nursery pests and diseases and their management. Seedling quality assessment, grading, packaging, storing and transportation. Vegetative propagation of *Eucalyptus, Casuarina, Neolamarckia cadamba, Leuceana leucocephala and Melia dubia.*

Practical

Introduction and identification of modern equipments and tools used in nursery. Pre-sowing seed treatments. Preparation of nursery beds and growing media for containerized nursery. Sowing of seed and other intermediate operations. Preparation and planting of cuttings. Use of vegetative propagation methods such as budding, grafting and layering. Miniclonal and microcutting technology. Use of plant bio-regulators for rooting. Assessment of seedling quality. Maintenance of nursery records. Identification of nursery insects and diseases and their control measures. Visit to forest nurseries. Nursery practices of commercially important tree species.

Suggested Readings

Bhardwaj RL and Sarolia DK. 2011. *Modern Nursery Management.* Published by grobios Publishing. New Delhi (India).

Kumar GA and Gopikumar. 2003. *Forest Nursery and Tree Husbandry.*

Kumar V. 2012. *Nursery and Plantation Practices in Forestry.* Scientific Publishers (India). Saini RS, Kaushik N, Kaushik RA and Godara NR. 2012. *Practical Nursery Production*. Agrobios, New Delhi (India).

Lecture Schedule
Theory

Sr. No.	Topic	No. of Lecture (s)
1	Introduction and importance of nursery,types of nurseries-temporary and permanent, bare root, containerized and clonal nursery	01
2	Nursery soil and water management, bed preparation, pre- sowing seed treatments, seed sowing and intermediate operations *viz.,* pricking, watering, fertilization, weeding and hoeing	02
3	Physiology and nursery environment interaction affecting seedling growth	01
4	Root culturing techniques	01
5	Containerized nursery - type and size of containers including root trainers, selection of growing medium	01
6	Vegetative propagation - importance, selection of superior genotypes	01
7	Advanced methods of propagation, containers, growing media, fertilizers, sanitation and management in vegetative propagation, types of green house and mist chamber for propagation.	03
8	Propagation structures and management	01
9	Clonal propagation: miniclonal and micro cuttings technology, special requirement for clonal propagation	01
10	Vegetative propagation of bamboos and canes. Factors affecting rooting of cuttings	02
11	Lifting windows	01

12	Important forest nursery pests and diseases and their management	01
	Seedling quality assessment, grading, packaging, storing and transportation	01
	Total	**17**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Introduction and identification of modern equipments and tools used in nursery	1
2	Pre-sowing seed treatments	1
3	Preparation of nursery beds and growing media for containerized nursery	2
4	Sowing of seed and other intermediate operations. Preparation and planting of cuttings	2
5	Use of vegetative propagation methods such as budding, grafting and layering	2
6	Miniclonal and microcutting technology	2
7	Use of plant bio-regulators for rooting. Assessment of seedling quality	2
8	Maintenance of nursery records. Identification of nursery insects and diseases and their control measures	2
9	Visit to forest nurseries. Nursery practices of commercially important tree species	2
	Total	**16**

SAF 507 PLANTATION FORESTRY 2+1

Objective

To acquaint students with various aspects of production, integrated nutrient and irrigation management and ecological factors in raising forest plantations.

Theory

UNIT I

Role of plantation forestry in meeting the wood demand – status of plantation forestry in India and world. Purpose of plantation, factors determining scale and rate of plantation. Land suitability and choice of species. Preliminary site preparation for establishing plantation. Plantation planning, project formulation and appraisal. Planting programme, time of planting, spacing, pattern and planting methods.

UNIT II

Nutritional dynamics and irrigation of plantation. Mechanization in plantation. Protection and after care of plantation. Pruning and thinning in plantations for quality wood production. Rotation in plantation. Failures of plantations. Impact of interaction and integration of plantation forestry.

UNIT III

Protective afforestation, afforestation of inhospitable sites. Plantation forestry for climate change mitigation-carbon forestry. Ecological factors and long term productivity. Sustainable yield from plantations. Case studies in plantations of Eucalyptus, Casuarina, Poplars, Acacias, Pine, Silver Oak, Gmelina, Teak, Sandal, Bamboo, etc. Production technology of energy plantations, industrial plantations. Emerging concepts in plantation forestry: mixed plantation, continuous cover forests. Important pests and diseases of commercially important tree crops.

Practical

Analysis of plantation problems in Asia and India. Preparation of plantation calendar–Preliminary arrangement for a plantation programme. Planting geometry and calculation of planting stock. Study of different cultural operations and site preparation for plantation. Studies on wood based industries – problems and prospects. Management of Eucalyptus, Casuarina, Teak, Sal, Poplar, Acacias and Bamboo plantations. Production

technology for energy plantations. INM in plantations. Irrigation and plantations. Economics of pulpwood, timber and energy plantations. Study of mixed plantation model.

Suggested Readings

Dwivedi AP. 1993. *Forestry in India*. Surya Publ.

Julius E. 1982. *Plantation Forestry in the Tropics*. Clarendon Press, Oxford. Kumar V. 1999. *Nursery and Plantation Practices in Forestry*. Scientific Publ. Luna RK. 1989. *Plantation Forestry in India*. International Book Distributors.

Prakash R, Chaudhari DC and Negi SS. 1998. *Plantation and Nursery Techniques of Forest Trees*. International Book Distributors.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Role of plantation forestry in meeting the wood demand – status of plantation forestry in India and world	02
2	Purpose of plantation, factors determining scale and rate of plantation	01
3	Land suitability and choice of species	02
4	Preliminary site preparation for establishing plantation	02
5	Plantation planning, project formulation and appraisal. Planting programme, time of planting, spacing, pattern and planting methods	03
6	Nutritional dynamics and irrigation of plantation	02
7	Mechanization in plantation	01
8	Protection and after care of plantation	01
9	Pruning and thinning in plantations for quality wood production. Rotation in plantation	01
10	Failures of plantations. Impact of interaction and integration of plantation forestry	02
11	Protective afforestation, afforestation of inhospitable sites	03
12	Plantation forestry for climate change mitigation- carbon forestry	02
13	Ecological factors and long term productivity. Sustainable yield from plantations	02
14	Case studies in plantations of Eucalypts, Casuarina, Poplars, Acacias, Pine, Silver Oak, Gmelina, Teak, Sandal, Bamboo, etc. Wasteland plantations	04
15	Production technology of energy plantations, Industrial plantations	02
16	Emerging concepts in plantation forestry: mixed plantation, continuous cover forests	02
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Analysis of plantation problems in Asia and India	1
2	Preparation of plantation calendar –Preliminary arrangement for a plantation programme	2
3	Planting geometry and calculation of planting stock	2

4	Study of different cultural operations and site preparation for plantation	2
5	Studies on wood based industries – problems and prospects	2
6	Management of *Eucalyptus, Casuarina,* Teak, Sal, Poplar, *Acacias* and Bamboo plantations	2
7	Production technology for energy plantations	1
8	INM in plantations. Irrigation and plantations	2
9	Economics of pulpwood, timber and energy plantations. Study of mixed plantation model	2
	Total	**16**

SAF 508 INDUSTRIAL AGROFORESTRY 1+1

Objective

To develop skill and expertise on industrial wood production and processing technology.

Theory

UNIT I

Role of forests in industrial sector, industrial raw material, demand and supply, indigenous and exotic industrial resources, extent of area, policy and legal issues towards industrial wood plantation. Major wood based industries in India; timber, pulp wood, plywood, matches etc. Raw material requirements and their procurements.

UNIT II

Industrial wood plantations – status in India and different states, preferred species – current plantation management and establishment, propagation and plantation technique, economics of industrial agroforestry, pest and disease management for major industrial wood species, harvesting, reduced impact logging, mechanization.

UNIT III

Supply chain; definition, concept, supply chain network, logistic activities, Marketing system; marketing type and channel, price patterns of various industrial wood agroforestry plantations. Contract farming: concept and methods, contract tree farming system in India. Industrial experiences– price support system – constraints. Corporates in industrial agroforestry: International and National corporate, success stories. Corporate social responsibilities. Tree insurance.

UNIT IV

Impacts of industrial agroforestry – ecological impacts; climatic, edaphic and biotic– carbon sequestration. Carbon storage potential of industrial agroforestry and carbon trading mechanism of industrial agroforestry, socio-economic impacts–clean development mechanism. Certification of industrial plantations.

Practical

Study of various wood based industries. Study on raw material requirement and sourcing of plywood, pulp and paper, matchwood, timber processing. Biomass power generation industries. Value addition technology of various wood products. Industrial wood plantations – economics and impact assessment.

Suggested Readings

Cosasalter C and C Pye-Smith. 2003. *Fast Wood Forestry - Myths and Realities*. CIFOR. Bogor, Indonesia. 50p.

Mehta T. 1981. *A Hand Book of Forest Utilization.* International Book Distributors, Dehradun. Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer Academic publishers.

Parthiban KT, Umarani R, Umesh Kanna S, Sekar I, Rajendran P and Durairasu P. 2014.

Industrial Agroforestry : Perspectives and Prospectives. Scientific Publishers. Tejwani KG. 1994. *Agroforestry in India*. Oxford and IBH publishing Co., New Delhi.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Role of forests in industrial sector, industrial raw material, demand and supply, indigenous and exotic industrial resources, extent of area, policy and legal issues towards industrial wood plantation	03
2	Major wood based industries in India; timber, pulp wood, plywood, matches etc. raw material requirements and their procurements	01
3	Industrial wood plantations – status in India and different states, preferred species – current plantation management and establishment, propagation and plantation technique, economics of industrial agroforestry	02
4	Pest and disease management for major industrial wood species, harvesting, reduced impact logging, mechanization	01
5	Supply chain; definition, concept, supply chain network, logistic activities	01
6	Marketing system; marketing type and channel, price patterns of various industrial wood agroforestry plantations	02
7	Contract farming; concept and methods, contract tree farming system in India	01
8	Industrial experiences– price support system – constraints. Corporates in industrial agroforestry; International and National corporate, success stories. Corporate social responsibilities. Tree insurance	01
9	Impacts of industrial agroforestry – ecological impacts; climatic, edaphic and biotic– carbon sequestration	01
10	Carbon storage potential of industrial agroforestry and carbon trading mechanism of Industrial agroforestry, socio-economic impacts–clean development mechanism	02
11	Certification of industrial plantations	01
	Total	**16**

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Industrial wood plantations – economics and impact assessment	3
2.	Study on raw material requirement and sourcing of plywood, pulp and paper, matchwood, timber processing	4
3.	Biomass power generation industries	3
4.	Value addition technology of various wood products	3
5.	Study of various wood based industries	3
	Total	**16**

SAF 509 CLIMATE CHANGE AND CONSERVATION SILVICULTURE 2+0

Objective

To understand the scenario of climate change and international treaties on climate change, adaptive silviculture for climate change mitigation, silviculture for conservation of ecosystems.

Theory

UNIT I

Global climate change-factors involved, green house gases, potential threats, global carbon cycle and

C-budget, carbon sequestration. Forests and climate change: Forest responses and vulnerabilities to climate change mitigation.Status of forests in global climate change. Harnessing Forests for Climate Change Mitigation, International climate negotiation, UNFCCC, IPCC, CoP :LULUCF, REDD++ and CDM.

UNIT II

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 III

Disturbance- natural and anthropogenic, short and long term impacts and their implications. Fire loss estimation in forests. Deforestation and degradation trends at global, national and regional levels. Mega development projects, Road widening projects and conservation of native and threatened species, management and rehabilitation plans. Impact of pollutants on growth and developments on trees. Impact of global warming on biodiversity

UNIT IV: Impacts of 'No Green Felling' on stand productivity and health. Restoration forestry- silvicultural treatments for habitat restoration, catchment area treatments, enrichment planting, Analog forestry for site productivity and carbon value. Expanding forest and tree cover area- TOF sector in India.

UNIT V

Role of canopy in regulating functional inputs to stand: canopy and forest continuum, Continuous Cover Forestry. Silviculture of old growth stands and sacred grooves- their ecological significance and biodiversity values. Carbon sequestration potential of Trees Outside forests (TOFs), homegardens and urban forests.

Suggested Readings

Anderson P and Palik B. 2011. *Silviculture for Climate Change.* U.S. Department of Agriculture, Forest Service, Climate Change Resource Center.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1.	Global climate change-factors involved, green house gases, potential threats, global carbon cycle and C-budget, carbon sequestration	02
2.	Forests and climate change: Forest responses and vulnerabilities to climate change mitigation	02
3.	Status of forests in global climate change.Harnessing Forests for Climate Change Mitigation International climate negotiation, UNFCCC, IPCC, CoP :LULUCF, REDD++ and CDM	03
4.	Silviculture and sustainability-criteria and indicators for sustainable plantation forestry in India-CIFOR guidelines	03
5.	Silvicultural and stand management strategies for carbon sink maximization and source minimization	03
6.	Adaptive silviculture for climate change	01
7.	Disturbance- natural and anthropogenic, short and long term impacts and their implications. Fire loss estimation in forests	02
8.	Deforestation and degradation trends at global, national and regional levels	02
9.	Mega development projects, Road widening projects and conservation of native and threatened species, management and rehabilitation plans	02
10.	Impacts of 'No Green Felling' on stand productivity and health	01
11.	Restoration forestry-silvicultural treatments for habitat restoration, catchment area treatments, enrichment planting	02

12.	Analog forestry for site productivity and carbon value	01
13.	Expanding forest and tree cover area- TOF sector in India	02
14.	Role of canopy in regulating functional inputs to stand,: canopy and forest continuum, Continuous Cover Forestry	02
15.	Silviculture of old growth stands and sacred grooves- their ecological significance and biodiversity values	02
16.	Carbon sequestration potential of Trees Outside forests (TOFs), homegardens and urban forests	02
	Total	**32**

SAF 510 TREES AND SHRUBS FOR AGROFORESTRY 1+1

Objective

To make students familiar with trees and shrubs (fruit, fodder and small timber) suitable for agroforestry.

Theory

UNIT I

Introduction, importance of woody elements in agroforestry systems, their role in biomass production. Suitability of species for different purposes. Multipurpose trees in agroforestry systems. Fodder from trees/ shrubs and their nutritive value, propagation techniques.

UNIT II

Role of nitrogen fixing trees/ shrubs. Choice of species for various agro-climatic zones for the production of timber, fodder, fuel wood, fibre, fruits, medicinal and aromatic plants. Generic and specific characters of trees and shrubs for agroforestry.

UNIT III

Fruit crop and small timber trees and their need and relevance in agroforestry, trees suitable for various assemblage and their planting plan in different agroclimatic zones and agroforestry system. Intercropping in fruit orchards like Apple, Walnut, Jack fruit, Mango, Sapota, Pomegranate, Orange, Citrus, Guava etc. Modification in tending and pruning operations and canopy management. Fertility management, yield and quality improvement. Fruit orchards of Ber, Lemon and Moringa.

Practical

Field survey and acquaintance with specialized features of trees, shrubs and fruit species and varieties for Agroforestry. Planting plans including wind breaks. Training and pruning of forest trees, shrubs and fruit trees for enhancing production in agroforestry system.

Suggested Readings

Dwivedi AP. 1992. *Agroforestry: Principles and Practice*s. Oxford & IBH. Nair PKR, Rai MR & Buck LE. 2004. *New Vistas in Agroforestr*y. Kluwer. Nair PKR. 1993. *An Introduction to Agroforestr*y. Kluwer.

Ong CK and Huxley PK. 199*6. Tree Crop Interactions – A Physiological Approac*h. ICRAF. Srivastava KK. 2007. *Canopy Management of Fruit Crops*, IBD.

Thampan PK. 1993. *Trees and Tree Farmin*g. Peekay Tree Crops Development Foundation.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Introduction, importance of woody elements in agroforestry systems, their role in biomass production	02
2	Suitability of species for different purposes. Multipurpose trees in agroforestry systems	02

3	Fodder from trees/shrubs and their nutritive value, propagation techniques	02
4	Role of nitrogen fixing trees/ shrubs	01
5	Choice of species for various agroclimatic zones for the production of timber, fodder, fuel wood, fibre, fruits, medicinal and aromatic plants	02
6	Generic and specific characters of trees and shrubs for agroforestry	01
7	Fruit crop and small timber trees and their need and relevance in Agroforestry	01
8	Trees suitable for various assemblage and their planting plan in different agroclimatic zones and agroforestry system	02
9	Intercropping in fruit orchards like Apple, Walnut, Jack fruit, Mango, Sapota, Pomegranate, Orange, Citrus, Guava etc.	02
10	Modification in tending and, pruning operations and canopy management, fertility management, yield and quality improvement	02
	Total	**17**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Field survey and acquaintance with specialized features of trees, shrubs and fruit species and varieties for Agroforestry	6
2	Planting plans including wind breaks	4
3	Training and pruning of tree, shrubs and fruit trees for enhancing production in agroforestry system	6
	Total	**16**

SAF 511 ECONOMICS OF AGROFORESTRY SYSTEMS 2+1

Objective

To acquaint the students with principles of economics and use of economic tools in appraisal of the agro-forestry systems. Evaluation of ecosystem services from agroforestry- economic and ecological aspects of agroforestry.

Theory

UNIT I

Basic principles of economics applied to agroforestry. Financial measures. Quantification and valuation of inputs and outputs- direct and indirect methods.

UNIT II

Optimization techniques-Planning, budgeting and functional analysis. Role of time, risk and uncertainty in decision making. Agroforestry budgeting. Risk analysis, re-assessment.

UNIT III

Financial and socio-economic analysis of agroforestry projects. Principles of financial management and harvesting, post harvest handling, value addition, marketing of agroforestry products including benefit sharing.

UNIT IV

Valuation of ecosystem services in agroforestry and payment for ecosystem systems. Bankable agroforestry projects, incentives, tree insurance etc. Certification process in agroforestry based carbon projects, carbon finance etc.

Practical

Exercises on agroforestry production relationships. Preparation of agroforestry based enterprise, partial and

complete budgets. Application of various methods in formulation and appraisal of agro- forestry projects. Case studies on harvesting, post harvest management and marketing of agro- forestry products. Valuation of ecosystem services in agroforestry and payment for ecosystem services.

Suggested Readings

Alavalapati JRR and Mercer D Evan. 2004 *Valuing Agroforestry Systems: Methods and Applications*. Kluwer Academic Publishers.

Kant S and Janaki A. 2014. *Handbook of Forest Resource Economics*. Publisher: Routledge

Nair PKR, Rai MR and Buck LE. 2004. *New Vistas in Agroforestry*. Kluwer Academic Publishers. Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer Academic Publishers.

Ong CK and Huxley PK. 1996. *Tree Crop Interactions – A Physiological Approach*. ICRAF. Sullivan Gregory M, Susan Hoke M and Jefferson M. Fox (editors). 1992. *Financial and Economic Analyses of Agroforestry Systems. Proceedings of a workshop held in Honolulu. Hawaii. USA. July* 1991. Paia, Ill: Nitrogen Fixing Tree Association.

Thampan PK. 1993. *Trees and Tree Farming*. Peekay Tree Crops Development Foundation.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Basic principles of economics applied to agroforestry	03
2	Financial measures	02
3	Quantification and valuation of inputs and outputs- direct and indirect methods	03
4	Optimization techniques-Planning, budgeting and functional analysis	03
5	Role of time, risk and uncertainty in decision making	02
6	Agroforestry budgeting , risk analysis, re-assessment	03
7	Financial and socio-economic analysis of agroforestry projects	03
8	Principles of financial management and harvesting, post harvest handling, value addition, marketing of agroforestry products including benefit sharing	04
9	Valuation of ecosystem services in agroforestry and payment for ecosystem systems	03
10	Bankable agroforestry projects, incentives, tree insurance etc.	03
11	Certification process in agroforestry based carbon projects, carbon finance etc.	03
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Exercises on agroforestry production relationships	3
2	Preparation of agroforestry based enterprise, partial and complete budgets	4
3	Application of various methods in formulation and appraisal of agro-forestry projects	3
4	Case studies on harvesting, post harvest management and marketing of	3
5	agro-forestry products	
6	Valuation of ecosystem services in agroforestry and payment for ecosystem services	3
	Total	**16**

SAF 512 TREE SEED TECHNOLOGY 2+1

Objective

To impart knowledge and to develop understanding about tree seed development, harvesting, processing, storage, dormancy, germination of tropical, sub-tropical and temperate species, their testing and certification.

Theory

UNIT I

Introduction, trends and development in tropical, sub-tropical and temperate forestry and their influence on seed demand. Seed problems, limiting factors in tree propagation and

afforestation.

UNIT II

Reproductive biology of seed plants - development and maturation of seed bearing organs and seeds - morphology of fruit and seed - seed dispersal - ecological fruit and seed types- seasonality and periodicity of flowering and fruiting - reproductive age - influence of external factors on seed production. Seed structure and chemical composition – development and maturation – germination – breakdown of storage products – endogenous hormonal regulation – effect of stimulators and inhibitors– dormancy – its causes and breakage specific problems of seeds of woody plants. Seed collection criteria.

UNIT III

Determining maturity indices. Factors influencing choice of collection methods. Methods of seed collection and processing. Storage methods – loss of viability during storage. Dormancy and pre- treatment. Germination and seedling establishment and seed testing techniques.

UNIT IV

Quality seed production technologies - seed certification.

UNIT V

Eco-physiological role of seed storage. Classification of seed storage potential. Factors affecting seed longevity. Pre-storage treatment. Physiological change during ageing. Storage of orthodox, recalcitrant and intermediate seeds, Fumigation and seed treatment.

Practical

Identification of forest seeds. Seed sampling, different storage methods, Seed quality testing- purity, viability and germination, collection and processing of seeds/ fruit. Tests of viability viz., cutting, hydrogen peroxide, excised embryo, tetrazolium, seed health testing primarily to the presence or absence of disease-causing organisms such as fungi, bacteria, virus and animal pests, recording, calculation and use of results of seed treatment.

Suggested Readings

Baldwin HI. 1942. *Forest Tree Seed of the North Temperate Regions*. Periodical Experts Book Agency, Delhi.

Bedell PE. 1998. *Seed Science and Technology: Indian Forestry Species*. Allied Publisher Limited.

Chin HF and Roberts EH. 1980. *Recalcitrant crop seeds*. Tropical Press Sdn. Bhd. Malaysia. Dutta M and Saini GC. 2010. *Forest Tree Improvement and Seed Technology.*

Hong TD and Ellis RH. 1996. *A protocol to determine seed storage behaviour*. IPGRI Technical Bulletin No. 1. (J. M. M. Engels and J. Toll, vol. Eds.) International Plant Genetic Resources Institute, Rome, Italy.

ISTA. 1993. *International Rules for Seed Testing*. International Seed Testing Association, Zurich, Switzerland.

Khullar P. *et. al*. 1992. *Forest Seed*. ICFRE, New Forest, Dehra Dun.

Leadem CL. 1984. *Quick Tests for Tree Seed Viability*. B.C. Ministry of Forests and Lands, Canada.

Schmidt L. 2000. *Guide to handling of tropical and subtropical forest seed*. DANIDA Forest Seed Centre,

Denmark.

Umarani R and Vanangamudi K. 2004. *An Introduction to Tree Seed Technology*. IBD, Dehradun. Vanangamudi K. 2007. *Advances in Seed Science and Technology*: (Vol. 1. to 5).

Willan RL. 1985. *A guide to forest seed handling*. FAO Forestry Paper 20/2, DANIDA Forest Seed Centre, Denmark and FAO, Rome.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Introduction, trends and development in tropical, sub-tropical and temperate forestry and their influence on seed demand	03
2	Seed problems, limiting factors in tree propagation and afforestation	01
3	Reproductive biology of seed plants - development and maturation of seed bearing organs and seeds	03
4	Morphology of fruit and seed - seed dispersal - ecological fruit and seed types	02
5	Seasonality and periodicity of flowering and fruiting - reproductive age - influence of external factors on seed production	02
6	Seed structure and chemical composition – development and maturation – germination – breakdown of storage products – endogenous hormonal regulation – effect of stimulators and inhibitors	03
7	Dormancy – its causes and breakage, specific problems of seeds of woody plants	02
8	Determining maturity indices	01
9	Factors influencing choice of collection methods. Methods of seed collection and processing, storage methods – loss of viability during storage	02
10	Dormancy and pre-treatment. Germination and seedling establishment and seed testing techniques	02
11	Quality seed production technologies - seed certification	03
12	Eco-physiological role of seed storage. Classification of seed storage potential. Factors affecting seed longevity	03
13	Pre-storage treatment. Physiological change during ageing	02
14	Storage of orthodox, recalcitrant and intermediate seeds. Fumigation and seed treatment	03
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Identification of forest seeds.	3
2	Seed sampling, different storage methods, Seed quality testing-purity, viability and germination, collection and processing of seeds/ fruit	6
3	Tests of viability viz., cutting, hydrogen peroxide, excised embryo, tetrazolium, seed health testing primarily to the presence or absence of disease-causing organisms such as fungi, bacteria, virus and animal pests, recording, calculation and use of results of seed treatment.	7
	Total	**16**

SAF 513 NUTRIENT AND WEED MANAGEMENT IN PRODUCTION FORESTRY 1+1

Objective

To make students to understand the concepts of nutrients and their management, weeds and their management in nurseries and plantations.

Theory

UNIT I

History o fnutrient management in forest nurseries and plantations. Essential nutrient elements and their deficiency. Mechanism of nutrient uptake by plants, functions and translocation/interactions. Concept of nutrient availability.

UNIT II

Climatic and soil conditions causing micronutrient deficiencies in plants. Occurrence and treatment of micronutrient disorders. Evaluation of soil for the supply of micronutrient. Rare and non-essential elements.

UNIT III

Technology and use of complex liquid and suspension fertilizers. Fertilizer use efficiency. Biological nitrogen fixation and bio-fertilizers. Farm yard manure and other organic fertilizers. Mycorrhizal associations and their significance. Economic implications of nutrient management. Importance of renewable wastes and their recycling. Potential of water soluble fertilizers. Important of fertigation in early growth.

UNIT IV

Principles of weed control. Methods of weed control-cultural, biological, mechanical and chemical. Herbicide/weedicide classification, properties and their application.

Practical

Methods of soil and plantanalysis.Preparationofnutrientsolutions.Practical application of fertilizers. Study of fertilizer response and diagnosis of deficiencysymptoms. Fertilizer testing and pot experiments. Nursery inoculation techniques of bio-fertilizers. Methods of application of formulated products-seed treatment, root dip, suckers treatment, soil application,foliar application and combination of different methods. Important weeds in forest nurseries and plantations. Control of weeds.

Suggested Readings

Allen V and Barker. 2007. *Handbook of Plant Nutrition*. Pilbeam London.

Dinesh Kumar, Sanjay Chowdhary and Rajvir Sharma. 2011. *Weed Management: Principles and Practices.* Narendra Publishing House.

Gupta OP. 2011. *Modern Weed Management*. Agrobios, New Delhi (India). Rajaram C. 2012. *Hand book of Plant Nutrition.* NehaPublishers& Distributors.

Rammoorthy and Subbian P. 2012. *Weed Management*. Agrotech Publishing Academy,

Udaipur (India).

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	History of nutrient management in forest nurseries and plantations	01
2	Essential nutrient elements and their deficiency	01
3	Mechanism of nutrient uptake by plants, functions and translocation/interactions	01
4	Concept of nutrient availability	01
5	Climatic and soil conditions causing micronutrient deficiencies inplants	01
6	Occurrence and treatment of micronutrient disorders	01

7	Evaluation of soil for the supply of micronutrient. Rare and non- essential elements	01
8	Technology and use of complex liquid and suspension fertilizers	01
9	Fertilizer use efficiency	01
10	Biological nitrogen fixation and bio-fertilizers	01
11	Farm yard manure and other organic fertilizers	01
12	Mycorrhizal associations and their significance	01
13	Economic implications of nutrient management	01
14	Importance of renewable wastes and their recycling	01
15	Principles of weed control	01
16	Methods of weedc ontrol-cultural, biological, mechanical and chemical	01
17	Herbicide/weedicide classification, properties and their application	01
	Total	**17**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Methods of soil and plant analysis	2
2	Preparation of nutrient solutions	2
3	Practical application of fertilizers	1
4	Study of fertilizer response and diagnosis of deficiencysymptoms	2
5	Fertilizer testing and pot experiments	2
6	Nursery inoculation techniques of bio-fertilizers.	2
7	Methods of application of formulated products-seed treatment, root dip, suckers treatment, soil application, foliar application and combination of different methods.	3
8	Important weeds in forest nurseries and plantations. Control of weeds	2
	Total	**16**

SAF 514 CROPS AND LIVE STOCK MANAGEMENT IN AGROFORESTRY 2+0

Objective

To impart knowledge on interactions between tree and live stock including their management, principles of crops and fodder production in agroforestry.

Theory

UNIT I

Choice of inter-crops for different tree species, sowing and planting techniques. Planting patterns, crop geometry, nutrient requirements, and weed management. Management of fodder tree species, thinning, lopping, pruning. Ecological and socio-economic interactions.

UNIT II

Role of tree architecture and its management on system's productivity. Production potentials of fodder based agroforestry systems in different agro-climatic conditions and crop combinations. Importance of cattle, sheep and goat vis-à-vis agro-forestry systems. Feed and fodder resources in agro-forestry systems and live stock management. Availability of green fodder during scarcity in Arid and Semi-arid region.

UNIT III

Nutrient analysis of forages derived from fodder trees/shrubs. Nutrient requirement for various livestock and their ration computation with agroforestry forages and tree leaves. Forage and tree leaves preservation.

UNIT IV

Calendars for forage crop production in agro-forestry systems including lopping schedules. Optimization of animal production. Animal products technology and marketing.

UNIT V

Integrated Agroforestry Farming System.

Suggested Readings

Bran Powell. 2017. *Livestock Production and Management.* L & K Education.

Kundu SS, Dagar JC, Prakash O, Chaturvedi and Sirohi SK. 2008. *Environment, Agroforestry & Livestock Management.*

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Choice of inter-crops for different tree species, sowing and planting techniques	03
2	Planting patterns, crop geometry, nutrient requirements, and weed management	03
3	Management of fodder tree species, thinning, lopping, pruning	02
4	Ecological and socio-economic interactions	02
5	Role of tree architecture and its management on system's productivity	02
6	Production potentials of fodder based agroforestry systems in different agro climatic conditions and crop combinations	02
7	Importance of cattle, sheep and goat vis-à-vis agro-forestry systems	02
8	Feed and fodder resources in agro-forestry systems and live stock management	02
9	Nutrient analysis of forages derived from fodder trees/shrubs	02
10	Nutrient requirement for various livestock and their ration computation with agroforestry forages and tree leaves	02
11	Forage and tree leaves preservation	02
12	Calendars for forage crop production in agro-forestry systems including lopping schedules	02
13	Optimization of animal production. Animal products technology and marketing	03
14	Integrated Agroforestry Farming System	03
	Total	**32**

Course Titles with Credit Load
Ph.D. in Silviculture and Agroforestry

Course Code	Course Title	Credit Hrs.
Major Courses		
SAF 601*	Quantitative Silviculture	2+1
SAF 602*	Agroforestry Research and Management	2+0
SAF 603	Forest Stand Dynamics	1+0
SAF 604	Productivity and Evaluation of Agroforestry Systems	2+1
SAF 605	Forest Stand Management Techniques	1+1
SAF 606	Agroforestry for Ecosystem Services and Environmental Benefits	2+0
SAF 607	Plantation Forest Productivity	1+1
SAF 608	Restoration Forestry	1+0
SAF 609	Regeneration Silviculture	2+1
SAF 610	Forest Soil Management	1+1
SAF 611	Agroforestry for Sustainable Agriculture	1+0
SAF 691*	Doctoral Seminar-I	1+0
SAF 692*	Doctoral Seminar-II	1+0
Minor Courses		
	Courses from Forest Biology and Tree Improvement or Forest Products and Utilization or Forest Resource Management	06
Supporting Courses		
FOR 610*	Research Methodology in Forestry	2+1
FOR 611	Research and Publication Ethics	1+1
	Note: The student may choose the above mentioned Supporting Course or other courses provided the opted courses are related to the research problem selected by the student and be mandatorily approved by the Student Advisory committee/HOD".	
ii) Thesis Research		
SAF 699	Doctoral Research	0+75

***Compulsory Core Courses**

Course Contents

SAF 601 QUANTITATIVE SILVICULTURE 2+1

Objective

To educate students with regard to forest stand growth and yield, quantitative techniques used for evaluating site quality, measuring stand density, predicting forest growth and yield.

Theory

UNIT I

Principles of tree and stand growth and yield. Habitat types; site quality; site index.

Growth functions - empirical, exponential, allometry and Backman's growth functions. Growth pattern and growth increment curve. Growth cycle and phases.

Quantifying site quality: Methods - tree and stand height data, periodic height growth. Techniques

- guide curves, difference equations, parameter prediction.

UNIT II

Stand density and stocking, measures of density: –3/2 power rule of self-thinning, point density, competition indices. Control of growing stock to achieve specific management objectives - growth-growing stock relations, Full site occupancy, Onset of competitive interactions. Langsaeter's hypothesis, stand density index and techniques for translating this understanding into rational density management regimes.

UNIT III

Techniques: stand density management diagrams and stocking charts. Construction and use of stand density management diagrams. Designing density management regimes to suit specific management objectives.

UNIT IV

Predicting growth and yield: normal and empirical yield tables, stand growth and yield equations, stand table projections. Simulation models: whole-stand models, size-class distribution models, single-tree/ distance-independent and distance-dependent models, process models, linkage of models at different levels. Evaluation, calibration, verification, and validation of forest growth and yield prediction systems. Introduction to existing forest growth and yield simulators.

Practical

Assessment of growth characteristics. Preparation of growth and increment curves. Site quality assessment, Stand density diagrams. Growth prediction models. Yield simulation techniques.

Suggested Readings

Clutter JL, Fortson JC, Pienaar LV, Brister GH and Bailey RL. 1992. *Timber Management: A Quantitative Approach.* Krieger Publishing Company.

Davis LS and Johnson KN. 1987. *Forest Management.* 3rd Ed. McGraw-Hill. Evans J. 1982. *Plantation Forestry in the Tropics*. Clarendon Press.

Johnson PS, Shifley SR and R. Rogers. 2009. *Self-thinning and Stand Density*. *The Ecology and Silviculture of Oaks*. CABI, Cambridge, MA.

Luna RK. 1989. *Plantation Forestry in India*. International Book distributors.

Vanclay JK. 1994. *Modeling Forest Growth and Yield: Application to Mixed Tropical Forests.*

CAB International.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Principles of tree and stand growth and yield	02
2	Habitat types; site quality; site index	02
3	Growth functions - empirical, exponential, allometry and Backman's growth functions	03
4	Growth pattern and growth increment curve. Growth cycle and phases	02
5	Quantifying site quality: Methods - tree and stand height data, periodic height growth	02
6	Techniques - guide curves, difference equations, parameter prediction	02
7	Stand density and stocking, measures of density: –3/2 power law of self-thinning, point density, competition indices	03
8	Control of growing stock to achieve specific management objectives - Growth-growing stock relations, Full site occupancy, Onset of competitive interactions. Langsaeter's hypothesis, stand density index and techniques for translating this understanding into rational density management regimes	03
9	Techniques: stand density management diagrams and stocking charts. Construction and use of stand density management diagrams. Designing density management regimes to suit specific management objectives	03
10	Predicting growth and yield: normal and empirical yield tables, stand growth and yield equations, stand table projections	03
11	Simulation models: whole-stand models, size-class distribution models, single-tree/ distance - independent and distance-dependent models, process models, linkage of models at different levels	04
12	Evaluation, calibration, verification, and validation of forest growth and yield prediction systems. Introduction to existing forest growth and yield simulators	03
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Assessment of growth characteristics	2
2	Preparation of growth and increment curves	3
3	Site quality assessment, Stand density diagrams	4
4	Growth prediction models	3
5	Yield simulation techniques	4
	Total	**16**

SAF 602 AGROFORESTRY RESEARCH AND MANAGEMENT 2+0

Objective

To teach how to refine the agroforestry systems, management practices and their integration for developing suitable agroforestry systems.

Theory

UNIT I

Recent trends in agroforestry research and development. Agroforestry land use systems and their salient features. Research designs and analysis in agroforestry. Multi-functionality of agroforestry systems-multiplicity of products and services, food and nutritional security, livelihood security, gender related

aspects. Constraints in agroforestry research - research prioritization.

UNIT II

Study of systems specification, prioritizing potential interventions and technology specifications; space and time related considerations.

UNIT III

Introduction to on-farm and on-station research experiments. Biomass production and allocation patterns-changes thorough agroforestry interventions.

UNIT IV

Belowground dynamics- role of fine roots in agroforestry productivity. Tree husbandry practices in agroforestry for productivity optimization. Soil-site sustainability and environmental resource sharing. Site-species compatibility. Competition, predation, mutualism, commensalisms. Simulation modeling of agroforestry systems.

UNIT V

Carbon and nutrient dynamics in agroforestry- carbon sequestration- carbon credits- mitigatory and adaptive roles of agroforestry in the context of climate change- climate negotiations and agroforestry.

UNIT VI

Management of multifunctional agroforestry – sustainability, links with UNFCCC, UNCCD and UNCBD. Carbon conservation, sequestration, and substitution functions of agroforestry trees. Domestication of useful species and crafting market regimes for the products derived from agroforestry and ethno-forestry systems. Contract fuel wood schemes, small-scale nursery enterprises, charcoal policy reform, novel market information systems, facilitating and capacity building of farmer and farm forest associations. Climate change and reforestation incentive policies.

UNIT VII

Market intelligence for agroforestry products. Agroforestry value chain models: consortia concepts. Successful case studies.

Suggested Readings

Chin K Ong, Colin Black, Julia Wilson. 2015. *Tree-Crop Interactions*, 2nd Edition: Agroforestry in a Changing Climate. CAB International.

Kumar BM and Nair PKR. 2011. *Carbon Sequestration Potential of Agroforestry Systems: Oportunities and Challenges.* Springer.

Nair PKR, Rai MR and Buck LE. 2004. *New Vistas in Agroforestry*. Kluwer.

Ong CK and Huxley PK. 1996. *Tree Crop Interactions – A Physiological Approach*. ICRAF. Snelder DJ. and Lasco RD. 2008. *Smallholder Tree Growing for Rural Development and Environmental Services*. Springer Science, Amsterdam.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Recent trends in Agroforestry research and development	02
2	Agroforestry land use systems and their salient features. Research designs and analysis in agroforestry	02
3	Multifunctionality of agroforestry systems - multiplicity of products and services, food and nutritional security, livelihood security, gender related aspects	02
4	Constraints in agroforestry research - research prioritization	02

5	Study of systems specification, prioritizing potential interventions and technology specifications; space and time related considerations	02
6	Introduction to on farm and on station research experiments	01
7	Biomass production and allocation patterns - changes thorough agroforestry interventions	01
8	Belowground dynamics- role of fine roots in agroforestry productivity	02
9	Tree husbandry practices in agroforestry for productivity optimization. Soil-site sustainability and environmental resource sharing. Site-Species compatibility	02
10	Competition, predation, mutualism, commensalisms. Simulation modeling of agroforestry systems	02
11	Carbon and nutrient dynamics in agroforestry- carbon sequestration- carbon credits- mitigatory and adaptive roles of agroforestry in the context of climate change- climate negotiations and agroforestry	02
12	Management of multifunctional agroforestry – sustainability, links with UNFCCC, UNCCD and UNCBD	02
13	Carbon conservation, sequestration, and substitution functions of agroforestry trees	02
14	Domestication of useful species and crafting market regimes for the products derived from agroforestry and ethnoforestry systems	02
15	Contract fuel wood schemes, small-scale nursery enterprises, charcoal policy reform, novel market information systems, facilitating and capacity building of farmer and farm forest associations	02
16	Climate change and reforestation incentive policies	02
17	Market intelligence for agroforestry products. Agroforestry value chain models: consortia concepts. Successful case studies	02
	Total	**32**

SAF 603 FOREST STAND DYNAMICS 1+0

Objective

The purpose is to help silviculturists and forest managers to understand and anticipate how forests grow and respond to intentional manipulations and natural disturbances.

Theory

UNIT I

Introduction-plant interactions and limitations of growth - mutualism and competition – the niche - limitations of growth - concept of growing space.

UNIT II

Tree architecture and growth- general growth patterns - shoot development patterns, crown shapes, height growth, root growth, and tree development.

UNIT III

Disturbances and stand development – impact of disturbances - major and minor- classification of disturbances - characteristics of disturbance agents. Stand structure and fire behaviour. Building resilience to disturbances.

UNIT IV

Overview of stand development patterns - temporal and spatial patterns of tree invasion - stand initiation stage - stem exclusion stage – understorey reinitiation stage - old growth stage - multicohort stands – behaviour of component cohorts- development of multicohort stands - quantification of stand development - forest patterns over long times and large areas. Gap dynamics.

Suggested Readings

Dagar JC, Tewari JC, Vindhya Prasad. 2018. *Agroforestry Anecdotal to Modern Science*. Springer. Daniel TW, Helms JA and Baker FS. 1979. *Principles of Silviculture*, 2nd edition, McGraw-Hill, 2nd ed. Kimmins JP. 1997. *Forest Ecology*, Macmillan Publishing Company, New York Upper Saddle River, Prentice Hall.

Koop H. 1989. *Forest Dynamics Silvi-star: A Comprehensive Monitoring System*. Springer-verlag. New York.

Oliver CD and Larson BC. 1996. *Forest Stand Dynamics*. John Wiley & Sons, Inc. New York New York: John Wiley & Sons, Inc.

Smith DM. 1986. *The Practice of Silviculture*, 8th ed, Wiley, New York.

Waring RH and Schlesinger WH. 1985. *Forest ecosystems: Concepts and management*, Academic. Press, San Diego.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Introduction - plant interactions and limitations of growth - mutualism and competition- the niche - limitations of growth - concept of growing space	03
2	Tree architecture and growth- general growth patterns - shoot development patterns, crown shapes, height growth, root growth, and tree development	03
3	Disturbances and stand development – impact of disturbances - major and minor- classification of disturbances - characteristics of disturbance agents	03
4	Stand structure and fire behaviour. Building resilience to disturbances	03
5	Overview of stand development patterns - temporal and spatial patterns of tree invasion - stand initiation stage - stem exclusion stage – understorey reinitiation stage - old growth stage	02
6	Multicohort stands – behaviour of component cohorts- development of multicohort stands - quantification of stand development - forest patterns over long times and large areas. Gap dynamics	03
	Total	**17**

SAF 604 PRODUCTIVITY AND EVALUATION OF AGROFORESTRY SYSTEMS 2+1

Objective

To acquaint the students with concepts in agroforestry systems productivity, managing the factors of production and sustained yield levels.

Theory

UNIT I

Concept of crop productivity. Productivity potential in relation to light, water and nutrients. Productivity potential in relation to space

UNIT II

System complementarity, supplementarity, competitiveness, sustainability and management techniques. Tree root architecture, re-allocation of resources within the plant system.

UNIT III

Biological yield and harvest index. Growth and yield functions. Land equivalent ratio. Water use efficiency, photosynthetic efficiency, radiation balance, canopy transmissivity, canopy management, plant geometry and crop yield.

UNIT IV

Allelopathic effects. Strategies to improve the efficiency and productivity of different land use systems. Role of Agroforestry in microclimate conservation.

UNIT V

Role of various financing agencies in agroforestry and critical evaluation of different credit systems with emphasis on agroforestry. Methodologies for evaluating agroforestry hedonic pricing, PES, LER and LEV.

UNIT VI

Financial, economic and social accounting of agroforestry projects. Advances in marketing management of agroforestry products. Evaluating combined productivity and profitability of different agroforestry systems *vis-a-vis* other competitive agro-based systems. Tree insurance schemes.

Practical

Techniques for leaf area index, photosynthetically active radiation, soil moisture and leaf water potential and canopy density measurements. Exercises on developing alternative optimal agroforestry plans under perfect and imperfect knowledge situations. Socio-economic and financial evaluation of agroforestry projects.

Suggested Readings

Alavalapati JRR and D Evan Mercer. 2004. *Valuing Agroforestry Systems: Methods and applications*, Kluwer Academic Publishers.

Kant Shashi and Janaki Alavalapati. 2014. *Handbook of Forest Resource Economics,* Publisher: Routledge.

Nair PKR, Rai MR and Buck LE. 2004. *New Vistas in Agroforestry*. Kluwer. Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer.

Ong CK and Huxley PK. 1996. *Tree Crop Interactions – A Physiological Approach*. ICRAF. Sullivan, Gregory M, Susan M Hoke and Jefferson M Fox (editors). 1992. *Financial and Economic Analyses of Agroforestry Systems. Proceedings of a workshop held in Honolulu. Hawaii. USA. July* 1991. Paia, Ill: Nitrogen Fixing Tree Association.

Tejwani KG 1994. *Agroforestry in India* Oxford and IBH publishing Co. Pvt.Ltd.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Concept of crop productivity. Productivity potential in relation to light, water and nutrients	02
2	System complementarily, supplementarity, competitiveness, sustainability and management techniques	03
3	Tree root architecture, reallocation of resources within the plant system	02
4	Biological yield and harvest index. Growth and yield functions. Land equivalent ratio	03
5	Water use efficiency, photosynthetic efficiency, radiation balance, canopy transmissivity, canopy management, plant geometry and crop yield	03
6	Allelopathic effects. Strategies to improve the efficiency and productivity of different land use systems	03
7	Role of various financing agencies in agroforestry and critical evaluation of different credit systems with emphasis on agroforestry	03
8	Methodologies for evaluating agroforestry hedonic pricing, PES, LER and LEV	03
9	Financial, economic and social accounting of agroforestry projects	04
10	Advances in marketing management of agroforestry products	02
11	Evaluating combined productivity and profitability of different agroforestry systems *vis-a- vis* other competitive agrobased systems	03
12	Tree insurance schemes	01
	Total	**17**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Techniques for leaf area index, photosynthetically active radiation, soil	6
2	moisture and leaf water potential and canopy density measurements.	
3	Exercises on developing alternative optimal agroforestry plans under	6
4	perfect and imperfect knowledge situations.	
5	Socio-economic and financial evaluation of agroforestry projects.	4
	Total	**16**

SAF 605 FOREST STAND MANAGEMENT TECHNIQUES 1+1

Objective

To develop understanding of students about advances in silviculture and silvicultural practice, effect of silvicultural practices on forest stand management and stand development, advances in coppice silviculture.

Theory

UNIT I

Philosophy of silviculture – advance reproduction methods and their role in silviculture – Judging successful establishment; Analysis of active and passive site preparation – Silviculture with an ecosystem approach.

UNIT II

Advances in silvicultural practices; tropical forest, sub-tropical forest and temperate forest.

UNIT III

Analysis of different techniques of silviculture in forest stand management, Technique for early stand development; Analysis of thinning methods and its impact on wood yield and quality; Stand protection and health management. Silvicultural use of prescribed fire. Mechanization and role in silviculture.

UNIT IV

Advance silviculture techniques for plantation forestry; Case studies of advance silviculture in India and abroad; mixed plantation forestry, Precision silviculture, silviculture of intensively managed plantations, silviculture for climate change mitigation. Sewage silviculture. Silviculture management for watershed and catchment areas. Silviculture for wildlife habitat improvement.

UNIT V

Adjusting silviculture to meet industrial demands – silviculture in perspective – Problem solving procedure for silviculture – silviculture in retrospect.

Practical

Study of components of silvicultural system for sustained yield; Management strategies for even aged and uneven aged stands; Choice of site preparation methods, Plantation map, Quality planting stock, Planning for tree planting, Release cutting operation, Selection of thinning methods, Intensity of thinning, Analysis of site quality and biomass production for timber, pulp wood and fuel wood species, Problems in silviculture in tropical, subtropical plantation and their solutions.

Suggested Readings

Brang P, Spathelf P, Larsen JB, Bauhus J, Bončina A and Chauvin C. 2014. *Suitability of Close- To-Nature Silviculture for Adapting Temperate European Forests to Climate Change*. Forestry. Colak AH, Rotherham ID and Calikoglu M. 2003. *Combining 'Naturalness Concepts' with Close- to-Nature Silviculture*. Forstwiss. Centralbl. 122, 421–431.

Cole DN and Yung L. (eds) 2010. *Beyond Naturalness: Rethinking Park and Wilderness Stewardship in an Era of Rapid Change* . Island Press.

Daniel TW, Helms JA and Baker FS. 1979. *Principles of Silviculture*, 2nd edition, McGraw-Hill, 2nd ed.

Fettig CJ, Reid ML, Bentz BJ, Sevanto S, Spittlehouse DL and Wang T. 2013. *Changing climates, changing forests: A western North American perspective*.

Franklin JF. 1989. *Towards a New Forestry*. Am. For.

Holm-Nielsen LB, Nielsen IC and Balsev H. (eds.) 1989. *Tropical Forests*, Academic Press, London.

Pukkala T and Gadow KV. 2012. *Continuous Cover Forestry*. 2nd Edition Springer.

Sairll PS, Evans J, Auclair D and Flack J. 1997. *Plantation Silviculture in Europe*. Oxford University Press.

Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. *The Practices of Silviculture*: Applied Forest Ecology. John Wiley & Sons.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Philosophy of silviculture – Advance reproduction methods and their role in silviculture -judging successful establishment	01
2	Analysis of active and passive site preparation -silviculture with an ecosystem approach	01
3	Advances in silvicultural practices; tropical forest, sub-tropical forest and temperate forest	02
4	Analysis of different techniques of silviculture in forest stand management, technique for early stand development	01
5	Analysis of thinning methods and its impact on wood yield and quality	01
6	Stand protection and health management. Silvicultural use of prescribed fire	01
7	Mechanization and role in Silviculture	01
8	Advance silviculture techniques for plantation forestry; Case studies of advance silviculture in India and abroad	02
9	Mixed plantation forestry, Precision Silviculture, Silviculture of intensively managed plantations	01
10	Silviculture for climate change mitigation. Sewage silviculture	01
11	Silviculture management for watershed and catchment areas	01
12	Silviculture for wildlife habitat improvement	01
13	Adjusting silviculture to meet industrial demands-silviculture in perspective – Problem solving procedure for silviculture -silviculture in retrospect	02
	Total	**16**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Study of components of silvicultural system for sustained yield	3
2	Management strategies for even aged and uneven aged stands	3
3	Selection of thinning methods, Intensity of thinning	3
4	Analysis of site quality and biomass production for timber, pulp wood and fuel wood species	3
5	Problems in silviculture in tropical, subtropical plantation and their solutions	4
	Total	**16**

SAF 606 AGROFORESTRY FOR ECOSYSTEM SERVICES AND ENVIRONMENTAL BENEFITS 2+0

Objective

To develop understanding of students about ecosystem services and environmental benefits and quantification of ecosystem services and their valuation.

Theory

UNIT I

Multifunctionality of agroforestry. Major ecosystem services and environmental benefits and international conventions and charters on climate change (UNFCCC, UNCCD, agroforestry and climate change negotiations: CoP) and biodiversity conservation (CBD) – an overview.

UNIT II

Agroforestry for carbon conservation, sequestration, substitution – role and potentials of various agroforestry systems. Estimates of carbon sequestration potential – measurement - prospects and problems. Factors affecting above and belowground carbon sequestration potential.

UNIT III

Agroforestry for soil enrichment – mechanisms – litter and fine root dynamics, rhizo-deposition and other rhizosphere effects, symbiotic and free-living N2 fixation, mycorrhizal associations. Soil and water conservation benefits.

UNIT IV

Agroforestry for biodiversity conservation. Synergy with climate change mitigation. Landscape connectivity for wildlife, supporting the pollinators of plant species. Agroforestry for improved air and water quality. Non-point source pollution in Indian agro-ecosystems. Riparian buffers for alleviating agricultural non-point source pollution.

UNIT V

Private profitability vs. social profitability - exclusion or inclusion of social benefits and costs and non-market values, or externalities. Theory of externalities, effect of environmental costs and benefits on the profitability of agroforestry practices. Valuing environmental services. Profitability of timber-based agroforestry systems. Costs and benefits in agroforestry- valuation of inputs and outputs- environmental outputs.

Suggested Readings

Alavalapati JRR, Shrestha RK, Stainback GA and Matta JR. 2004. *Agroforestry development: An environmental Economic Perspective. Agroforestry Systems.* 61: 299–310.

Huxley P. 1999. *Tropical Agroforestry*. Blackwell.

IPCC. 2007. Climate Change 2007. *Mitigation of Climate Change*. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

Jain SK and Singh P. 2000. *Economic Analysis of Industrial Agroforestry: Poplar (Populus deltoides) In Uttar Pradesh (India). Agroforestry Systems.* 49: 255–273.

Jeffers JNR. 1978. *An Introduction to System Analysis with Ecological Application*. Edward Arnold.

Jose S. 2009. *Agroforestry for Ecosystem Services and Environmental Benefits: An Overview*. *Agroforestry Systems.* 76: 1-10.

Lyngbaek AE, Muschler RG and Sinclair FL. 2001. *Productivity and Profitability ff Multistrata Organic Versus Conventional Coffee Farms in Costa Rica*. *Agroforest. Syst.* 53: 205–213.

Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer, Netherlands.

Schroth G and Sinclair F. 2003. *Tree Crops and Soil Fertility: Concepts and Research Methods*, CABI, Wallingford, UK.

Young A. 1997. *Agroforestry for Soil Management*. 2nd ed. CABI, Wallingofrd, UK.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Multifunctionality of agroforestry	01
2	Major ecosystem services and environmental benefits and international conventions and charters on climate change (UNFCCC, UNCCD, agroforestry and climate change negotiations: CoP) and biodiversity conservation (CBD) – an overview	04
3	Agroforestry for carbon conservation, sequestration, substitution – role and potentials of various agroforestry systems	03
4	Estimates of carbon sequestration potential – measurement - prospects and problems. Factors affecting above and belowground carbon sequestration potential	04
5	Agroforestry for soil enrichment – mechanisms – litter and fine root dynamics, rhizo-deposition and other rhizosphere effects, symbiotic and free-living N_2 fixation, mycorrhizal associations. Soil and water conservation benefits	03
6	Agroforestry for biodiversity conservation. Synergy with climate change mitigation. Landscape connectivity for wildlife, supporting the pollinators of plant species	03
7	Agroforestry for improved air and water quality. Non-point source pollution in Indian agro-ecosystems. Riparian buffers for alleviating agricultural non-point source pollution	03
8	Private profitability vs. social profitability - exclusion or inclusion of social benefits and costs and nonmarket values, or externalities	03
9	Theory of externalities, effect of environmental costs and benefits on the profitability of agroforestry practices	02
10	Valuing environmental services. Profitability of timber-based agroforestry systems	03
11	Costs and benefits in agroforestry- valuation of inputs and outputs- environmental outputs	03
	Total	**32**

SAF 607 PLANTATION FOREST PRODUCTIVITY 1+1

Objective

To develop understanding of students about plantation forest productivity, dynamics of plantation growth, thinning and fertilization of plantation.

Theory:

UNIT I

Plantation forests - scope and perspectives, international and national scenario.

UNIT II

Dynamics of plantation growth – site quality, stand density, dynamics of nutrient cycling, thinning, spacing and crown efficiency, nutrient pools and dynamics, biological factors in nutrient supply. Impact of pest and disease management on plantation forest productivity.

UNIT III

Advances in site preparation techniques. Recent trends in fertilization and irrigation of plantations. Tending and cultural operations and plantation productivity - prospects of mechanization in tropical plantations. Reduced impact logging. Clonal forests, their management and productivity comparisons.

UNIT IV

Productivity decline in plantation forests – second rotation decline - harvest related resource export

- Modern silvicultural interventions.

UNIT V

Project formulation, designing and appraisal of different kinds of plantations to meet specific objectives.

Practical

Plantation productivity analysis – growing stock and MAI assessment - stand density estimation, fertilizers and fertilizer application in plantation, response of plantation to irrigation, productivity of clonal forestry, modern tools in site preparation, weed management methods, management strategies for enhancing plantation productivity.

Suggested Readings

Evans J and Turnbull JW. 2004. *Plantation Forestry in the Tropics: The Role, Silviculture and Use of Planted Forests for Industrial, Social, Environmental and Agroforestry Purposes*. OUP Oxford.

Evans J. 1982. *Plantation Forestry in the Tropics*. Clarendon Press. Ford ED. 1984. *Nutrition of Plantation Forests*. Academic Press.

Krishnapillay B. 2000. *Silviculture and Management of teak plantations*. *Unasy.* 201. 51:14-21p. Nambiar EKS, Cossalter C and Tiarks A. 1998. *Site Management and Productivity in Tropical Plantation Forests.* Workshop Proceedings, South Africa.

Sairll PS, Evans J, Auclair D and Flack J. 1997. *Plantation Silviculture in Europe*. Oxford University Press.

Smith DM. 1980. *The Practice of Silviculture*. 8th ed., John Wiley & Sons.

Suzuki K, Ishii K, Sakurai S and Sasaki S. 2006. *Plantation Forestry in the Tropics*. Springer Tokyo.

Zobel BJ, Wyk G and Stahlper P. 1987. *Growing Exotic Forests*. John Wiley & Sons.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Plantation forests - scope and perspectives, international and national scenario	02
2	Dynamics of plantation growth – site quality, stand density, dynamics of nutrient cycling, thinning, spacing and crown efficiency, nutrient pools and dynamics, biological factors in nutrient supply	03
3	Advances in site preparation techniques. Recent trends in fertilization and irrigation of plantations	02
4	Tending and cultural operations and plantation productivity - prospects of mechanization in tropical plantations	02
5	Reduced impact logging	01
6	Clonal forests, their management and productivity comparisons	02
7	Productivity decline in plantation forests – second rotation decline - harvest related resource export - Modern silvicultural interventions	02
8	Project formulation, designing and appraisal of different kinds of plantations to meet specific objectives	03
	Total	**17**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Plantation productivity analysis – growing stock and MAI assessment - stand density estimation	3

2	Fertilizers and fertilizer application in plantation, response of plantation to irrigation	3
3	Productivity of clonal forestry, modern tools in site preparation	4
4	Weed management methods	2
5	Management strategies for enhancing plantation productivity	4
	Total	**16**

SAF 608 RESTORATION FORESTRY 1+0

Objective

To develop understanding of students about advances in restoration forestry and forest landscape restoration.

Theory

UNIT I

Introduction to restoration forestry, scope and opportunities for forest restoration, Natural regeneration, forest and land degradation in the Asia-Pacific region. Forest restoration techniques, tools for prioritization, decision-making and monitoring to enhance restoration success, The Bonn Challenge, The Bonn Challenge in Asia, Africa and Latin America.

UNIT II

Forest landscape restoration, environment for natural regeneration in forest and landscape restoration, economic and social aspects for successful integration of natural regeneration in forest landscape restoration, adaptive management for forested landscapes in transformation, measures to improve resilient and genetically diverse forests. Mangrove restoration.

UNIT III

Case studies on successful forest landscape restoration.

Suggested Readings

Beatty CR, Cox NA and Kuzee ME. 2018. *Biodiversity Guidelines for Forest Landscape Restoration Opportunities Assessments.* First edition. Gland, Switzerland: IUCN.

Blakesley D and Buckley P. 2016. *Grassland Management and Restoration.* Conservation handbooks. Pelagic Publishing. Food and Agriculture Organization of the United Nations.

Chokkalingam U, Shono K, Sarigumba MP, Durst PB and Leslie R. (eds). 2018. *Advancing the Role of Natural Regeneration in Large-Scale Forest and Landscape Restoration in the Asia- Pacific Region.* FAO and APFNet. Bangkok.

FAO. 2010. *Forests Beneath the Grass.* Proceedings Of The Regional Workshop On Advancing The Application Of Assisted Natural Regeneration For Effective Low-Cost Forest *Restoration.* Bangkok, FAO.

FAO/RECOFTC. 2016. *Forest Landscape Restoration in Asia-Pacific Forests*. by Appanah, S. (ed.). Bangkok, Thailand.198p

Prober SM, Byrne M, McLean EH, Steane DA, Potts BM, Vaillancourt RE and Stock WD. 2015. *Climate-Adjusted Provenancing: A Strategy for Climate-Resilient Ecological Restoration.* Frontiers in Ecology and Evolution, 23 June.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1	Introduction to restoration forestry, scope and opportunities for forest restoration	01
2	Natural regeneration, forest and land degradation in the Asia Pacific region	02
3	Forest restoration techniques	02
4	Tools for prioritization, decision-making and monitoring to enhance restoration success, The Bonn Challenge, The Bonn Challenge in Asia, Africa and Latin America.	03
5	Forest landscape restoration, environment for natural regeneration in forest and landscape restoration, economic and social aspects for successful integration of natural regeneration in forest landscape restoration, adaptive management for forested landscapes in transformation	03
6	Measures to improve resilient and genetically diverse forests	02
7	Mangrove restoration	01
8	Case studies on successful forest landscape restoration	03
	Total	**17**

SAF 609 REGENERATION SILVICULTURE 2+1

Objective

To develop understanding of students about advances in regeneration silviculture, forest continuum, advancement in artificial regeneration.

Theory

UNIT I

Planning for regeneration, setting the objectives for regeneration, principles and methodologies of forest regeneration, ecological basis of natural regeneration techniques.

UNIT II

Basic Concepts in forest regeneration, importance of different combinations of light, moisture, soil in determining success or failure of regeneration. Factors affecting natural and artificial regeneration- kinds, extent and quality of sites.

UNIT III

Techniques of canopy manipulation and forest continuum in regular and irregular forests canopy, light pattern and regeneration establishment. Regeneration survey and methodology. Major silvicultural systems of tropical and temperate parts of the world. Continuous cover forestry. Advances in coppice silviculture. Silviculture in a changing world.

UNIT IV

Advances in artificial regeneration techniques, advances in vegetative propagation techniques like mini and micro-cutting techniques, production technology for quality planting stock, carbon enrichment techniques for production of quality planting stock. Integrated nutrient management in nursery production. Plant quality assessment tools.Nursery production system of important timber and Non-Timber Forest Products, NTFP's yielding species in the region.

UNIT V

Sustainable site establishment practices, Novel tree establishment techniques. Regeneration problems of important conifers and broad leaved species-case studies.

Practical

Factors affecting natural and artificial regeneration, Advances in vegetative propagation techniques like

mini and micro-cutting techniques, Production technology for quality planting stock, Carbon enrichment techniques for production of quality planting stock, Integrated nutrient management in nursery production. Novel tree establishment techniques. Modern approaches in containerized seedling production.

Suggested Readings

Colak AH, Rotherham ID and Calikoglu M. 2003. *Combining 'naturalness concepts' with close- to-nature silviculture*. Forstwiss. Centralbl. 122, 421–431.

Sairll PS, Evans J, Auclair D and Flack J. 1997. *Plantation Silviculture in Europe*. Oxford University Press.

Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. *The Practices of Silviculture*: Applied Forest Ecology. John Wiley & Sons.

Lecture Schedule

Theory

Sr. No	Topic	No. of Lecture (s)
1	Planning for regeneration, setting the objectives for regeneration, principles and methodologies of forest regeneration, ecological basis of natural regeneration techniques	03
2	Basic concepts in forest regeneration, importance of differentcombinations of light, moisture, soil in determining success or failure of regeneration	03
3	Factors affecting natural and artificial regeneration- kinds, extent and quality of sites	02
4	Techniques of canopy manipulation and forest continuum in regular	03
5	and irregular forests canopy, light pattern and regeneration establishment Regeneration survey and methodology	02
6	Major Silvicultural systems of tropical and temperate parts of the	02
7	world. Continuous cover forestry Advances in coppice Silviculture. Silviculture in a changing world	02
8	Advances in artificial regeneration techniques, advances in vegetative propagation techniques like mini and micro-cutting techniques, production technology for quality planting stock, carbon enrichment	02
9	Techniques for production of quality planting stock. Integrated nutrient management in nursery production	02
10	Plant quality assessment tools	04
11	Nursery production system of important timber and Non-Timber Forest Products, NTFP's yielding species in the region	02
12	Sustainable site establishment practices, Novel tree establishment techniques	02
13	Regeneration problems of important conifers and broad leaved species-case studies	03
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Factors affecting natural and artificial regeneration,	2
2	Advances in vegetative propagation techniques like mini and micro- cutting techniques,	3
3	Production technology for quality planting stock,	3

4	Carbon enrichment techniques for production of quality planting stock,	2
5	Integrated nutrient management in nursery production.	2
6	Novel tree establishment techniques.	2
7	Modern approaches in containerized seedling production.	2
	Total	**16**

SAF 610 FOREST SOIL MANAGEMENT 1+1

Objective

To develop understanding of students about advances in forest soil management, forest soils and vegetation management.

Theory

UNIT I

Forest soils and vegetation development. Physical properties of forest soils. Forest soil classification. Soils of the major forest biomes – temperate forest, soils under different forest types - tropical rainforest soils – moist deciduous forests – dry deciduous-. Soils and plant roots.

UNIT II

Soil chemistry and nutrient uptake. Soil organic matter - maintenance and buildup. Biology of forest soils - role of microorganisms in ameliorating soils; N and C cycles. Forest biogeochemistry. Micorrhizae. Role of forests in conserving soils.

UNIT III

Nutrient transformation in soils. Nitrogen fixation in tropical forest plantations: N_2 fixation process, species, rates of N_2 fixation, factors influencing N_2 fixation; nutrient cycling - comparison of plantation productivity - case studies. Nutrition management: nutrient limitations, fertilization. Soil carbon sequestration - processes and mechanisms.

UNIT IV

Soil management for reforestation of salt affected soils, acid soils, coastal soils. Effects of fire on soils and their properties.

UNIT V

Management of long term soil productivity - soil compaction and erosion - harvest removal and nutrient budgeting - harvest effect on water quality - strategies for future management.

Practical

Nutrient budgeting for different plantation systems, quantification of physical and chemical soil constraints in plantation and agroforestry systems, evolving new strategies for soil and site development.

Suggested Readings

Binkley D and R. Fisher. 2012. *Ecology and Management of Forest Soils* (4th Edition), John Wiley & Sons Singapore Pte. Ltd., Singapore.

Fisher RF, Binkley D and Pritchett WL. 2000. *Ecology and Management of Forest Soils*. 3rd Ed.John Wiley & Sons Inc., New York.

Havlin *et al.* 2014. *Soil Fertility and Fertilizers: An Introduction to Nutrient Management* (8th Edition), PHI Learning Pvt. Ltd., Delh

Khan TO. 2013 *Forest Soils: Properties and Management*, Springer International Publishing, Switzerland.

Pritchett and Fisher RF 1987. *Properties and Management of Forest Soils*. John Wiley, New York. Reddy MV. 2001. *Management of Tropical Plantation Forests and Their Soil Litter System-Litter, Biota and Soil Nutrient Dynamics.* Science Publishers, U. S.

Sadanandan Nambiar EK and Grown AG. (Eds.). 1997. *Management of Soil, Nutrients and Water in Tropical Plantation Forests*. ACIAR, CSIR and CIFOR, Australia.

Schulte A and Ruhiyat D. 1998. *Soils of Tropical Forest Ecosystems*: *Characteristics, Ecology, and Management*. Springer Verlag,Berlin, New York.

Lecture Schedule

Theory

Sr. No	Topic	No. of Lecture (s)
1	Forest soils and vegetation development	01
2	Physical properties of forest soils, Forest soil classification	01
3	Soils of the major forest biomes – soils under different forest types - tropical rainforest soils – moist deciduous forests – dry deciduous	01
4	Soils and plant roots, Soil chemistry and nutrient uptake	01
5	Soil organic matter - maintenance and buildup	01
6	Biology of forest soils - role of microorganisms in ameliorating soils; N and C cycles	01
7	Forest biogeochemistry. Micorrhizae. Role of forests in conserving soils	01
8	Nutrient transformation in soils	01
9	Nitrogen fixation in tropical forest plantations: N_2 fixation process, species, rates of N fixation, factors influencing N_2 fixation	01
10	Nutrient cycling - comparison of plantation productivity - case studies	01
11	Nutrition management: nutrient limitations, fertilization	01
12	Soil carbon sequestration - processes and mechanisms	01
13	Soil management for reforestation of salt affected soils, acid soils, coastal soils	01
14	Effects of fire on soilsand their properties	01
15	Management of long term soil productivity - soil compaction and erosion - harvest removal and nutrient budgeting	01
16	Harvest effect on water quality - strategies for future management	01
	Total	**16**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Nutrient budgeting for different plantation systems,	5
2	Quantification of physical and chemical soil constraints in plantation and agroforestry systems,	6
3	Evolving new strategies for soil and site development	5
	Total	**16**

SAF 611 AGROFORESTRY FOR SUSTAINABLE AGRICULTURE 1+0

Objective

To develop understanding of students about the role of agroforestry in sustainable agriculture, current agricultural scenario, role of trees in enhancing productivity of agricultural land on sustainable basis.

Theory

UNIT I

Current Agricultural scenario in India. Sustainable agriculture: issues and challenges. Land use changes-agroforestry: an opportunity for sustainability and rainfed agriculture.

UNIT II

Agroforestry options for sustainable agriculture: integration of perennial components in agriculture. Role of trees in enhancing the productivity of traditional agriculture. Strategies on integration of trees suitable for different cropping systems for important agro-ecological regions. Tree management for productivity optimization.

UNIT III

Agroforestry for different land holdings. Integrated farming systems. Agroforestry strategies for short term and long term returns.

UNIT IV

Processing, value addition and marketing of agroforestry products.

Suggested Readings

Chin K Ong, Colin Black and Julia Wilson. 2015. *Tree-Crop Interactions*, 2nd Edition: Agroforestry in a Changing Climate. CAB International ICRAF.

Nair PKR, Rai MR and Buck LE. 2004. *New Vistas in Agroforestr*y. Kluwer. Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer, Netherlands.

Ong CK and Huxley PK. 1996. *Tree Crop Interactions – A Physiological Approach*.

Schroth G and Sinclair F. 2003. *Tree Crops and Soil Fertility: Concepts and Research Methods*. CABI, Wallingford, UK.

Snelder DJ and Lasco RD. 2008. *Smallholder Tree Growing for Rural Development and Environmental Services*. Springer Science, Amsterdam.

Lecture Schedule

Theory

Sr. No	Topic	No. of Lecture (s)
1	Current Agricultural scenario in India. Sustainable agriculture: Issues and challenges and land use changes	02
2	Agroforestry: An opportunity for sustainability and rainfed agriculture	02
3	Agroforestry options for sustainable agriculture: Integration perennial components in agriculture	02
4	Role of trees in enhancing the productivity of traditional agriculture	01
5	Strategies on integration of trees suitable for different cropping systems for important agro-ecological regions. Tree management for productivity optimization	03
6	Agroforestry for different land holdings. Integrated farming systems	02
7	Agroforestry strategies for short term and long term returns	02
8	Processing, value addition and marketing of agroforestry products	03
	Total	**17**

Supporting Courses

Compulsory at M.Sc. level

Course Contents

FOR 511 GENERAL STATISTICAL METHODS AND COMPUTER APPLICATIONS 2+1

Objective

This course is meant for students who do not have sufficient background of statistical methods. The students would be exposed to concepts of general statistical methods and statistical inference that would help them in understanding the importance of statistical methodology. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation of results.

Theory UNIT I

Review of probability. Random variable and mathematical expectation. Discrete and continuous probability distributions viz. Binomial, Poisson and Normal distributions.

UNIT II

Correlation and regression, Rank correlation, Non-linear regression, Partial and multiple correlation coefficient, Intra class correlation,Multiple linear regression.

UNIT III

Introduction to theory of estimation, Testing of statistical hypothesis: chi-square, t and F distributions. Tests of significance based on chi-square, t and F tests. Large sample tests, Fisher Z transformation.

UNIT IV

Analysis of variance: One way and two way classification. Design of Experiments: Basic Principles of design of experiments, Completely Randomised Design, Randomised Block Design, Latin Square Design. Elementary idea of factorial experiments. Estimation of genetic parameters from ANOVA table.

UNIT V

Non-parametric tests: Sign test, Wilcoxon test, Mann-Whitney U-test, Wald Wolfowitz run test, Median test, Kruskal- Wallis test. MS Excel, Introduction to computer softwares.

Practical

Random variable and mathematical expectation. Fitting of distributions viz. Binomial, Poisson, Normal; Correlation and regression, non-linear regression, multiple linear regression. Testing of hypothesis based on chi square, t and F tests. Large sample tests. Completely Randomised Design, Randomised Block Design, Latin Square Design and Factorial experiments. Non-parametric tests. Exercises based on computer software.

Suggested Readings

Aggarwal BL. 1996. *Basic Statistics*. Wiley Eastern Limited, New Age International Ltd.

Bansal ML, Singh S, Singh TP and Kumar R. 2004. *Statistical Methods for Research Workers*. Kalyani Publishers.

Chandel SRS. 2014. *A Handbook of Agricultural Statistics*. Achal Prakashan.

Goon AM, Gupta MK and Dasgupta B. 1968. *Fundamentals of Statistics*, vol I, II. The World Press, Calcutta.

Snedecor GW and Cochran WG. 1980. *Statistical Methods.* East West Press.

Lecture Schedule

Theory

Sr. No	Topic	No. of Lecture (s)

Sr. No.	Topic	No. of Lecture (s)
1	Review of probability. Addition and multiplication law of probability	2
2	Random variable and mathematical expectation	1
3	Discrete and continuous probability distributions: Binomial, Poisson and Normal distributions	4
4	Correlation and regression. Rank correlation	2
5	Non-linear regression	1
6	Partial correlation coefficient, multiple correlation coefficient, Multiple linear regression. Intra class correlation	4
7	Introduction to theory of estimation	1
8	Testing of statistical hypothesis: chi-square, *t* and *F* distributions. Tests of significance based on chi-square, *t* and *F* tests. Large sample test . Fisher z transformation	5
9	Analysis of variance: One way and two way classification	2
10	Design of Experiments: Basic Principles of design of experiments, Completely randomised design, Randomised block design, Latin square design	4
11	Elementary idea of Factorial experiments. Estimation of genetic parameters from ANOVA table	3
12	Non-parametric tests - sign, Wilcoxon, Mann-Whitney U-test, Wald Wolfowitz run test, Median test, Kruskal- Wallis test	2
13	MS Excel, Introduction to computer software	2
	Total	**33**

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Random variable and mathematical expectation	1
2.	Discrete and continuous probability distributions: Binomial, Poisson and Normal distributions	2
3.	Correlation and regression. Rank correlation	1
4.	Non-linear regression	1
5.	Multiple linear regression. Intra class correlation	2
6.	Tests based on chi-square, *t* and *F* tests. Large sample test	2
7.	Analysis of variance: One way and two way classification	1
8.	Design of Experiments: Basic Principles of design of experiments, Completely randomised design, Randomised block design, Latin square design	2
9.	Elementary idea of Factorial experiments. Estimation of genetic parameters from ANOVA table	1
10.	Non-parametric tests - sign, Wilcoxon, Mann-Whitney U-test, Wald Wolfowitz run test, Median test, Kruskal- Wallis test.	1
11.	MS Excel, Applications of computer software to statistical analysis	2
	Total	**16**

Compulsory at Ph.D. level

Course Contents

FOR 610 RESEARCH METHODOLOGY IN FORESTRY 2+1

Objective

The students would exposed to concepts of design of experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental/field data. The students would also be exposed to elementary sampling techniques. It would help them in understanding the concepts involved in planning and designing their surveys, presentation of survey data, analysis of survey data and presemntation of results.

Theory

UNIT I

Experimental Design**:** Research problem. Types of Research. Need for designing of experiments, Basic principles of design of experiment. Uniformity trials, size and shape of plots and blocks; Analysis of variance, Completely Randomized Design, Randomized Block Design and Latin Square Design. Factorial experiments, (symmetrical as well as asymmetrical). Confounding in symmetrical factorial experiments, Factorial experiments with control treatment. Split plot and strip plot designs; Analysis of covariance and missing plot techniques. Balanced incomplete block design, Fitting of response surfaces. Transformations of data. Groups of experiments.

UNIT II

Sampling Theory: Basic terms used in sampling. Simple random sampling, Stratified random sampling, Systematic random sampling. Elementary idea of probability proportional to size, multistage, cluster and inverse sampling.

UNIT III

Elementary idea to multivariate analytical tools- Classification and Discriminant function. Factor analysis, Principal component and cluster analysis.

Practical

Analysis of data obtained from CRD, RBD, LSD; Analysis of factorial experiments without and with confounding; Analysis with missing data; Split plot and strip plot designs; Transformation of data; Fitting of response surfaces. Balanced incomplete block design. Groups of experiments. Simple random sampling, Stratified random sampling, Systematic random sampling.

Suggested Readings

Aggarwal BL. 2011. *Theory and Analysis of Experimental Designs*. CBS Publisher, New Delhi. Gomez KA and Gomez AA. 1984. *Statistical Procedure for Agricultural Research*. John Wiley & Sons.

Johnson Richard A and Dean W Wichern. 2015. *Applied Multivariate Statistical Analysis*. Prentice Hall of India.

Mukopadhyay Parimal. 2008. *Theory and Methods of Survey Sampling*. Prentice Hall of India. Sahu PK and Das AK.2014. *Agriculture and Applied Statistics* 2. Kalyani Publisher.

Singh Daroga and Chaudhary FS. 2018. *Theory and Analysis of Sample Survey Design*. New Age International Ltd.

Zar Jerrold H. 2010. *Biostatistical Analysis*. Prentice Hall.

Lecture Schedule

Theory

Sr. No	Topic	No. of Lecture (s)
1	Need for designing of experiments, Basic principles of design of experiment. Uniformity trials, size and shape of plots and blocks	3
2	Analysis of variance, Completely Randomized Design, Randomized Block Design and Latin Square Design	4
3	Factorial experiments, Confounding in symmetrical factorial experiments	4
4	Factorial experiments with control treatment	1
5	Split plot and strip plot designs	3
6	Analysis of covariance and missing plot techniques	2
7	Balanced incomplete block design, Fitting of response surfaces. Transformations of dat	3
8	Groups of experiments	2
9	Basic terms used in sampling. Simple random sampling	3
10	Stratified random sampling, Systematic random sampling	3
11	Elementary idea of multistage, cluster and inverse sampling	2
12	Elementary idea to multivariate analytical tools- Classification and Discriminant function Factor analysis, Principal component and cluster analysis	2
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1	Analysis of variance, Completely Rando ized Design, Randomized Block Design and Latin Square Design	3
2	Factorial experiments, Confounding in symmetrical factorial experiments	3
3	Factorial experiments with control treatment	1
4	Split plot and strip plot designs	2
5	Analysis of covariance and missing plot techniques	2
6	Balanced incomplete block design, Fitting of response surfaces. Transformations of data	2
7	Groups of experiments	1
8	Simple random sampling, Stratified random sampling, Systematic random sampling	2
	Total	**16**

Non- Gradial Common Courses

Course Title with Credit Load

Non- Gradial Common Courses

Sr. No	Course Code	Course Title	Credit
1	PGS -501	Library and Information Services	(0+1)
2	PGS -502	Technical Writing and Communications Skills	(0+1)
3	PGS -503	Intellectual Property and Its Management In Agriculture	(1+0)
4	PGS -504	Basic Concepts in Laboratory Techniques	(0+1)
5	PGS -505	Agricultural Research, Research Ethics and Rural Development Programmes	(1+0)
6	PGS -506	Advertising and Brand Management	(1+0)
Note: (a) For all the faculties other than M.B.A. (ABM) five courses i.e., (1),(2), (3), (4) and (5) are compulsory. (b) For M.B.A. Faculty, five courses i.e., (1), (2), (3), (5) and (6) are compulsory			

Course Contents

PGS – 501 LIBRARY AND INFORMATION SERVICES (0+1)

Objective

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines etc.) of information search.

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.

PGS – 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS (0+1)

Objective

To equip the students/scholars with skills to write dissertations, research papers, etc. To equip the students/ scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical

Technical Writing –

Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article. Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

Suggested Readings

1. Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
2. Collins' Cobuild English Dictionary. 1995.
3. Harper Collins. Gordon HM & Walter JA. 1970. Technical Writing. 3rd Ed.
4. Holt, Rinehart & Winston. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.
5. James HS. 1994. Handbook for Technical Writing. NTC Business Books.
6. Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East- West Press.
7. Mohan K. 2005. Speaking English Effectively. MacMillan India.
8. Richard WS. 1969. Technical Writing.
9. Barnes & Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.

10. Abhishek. Sethi J & Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.

11. Wren PC & Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

PGS – 503 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (1+0)

Objective

The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

1. Erbisch FH & Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.

2. Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.

3. Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.

4. Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.

5. Rothschild M & Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.

6. Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.

PGS – 503 BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

Objective

To acquaint the students about the basics of commonly used techniques in laboratory.

Practical

- Safety measures while in Lab;
- Handling of chemical substances;
- Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets;

- Washing, drying and sterilization of glassware;
- Drying of solvents/ chemicals;
- Weighing and preparation of solutions of different strengths and their dilution;
- Handling techniques of solutions;
- Preparation of different agro-chemical doses in field and pot applications;
- Preparation of solutions of acids;
- Neutralization of acid and bases;
- Preparation of buffers of different strengths and pH values;
- Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sand bath, water bath, oil bath;
- Electric wiring and earthing;
- Preparation of media and methods of sterilization;
- Seed viability testing, testing of pollen viability;
- Tissue culture of crop plants;
- Description of flowering plants in botanical terms in relation to taxonomy.

Suggested Readings

1. Furr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press.
2. Gabb MH and Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

PGS – 505 AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (1+0)

Objective

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory

UNIT I

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II

Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co- operatives, Voluntary Agencies/Non-Governmental Organisations. Critical

evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

1. Bhalla GS & Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
2. Punia MS. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.
3. Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publ.
4. Singh K. 1998. Rural Development - Principles, Policies and Management. Sage Publ.

PGS – 506 ADVERTISING AND BRAND MANAGEMENT (1+0)

LEARNING OUTCOMES

This course investigates various promotional tools used in the communication mix, such as advertising, sales promotion, and publicity, to sell products and services. Concepts include: advertising planning processes, determining advertising and promotional goals and objectives, control and evaluation of advertising and promotional programs, and regulatory issues. Students will develop a comprehensive advertising campaign for a real or imaginary product.

Theory

BLOCK 1: INTRODUCTION

UNIT 1

Introduction to Advertising Management: Integrated Marketing Communications, Setting Goals and Objectives, how advertising works: Segmentation and Positioning Assess the strengths, weaknesses, opportunities and threats (SWOT) of different kinds of promotional campaigns

UNIT 2

Message Strategy: Attention and comprehension, Advertising appeals, Associating Feelings with the Brand, Brand Equity, Image and Personality and Group Influence and word of mouth advertising, Media Planning and Media Strategy, Media Strategy and Tactics, Legal, Ethical and Social concerns of Advertising.

UNIT 3

Consumer Promotions and Trade Promotions: Their purpose and types How to plan and evaluate a successful promotion, The relationship between advertising and promotions, Introduction to Global Marketing, Advertising and sales promotion.

BLOCK 2: BRANDING DECISION

UNIT 1

Major Brand Concepts and branding Decision: Identifying and selecting brand name Building brand personality, image and identity; Brand positioning and re-launch; Brand extension; Brand portfolio; communication for branding Enhancing brand image through sponsorship and even management.

UNIT 2

Managing Brand Equity and Loyalty: Brand Building in Different Sectors - Customers, industrial, retail and service brands. Building brands through Internet, social Media. Building Indian brands for global markets.

TEACHING METHODS/ACTIVITIES:

- Lecture and Discussion

- Case Study
- PPT presentation

SUGGESTED READINGS

- Keller, Kevin Lane; *Strategic Brand Management;* Pearson education, New Delhi Verma, Harsha*: Brand Management;* Excel Books; New Delhi
- Kapferer, Jean Noel; *Strategic Brand Management;* Kogan Page; New Delhi
- Kumar, S. Ramesh; *Marketing and Branding–The Indian Scenario;* Pearson Education; New Delhi Kapoor, Jagdeep ; *24 Brand Mantras*, Sage Publications; New Delhi
- *Sengupta Subroto; Brand Positioning: Strategies for competitive advantage; Tata Mc Graw Hill; New Delhi Clifton, Rita & Simmons., John; Brands and Branding; The Economist; Delhi*

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