



Maharashtra Education Society

Abasaheb Garware College

(Autonomous)

(Affiliated to Savitribai Phule Pune University)

**Two Year M.Sc. Degree Program in
Biodiversity-Monitoring and Utilization
(Faculty of Science and Technology)**

Syllabi under NEP

M.Sc. II (Biodiversity - Monitoring and Utilization)

To be implemented from Academic Year 2024-2025

Title of the Course: M.Sc. Biodiversity - Monitoring and Utilization

Preamble

M. Sc. Biodiversity - Monitoring and Utilization (credit and Semester System) is a two year postgraduate course, comprising four semesters. The curriculum gives holistic coverage to the extremely valuable field of Biodiversity. Biodiversity is the largest source of potential wealth for the country, which remains grossly under-explored. One of the reasons for the under utilization is the dearth of trained manpower. The current generation of biologists is largely divided into field-oriented taxonomists and ecologists on the one hand and the lab oriented functional and molecular biologists on the other. This divide has become a limiting factor in the study of Biodiversity. The present program intends to bridge the gap by inculcating excellence in field and laboratory biology simultaneously. This capacity building exercise will help generate wealth through a prudent and sustainable use of the country's bioresources.

The course consists of four semesters:

- The first year comprising two semesters is extensively field oriented and the second year is lab intensive.
- The first semester is devoted to taxonomy and diversity of various life forms and emphasizes on basic techniques of exploration of diversity.
- Second semester focuses on natural history and is supplemented adequately with quantitative techniques in biology and ecology. Biogeography component which forms the key component in shaping up of natural systems has also been included here.
- First and second semesters together emphasize on conceptual as well as empirical knowledge of the ways in which natural systems work.
- The first two semesters can make a good naturalist and ecologist.
- Third and fourth semester will expose students to various facets of environment, conservation and utilization of bioresources.

Program outcomes

1. Educate new age custodians of biodiversity
2. To conduct field and laboratory research for biodiversity monitoring, conservation and policy input
3. Enhance awareness and help address societal challenges in biodiversity

Eligibility: a. Bachelor in - Science (any branch) / Agriculture / Fisheries / Pharmacy / Forestry / Medicine / Engineering (any branch) with minimum 50% of marks

b. Clearing the entrance examination

Admission: The candidate should appear for the entrance test. The merit list will be based only on marks obtained in entrance test. Marks of qualifying graduate examination will be considered for tie-breaking.

Fee Structure: As per Savitribai Phule Pune University guidelines for self-supported post graduate courses in colleges.

Medium of instruction – English

Structure of the Course: M.Sc. Biodiversity-Monitoring and Utilization

OJT: On Job Training: Internship/apprenticeship; FP: Field Projects; RM: Research Methodology; RP: Research Project

Year	Semester	Course Type	Course Code	Course Title	Remark	Credit
1	I	Compulsory	BD-501-MJ	Plant Taxonomy, Diversity and Economic Botany	Theory	4
			BD-502-MJ	Animal Taxonomy and Diversity	Theory	4
			BD-503-MJ	Introduction to Ecology and Biodiversity Management	Theory	2
			BD-504-MJ	Taxonomy and Diversity: Field Methods	Practical	4
		Elective	BD-510-MJ	Plant and Animal tissue culture	Theory (Select any one)	4
			BD-511 -MJ	Environmental Pollution and Climate change		4
			BD-541-RM	Research Methodology	RM	4
	II	Compulsory	BD-551-MJ	Microbial Diversity and Molecular Biology	Theory	4
			BD-552-MJ	Population Ecology and Quantitative Biology	Theory	4
			BD-553-MJ	Biogeography & Evolutionary biology	Theory	2
			BD-554-MJ	Taxonomy and Diversity: Lab Methods	Practical	4
		Elective	BD-560-MJ	Agrobiodiversity and Livestock diversity	Theory (Select any one)	4
			BD-561-MJ	Biodegradation and Pollution Control		
BD-581-OJT			On Job Training / Field Projects (OJT/FP)	Training /project	4	

Year	Semester	Course Type	Course Code	Course Title	Remark	Credit
2	III	Compulsory	BD-601-MJ	Bioinformatics and Phylogenetics	Theory	4
			BD-602-MJ	Wildlife and Conservation Biology	Theory	4
			BD-603-MJ	Socio-economic Aspects of Biodiversity	Theory	2
			BD-604-MJ	Bioinformatics techniques	Practical	4
		Elective	BD-610-MJ	Introduction to environment laws and policies	Theory (Select any one)	4
			BD-611-MJ	Environmental Journalism		
			BD-631-RP	Research Project	Project	4
	IV	Compulsory	BD-651-MJ	Chemical Diversity	Theory	4
			BD-652-MJ	Scientific Communication & Advanced Data Science in Biodiversity	Theory	4
			BD-653-MJ	Environment Management and Restoration	Theory	4
		Elective	BD-660-MJ	Developing Biomolecules as drugs	Theory (Select any one)	4
			BD-661-MJ	Forestry		
			BD-681-RP	Research Project	Project	6

Numbering to the subjects are given as under

Course Numbers:

Program	Year	Sem	Major				Minor
			Core	Elective	VSC	FP/OJT/CEP/ RP	
Post Graduation on PG	First Year	1	501 to 509	510 to 529	-	531 to 539	541 to 549
		2	551 to 559	560 to 579	-	581 to 589	-
	Second Year	1	601 to 609	610 to 629	-	631 to 639	-
		2	651 to 659	660 to 679	-	681 to 689	-

Course code and Title
BD-601-MJ Bioinformatics and Phylogenetics

Course outcome:**(Credits-4)**

Students will be able to understand bioinformatics tool and perform *in silico* analysis of biological queries. They can demonstrate proficiency in using, retrieving and analyzing biological data for sequence and structure analysis. Apply critical thinking skills to interpret phylogenetic trees and evolutionary relationships. They would design and execute bioinformatics project, integrating multiple analytical techniques.

A. Overview of Bioinformatics**(1 credit)**

- a. Major bioinformatics resources, biological databases
- b. Nucleic acid sequence databases: GenBank, RefSeq, EMBL, DDBJ.
- c. Protein sequence databases: PIR-PSD, SwissProt, UniProtKB, TrEMBL/GenPept.

B. Introduction to Sequence Alignment**(1 credit)**

- a. Introduction to BLAST and FASTA
- b. Pairwise sequence alignment, Global and local sequence alignment- Needleman Wunsch algorithm and Smith Waterman algorithm
- c. Molecular Phylogenetics – comparison of sequences, global and local alignments, Pair-wise and Multiple sequence alignments, comparative genomics tools.

C. Tools used in Proteomics & Genomics**(1 credit)**

- a. Tools in proteomics: Isoelectric focusing, PAGE, 2D PAGE, X-ray crystallography, Mass Spectrometry and Maldi-Tof, Protein Microarray
- b. Genome/Transcriptome Sequencing: Basic DNA sequencing Classical sequencing Methods, automated DNA sequencing, Next generation sequencing methods
- c. Data analysis principles.

D. Constructing Phylogenetic trees**(1 credit)**

- a. Fundamentals of a phylogenetic tree- node, clade, root, paralog, ortholog, homolog
- b. Constructing phylogenies and estimating molecular distances

- c. Different types of Phylogenetic trees based on distance-based methods (UPGMA & Neighbor joining), parsimony, Maximum likelihood, and Bayesian inference methods.

Suggested Reading

1. Warren J. Ewens and Gregory R. Grant *Statistical Methods in Bioinformatics*.
2. Supratim Choudhuri *Bioinformatics for Beginners: Genes, Genomes, Molecular Evolution, Databases and Analytical Tools*
3. Angelika Börsch-Haubold and Bernhard Haubold *Bioinformatics for Evolutionary Biologists: A Problems Approach*.
4. Baxevanis, A.D. & Ouellette, B.F.F.: *Bioinformatics: a practical guide to the analysis of genes and proteins*. 2nd Ed.. 2002. John Wiley & Sons, Inc. Publications, New York.
5. Guigo R. Ed. & Gusfield D. *Algorithms in bioinformatics* by Ed.: Berlin. Springer-Verlag
6. Orengo, C., Jones, D. & Thornton, J.: *Bioinformatics: genes, proteins and computers*. 2003. Bios Scientific Publishers, Ltd. Oxford.
7. Supratim Choudhuri (2014). *The Beginning of Bioinformatics in Bioinformatics for Beginners*.
8. David Mount (2004). *Bioinformatics Sequence and Genome Analysis*. Cold Spring Harbor laboratory Press.
9. Christine Orengo, David Jones, Janet Thornton (2003) *Bioinformatics: Genes, Proteins and Computers* (Advanced Texts) 1st Edition.
10. Jin Xiong (2006) *Essential Bioinformatics*, Cambridge University Press.
11. Arthur Lesk (2008) *Introduction to Bioinformatics*, Oxford University Press.

Course code and Title
BD-602-MJ Wildlife and Conservation Biology

Course Outcome: **(Credits-4)**

This course is in conjunction to the course BD TC 103 in the first semester which gave an overview of the biological diversity and its conservation practices. This course deals with various scientific aspects of conservation namely, wildlife; landscape approach and people.

A. Introduction to Wildlife Conservation **(1 credit)**

- a. Scope of wildlife biology – Basics and historical perspectives
- b. Wildlife and human welfare
- c. Threats to Wildlife & habitats

B. Wildlife Conservation Strategies **(1 credit)**

- a. Species based conservation approach (animals & plants)- how to prioritize species for conservation (including marine), case studies
- b. Use of wildlife Biology for conservation- Animal Physiology, pheromones, genetic diversity, mating behavior etc.
- c. Future of habitat conservation – policies and implementation

C. Landscape Ecology **(1 credit)**

- a. History and definition of landscape ecology, its relationship to other subfields of ecology and conservation
- b. Detecting and characterizing landscape patterns, landscape dynamics, Habitat edges, ecotones and interiors, habitat patches & corridors, habitat quality
- c. Effects of landscape pattern on organisms, populations, communities and ecosystem processes

D. People and Conservation **(1 credit)**

- a. Ethno ecological knowledge- past and present, Traditional conservation practices, Concept of Sacred Natural Sites, Community conserved areas, Heritage Sites
- b. Cultural history and biodiversity, hunting practices, Human Wild life interactions
- c. Natural resources documentation, Peoples' Biodiversity Register (PBR), Access benefit sharing.

Suggested reading:

1. Gary E Davis, *Science and Ecosystem Management in National Parks*, The University of Arizona Press, Tucson, 1996
2. India's 4th national reports on convention on Biodiversity, MOEF 2009.
3. Keya Acharya (2010), *Green pen*, Sage publications
4. Kailash C. Malhotra, Yogesh Gokhale, Sudipto Chatterjee, and Sanjeev Srivastava(2001). *Cultural and Ecological Dimensions of Sacred Groves in India*. Indian National Science Academy, New Delhi, and Indira Gandhi Rashtriya Manav Sangrahalaya, Bhopal.
5. *Maharashtra protection and preservation of trees Act, 1975*, Govt of Maharashtra, modified upto 9th June 2004.
6. Rosaleen Duffy (2010), *Nature crime: how we are getting conservation wrong*, Yale University Press, London,
7. Priya Ranja Trivedi and Uttam Kumar Singh, *Environmental laws on Wildlife*, Commonwealth Publishers
8. Rutwick Dutta, *Wildlife Law: A ready reckonor, A guide to wildlife Protection Act, 1972, as amended in 2002. Wildlife Trust of India, 2004*
9. Vivek Menon (1999), *Wildlife Crime*, Natraj Publishers, Dehradun.

Course code and Title**BD-603-MJ Socio-economic Aspectsof Biodiversity****Course Outcome:****(Credits-2)**

Management of bioresources is equally about management of people. Understanding the human angle is perhaps the most importance aspect of conservation. The course aims at giving conceptual understanding of the human factors involved and the economics related to the bioresources.

A. Resource use patterns and Economics of natural resource use (1 credit)

- a. Definition and concept of bio-resources, natural resources, forest resources and livelihood. Links and their use and issues associated with over exploitation, deforestation, timber extraction, mining, dams etc.
- b. Diversity, specificity and sustainability in the use of bio-resources. Interaction between social organizations and resource use patterns
- c. Tribal, agrarian, coastal communities and their links with bio-resources.
- d. Use value analysis, direct and indirect economic values, value chain, value addition, benefit sharing, commercialization.
- e. Local markets, National and international trade in Biodiversity, Indian and global examples, case studies.

B. Socio economic survey methods and village attachment (1 credit)

- a. Participatory Methods of Data Collection-Concept and Need of Data, Information, Appraisal.
- b. Participatory Rural Appraisal (PRA) and Rapid Rural Appraisal (RRA) – Concepts and principles.
- c. Objectives, logic and merits of PRA. Major methods of PRA. Challenges/ constraints of PRA.
- d. Key informants and selection of key informants. Semi-structured interviews, Question guide/ checklist and other relevant methods and their applications in forestry and natural resource management.
- e. Data collection, observation based method, use of PRA techniques with respect to village profile including socio-economic and cultural status, farm technology used, homesteads, agroforestry, biodiversity etc.,
- f. Bench Mark survey of plant resources (cropping pattern, homesteads, agroforestry, biodiversity, yield system etc.)

Suggested Readings

1. Tom Totenberg and Lynne Lewis. 2009. *Environmental and Natural Resource Economics* Pearson – Addison Wesley publication, 9th edition.
2. Alavalapati JRR and Mercer D Evan. 2004 *Valuing Agroforestry Systems: Methods and Applications*. Kluwer Academic Publishers.
3. Kant S and Janaki A. 2014. *Handbook of Forest Resource Economics*. Publisher: Routledge
4. Thakur, D. 1986. *Socio-economic development of tribes in India*. Deep and Deep Publications, New Delhi
5. Martin, G. (1995) *Ethnobotany: A Methods Manual*. WWF International, UNESCO and Royal Botanic Gardens, Kew/Chapman and Hall, London.
6. Abhijit Dutta et.al (2005), *Environmental Economics*, APH Publishing Corporation, New Delhi
7. Hackett, S. C. (1998). *Environmental and Natural Resource Economics*. M. E. Sharpe, London
8. Karpagam, M. (1991). *Environmental Economics*. Sterling Pub., New Delhi
9. Katar Singh & Anil Shishodia (2007), *Environmental Economics*, Sage publications, New Delhi
10. Gadgil Madhav and Guha Ramachandra, *This Fissured Land: An Ecological History of India*. Oxford India Perennials Series.
11. G. *Socio Economic Review of Districts- Directorate of Economics and Statistics* .g. - aMaMaMrahaMhttps://mahades.maharashtra.gov.in/publication.do?pubCatId=DSA
12. H. Mark Q. Sutton and E.N. Anderson. *Introduction to Cultural Ecology*. Rowman & Littlefield Publishers Inc. Second Edition.
13. Jha, A. 2002. *Traditional Knowledge Systems in India*
14. Narayanasamy, N. 2009. *Participatory Rural Appraisal: Principles, Methods and Application*. SAGE Publications India Pvt Ltd

Course code and Title
BD-604-MJ Bioinformatics techniques

A. Database search (1 credit)

- a. Navigating and querying bioinformatics databases for nucleic acid GenBank/NCBI/DDBJ using various search strategies.
- b. Navigating and querying bioinformatics databases for proteins using Uniprot/NCBI/Swissprot using various search strategies.

B. Sequence comparison and alignment (1 credit)

- a. DNA/Protein sequence retrieval using GenBank/ DDBJ/UniProt
- b. Perform pair-wise, multiple sequence alignments using tools like BLAST, ClustalW or MUSCLE

C. Exploring Structure databases and software's (1 credit)

- a. Retrieving protein structures from databases like PDB and NDB
- b. Visualizing 3D structure of protein in PyMOL

D. Phylogenetic tree construction (1 credit)

- a. To construct phylogenetic trees using MEGA/PHYMLIP
- b. Construction of Dendograms, rooted and unrooted trees and interpreting phylogenetic relationships

Course code and Title**BD-610-MJ Introduction to environment laws and policies****Course Outcome: (Credits-4)**

Environmental laws in India play an important role in the bureaucracy of natural resource management systems. The objective of the course is to make the students aware of the laws related to the subject and how they have changed with the time. The aim is also to relate how the steps taken internationally have an effect on our national laws and policies related to the environment.

A. India's National Environmental Policies (1 credit)

- a. History of Environmental values and issues
- b. Basics and Principles related to development of Environmental policies
- c. Environment and Indian Constitution, Responsibilities of centre and state governments

B. Environmental Laws in India and Environmental Equity (1 credit)

- a. Environmental laws: Air Act, Water Act, Environmental Protection Act
- b. Institutional setup and implementation authorities of the Act
- c. Environmental Equity: Concept, Domestic issues, Proactive measures to sustain environmental equity

C. Biodiversity Laws in India and Implementation (1 credit)

- a. Indian Forest Act, Wildlife Protection Act
- b. Biodiversity Act, Forest Rights Act, IBBI declaration
- c. Institutional setup and implementation authorities

D. International Environmental Policies (1 credit)

- a. International laws, treaties (UNCHE, UNFCCC, Rio Earth Summit, CBD (Nagoya protocol, Cartagena protocol), GATT, Ramsar Convention, Kyoto Protocol, CITES, Paris Convention)
- b. United Nation Sustainable Development Goals (UNSDGs), AICHI Targets
- c. Linkages with National policies

Suggested reading:

1. Anjaneyulu Y. (2002) *Environmental Impact Assessment Methodologies*. B.S Publication Hyderabad.
2. Anjaneyulu, Y. and Manickam, V. (2002). *Environmental Impact Assessment Methodologies*. B.S. Publications.
3. Boland, R.G.A. (Ed) (1993). *Environmental Management Training*. Sterling Publishers Pvt. Ltd. New Delhi.
4. Canter, S.L.(1996)*Environmental Impact Assessment.2nd Edition*. McGraw-hill Book Company, New York.
5. Cutter, S.L. (1999) *Environmental Risks and Hazards*. Prentice Hall of India, New Delhi.
6. Declaration of: The Stockholm Conference, Rio, Rio+5 and Rio+10.
7. Glasson, J. Therivel, R. and Chadwick, A.(2006)*Introduction to Environmental Impact Assessment*. Routledge, London.
8. Jaswal,P.S. and Jaswal,N. *Environmental Law*. Pioneer Publications, Delhi. 2003.
9. Khitolia, R.K. *Environmental Management and Conservation* , Chand Publication.
10. Kulkarni, V. and Ramachandra, T.V. (2006).*Environmental Management*. Capitol Pub. Co., New Delhi.
11. Leelakrishnan, P.(2005).*Environmental Law in India*. LexisNexis Butterworths Wadhwa, Nagpur.
12. Morris, P. and Therivel R. (Eds) (2001) *Methods of Environmental Impact Assessment. 2nd Edition*, Spon Press London.
13. Paliwal, U.L. (2002) *Environment Audit*. Indus Valley Publications. Jaipur
14. Petts, J. *Handbook of Environmental Impact Assessment- Volume 1 and 2*. Blackwell
15. Shastri, S.C. (2008) *Environmental law in India*. Eastern Book Co, Lucknow.
16. The Wildlife [Protection] Act, 1972 [as amended up to 1991, Natraj Publishers, Dehradun, India, 1994.
17. Tiwari, R. K. (2007) *Global Environmental Policies*. A B D Publishers.

Course code and Title
BD-611-MJ Environmental Journalism

Course Outcome:**(Credits-4)**

Media plays a very important role in the dissemination of issues related to biodiversity. The course aims to give exposure to the students regarding the aspects of journalism and media for effective communication of biodiversity and environment issues.

A. Environment and need for environmental journalism (1 credit)

- a. Introduction to media and its aspect from to environment protection and conservation: Concepts and perspective.
- b. Environment and society
- c. Relation of environment with development, economy and health
- d. Analysis of current status of environmental journalism

B. Comparison between traditional and modern journalism, advent of scientific journalism (1 credit)

- a. Types of media – an overview, classification of media
- b. Historical perspectives
- c. Comparison of traditional with modern media
- d. Scientific journalism – A role in environmental issues and societal progress
- e. Environment reporting- Source and collection of data for environment report writing. Collection of data, laws and ethics involve in reporting.

C. Global and local issues related to environment (1 credit)

- a. Environment and development
- b. Biodiversity conservation
- c. Pollution
- d. Energy
- e. Management of natural resources
- f. Climate change

D. Various media and their contribution in documentation of their success stories**(1 credit)**

- a. Environmental journalism and its impact: Generation of awareness amongst masses, Conversion into action, social response, Policy making, Implementation level
- b. Contribution of media- Print media, Audio media, Audio visual media, and social media
- c. Discussions based on Case studies

Suggested reading:

1. Arunamurthy, Vasundhara, Bhuwaneshwar, (2005) *EIA process in India and its drawbacks*
2. Corporate document repository, www.fao.org
3. Dr Y PrabhanjanYadav, *Role of communication in climate change and sustainable development*, Global media journal, Indian edvol 2, no 2
4. J. Taylor Miller, Thomson, *Environmental sciences*
5. Michael P Murphy and Luke A. J. O' Neill. *What is life? the next 50 years*
6. PriyaUttam, K 'Cherry and Tripat Kaur, *Global environmental issues*
7. Ramsar convention – India, Current science, vol-101, no 10, 25th Nov 2011
8. R S Deshpande, *Current land policy issues in India*
9. Rachael Carson (1962), *The silent spring*, Houghton Mifflin
10. Richard Mabey ,*The oxford book of nature writing*
11. State mineral policy and related matters (manual) govt of Maharashtra, 1999.

Important links / websites

- 1) www.myfootprint.org
- 2) www.ramsar.org
- 3) www.moef.nic.in

Course code and Title
BD-631-RP Research Project

Students will undertake a Research Project in the second year.

1. Students will undertake Research project (Research Project) in the second year, in the third and fourth semester.
2. Research Project can be carried out by a single student or by group of maximum three students. The Research Project report will be prepared as per the thesis format. One copy of the report will be preserved in the department. If there is more than one student carrying out a single Research Project, a single report can be submitted. These students will be assessed based on presentation. In such case, presentation should be carried out by all the students; dividing the presentation equally among them.
3. Students must submit a concept note regarding the topic of Research project (Research Project). The note should contain details like the proposed area of work, brief description of the problem, brief methodology and name and signature of the student and supervisor. For project work chosen outside College, involving other research Institutes and supervisors, there should be one faculty coordinator from the Dept. who will interact with the student and external supervisor throughout the project period.
4. The assessment of the Research project (Research Project) is for total of 250 marks. The assessment will be conducted as per following matrix.

Subject	In-semester evaluation (Marks)	End-semester evaluation (Marks)	Total (Marks)
BD-631-RP Research Project	50	50	100
BD-681-RP Research Project	75	75	150

5. The assessment will be carried out on the basis of the points given in the accompanied guidelines. Head of the department should communicate this point wise assessment system to the Research Project supervisor (Guide), well in advance. Guide will give appropriate marks, point-wise and submit it in a sealed envelope to the Head of the respective department.

I. Guidelines for Research Project evaluation:**BD-631-RP Research Project I (In-Semester evaluation)**

Evaluation at the department level

Criteria	Max. Marks
Project Concept / Defining scope of work/Hypothesis generation	10
Field book/Lab diary	10
Motivation, Punctuality, perseverance, meeting Deadlines and Ability to work with others	10
Communication both oral and written	10
Inputs of students in development of work plan, ideas, implementation	05
Developing funding Proposal	05
Total	50

II. Guidelines for Research Project evaluation:**BD-631-RP (End-Semester evaluation)**

Evaluation to be filled by the Guide/Supervisor

Criteria	Max. Marks
Literature Review	10
Field work/Experimentation/data collection	10
Data representation and report writing	30
Total	50

Course code and Title
BD-651-MJ Chemical Diversity

Course Outcome:**(Credits-4)**

Metabolites from animals, plants and microbes represent a vast array of chemical substances. These metabolites play a role in mediating a dynamic interaction between microbes, plants and animals. A large number of such compounds from natural sources largely remain unexplored. This course intends to train the students in the methods of detecting and assaying such a compound and encourage them to find new compounds.

A. Introduction of Chemical diversity in Biodiversity study (1 credit)

- a. Introduction to Chemical Ecology- Chemical signals like olfactory cues, pheromones, Allelochemicals
- b. Understanding the chemical signal mechanism in Defense, reception, and perception by different taxa (insects, plants, and microbes).
- c. Evolution of chemical defenses in plants and animals, coevolutionary dynamics of predator-prey interactions

B. Natural product chemistry – Primary and Secondary Metabolites (1 credit)

- a. Importance and production of Secondary Metabolites (from Plants, Animals and Microbes)
- b. Introduction to classes of naturally occurring compounds: Fatty acids, Alkaloids, Terpenoids, Steroids, Flavonoids, Anthocyanins, Carbohydrates, Essential oils
- c. Case studies like aphid alarm signal, interaction with milkweed, plant pollinator interaction, sex pheromone and mate preference, interaction due to herbivore induced volatile organic compounds

C. Extraction & Analysis methods – Physical and chemical (1 credit)

- a. Extraction of Phytochemicals: Maceration, Soxhlet extraction, Steam distillation, Hydrodistillation, Wax extraction
- b. Physical Methods, Elemental analysis- Kjeldahl method
- c. Chromatographic Techniques- Paper chromatography, column chromatography, Gas chromatography, high performance liquid chromatography, spectral methods-NMR, X-ray spectroscopy.

D. Applications of chemical ecology (1 credit)

- a. Chemical Ecology in Agriculture: Applications of chemical ecology in pest management and crop protection. Use of semiochemicals for monitoring and control of agricultural

- pests, sustainable agriculture practices followed by chemical ecology principles.
- b. Chemical ecology in Conservation Biology: Role of chemical signaling in species interactions and habitat selection, Conservation applications of chemical ecology for endangered species management, Restoration ecology and the use of chemical cues in ecosystem restoration
 - c. Biomedical applications of chemical ecology: Pharmacological potential of natural products derived from chemical ecology research, Drug discovery and development inspired by ecological interactions, Ethnobotanical and traditional medicinal knowledge informed by chemical ecology.

Suggested reading:

1. Harborne, J. B. (1973) English, Book, *Illustrated edition: Phytochemical methods: a guide to modern techniques of plant analysis.*
2. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). *Methods for dilution antimicrobial susceptibility testing for bacteria that grows aerobically.* Approved Standards M7-A4. Villanova, PA: NCCLS, 1997.
3. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). *Performance standards for antimicrobial susceptibility testing; 12th information supplement (M100-S1).* Villanova, PA; NCCLS: 2002
4. Silverstein R. M., Bassler G. C., (1968), *Spectrometric Identification of Organic Compounds, 2nd Ed.*
5. Trease & Evans, (2008), *Pharmacognosy 15th Ed, Elsevier Publication (India)*
6. Thomas Eisner, in *Insect Biology in the Future, 1980. Chemistry, Defense, and Survival: Case Studies And Selected Topics.*
7. Yi-Ping Phoebe Chen, Paolo Carloni (2010) *Modern Methods in Natural Products Chemistry*, Comprehensive Natural Products II.
8. Chemical Ecology: The Chemistry of Biotic Interaction (1995); The Chemistry of Defense theory and Practice.

9. Herbivores Their Interactions with Secondary Plant Metabolites, Second Edition, Volume II: Ecological and Evolutionary Processes
10. Martin Luckner (1984). *Secondary metabolism in microorganisms, plants and animals*. Springer.
11. Stevenson P., Nicolson S., Wright G. (2017) *Plant secondary metabolites in nectar: Impacts on pollinators and ecological functions*. *Functional Ecology*, 31(1), 65-75.
12. James Hanson. *Natural Products: The Secondary Metabolites*. Royal Society of Chemistry.
13. Vogel Text book of Practical Organic Chemistry, fifth edition

Course code and Title**BD-652-MJ Scientific Communication & Advanced Data Science in Biodiversity****Course Outcome:****(Credits-4)**

Students completing this course will be able to communicate their scientific data effectively using different media such as papers, documentaries etc. Apply knowledge of scientific ethics and produce good quality of research material. Design and execute research plans using different statistical tools to answer disciplinary specific questions.

A. Theory behind Scientific Communication and Research Ethics (1 credit)

- a. Importance of scientific communication, Types of scientific communications, Ethics in Scientific communication
- b. Social implications of research, Animal experimentation ethics, wild-life ethics and human experimentation ethics.
- c. Ethics in science and research -data fudging, plagiarism, statistical ethics (p-value, sample size, sample exclusion), etc.

B. Different Modes of Scientific Communication (1 credit)

- a. Proposal writing: Statement of Purpose (SOP) and Concept note, Proposal for funding, Report Writing
- b. Scientific writing: Different types of research articles -Reviews, short notes, full paper, letter to editors and peer review, thesis writing, data visualization, data papers, popular scientific writing, graphical abstract.
- c. Oral forms of scientific communication: Transformation of written content to oral form, Poster presentation, Oral presentations
- d. Legal forms of communication of science: IPR, patents submissions, registration of plant / crop variety, communication in photography and videography, laws etc.

C. Data science in Environmental Conservation (1 credit)

- a. Global dataset (gbif, iNat, etc), Data organization, concept of decision support system
- b. Biodiversity monitoring and visualization: Species tracking, habitat analysis, Ecological modeling
- c. Climate change mitigation and adaptation: climate modeling, predicting natural disaster

D. Future trends and Challenges**(1 credit)**

- a. Advancement in technology: Artificial intelligence and machine learning, policy and regulation.
- b. Data quality and accessibility
- c. Privacy and security, Ethical use of data

Suggested reading:

1. Jeffrey M. Stanton (2017). Introduction to Data Science, SAGE Publications ISBN:9781506377520
2. Martha Davis (2005) *Scientific Papers and Presentations*
3. Yatendra Joshi, *Communicating in Style*, New Delhi TERI 2003
4. Anthony M. Graziano, Michael, L. Raulin, Research Methods: A Process of Inquiry 6th Ed
5. Barrow and Tipler (1988) *The Anthropic Principle*, Oxford University press
6. Jetz, W., McGeoch, M.A., Guralnick, R. et al. Essential biodiversity variables for mapping and monitoring species populations. *Nat Ecol Evol* 3, 539–551 (2019). <https://doi.org/10.1038/s41559-019-0826-1>
7. Pereira, H.M. et al. (2017). Monitoring Essential Biodiversity Variables at the Species Level. In: Walters, M., Scholes, R. (eds) *The GEO Handbook on Biodiversity Observation Networks*. Springer, Cham. https://doi.org/10.1007/978-3-319-27288-7_4
8. Kacic, Patrick, and Claudia Kuenzer. 2022. "Forest Biodiversity Monitoring Based on Remotely Sensed Spectral Diversity—A Review" *Remote Sensing* 14, no. 21: 5363. <https://doi.org/10.3390/rs14215363>
9. Jain, H., Dhupper, R., Shrivastava, A. et al. AI-enabled strategies for climate change adaptation: protecting communities, infrastructure, and businesses from the impacts of climate change. *Comput.Urban Sci.* 3, 25 (2023). <https://doi.org/10.1007/s43762-023-00100-2>
10. Next generation climate models: a step change for net zero and climate adaptation. <https://royalsociety.org/-/media/policy/projects/climate-change-science-solutions/climate-science-solutions-modelling.pdf>

Course code and Title
BD-653-MJ Environment Management and Restoration

Course Outcome: **(Credits-4)**

This course aims to provide application-based environment management studies pertaining to policy level developments and introducing upcoming practices like bioremediation and restoration. Understanding this course will aid to design several management and mitigation strategies to maintain ecological balance and ecosystem stability.

A. Environment Impact Assessment **(1 credit)**

- a. Background need and concept, types of EIA
- b. Environment, Biodiversity and Socio-economic aspects of EIA
- c. EIA notification in India, categories of Industries/establishments requiring EIA
- d. Environment clearance process

B. Environmental Management Systems **(1 credit)**

- a. Concept and scope, standards- National and International
- b. Cost benefit analysis, Environmental audit
- c. Life cycle Analysis- goals, scope, life cycle inventory
- d. Environment management plan (EMP)

C. Environmental mitigation and Management **(1 credit)**

- a. Bioremediation and Phytoremediation- Types of contaminants/pollutants, Fate and Transport of contaminants, Levels of Bioremediation (Biostimulation, bioaugmentation, Bioventing, Biosparging)
- b. Potential Use of GMOs in Bioremediation
- c. Biodegradation of common contaminants, Degradation of xenobiotics and elimination of toxicants.

D. Environmental restoration ecology **(1 credit)**

- a. Definition, aims and objectives of restoration, principles, concepts and strategies (long term vs. short term); physical, chemical and biological restoration; role of ecological principles in restoration, holistic approach in restoration.
- b. Restoration of natural resources; restoration of biodiversity; degraded land/waste land, range land, forest, river corridor, water resources and mine spoils.

- c. The concept of sustainable development, environmental degradation and conservation issues, global change & sustainable issues

Suggested reading:

1. Abbasi, S.A. (2001) *Water resources projects and their environmental impacts*. Discovery publishing house, New Delhi.
2. Gangstad, I. (1990). *Natural Resource management of water and land*. VanNorstrand Reinhold, New York.
3. Petak, w.J and Atkisson, A.A. (1982). *Natural Risk Hazard Assessment and Publicpolicy*. Springer- Verlag, New York.
4. M. A. Palmer, J. B. Zedler and D. A. Falk. Editors. 2016. *Foundations of Restoration Ecology*. Second Edition. Island Press. ISBN-13: 978-1610916974 and ISBN ISBN-10: 1610916972 2) A. F. Clewell and J. Aronson. 2013.
5. *Ecological Restoration: Principles, Values, and Structure of an Emerging Profession*. Island Press. ISBN 978-1-610911672 (Hardcover), 978-1-610911689 (Paperback), 978-1-597263238 (Ebook).
6. EIA- EMP manual/. Review/. Case studies book. Paper.
7. Sheldon Christopher, Yoxon Mark (2006). *Environmental Management Systems: A Step-by-Step Guide to Implementation and Maintenance*, Earthscan.
8. Cheremisinoff Nicholas (2006) *Environmental Management Systems Handbook for Refineries*, Gulf Publishing Company.

Course code and Title
BD-660-MJ Developing Biomolecules as drugs

Course Outcome:**(Credits-4)**

This course explores the intersection of biodiversity conservation and drug discovery by focusing on the development of biomolecules derived from natural sources for therapeutic applications. Students will examine the rich biodiversity of plant, marine, and microbial ecosystems and learn how to identify, isolate, and optimize bioactive compounds with pharmaceutical potential. Through a combination of lectures, case studies, and laboratory exercises, students will gain insights into sustainable drug discovery practices that leverage biodiversity while promoting conservation efforts.

A. Introduction to Biodiversity and Drug Discovery**(1 credit)**

- a. Overview of biodiversity and its importance for drug discovery
- b. Historical perspective and examples of natural products as drugs, Sources of bioactive compounds in nature (e.g., plants, marine organisms, microorganisms)
- c. Ethical considerations in biodiversity-based drug development

B. Screening of bioactive molecules**(1 credit)**

- a. Drug discovery and evaluation: pharmacological Assays, pharmacological screening, high throughput screening, hit and lead molecule, chemical libraries
- b. Antimicrobial Bioassays: Bioactive, classification of bioassay *in vitro/in vivo* assay, Types of bioassay- Qualitative and Quantitative, Antimicrobial susceptibility tests, diffusion, dilution, bioluminescence, MIC, MBC, LC50, ED50.
- c. Laboratory evaluation of new compounds/antibiotics: Animal models for activity testing, toxicity, tolerability, carcinogenicity, and allergy testing

C. Molecular Targets in Drug Development**(1 credit)**

- a. Identification and validation of drug targets
- b. Understanding biological pathways and disease mechanisms
- c. Target prioritization strategies

D. Pharmacokinetics and Pharmacodynamics**(1 credit)**

- a. ADME (absorption, distribution, metabolism, excretion) considerations

- b. PK/PD modeling and simulation
- c. Drug-drug interactions and toxicity assessment

Suggested reading:

1. Albert T. Sneden (2004) Introduction to Natural Products.
2. G.A. Poulton and C. Spino, "Natural Products Chemistry", available as a Chemistry 433 Course.
3. Harborne, J. B. (1973) English, Book, *Illustrated edition: Phytochemical methods: a guide to modern techniques of plant analysis.*
4. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). *Methods for dilution antimicrobial susceptibility testing for bacteria that grows aerobically.* Approved Standards M7-A4. Villanova, PA: NCCLS, 1997.
5. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). *Performance standards for antimicrobial susceptibility testing; 12th information supplement (M100-S1).* Villanova, PA; NCCLS: 2002
6. Silverstein R. M., Bassler G. C., (1968), *Spectrometric Identification of Organic Compounds, 2nd Ed.*
7. Trease & Evans, (2008), *Pharmacognosy 15th Ed, Elsevier Publication (India)*
8. Thomas Eisner, in *Insect Biology in the Future, 1980. Chemistry, Defense, and Survival: Case Studies And Selected Topics.*
9. Yi-Ping Phoebe Chen, Paolo Carloni (2010) *Modern Methods in Natural Products Chemistry*, Comprehensive Natural Products II.
10. *Chemical Ecology: The Chemistry of Biotic Interaction (1995); The Chemistry of Defense theory and Practice.*
11. *Herbivores Their Interactions with Secondary Plant Metabolites, Second Edition, Volume II: Ecological and Evolutionary Processes*
12. Martin Luckner (1984). *Secondary metabolism in microorganisms, plants and animals.* Springer.

Course code and Title

BD-661-MJ Forestry

Course Outcome:

(Credits-4)

This course provides an overview of the principles and practices of forestry, covering topics such as forest ecosystems, tree identification, silviculture, forest management, and sustainable forestry practices.

A. Forests

(1 credit)

Forest definitions, role, benefits - direct and indirect, History of Indian Forestry. Classification of origin of forests - High forests, coppice forests, virgin forest, pure and mixed forests, even and uneven aged stands, Forest types of India- classification. Introduction to the concept of forestry as a common property resource. Definition, scope, concepts, and objectives of Agroforestry, Farm forestry, Community Forestry and Social forestry. List of various acts and policies related to Indian forest.

B. Agroforestry

(1 credit)

Overview of agroforestry around the world. Agroforestry systems in India. Concept of demands and supply of fuel wood, fodder and timber. Social, ecological, and economic reasons for agroforestry. Agroforestry Systems – definition, structural and functional attributes. Components of Agroforestry- Provisioning and regulator services of agroforestry- Nutrient cycling Soil improvement, Increased production and productivity. Microclimate amelioration and introduction to carbon sequestration under agroforestry systems. Agroforestry types - including shifting cultivation, Taungya systems and Alley cropping. Multipurpose trees and shrubs on farmlands and agricultural fields. Tree - crop combinations. Commercial crops under shade of planted trees and natural forests. Windbreaks & Shelterbelts, grassland. Home gardens –structural and functional attributes.

C. Silviculture

(1 credit)

Definition, objectives and scope of silviculture. Relation with other branches of Forestry. Silvicultural systems- Silviculture systems (historical and future), plus species, definition,

scope and classification. Clear felling systems, Shelterwood system, Selection system and Coppice systems their modifications, accessory systems. Culm selection system in Bamboo, Canopy lifting system in Andaman.

D. Forestry for special purpose

(1 credit)

Definition, need and purpose, historic development of social forestry. History of social forestry, Green audit, REDD, ecotourism, NTFPS. Integrated rural development approach with proper marketing facility, employment generation in raising, tending and harvesting of tree crops. Joint Forest management (JFM): concept, legislation, rules, importance. Case studies of JFM implementation- problems and prospects, Microplan Preparation. JFMs, FDCs, VFCs, CBOs, NGOs and co-operative societies. Afforestation, current Government efforts for forestry, PPP.

Suggested readings

1. Khanna, L.S. 1989. Principles and Practice of Silviculture. Khanna Bandhu, New Delhi, 473p.
2. Negi S S . 1985. World Forestry systems. Bishinpal Mahinder Pal Singh, Dehradun
3. Pathak P.S. and Ram Newaj (eds.) 2003. Agroforestry: Potentials and Opportunities. Agrobios, Jodhpur.
4. Chundawat B S and S K Gautam. Text Book of Agroforestry, Oxford and IBH Publishing NewDelhi.
5. Dwivedi A P . Principles and Practices of Agroforestry.
6. Dwivedi.A.P. 1993.Textbook of Silviculture. International Book Distributors. Dehradun
7. Ramprakash, (1986). Forest Management, IBD, Dehradun.
8. Balakathiresan,S (1986). Essentials of Forest Management, Nataraj Publishers, Dehradun.
9. Bhatt acharya P., Kandya A. K. and Krishna Kumar (2008). Joint Forest Management in India, Aavishkar Publisher, Jaipur.
10. Beazley, M. 1981. The International Book of Forest. Mitchell Beazly Publishers, London. Champion, H, G and Seth, S.K. 1968. Forest types of India, a revised survey of forest types of India, GOI Press,New Delhi, 404p.
11. Grebner, D.L., Bettinger, P and Siry, J.P. 2012. Introduction to Forestry and Natural Resources. Academic Press. 508p (Google eBook).
12. Mather, A.S. 1990. Global forest resources. Belhaven, London.

13. Westoby, J. 1991. Introduction to World Forestry. Wiley, 240p
14. Huxley, P. 1999. Tropical Agroforestry. Wiley: 384p.
15. Kumar, B.M. and Nair, P.K.R (eds). 2011. Carbon Sequestration Potential of Agroforestry Systems: Opportunities and challenges. Advances in Agroforestry 8. Springer Science, The Netherlands: 307p.
16. Nair, P.K.R, Rao MR, and Buck, L.E (eds), 2004. New Vistas in Agroforestry: A Compendium for the 1st World Congress of Agroforestry, Kluwer, Dordrecht, The Netherlands.
17. Baker,F.S.1950. Principles of Silviculture, McGrawHill, N . Y . Champion, H. G. and Trevor, G. 1936. Handbook of Silviculture, Cosmo Publication, New Delhi.
18. Evans, J E. 1982. Plantation Forestry in the Tropics. The English Language Book Society and Clarendon Press–Oxford
19. Gunter, S., Weber, M,M Smith, B and Mosandl, R. 2011. Silviculture in the Tropics. Springer-Verlag- Berlin.
20. Smith, D.M.1986. The Practice of Silviculture, Edn 8. NewYork, JohnWiley..
21. Desai,V.(1991). Forest Management in India – Issues and Problems. Himalaya Pub. House, Bombay.
22. Recknagel, A and Bentley. J. (1988). Forest Management. IBD, Dehradun.
23. Trivedi, P, R and Sudarshan, K, N.(1996). Forest Management. Discovery publications, New Delhi

Course code and Title
BD-681-RP Research Project

BD-681-RP (In-Semester evaluation)

Criteria	Max. Marks
Presentation at the end of 4 th Semester	15
Evaluation of Bimonthly progress reports	20
Field book or lab diary	20
Presentation at National / International Symposia	10
Publication	10
Total	75

BD-681-RP (End-Semester evaluation) Point-wise marking scheme, to be filled by external examiner

Criteria	Max. Marks
Report writing	50
Work performance rubric (separate sheet attached)	25
Total	75

BD-681-RP Research Project (End-Semester evaluation)

Point-wise marking scheme (rubric) to be filled in by the **External Examiner**
(Based on final report submitted by the candidate)

Name of the Student

Title of the Research Project

Name of the Subject Expert

Please grade the student on a scale of 1 to 10 for each criterion. : **Encircle** the grade.

1. How do you grade the student regarding understanding of the basic concepts related to the projectwork?

1 2 3 4 5

2. Quality of the project report (Data generation & presentation).

1 2 3 4 5

3. Novelty of work

1 2 3 4 5

4. According to you, is the work performed publishable/ patentable?

1 2 3 4 5

5. Rate the quality of work with the work on the same lines being carried out elsewhere.

1 2 3 4 5

Other comments: