DEPARTMENT OF ENVIRONMENTAL STUDIES

Category-I

SEMESTER - IV

BSC (H) ENVIRONMENTAL SCIENCE

DISCIPLINE SPECIFIC CORE COURSE – 10 (DSC-EVS-10): SYSTEMATICS AND BIOGEOGRAPHY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-EVS-10: SYSTEMATICS AND BIOGEOGRAPHY	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Gain insights into the principles and methods of systematic biology for determining evolutionary relationships among organisms
- Describe major biogeographic regions of the world and identify underlying factors responsible for their formation and evolution
- Familiarize with the different types of molecular and morphological characters used in systematic analysis
- Interpret phylogenetic trees constructed using molecular and morphological data in an evolutionary context
- Evaluate literature in systematics and biogeography and critically assess research questions and methods

Learning outcomes

After this course, students will be able to:

- Identify and classify different taxa using morphological and molecular characters
- Construct and interpret phylogenetic trees based on molecular and morphological data
- Analyze biogeographic patterns and use them to make inferences about evolutionary history

- Apply the principles and methods of systematics and biogeography to practical problems in conservation biology, ecology, and biotechnology
- Communicate effectively about the principles and methods of systematics and biogeography, and their applications to various areas of research and practice

SYLLABUS OF DSC-EVS-10

Theory (02 Credits: 30 lectures)

UNIT – I Concept, systematics approaches and taxonomic hierarchy (3 Week) (6 lectures)
Definition of systematics; taxonomic identification; keys; field inventory; herbarium; museum; botanical gardens; taxonomic literature; nomenclature; evidence from anatomy, palynology, ultrastructure, cytology, phyto-chemistry, numerical and molecular methods; taxonomy databases.

Concept of taxa (species, genus, family, order, class, phylum, kingdom); concept of species (taxonomic, typological, biological, evolutionary, phylogenetic); categories and taxonomic hierarchy

UNIT – II Nomenclature and systems of classification (2½ Week) (5 lectures)
Principles and rules (International Code of Botanical and Zoological Nomenclature); ranks and names; types and typification; author citation; valid publication; rejection of names; principle of priority and its limitations; names of hybrids; classification systems of Bentham and Hooker; Angiosperm Phylogeny Group (APG III) classification.

UNIT – III Numerical and molecular systematics (1½ Week) (3 lectures)
Characters; variations; Operational Taxonomic Units; character weighting and coding; phenograms; cladograms; DNA barcoding; phylogenetic tree (rooted, unrooted, ultrametric trees); clades: monophyly, paraphyly, polyphyly; homology and analogy; parallelism and convergence.

UNIT – IV Biogeography, Speciation and extinction (3½ Week) (7 lectures)
Genes as unit of evolutionary change; mutation; genetic drift; gene flow; natural selection; geographic and ecological variation; biogeographical rules – Gloger's rule, Bergmann's rule, Allen's rule, Geist rule; biogeographical realms and their fauna; endemic, rare, exotic, and cosmopolitan species.

Types and processes of speciation – allopatric, parapatric, sympatric; ecological diversification; adaptive radiation, convergent and parallel evolution; dispersal and immigration; means of dispersal and barriers to dispersal; extinction.

UNIT – V Historical and ecological Biogeography (3½ Week) (7 lectures)
Earth's history; paleo-records of diversity and diversification; continental drift and plate tectonics and their role in biogeographic patterns – past and present; biogeographical dynamics of climate change and Ice Age.

Species' habitats; environment and niche concepts; biotic and abiotic determinants of communities; species-area relationships; concept of rarity and commonness; Island Biogeography theory; Equilibrium Theory of Insular Biogeography; geography of diversification and invasion; phylogeography.

UNIT – VI Conservation Biogeography (1 Week) (2 lectures)

Application of biogeographical rules in design of protected area and biosphere reserves; use of remote sensing in conservational planning.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Construct and compare phylogenetic trees based on morphological and molecular data
2. Extract and quantify DNA from various organisms
3. Conduct PCR and amplify a specific gene using a target primer
4. Identify different taxa using morphological and molecular characters
5. Construct, analyze and infer phylogenetic trees based on molecular data by using software like PAUP*, RAxML, and MrBayes
6. Use and construct a phylogenetic tree based on morphological characters
7. Molecular Characters: Students should learn how to use molecular characters to construct a phylogenetic tree
8. Compare and contrast the anatomy of different organisms to understand their evolutionary relationships
9. Map and identify the distribution of organisms across the world and the factors that influence their distribution
10. Analyze the factors explaining biogeographic patterns of distribution of a target species using hypothesis of vicariance and dispersal
11. Estimate the timing of evolutionary events based on molecular clocks
12. Identify and analyze different biogeographic regions of the world and the unique flora and fauna found in each
13. Estimate divergence times between different lineages using molecular data

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Essential/recommended readings

- Baum, D. A., & Smith, S. C. (2013). Systematic Biology. John Wiley & Sons.
- Briggs, C. J. (2016). Biogeography: An ecological and evolutionary approach. Wiley-Blackwell.
- Cox, L. R., & Moore, P. D. (2010). Biogeography: An introduction to the study of plants and animals in time and space. Wiley-Blackwell.
- Heads, M. (2019). Biogeography and evolution. New Zealand. CRC Press.
- Lieberman, B. S., & Garland, R. L. (2020). Phylogenetic trees made easy: A how-to manual. Sinauer Associates.
- Lomolino, I., Riddle, B. R., & Whittaker, R. J. (2016). Biogeography: Principles and Practice. Sinauer Associates.

- Pressey, R. L., Anderson, M. B., & Groves, R. G. (2019). Systematic conservation planning. Oxford University Press.
- Wiley, E. H., & Lieberman, B. S. (2011). Systematics and evolution: Theory and practice. Wiley-Blackwell.

Suggestive readings

- Antonelli, A. (2019). Historical biogeography: An introduction. Princeton University Press.
- Dayrat, B. H. E. W. (2005). Phylogenetic systematics. University of Kansas Press.
- Guglielmino, A. G., & Barbujani, A. V. (2017). Biogeography: A natural science of human diversity. Cambridge University Press.
- Hennig, P. (1966). Systematics: A course of lectures. Columbia University Press.
- Nei, M., & Kumar, S. (2020). Molecular evolution and phylogenetics. Oxford University Press.
- Revell, L. V. (2020). Phylogenetic comparative methods: A guide for ecologists. Princeton University Press.
- Wiley, E. O. (2020). Phylogenetics: Theory and practice of phylogenetic systematics. John Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 11 (DSC-EVS-11): ENVIRONMENTAL TOXICOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-EVS-11: ENVIRONMENTAL TOXICOLOGY	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Analyze sources, fate, and effects of toxic substances in the environment
- Train in methods relevant to assess and manage environmental risks associated with toxic substances
- Investigate the impact of environmental toxicants on wildlife and ecosystems, including the effects on reproductive success and population dynamics.
- Examine management practices related to the use, disposal, and treatment of hazardous substances and wastes.
- Compare scientific methods and techniques to measure and monitor environmental toxicants in different environmental media.
- Familiarize with emerging issues and technologies in environmental toxicology
- Promote critical thinking and problem-solving skills through case studies and hands-on activities related to environmental toxicology.

Learning outcomes

After this course, students will be able to

- Define and describe the scope and historical background of environmental toxicology.
- Identify, classify, and predict fate and transport of different types of toxic substances in the environment
- Evaluate the risks associated with toxic substances and apply risk assessment and management strategies
- Analyze the effects of toxic substances on wildlife and ecosystems, and propose solutions to mitigate their impacts.
- Compare and contrast the toxicity of different pollutants and their possible mechanisms of action.
- Apply their knowledge of environmental toxicology to current environmental issues and develop potential solutions.

SYLLABUS OF DSC-EVS-11

Theory (02 Credits: 30 lectures)

UNIT – I Introduction to Environmental Toxicology (1 Week) (2 lectures)

Definition, Historical perspective, Types of Toxic substances: types, properties, sources, and fate and transport, biomagnification and bioaccumulation.

UNIT –II Toxicology of Air and Water (2 Weeks) (4 lectures)

Toxic air contaminants, Health effects of air pollution, Acid rain and its impacts, Ozone depletion and its impacts, Water pollution and its sources, Health effects of water pollution, Eutrophication and hypoxia in aquatic ecosystems, Marine pollution and its impacts, Emerging issues in air and water toxicology

UNIT –III Toxicology of Soil and Hazardous Waste (3½ Weeks) (7 lectures)

Sources and types of hazardous waste, Health effects of soil contamination: from heavy metals, metalloids, and organic contaminants; Brownfields and urban redevelopment, Superfund sites and environmental justice, Pesticide and Pharmaceuticals: classification, history of use, distribution in environment, fate and transport, health effects, and ecotoxicology; Emerging issues in environmental toxicology by hazardous waste, pesticides and pharmaceuticals

UNIT –IV Toxicology of Radiation and Nanoparticles (3 Weeks) (6 lectures)

Ionizing and non-ionizing radiation, Health effects of radiation, Radioactive waste and nuclear accidents, Nanoparticles: properties, behavior in the environment, fate and transport, health effects, and ecotoxicology; Emerging issues in radiation and nanoparticle toxicology, Risk assessment and risk management of radiation and nanoparticles

UNIT –V Emerging Issues in Environmental Toxicology (2½ Weeks) (5 lectures)

Endocrine disruption and its impacts, Climate change and toxicology, Emerging contaminants (e.g., microplastics, PFAS), Global perspectives, Ethics in environmental toxicology, Careers in environmental toxicology, Future directions in environmental toxicology research

UNIT –VI Management and regulation of environmental toxicants (1½ Weeks) (3 lectures)

Environmental regulations and policy, Hazardous waste regulations and management, Pesticide and pharmaceutical use and regulation, Ecotoxicology and wildlife toxicology, Risk assessment and risk management, Remediation and restoration of contaminated sites

UNIT –VII Environmental forensics (1½ Weeks) (3 lectures)

Definition, Applications in environmental toxicology, Common techniques (e.g., isotope analysis, DNA fingerprinting), Case studies in identifying sources of contamination, Future developments and potential applications in environmental sustainability.

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Analyze effects of pH on the toxicity of heavy metals on model organism, such as Daphnia

2-3. Determine toxicity of varying concentration of industrial effluent on common alga and measure its growth and survival rates

4-5. Effects of heavy metal toxicity on plant growth, focussing on different plant parts and physiological characteristics

6. Analyze effects of climate change on the abundance and diversity of pollinators under different climatic conditions
7. Analyze the abundance and diversity of nematodes (e.g., Caenorhabditis elegans) in the background of use of environmental chemicals
8. Effects of herbicides on the abundance and diversity of weed populations in response to the use of different herbicides
9. Test the effects of a target organic contaminant on behaviour and mortality of earthworm

10-11. Measure developmental abnormalities in zebrafish embryos due to toxicity of target environmental chemicals

12-13. Prepare and characterize nanoparticles of selected heavy metal and assess effect of nanoparticles on plant growth

14. Effects of various concentrations of road salt on freshwater organisms (e.g., zooplankton) and measure changes in their behavior and survival

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Crosby, D. G. (2019). Environmental toxicology and chemistry (3rd ed.). CRC Press.
- Landis, W. G., Sofield, R. M., & Yu, M.-H. (2019). Introduction to environmental toxicology (4th ed.). CRC Press.
- Lehrer, I., & Poole, J. B. (2019). Principles of environmental toxicology (4th ed.). CRC Press.
- Newman, M. C., Roberts, M. H., Hale, R. C., & Robinson, E. M. (Eds.). (2020).

Environmental Toxicology: Biological and Health Effects of Pollutants (4th ed.). CRC Press.

- Yu, M.-H., & Yan, G. W. S. (2020). Environmental toxicology: Biological and health effects of pollutants (3rd ed.). CRC Press.

Suggestive readings

- Ballantyne, B., Marrs, T. C., & Syversen, T. (2020). Toxicology: The basic science of poisons (4th ed.). CRC Press.
- Kamrin, M. A. (2020). Introduction to Environmental Toxicology: Molecular Substructures to Ecological Landscapes (5th ed.). CRC Press.
- Meyers, R. A. (Ed.). (2018). Environmental toxicology: Selected entries from the Encyclopedia of Sustainability Science and Technology. Springer
- Smart, R. C., & Hodgson, E. (2018). Molecular and biochemical toxicology (5th ed.). John Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 12 (DSC-EVS-12): RESTORATION ECOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-EVS-12: RESTORATION ECOLOGY	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Gain insights into principles and concepts of restoration ecology to understand various approaches and techniques used in ecological restoration
- Provide hands-on experience with ecological restoration techniques and field methods
- Promote critical thinking and problem-solving skills in the context of ecological restoration for innovation related methods
- Investigate the interdisciplinary issues and practices linked with ecological restoration

Learning outcomes

After this course, students will be able to

- Describe the ecological, economic and social factors that lead to ecosystem degradation
- Evaluate and select appropriate ecological restoration techniques for different types of ecosystems
- Design ecological restoration projects and identify appropriate methods to monitor and evaluate the restoration practices
- Undertake collaborative programmes to understand and solve ecological restoration problems
- Critically evaluate the scientific and technical aspects of ecological restoration research and practice.

SYLLABUS OF DSC-EVS-12

Theory (02 Credits: 30 lectures)

UNIT – I Fundamentals of Restoration Ecology (3½ Weeks) (7 lectures)

Definition and history of restoration ecology, Principles of restoration ecology, Restoration process: planning, implementation, and monitoring; Ecosystem services and the importance of restoration ecology; Challenges and limitations of restoration ecology; Case studies in restoration ecology; Ethics and values in restoration ecology; Restoration ecology and environmental policy

UNIT – II Ecological Foundations for Restoration Ecology: (3 Weeks) (6 lectures)

Role of ecological concepts in restoration ecology: ecological succession. Biodiversity, ecological interactions, and habitat fragmentation and ecosystems; Climate change and its impact on restoration ecology, Invasive species and their role in ecosystem degradation and restoration, Ecological thresholds, and their relevance to restoration ecology

UNIT – III Techniques and Tools for Restoration Ecology (3 Weeks) (6 lectures)

Ecological site assessment and inventory, Restoration planning and design, Techniques for soil and water conservation in restoration ecology, Seed collection, propagation, and planting techniques for restoration, Wildlife management in restoration ecology, Restoring aquatic ecosystems: techniques and challenges, Biomimicry and ecological engineering in restoration ecology. Evaluating and monitoring restoration outcomes

UNIT – IV Ecosystem Restoration (2 Weeks) (4 lectures)

Restoration of: grasslands, forests, wetlands, agricultural and urban landscapes, mining and industrial sites; Restoration of ecosystem services in aquatic ecosystems

UNIT – V Synthesis and Applications of Restoration Ecology (3½ Weeks) (7 lectures)

Integrating restoration ecology with conservation biology, Adaptive management in restoration ecology, Restoring ecosystem services and human well-being, Restoring cultural and spiritual values in ecosystems, Restoring resilience and resistance in ecosystems, Restoring ecosystem connectivity and migration corridors, Restoring biodiversity in the face of global change, and The future of restoration ecology and its role in sustainability

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Field visits to assess the magnitude of degradation in selected ecosystems
2. Analyse the success of ecosystem restoration case studies in Delhi and identify the underlying principles
3. Assess the current status of a degraded ecosystem and identify potential areas for restoration
4. Learn techniques for collecting and propagating native plant species for use in restoration projects

5-6. Design methods for reducing erosion and managing nutrient runoff in restored ecosystems
7-8. Examine techniques for planting and establishing native plant species in a restored ecosystem
9-10. Evaluate methods for assessing and managing wildlife habitat in a restored ecosystem
10-11. Assess efficacy of different methods for monitoring and evaluating restoration outcomes in a restored ecosystem
12. Learn techniques for managing invasive species in a restored ecosystem
13-14. Design and implement a restoration plan for selected degraded ecosystems (terrestrial and aquatic) to improve the quality of habitat

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Clewell, A. F., & Aronson, J. (Eds.). (2013). Ecological restoration: Principles, values, and structure of an emerging profession (2nd ed.). Island Press.
- Erickson, A. L., Ryan, C. M., & Jones, T. A. (Eds.). (2021). The science of ecological restoration: Creating resilience in a changing world. Island Press.
- Hobbs, R. J., & Suding, K. N. (2018). New models for ecosystem dynamics and restoration. CRC Press.
- Palmer, M. A. (2016). Restoration: The science of restoring ecosystems and the human spirit. Island Press.
- Temperton, V. M., Hobbs, R. J., Nuttle, T., Halle, S., & Tonev, C. (Eds.). (2020). Novel ecosystems: Intervening in the new ecological world order. John Wiley & Sons.
- Yaffee, S. L., & Wondolleck, J. M. (2019). Ecosystem management in the United States: An assessment of current experience. Routledge.

Suggestive readings

- Allison, S. D., & Murphy, S. D. (Eds.). (2019). Ecosystem collapse and restoration. Oxford University Press.
- Benedetti-Cecchi, L. (2021). Marine restoration ecology. Oxford University Press.
- Benson, M. H., & Phillips, A. (Eds.). (2016). Ecosystem services and conservation in urbanizing Asia. Springer.
- Higgs, E. S., Falk, D. A., Guerrini, A., Hall, M. P., & Harris, J. G. (Eds.). (2021). The Routledge handbook of ecological and environmental restoration. Routledge.
- Moreno-Mateos, D., & Perring, M. P. (Eds.). (2019). Ecological restoration and environmental change: Renewing damaged ecosystems in a changing world. Routledge.
- Palmer, M. A., Zedler, J. B., & Falk, D. A. (Eds.). (2021). Foundations of restoration ecology (2nd ed.). Island Press.

- Suding, K. N., & Hobbs, R. J. (Eds.). (2019). Handbook of restoration ecology (2nd ed.). Oxford University Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.