COTTON COLLEGE STATE UNIVERSITY

DEPARTMENT OF ENVIRONMENTAL BIOLOGY AND WILDLIFE SCIENCES

Postgraduate Environmental and Wildlife Sciences Syllabus

DISTRIBUTION OF PAPERS/CREDITS (L+T+P format)

Semester – I

Paper Code	Paper Name	Credits
EWS 701C	Basic Ecology, Wildlife and Environmental Science	3+1+0
EWS 702C	Ecology and Ecosystem Dynamics	3+1+0
EWS 703C	Habitat Ecology	3+1+0
EWS 704C	Quantitative Methods in Ecology and Environment	3+1+0
EWS 705C	Field Visits (Total 6)	0+0+2
	Elective Paper (to be selected from the list given here)	2+1+0

Semester – II

Paper Code	Paper Name	Credits
EWS 801C	Environmental Chemistry and Pollution	3+1+0
EWS 802C	Global Climate Change	3+1+0
EWS 803C	Environmental and Wildlife Management	2+1+0
EWS 804C	Conservation and management issues of northeastern india	1+1+0
EWS 805C	Laboratory (Environmental Chemistry and Pollution)	0+0+2
EWS 806C	Field Activities (Environmental and Wildlife Management)	0+0+2
	Elective Paper (to be selected from the list given here)	2+1+0

Semester – III

Paper Code	Paper Name	Credits
EWS 901C	Environmental Health and Risk Assessment	3+1+0
EWS 902C	Environment Laws and Policies	3+1+0
EWS 903C	Environment and Society	3+1+0
EWS 904C	Environmental Microbiology and Biotechnology	3+1+0
EWS 905C	Laboratory Course (Environmental Health and Risk Assessment)	0+0+1
	Elective Paper (to be selected from the list given here)	2+1+0

Semester – IV

Paper Code	Paper Name	Credits
EWS 1001C	Analytical Techniques in Environment and Wildlife	2+1+0
EWS 1002C	Landscape Ecology, GIS and Remote Sensing	2+0+0
EWS 1003C	Urban Ecology	2+1+0
EWS 1004C	Stress Biology	2+1+0
EWS 1005C	Practical (Landscape Ecology, GIS and Remote Sensing)	0+0+2
EWS 1006C	Practical (Stress Biology)	1 (0+0+1)
EWS 1007C	Project	6 (0+0+6)

LIST OF ELECTIVE PAPERS

Semester – I

Paper Code	Paper Name	Credits
EWS 1201E	History and Development of Ecology	2+1+0
EWS 1202E	Environmental Economics, Sociology and Sustainability	2+1+0
EWS 1203E	Agriculture, Environment and Society	2+1+0

Semester – II

Paper Code	Paper Name	Credits
EWS 1301E	Conservation Genetics	2+1+0
EWS 1302E	Ecotechnology and Other Techniques for Water and Wastewater Treatment	2+1+0
EWS 1303E	Soil Biology	2+1+0

Semester – III

Paper Code	Paper Name	Credits
EWS 1401E	Ecotoxicology and Health Risk Assessment	2+1+0
EWS 1402E	Plant Growth Hormones	2+1+0
EWS 1403E	Social Science Methods in Conservation	2+1+0

SEMESTER – I

PAPER: EWS 701C

BASIC ECOLOGY, WILDLIFE AND ENVIRONMENTAL SCIENCE

CREDITS: 4 (3+1+0)

Unit 1: Art and Science of Natural History [10 lectures]

Natural history as a descriptive and inductive science, philosophical and historical perspectives on natural history, the relationship between natural history and ecology; levels of ecological organisation as traditionally conceived; asking questions; the skill of observation; taking field notes; introduction to eBird, iNaturalist and India Biodiversity Portal; developing skills at field identification of plant, insects, birds, fungi, herpetofauna, fishes, mammals and other; basic geology; the power of names; the importance of natural history collections, how to become a good naturalist?

Unit 2: Systematics and Taxonomy [8 lectures]

Review of basic principles and concepts in systematics; construction of a classification: evolutionary, numerical, cladistic approaches; understanding relationships: types of characters and their application (molecular, morphological, behavioural, biochemical); the species problem: concepts, speciation process, delimitation and description. "New generation" technology and its application (DNA barcoding and metagenetics); principles of International Commission on Zoological Nomenclature (ICZN); character coding; importance of taxonomy; cryptic species and taxonomy; case studies in systematics and diversity

Unit 3: Organism and their Abiotic Environment [10 lectures]

Organisational levels of environmental biology-cell to biosphere; structure of cell in prokaryotes and eukaryotes; cell cycle; mitosis and meiosis; origin of life; molecular evolution; mechanisms of speciation; principles of Mendelian inheritance; structure and function of biomolecules- amino acids, polypeptides, proteins, carbohydrates, lipids, nucleic acids; interaction between abiotic and biotic factors; limits of tolerance; adaptation of plant and animal to their environment including adaptation in deserts, deep oceans and high altitudes; macro and micro-environment.

Unit 4: **Biogeography [10 lectures]**

History of biogeography; ecology of dispersal and faunal exchange, barriers, mode of dispersal, origins and radiation; island biogeography theory; historical biogeography, biogeographical processes, endemism, refugia; continental drift; dispersal and vicariance biogeography; cladistics; dispersal mechanisms and dispersal barriers; reconciling distribution of fauna and flora; applied biogeography; biogeographical

realms, provinces and ecoregions; the biogeographic affinities of the fauna and flora of the Indian sub-continent; India's biogeographic classification.

Unit 5: Fundamentals of Environmental Science [10 lectures]

Definitions and concepts in environmental science; principles and scope of environmental science; components of environment-atmosphere, hydrosphere, pedosphere, biosphere and socioeconomic and cultural environment and their interactions; concept of sustainable growth; earth capital and environmental degradation; ecological and food security; pollution; resource depletion; trans-boundary movement of pollutants and toxic materials; migration; green revolution; industrial revolution; international conventions on the environment; Indian international obligations and environmental priorities

Suggested Reading:

Books

1. Smith TM and Smith RL (2012). Element of Ecology (9th edition). Pearson Publication
2. Begon M, Townsend CR and Harper JL (2006). Ecology From individuals to Ecosystems (4th edition). Blackwell Publishing
3. Ricklefs RE and Miller GL (1999). Ecology (4th edition). WH Freeman Publication
4. Mani MS (1974). Ecology and Biogeography in India. Springer Netherlands
5. Cox CB, Moore PD and Ladle R (2010). Biogeography: An Ecological and Evolutionary Approach (9th Edition). Wiley-Blackwell.
6. Huggett RJ (2004). Fundamentals of Biogeography (2nd edition). Routledge London and New York
7. Ladle R and Whittaker RJ (2011). Conservation Biogeography. Wiley-Blackwell
8. MacArthur RH (1984). Geographical Ecology: Patterns in the Distribution of Species. Princeton University Press.
9. MacArthur RH and Wilson EO (2001). The Theory of Island Biogeography. Princeton University Press.
10. Mayr E (1969). Principles of Systematic Zoology. Tata McGraw Hill Publ. Co.
11. Mayr E (1942). Systematics And The Origin Of Species. Columbia University Press.
12. Mayr E and Ashlock PD (1991). Principles of Systematic Zoology. McGraw Hill International Edition.
13. Simpson GG (1961). Principles of Animal Taxonomy. Columbia University Press.
14. Hillis DM (1996) (ed). Molecular Systematics. Sinauer Publ Inc.

15. Ivnish TJ and Sytsma K (eds) (1997). Molecular Evolution and adaptive radiation.
16. Hillis DM, Moritz C and Mable BK (eds), (1996). Molecular systematics.
17. Wilkins JS (2010). Species: A History of the Idea. University of California Press,
18. Wheeler QD and Meier R (eds) (2000). Species Concept and Phylogenetic Theory: A Debate. Columbia University Press, New York.
19. Dobzhansky T (1937). Genetics and the origin of species. Columbia University Press, New York.
20. Hall BG (2007). Phylogenetic Trees Made Easy: A How To Manual. Sinaur Associates Inc.
21. Miller GT (2000). Living in the Environment, Brooks/Cole
22. Seigo C (1999). Environmental Science. McGraw Hill
23. Miller TG (2004) Environmental Science - Working with the Environment. BS Publication, Hyderabad

SEMESTER – I

PAPER: EWS 702C

ECOLOGY AND ECOSYSTEM DYNAMICS

CREDITS: 4 (3+1+0)

Unit 1: Population Ecology [8 lectures]

Basics of demography and population description; population dynamics, density-dependence; resource limitation; life tables and modelling; chaos and cycles; predator-prey dynamics; dispersal, patches and metapopulations; movement ecology.

Unit 2: Community Ecology [10 lectures]

Definition of community; species richness and diversity; community structuring - top-down versus bottom up, parasites and disease, competition and the 'ghost' of competition past, body size, niche versus neutrality. Community functioning – keystone species, the diversity-stability debate; patterns in ecological communities – commonness and rarity; species area relationship; phylogenetic relationships in communities; global and local patterns in species richness; island biogeography and community ecology; community turnover in space and time; mechanisms of species co-existence.

Unit 3: Ecosystem Ecology [8 lectures]

The ecosystem concept: history, approaches, theories, and utility; energetics: primary and secondary production, decomposition, and food webs; biogeochemical cycles at local to global scales, including Carbon, Nitrogen, and Phosphorus; human impact on nutrient cycles.

Unit 4: Evolution and Behavioural Ecology [12 lectures]

Theories of evolution; natural selection; genetic and geographic variation; basic population genetics; speciation and adaptive radiation; sexual selection; evolutionary arms races; signal selection and the handicap principle; altruism; game theory and ESS; basic behavioural ecology (optimal foraging, cooperation and conflict, reproductive strategies, communication); socio-biology

Unit 5: Plant-animal interaction [10 lectures]

Herbivory (including leaf/stem/root feeding, frugivory, seed and seedling predation); how plants respond to herbivory (chemical and physical defences); how herbivores respond to plant attributes (nutritional quality, architecture); indirect interactions (e.g. between insect herbivores, mediated through plants or parasitoids); pollination and seed/fruit dispersal; mutualisms (e.g. ant-plant interactions); impacts of herbivory on plants at the population and community level; and applied aspects (grazing management; herbivore pest control; conservation of interactions); introduction to chemical ecology.

Suggested Reading:

1. Smith TM and Smith RL (2012). Element of Ecology (9th edition). Pearson Publication
2. Begon M, Townsend CR and Harper JL (2006). Ecology From individuals to Ecosystems (4th edition). Blackwell Publishing
3. Ricklefs RE and Miller GL (1999). Ecology (4th edition). WH Freeman Publication
4. Futuyma D (2013). Evolution (3rd Edition). Sinauer Associates, Inc.
5. Ridley M (2004). Evolution (3rd Edition). Blackwell Publishing
6. Alcock J (2001). Animal Behaviour: An Evolutionary Approach, (7th edition). Sinauer, Sunderland, Mass.
7. Bateson P and Martin P (1993). Measuring Behaviour: An Introductory Guide (2nd edition). Cambridge University Press, Cambridge.
8. Krebs JR and Davies NB (1993). An Introduction to Behavioural Ecology (3rd edition). Blackwell Scientific Publications, Oxford.
9. Krebs JR and Davies NB (1997). Behavioral Ecology: An Evolutionary Approach (4th edition). Blackwell Scientific Publications, Oxford.

10. Lehner PN (1996). Handbook of Ethological Methods (2nd edition). Cambridge University Press, Cambridge.
11. Manning A and Dawkins MS (1998). An Introduction to Animal Behaviour. Cambridge University Press, Cambridge.
12. McFarland D (1999). Animal Behaviour: Psychobiology, Ethology and Evolution (3rd edition). Longman, London.
13. Morin PJ (2011). Community Ecology (2nd Edition). Wiley-Blackwell
14. Mittelback (2012). Community Ecology (1st Edition). Sinauer Associates, Inc.
15. Rockwood LL (2006). Introduction to Population Ecology. Wiley-Blackwell
16. Gotelli NJ (2008). A primer of ecology (4th Edition). Sinauer Associates, Inc.
17. Howe HF and Westley LC (1988). Ecological Relationships of Plants and Animals. Oxford University Press, Oxford. □
18. Abrahamson WG (1989). Plant-animal interactions. McGraw-Hill, New York, USA.
19. Futuyma DJ and Slatkin M (1983). Coevolution. Sinauer Associates, Sunderland, Massachusetts, USA. □
20. Herrera CM and Pellmyr O (2002). Plant-Animal Interactions: An Evolutionary Approach. Wiley-Blackwell
21. Caughley G (1978). Analysis Of Vertebrate Populations. John Wiley, Chichester. □
22. Hastings A (1997). Population Biology: Concepts And Models. Springer-Verlag, □New York.
23. Neal D (2004). Introduction to population biology. Cambridge University Press. □UK
24. Ricklefs R (2010). The Economy of Nature (6 edition). W. H. Freeman
25. Tokeshi M (1998). Species Coexistence: Ecological and Evolutionary Perspectives. Wiley Blackwell
26. Hubbell SP (2001). The Unified Neutral Theory of Biodiversity and Biogeography. Princeton University Press.
27. Chase JM and Leibold MA (2003). Ecological Niches: Linking Classical and Contemporary Approaches. The University of Chicago Press

SEMESTER – I

PAPER: EWS 703C

HABITAT ECOLOGY

CREDITS: 4 (3+1+0)

Unit 1: Tropical Forest Ecology [12 lectures]

What are where are the tropics; biogeography and evolution in the tropics; importance of tropical forests; characteristic of tropical forests; structure of the tropical rain forests; rainforest development and dynamics; carbon flux and climate change in tropical ecosystems; nutrient cycling and tropical soils; human as part of tropical ecosystem; tropical lowland rain forest of northeastern India, their composition, function and biodiversity; introduction to canopy ecology; animal communities of tropical forests.

Unit 2: Grassland Ecology [12 lectures]

Introduction to grasslands; general description of world grasslands; traditional versus modern views of grass classification; characteristics of Poaceae; C3 and C4 photosynthesis; secondary compounds; anti herbivores defences and allelochemicals; succession; when is a 'forest' a savanna and why does it matters; drivers of savanna structure and function-bottom-up and top down control of savannas; Indian savanna and its extent; animal communities of grassland.

Unit 3: Freshwater and Wetland Ecology [12 lectures]

Ecology of freshwater and wetland ecosystem; definition of wetland; wetland classification; wetland hydrology; wetland soils; wetland soil and biogeochemistry; wetland vegetation and succession; human impacts and management of wetlands; wetland laws and protection; wetland ecosystem services; wetlands and climate change; faunal communities of wetland.

Unit 4: High altitude Ecology [12 lectures]

Ecology of high altitude habitats (alpine, subalpine and upper temperate); species diversity and abundance, vegetation structure and composition; quantification of habitats and animal use, conservation issues and management practices; research in the high altitudes of the Himalaya; animal communities of high altitudes of Indian Himalays and determinant of their structure.

Suggested Radings:

Books:

1. Gibson DJ (2009). *Grasses and Grassland Ecology.* Oxford University Press
2. Mitsch WJ and Gosselink JG (2015). *Wetland (5th ed).* Wiley

3. Turner IM (2004). *The Ecology of Trees in the Tropical Rain Forest*. Cambridge University Press
4. Lowman MD and Rinker HB (eds) (2004). *Forest Canopies (2nd eds)*. Elsevier Academic Press
5. Kricher J (2011). *Tropical Ecology*. Princeton University Press
6. Montagnini F and Jordan CF (2005). *Tropical Forest Ecology – The basis for conservation and management*. Springer

PhD Thesis:

1. Mishra C (2001). *High altitude survival: conflict between pastoralism and wildlife in the Trans-Himalaya*. Wagenigen University, Wageningen, The Netherlands.
2. Namgail, T. (2009) *Geography of mammalian herbivores in the Indian Trans-Himalaya: patterns and processes*. Doctoral Thesis, Wageningen University, Wageningen, The Netherlands.

SEMESTER – I

PAPER: EWS 704C

QUANTITATIVE METHODS IN ECOLOGY AND ENVIRONMENT

CREDITS: 4 (3+1+0)

Unit 1: The Philosophy and practice of science [8 lectures]

Philosophy of science from Aristotle through Popper to Feyerabend; eastern/Old World traditions; ethics in science and conservation; logic and experimentation; deductive and inductive inference; 'hard' and 'soft' science; critiques of science; experimental design and scientific method (natural history, descriptive approaches, hypothesis testing, ANOVA designs, statistical power, Bayesian techniques, modelling, sociological methods).

Unit 2: Basic mathematics [8 lectures]

Basic algebra: the grammar of mathematics; numbers, real and imaginary: decimals, fractions, ratios, percentages, and simultaneous equations; a relevant digression: SI units, trigonometry: shapes, areas, volumes, angles, radians, and degrees, linear and non-linear functions: simple linear equations, logarithmic functions, power and exponential functions, quadratic and polynomial functions; just a little calculus: differentiation and integration

Unit 3: Biostatistics [15 lectures]

Descriptive statistics: telling as is; central tendency and variation, sampling experimental design; probability basics; hypothesis testing: parametric, non-parametric, and randomization, chi-square test, t-test and F-test, ANOVA and their

limitations; analysis of frequencies and sequences; relationships: correlation, regressions: linear, multiple, and non-linear,; introduction to multivariate statistics: clusters and MDS, PCA and DFA, Visualising raw data and results of statistical tests.

Unit 4: Field Techniques [17 lectures]

Animal behaviour: sampling methods, observer effects and reliability, individual identification and naming, data collection and recording, ethograms, individual behaviour, social behaviour, and social organization. Plant and animal populations: sampling methods (quadrats, lines, points), distance sampling and nearest-neighbour techniques, mark-recapture methods, habitat description. Sociological methods: official statistics, questionnaires, interviews, participant observation, documentary and comparative research. Introduction to GPS, GIS and Remote Sensing; study design - representativeness, independence (and associated statistical concept of degrees of freedom), sample sizes, power analysis

Suggested Reading:

1. Berry, D.A. (1995). Statistics: A Bayesian Perspective. Duxbury Press
2. Pickett STA, Kolasa J, Jones CH (2007). Ecological Understanding: The Nature of Theory and the Theory of Nature (2nd Edition). Associate Press.
3. Fowler, J., Cohen, L. and Jarvis, P. (1999). Practical Statistics for Field Biology. John Wiley & Sons.
4. Sokal, R.R. and Rohlf, F.J. (1994). Biometry: The Principles and Practice of Statistics in Biological Research. W H Freeman & Co.
5. Zar JH (2010). Biostatistical Analysis (5th Edition). Prentice Hall
6. Dytham C (2010). Choosing and Using Statistics: A Biologist's Guide (3rd Edition). Wiley-Blackwell.
7. Krebs CJ (1998). Ecological Methodology (2nd Edition). Benjamin Cummings
8. Mayr E (1998). This is Biology: The Science of the Living World (Reprint Edition). Harvard University Press.
9. Golley FB (1996). A History of the Ecosystem Concept in Ecology: More Than the Sum of the Parts. University of Dallas Library.
10. Keller DR and Gollet FB (2000). The Philosophy of Ecology: From Science to Synthesis. University of Georgia Press.
11. Batschelet E (1971). Introduction to Mathematics for Life Scientists. Springer-Verlag Berlin Publishers, New York.

SEMESTER – I

PAPER: EWS 705C

FIELD EXERCISES

CREDITS: 2 (0+0+2)

Field Visit 1: Orientation to field biology and natural history; observations and collection of study material, wildlife signs and evidences; identification of soil and rock types, use of basic field equipment: compass, binoculars, GPS, range finder, spherical densiometer, eBird, altimeter.

Field Visit 2: Techniques Tour: exercise on wildlife population parameters and census methods for various species, vegetation studies including phenology study; herbarium; behavioural study; questionnaire surveys.

Field Visit 3: Visit a wetland; appraise the habitat; waterfowl census; and documentation of threats to wetlands.

Field Visit 4: Visit a tropical rainforest; appraise the habitat; identify key faunal group and document the threat.

Field Visit 5: Visit a grassland habitat; identify grassland species of plant; birds and other animals, and document the threat

Field Visit 6: Visit a high altitude region; document the floral and faunal group, and document the threat.

SEMESTER – I

PAPER: EWS 1201E

HISTORY AND DEVELOPMENT OF ECOLOGY

CREDITS: 3 (2+1+0) [32 Lectures]

Early ecology: period when ecology had no name: early Greek origin of ecology: Aristotle and Theophrastus; influence of Carl Linnaeus and Carl Ludwig Wildenow, budding concept of ecological succession; Alexander von Humboldt, foundation of biogeography; Charles Darwin and Alfred Russel Wallace and the theory of Natural Selection; Gregor Mendel and science of population genetics; expansion of ecological thought – the biosphere (Edward Suess, Henry Chandler Cowles, and Vladimir Vernadsky), the ecosystem (Arthur Tansley) and ecological succession (Henry Chandler Cowles); transition from natural history to quantitative ecology; Alfred Lotka and Vito Volterra and foundation of population ecology; differences and integration of plant and animal ecology. Fredrick Clements and Victor Shelford and concept of biome; Clements versus Gleason or organismic versus individualistic concept of community; Arthur Tansley, Raymong Lindeman and Eugene and Howard Odum, G Evelyn Hutchinson and the dawn of ecosystem and systems ecology; Niko Tinbergen and the foundation of animal behaviour; Aldo Leopold, John Muir and Rachel Carson: modern environmental movement; EO Wilson and theory of sociobiology; the revolution of theoretical ecology and influence of Robert MacArthur; modern ecology.

Suggested Reading

1. Pickett STA, Kolasa J, Jones CH (2007). *Ecological Understanding: The Nature of Theory and the Theory of Nature (2nd Edition)*. Associate Press
2. Kingsland SE (1985). *Modeling Nature: Episodes in the History of Population Ecology*. University of Chicago Press, Chicago
3. McIntosh RP (1985). *The Background of Ecology: Concept and Theory*. Cambridge University Press. Cambridge and London.
4. Worster D (1985). *Nature's Economy: A History of Ecological Ideas (2nd Edition)*. Cambridge University Press. Cambridge and London.
5. Golley FB (1996). *A History of the Ecosystem Concept in Ecology: More Than the Sum of the Parts*. University of Dallas Library.
6. Keller DR and Gollet FB (2000). *The Philosophy of Ecology: From Science to Synthesis*. University of Georgia Press.
7. Egerton FN (2012). *Roots of Ecology: Antiquity to Haeckel*. University of California Press, USA

SEMESTER – I

PAPER: EWS 1202E

ENVIRONMENTAL ECONOMICS, SOCIOLOGY AND SUSTAINABILITY

CREDITS: 3 (2+1+0)

Unit 1: Introduction to environmental economics [8 lectures]

World environmental history and economic development; valuation of natural goods and services; valuation of tangibles and intangibles; accounting of forest, land and water resources; wetlands, green building concept; ecological foot print; carbon credit; carbon trading; clean development mechanism (CDM); principles of cost-benefit analysis; intellectual property rights.

Unit 2: Environmental issues and movements [8 lectures]

Land degradation; climate change; energy crisis; nuclear issues; natural disaster; intensive farming; genetically modified food controversies; global and national movements of significant impact: RAMSAR Convention; green belt movement; green peace; chipko movement; Narmada Bachao Andolan; silent valley; global environmental agreements and movements: Stockholm and beyond – evolution of international environmental laws.

Unit 3: Environmental sociology [8 lectures]

Interaction between society and environment; environmental problems in historical perspective; problem of increasing population: population status in India and the world; family welfare programme; environment and human health; human rights; role of environmental education in the management of environment.

Unit 4: Sustainability [8 lectures]

Concept of sustainability and sustainability science, sustainable development and its different constituents, sustainable development goals; international mechanism of sustainable development indicators of sustainability, Millennium Ecosystem Assessment, models of sustainable development; sustainable development scenario – global, national.

Suggested Readings:

1. Kemp DD (1988) *Global environmental issues: a climatological approach*.Taylor and Francis
2. Baumol and Oates (1988) *Theory of Environmental Policies.* Cambridge University Press, Cambridge, UK.
3. Freeman AM (2001) *Measures of value and Resources: Resources for the future*. Washington DC.
4. Bromley DW (ed.) (1995) *Handbook of Environmental Economics*. Blackwell.
5. Bhattacharya RN (ed.) (2001) Environmental Economics: An Indian Perspective, Oxford University Press.
6. Kolstad C (2000) *Environmental Economics*, Oxford University Press
7. Freeman AM (2003) *Millennium Ecosystem Assessment: Conceptual framework*. Island Press

SEMESTER – I

PAPER: EWS 1203E

AGRICULTURE, ENVIRONMENT AND SOCIETY

CREDITS: 3 (2+1+0)

Unit 1: Origin of agriculture [8 lectures]

Origin hypotheses, history of crop domestication, ancient civilizations and crop cultivation, Middle ages and Modern agriculture, Green Revolution, Agricultural evolution.

Unit 2: Agronomy and agro-ecology [8 lectures]

Definitions, principal areas of agronomy (plant breeding, biotechnology, soil science, soil conservation, agro-ecology), conventional and modern agricultural management practices, cropping systems, crop-pollinator interaction in agro-ecosystem, agriculturally important soil organisms, agricultural pests and their control, factors

affecting agricultural production-soil health, water and air quality, other environmental factors (light, temperature, moisture etc.), traditional and high yielding crop varieties.

Unit 3: Environmental impacts of agriculture [8 lectures]

Mechanization of agriculture, power and fossil fuel consumption-air pollution, heavy use of synthetic nitrogenous fertilizers, agriculture as a source of greenhouse gas emissions, agriculture and food security, deforestation, loss of habitat and biodiversity, genetically engineered crops and dominance of weeds, depletion of water resources due to irrigation, waterlogging, salinization, soil and water pollution due to use of synthetic pesticides, herbicides, insecticides etc., soil erosion, soil degradation, impact on soil micro and macro-fauna, measures for practicing sustainable agriculture.

Unit 4: Sociocultural dimensions of agriculture [8 lectures]

Agriculture dependent livelihoods of local communities, markets for agricultural produce, participation of women in agriculture, harvest festivals around the world, agricultural practices in north east India, *Jhum* or shifting cultivation, traditional rice cultivation practices in Assam, rice agriculture and the economy of Assam.

Suggested readings:

1. Martin K and Sauerborn J (2013). *Agroecology*. Springer.
2. Lockie S and Carpenter D (eds) (2010). *Agriculture, Biodiversity and Markets*. Earthscan, London, Washington D.C., 2010.
3. Cauvin J (2000). *The Birth of the Gods and the Origins of Agriculture*. Cambridge University Press.
4. Sundh et al. (eds) (2012). *Beneficial microorganisms in Agriculture, Food and the Environment*. CAB International.
5. Maxted et al. (eds) (2012). *Agrobiodiversity Conservation: Securing the diversity of crop wild relatives and landraces*. CAB International.

SEMESTER – II

PAPER: EWS 801C

ENVIRONMENTAL CHEMISTRY AND POLLUTION

CREDITS: 4 (3+1+0)

Unit 1: Aquatic Chemistry and Pollution [14 lectures]

Water quality parameters: physical, chemical and biological; environmental significance of water quality parameters; criteria and standards; distribution of chemical species in water; concept of oxygen demand; solubility of gases in water; carbonate system; water pollutants; sources and ecological aspects of water pollution; characteristics of domestic, industrial and agricultural wastes; water quality indices; rivers and wetlands pollution with special emphasis on northeast India; arsenic and fluoride contamination in groundwater of northeast and other parts of India.

Unit 2: Soil Chemistry and Pollution [14 lectures]

Soil formation; physical, chemical and biological properties of soil: texture, porosity; density, permeability, soil water, pH, acidity, salinity, enzymes, organic matter, cation exchange capacity, macro and micronutrients; soil pollution from use of fertilizers, pesticides, heavy metals, waste disposal, industrial effluents and surfactants; soil and sediment as source and sink of pollutant; radioactive pollution; effects of soil pollutants

Unit 3: Atmospheric Chemistry and Pollution [14 lectures]

Chemical composition of atmosphere-particles, ions and radicals; types and sources of air pollutants; air quality indices; stratospheric and tropospheric ozone; chemistry of ozone layer depletion; role of hydrocarbons, oxides of sulphur and nitrogen; particulate matter; aerosols; reaction of pollutants in air forming smog, PAN (Peroxy-Acyl-Nitrate), acid rain; atmospheric diffusion, transport of air pollutants and stack performance; Gaussian plume model; impacts of air pollutants on flora and fauna

Unit 4: Noise Pollution [6 lectures]

Definition, sources of noise pollution and noise monitoring; effects of noise pollution on fauna and human health

Suggested Readings:

1. Manahan SE (2001) *Fundamentals of Environmental Chemistry*. 2nd ed. CRC Press, Inc., USA
2. Sawyer CN, McCarty PL, Parkin GF (2003) *Chemistry for Environmental Science and Engineering*,Tata-McGraw-Hill Edition
3. De AK (2000) *Environmental Chemistry*. 4th ed. New Age International (P) Ltd., New Delhi, India.
4. Dunnivant FM, Anders E (2006) *A Basic Introduction to Pollutant Fate and Transport: An Integrated Approach With Chemistry, Modeling, Risk Assessment, and Environmental Legislation*, A John Wiley & Sons, Inc., Publication
5. Connell DW (1997) *Basic Concept of Environmental Chemistry*, Lewis
6. Baird C, Cann M (2008) *Environmental Chemistry*. W.H. Freeman and Company
7. Clesceri LS (1998) American Public Health Association (APHA). *Standard methods for the examination of water and wastewater analysis*, 20th Ed., American Public Health Association, Washington, DC

SEMESTER – II

PAPER: EWS 802C

GLOBAL CLIMATE CHANGE

CREDITS: 4 (3+1+0)

Unit 1: Climatology and Climate Change [6 lectures]

Atmospheric processes and climate, fronts and weather systems, cyclones, anticyclones, monsoons, El Nino, La Nina, ENSO, general circulation, jet stream; history of climate change-natural and human-induced climate change; future climate scenarios.

Unit 2: Causes of climate change [6 lectures]

Natural causes-changes in the sun's energy, changes in the earth's reflectivity; Anthropogenic causes-Greenhouse gas emissions (sources and sinks, greenhouse effect, global warming potential, radiative forcing); land use land cover change (deforestation, expansion of concrete cover and agricultural lands, retreating glaciers-impact on earth's energy and water balance, impact on local regional and global climate).

Unit 3: Soil, agriculture and climate change [12 lectures]

Agricultural sector as a major source of greenhouse gas emissions-Green Revolution; agricultural machinery-fossil fuel and power consumption-CO_2 emissions; soil carbon, soil respiration and CO_2 emissions; microbial production of non-CO_2 greenhouse gases methane and nitrous oxide in soil; methane and nitrous oxide emissions from agriculture (rice cultivation, biomass burning etc.); greenhouse gas emissions from ruminant livestock.

Unit 4: Consequences of climate change [12 lectures]

Changes in precipitation patterns (monsoons), extreme weather events, melting ice caps and glaciers, rising sea levels, frequent natural calamities, shift in climatic belts, warming of lakes and oceans, ocean acidification-effect on biota, impact on global water resources, land degradation, desertification, soil erosion, threats to global food security-impact on agricultural crops, impact on ecosystem goods and services, impact of climate change on biodiversity with special reference to North East India (Sikkim).

Unit 5: Climate change adaptation and mitigation [12 lectures]

Difference between adaptation and mitigation; measures for adaptation-local planning, development of climate resilient crops, managing water and forest resources, geo-engineering; measures for mitigation-urban planning, energy conservation and efficiency, adoption of renewable energy technologies, agricultural management, carbon sequestration, carbon farming and trading.

Suggested readings:

1. Climate and Climate Change (The living Earth), John P. Rafferty (Ed.), Britannica Educational Publishing, New York, 2011.
2. A short introduction to Climate Change, Tony Eggleton, Cambridge University Press, New York, 2013.
3. Climate Change and Agriculture: Impacts, Adaptation and Mitigation; Anita Wreford et al., OECD publications, 2010.
4. Climate Change and Food Security: Adapting agriculture to a warmer world, David Lobell, Marshall Burke (Eds.), Springer, 2010.
5. Global Change: Impacts on water and food security, Claudia Ringler et al. (Eds.), Springer, 2010.
6. Biodiversity and Conservation (2nd Edition), Michael A. Jeffries, Routledge (Taylor and Francis Group), London and New York, 2006.
7. Adaptation and Mitigation strategies for Climate Change, Akimasa Sumi et al. (Eds.), Springer, 2010.

SEMESTER – II

PAPER: EWS 803C

ENVIRONMENTAL AND WILDLIFE MANAGEMENT
CREDITS: 3 (2+1+0)

Unit 1: Pollution control and management [10 lectures]

General methods of control of gaseous pollutants and particulate matter;green belt development; alternate fuels: source and mechanism of various biofuel production; primary, secondary and tertiary treatment of wastewater; sludge treatment & disposal: digestion process, composting, management and disposal of residues; noise pollution control: absorbing materials, barrier materials, damping materials, acoustical enclosures, reactive silencers and filters; active noise control methods; solid waste and hazardous waste management: waste categorization, generation, collection, transport, treatment and disposal; waste processing and management technologies: mechanical and thermal volume reduction, biocomposting, vermicomposting; applications of biofertilizer and biopesticides; rain water harvesting; wetland conservation and reclamation

Unit 2: Wildlife management [11 lectures]

Interface between forest and wildlife management in India; legal instruments for managing wildlife in India; principles and practices of wildlife management; management strategies (in-situ versus ex-situ); coarse and fine filter approaches for wildlife management; analysis of wildlife management problems in plantations and exploited forests; Indian and global scenario; species conservation projects; tiger, rhino, vultures, pygmy hog etc; protected area network in India; concept of biosphere reserve; management plan for protected areas: forest working plans and wildlife management plans; principles of management planning, objectives, resource surveys, analysis of surrounding region, management zones; eco-development programme; compensation scheme; understanding and managing conflicts: contextual knowledge and adaptive management; wildlife tourism; wildlife trade; sacred groves; management of species outside the protected areas,

Unit 3: Conservation Biology [11 lectures]

Concept of biodiversity; conservation values and the ethics of conservation of biodiversity; why conserve?; levels of biological organisation; traditional versus 'new' conservation; corruption and debates on sustainability; key conservation issues across the country: extinction; logging; deforestation; habitat loss and fragmentation; hunting and poaching; livestock grazing; impacts of extractive uses; restoration and re-introductions; invasive species; fire and biodiversity; linear infrastructure (road, railways, pipelines etc.,) and their impacts on biodiversity; shifting cultivation; oil palm

cultivation; large developmental projects; introduction to the extent and ecology of human-wildlife conflicts including livestock and crop depredation, loss of property, loss of life; the importance of perception vis-à-vis reality; case studies on leopards and elephants; basic conservation genetics; reintroduction and rewilding; biological corridors and connectivity; citizen science and nature conservation; conservation and religion, folklore and faith; renewable and non-renewable resources; gene bank

Suggested Reading

Books

1. Sutherland WJ (2000). *The Conservation Handbook: Research, Management and Policy*. Blackwell Science
2. Sodhi NS and Ehrlich PR (2010). *Conservation Biology for All*. Oxford University Press
3. Bawa KS, Primack RB and Oommen MA (2011). *Conservation Biology: A Primer for South Asia (1st edition)*. University Press
4. Macdonald D and Willis KJ (eds) (2013). *Key topics in Conservation Biology*. Wiley-Blackwell

SEMESTER – II

PAPER: EWS 804C

CONSERVATION AND MANAGEMENT ISSUES OF NORTHEASTERN INDIA

CREDITS: 2 (1+1+0)

This paper involves reading of papers, reports, articles published on the key conservation and management issues of northeastern India. The instructor will introduce each topic for 1 hour followed by discussion, presentation, group discussion among the students.

Session 1: Hunting and Poaching [1 lecture]

- Datta, A., Anand, MO., and Naniwadekar (2008). Empty forests: Large carnivore and prey abundance in Namdapha National Park, northeast India. Biological Conservation 141:1429-1435

- Naniwadekar, R., Shukla, U., Isvaran, K, Datta A. 2015. Reduced Hornbill Abundance Associated with Low Seed Arrival and Altered Recruitment in a Hunted and Logged Tropical Forest. PLoS ONE 10(3): e0120062. doi:10.1371/journal.pone.0120062

- Cédric, G., Neha, P., Roshan, P., Uttam, S., & Rajendra, G. (2016). Assessing and managing the rising rhino population in Kaziranga (India). Ecological Indicators, 66, 55-64.

- Aiyadurai, A. (2011). Wildlife hunting and conservation in Northeast India: a need for an interdisciplinary understanding. Int J Galliformes Conserv, 2, 61-73.

- Aiyadurai, A., Singh, N. J., & Milner-Gulland, E. J. (2010). Wildlife hunting by indigenous tribes: a case study from Arunachal Pradesh, north-east India. Oryx, 44(04), 564-572.

- Martin, E., Talukdar, B. K., & Vigne, L. (2009). Rhino poaching in Assam: challenges and opportunities. Pachyderm, (46), 25-34.

Session 2: Logging [1 lecture]

- Velho, N., Ratnam, J., Srinivasan U. and M. Sankaran. 2012. Shifts in community structure of tropical trees and avian frugivores in forests recovering from past logging. *Biological Conservation* 153:32-40.

- Velho, N., Ratnam, J., Srinivasan U. and M. Sankaran. 2012. Shifts in community structure of tropical trees and avian frugivores in forests recovering from past logging. *Biological Conservation* 153:32-40.

- Srinivasan, U., J.E. Hines & S. Quader (2015) Demographic superiority with increased logging in tropical understorey insectivorous birds. *Journal of Applied Ecology*, 52, 1374-1380.

- Srinivasan, U. (2013) A slippery slope: logging alters mass-abundance scaling in ecological communities.*Journal of Applied Ecology*, 50, 920-928.

- Datta, A. (1998). Hornbill abundance in unlogged forest, selectively logged forest and a forest plantation in Arunachal Pradesh, India. *Oryx*, *32*(4), 285-294.

Session 3: Disease and Conservation [1 lecture]

- Velho, N., Srinivasan, U., Prashanth, N.S, and W.F. Laurance. 2011. Human disease hinders anti-poaching efforts in Indian nature reserves. *Biological Conservation* 144:2382-2385.

- Nath, M. J., Bora, A., Talukdar, P. K., Das, N. G., Dhiman, S., Baruah, I., & Singh, L. (2012). A longitudinal study of malaria associated with deforestation in Sonitpur district of Assam, India. Geocarto International, 27(1), 79-88.

- Saxena, R., Nagpal, B. N., Singh, V. P., Srivastava, A., Dev, V., Sharma, M. C., ... & Gupta, S. K. (2014). Impact of deforestation on known malaria vectors in Sonitpur district of Assam, India. Journal of vector borne diseases, 51(3), 211.

Session 4: Community forest vs protected areas [1 lecture]

- Velho, N., **U. Srinivasan**, P. Singh & W.F. Laurance (2015) Large mammal use of protected and community-managed lands in a biodiversity hotspot. *Animal Conservation*, doi: 10.1111/acv.12234

- Naniwadekar R., Mishra, C., Isvaran, K., Madhusudan, MD and Datta, A. Oryx. 49:303-311

- Goswami, V. R., S. Sridhara, K. Medhi, A. C. Williams, R. Chellam, J. D. Nichols, and M. K. Oli (2014). Community-managed forests and wildlife-friendly agriculture play a subsidiary but not substitutive role to protected areas for the endangered Asian elephant. Biological Conservation 177:74–81.

Session 5. Oil palm cultivation [1 lecture]

- Srinivasan, U. (2014) Oil palm expansion: ecological threat to to north-east India. *Economic and Political Weekly*, XLIX, Sep. 06, 2014.

- Raman TRS (2016). Is Oil palm expansion good for Mizoram? The Frontier Despatch, March 18-24; Pages 6-7

- Raman TRS 2014. Perils of Oilpalm. Newslink (Aizawl). 20 August 2014, page 2.

- Raman TRS 2014. Mizoram: Bamboozled by land use policy. The Hindu. Op-ed Comment Page 9

- *Dasgupta, S. (2014). India plans huge palm oil expansion, puts forests at risk. Mongabay. http://news.mongabay.com/2014/ 10/india-plans-huge-palm-oil-expansion-puts-forests-at-risk/*

Session 6: Deforestation [1 lecture]

- Velho, N., M. Agarwala, U. Srinivasan & W.F. Laurance (2014) Collateral damage: impacts of ethno-civil strife on biodiversity and natural resource use near Indian nature reserves. *Biodiversity and Conservation*. 23, 2515-2527.

- Lele, N and P K Joshi (2009): Analysing Deforestation Rates, Spatial Forest Cover Changes and Identify- ing Critical Areas of Forest Cover Changes in North-East India during 1972-1999", Environmental Monitoring and Assessment, 156(1): 159-70.

- Sharma N., Madhusudan MD and Sinha A. 2012. Socio-economic Drivers of Forest Cover Change in Assam: A Historical Perspective. Economic and Political Weekly. 47: 64-72

- Sarma, P. K., Lahkar, B. P., Ghosh, S., Rabha, A., Das, J. P., Nath, N. K., ... & Brahma, N. (2008). Land-use and land-cover change and future implication analysis

in Manas National Park, India using multi-temporal satellite data. Current Science, 95(2), 223-227.

Session 7: Shifting cultivation [1 lecture]

- Raman TRS (2016). Why Mizoram must revive, not eradicate jhum. The Frontier Despatch, March 4-10; pages 6
- Mandal J and Raman TRS 2016. Shifting agriculture supports more tropical forest birds than oil palm or teak plantation in Mizoram, northeast India
- Raman TRS. 2001. Effect of Slash-and-Burn Shifting Cultivation on Rainforest Birds in Mizoram, Northeast India
- Raman TRS, Rawat GS and Johnsingh AJT. 1998. Recovery of tropical rainforest avifauna in relation to vegetation succession following shifting cultivation in Mizoram, northeast India.
- Teegalapalli, K., and A. Datta (In press). Top-down or bottom-up: The role of government and local institutions in regulating shifting cultivation in the Upper Siang district, Eastern Himalaya, India. In The Policy Environment in Which Shifting Cultivation Takes Place: Trying to Get It Right (M. Cairns, Editor). Routledge, UK.
- Sengupta, M. (2013). Shifting cultivation and the Reang tribe in Tripura. Economic and Political Weekly 48:59–65.
- Ramakrishnan, P. S. (1992). Shifting Agriculture and Sustainable Development: An Interdisciplinary Study from North-Eastern India. Parthenon Publishing Group, Carnforth, UK.
- Pawar, S. S., G. S. Rawat, and B. C. Choudhury (2004). Recovery of frog and lizard communities following primary habitat alteration in Mizoram, Northeast India. BMC Ecology 4:10. doi:10.1186/1472-6785-4-10

Session 8: Mining [1 lecture]

- Jesudasanm, A and Goswami 2012. Mined to death: an elegy for the rivers of Meghalaya. Down to Earth. 30 July 2012. http://www.downtoearth.org.in/blog/mined-to-death-an-elegy-for-the-rivers-of-meghalaya-38771
- Sarma, K., Kushwaha, S. P. S., & Singh, K. J. (2010). Impact of coal mining on plant diversity and tree population structure in Jaintia Hills district of Meghalaya, North East India. *New York Science Journal*, *3*(9), 79-85.
- Swer, S., & Singh, O. P. (2003). Coal mining impacting water quality and aquatic biodiversity in Jaintia Hills district of Meghalaya. *Himalayan Ecology*,*11*(2), 29.

Session 9: Ethno-political conflict [1 lecture]

- Goswami R and Ganesh T 2011. Conservation amindst political unrest: the case of Manas National Park, India

- Goswami R and Gamesh 2014. Carnivore and herbivore densities in the immediate aftermath of ethno-political conflict: the case of Manas National Park, India.

Session 10: Rubber plantation [1 lecture]

- Majumdar, A., Datta S., Choudhury BK and Majumdar, K (2014). Do extensive rubber plantation influcnes local environment? A case study from Tripua, northeast India. Current World Environment 9(3).

Session 11: Habitat loss and fragmentation [2 lectures]

- Kushwaha, S. P. S., & Hazarika, R. (2004). Assessment of habitat loss in Kameng and Sonitpur Elephant Reserves. Current Science, 87(10), 1447-1453.

- Sharma N, Madhusudan, MD, and Sinha A. 2014. Local and landscape correlates of primate distribution and persistence in the remnant lowland rainforests of the Upper Brahmaputra Valley, Conservation Biology 28: 95-106

- Sharma N, Madhusudan, MD, Sarkar P, Bawri M, and Sinha A. 2012. Trends in extinction and persistence of diurnal primates in the fragmented lowland rainforests of the Upper Brahmaputra Valley, northestern India. Oryx 46: 308-311

- Lele, N., Joshi, P. K., & Agrawal, S. P. (2008). Assessing forest fragmentation in northeastern region (NER) of India using landscape matrices. Ecological Indicators, 8(5), 657-663.
  Session 11: NTFP Collection

- Bhatt, B. P., & Sachan, M. S. (2004). Firewood consumption pattern of different tribal communities in Northeast India. Energy Policy, 32(1), 1-6.

- Saha, D., & Sundriyal, R. C. (2012). Utilization of non-timber forest products in humid tropics: Implications for management and livelihood. Forest Policy and Economics, 14(1), 28-40.

Session 12: Human-wildlife conflict [1 lecture]

Jadhav, S., & Barua, M. (2012). The Elephant Vanishes: Impact of human–elephant conflict on people's wellbeing. Health & place, 18(6), 1356-1365.

Choudhury, A. (2004). Human–elephant conflicts in Northeast India.Human Dimensions of Wildlife, 9(4), 261-270.

Wilson, S., Davies, T. E., Hazarika, N., & Zimmermann, A. (2015). Understanding spatial and temporal patterns of human–elephant conflict in Assam, India. Oryx, 49(01), 140-149.

- Barua, M., Bhagwat, S. A., & Jadhav, S. (2013). The hidden dimensions of human–wildlife conflict: health impacts, opportunity and transaction costs.Biological Conservation, 157, 309-316.

Session 13: Large hydroelectric projects [1 lecture]

- Vagholikar N and Das PJ (2010). Damming Nortehast India: Juggernaut of hydropower projects threatens social and environemental security of region. Kalpavriksh, Aaranyak, and Action Aid India

- Menon M and Kohli K (2005). Large dams for hydropower in northeast India- A Dossier. Kalpavriksh and South Asia Network on Dams, Rivers and People.

Session 14: Linear infrastructure [1 lecture]

- Raman TRS (2011). Framing ecologically sound policy on linear intrusions affecting wildlife habitats: Background paper for the National Board for Wildlife.

- Das, A., Ahmed, M. F., Lahkar, B. P., & Sharma, P. (2007). A preliminary report of reptilian mortality on road due to vehicular movements near Kaziranga National Park, Assam, India. Zoos' Print J, 22(7), 2742-2744.

Session 15: Invasive species [1 lecture]

- Talukdar, B. K., Lahkar, B. P., & Sarma, P. K. (2011). Invasive species in grassland habitat: an ecological threat to greater one horned rhino (Rhinoceros unicornis). Pachyderm, (49), 33-39.

- Kosaka, Y., Saikia, B., Mingki, T., Tag, H., Riba, T., & Ando, K. (2010). Roadside distribution patterns of invasive alien plants along an altitudinal gradient in Arunachal Himalaya, India. Mountain Research and Development, 30(3), 252-258.

SEMESTER – II

PAPER: EWS 805C

LABORATORY

ENVIRONMENTAL CHEMISTRY AND POLLUTION

CREDITS: 2 (0+0+2)

Unit 1: Water and wastewater analysis

pH and electrical conductivity; total dissolved solids; turbidity; hardness; alkalinity; acidity; chloride; phosphate; sulphate; nitrate-nitrogen; dissolved oxygen; biological oxygen demand; chemical oxygen demand; fluoride; heavy metals

Unit 2: Soil analysis

Soil pH and electrical conductivity; soil organic matter; N,P, K in soil

Unit 3: Atmospheric Analysis

Gaseous and particulate matter sampling and analysis

Suggested Readings

1. Manahan SE (2001) Fundamentals of Environmental Chemistry. 2nd ed. CRC Press, Inc., USA
2. Sawyer CN, McCarty PL, Parkin GF (2003) Chemistry for Environmental Science and Engineering, Tata-McGraw-Hill Edition
3. Clesceri LS (1998) American Public Health Association (APHA). Standard methods for the examination of water and wastewater analysis, 20th Ed., American Public Health Association, Washington, DC

SEMESTER – II

PAPER: EWS 806C

FIELD ACTIVITIES

CREDITS: 2 (0+0+2)

Field tour designed to examine wildlife conservation issues in a variety of ecological situations in northeastern India. Understand wildlife management practices, eco-development applications and field exercises in Protected Areas.

SEMESTER – II

PAPER: EWS 1301E

CONSERVATION GENETICS

CREDITS: 3 (2+1+0)

Unit 1: Introduction to conservation genetics [7 lectures]

Biodiversity and 'loss' of biodiversity; understanding conservation efforts in populations and species; threatened and endangered species; species extinction (its relation with inbreeding and loss of genetic diversity); scopes of conservation genetics; metapopulations

Unit 2: Genetic diversity of natural populations [7 lectures]

What is genetic diversity?; measuring genetic diversity; processes contributing to genetic diversity: mutation, migration, random mating; natural selection; random genetic drift; interaction between genotype and environment

Unit 3: Characterising genetic diversity [7 lectures]

Allele and genotype frequencies; ideal population and Hardy-Weinberg equilibrium; deviations from Hardy-Weinberg equilibrium

Unit 4: Population size and maintenance of genetic diversity [7 lectures]

Evolutionary processes in small and large populations (evolutionary impacts of selection, mutation, migration, random genetic drift and random mating on small and large populations); genetic diversity and small population size; Small population size: random genetic drift; fixation; population bottlenecks; inbreeding and inbreeding depression; measuring population size (effective population size); population fragmentation

Unit 5: Resolving taxonomic uncertainties and genetic management of wild populations [4 lectures]

Species, subspecies and higher order taxonomic groups; genetic distance and differences between populations; constructing phylogenetic trees; wild populations and understanding conservation issues; genetic management in small inbred populations and in fragmented populations

Suggested Books

1. Allendorf FW and Luikart G (2007). *Conservation and the Genetics of Populations*. Blackwell Publishing
2. Frankham R, Ballou and Briscoe, DA (2010). *Introduction to Conservation Genetics (Second edition)*. Cambridge University Press
3. Hamilton MB (2009). *Population Genetics*. Wiley-Blackwell

SEMESTER – II

PAPER: EWS 1302E

ECOTECHNOLOGY AND OTHER TECHNIQUES FOR WATER

AND WASTEWATER TREATMENT

CREDITS: 3 (2+1+0)

Unit 1: Introduction on ecotechnology [10 lectures]

Historical overview of water treatment; basic concepts of ecotechnology and echotechnological approaches; water quality scenario in India, water quality parameters; drinking water quality guidelines; types of wastewater discharge and characteristic; wetland ecosystems-ecological significance, natural purifying potential; constructed wetlands-their design, structure, functioning, applications; phytoremediation, phycoremediation technologybioremediation technology of wastewater

Unit 2: Drinking water treatment [8 lectures]

Sedimentation principle; coagulation and floculation process, filtration process and type; disinfection by chlorination: advantages and disadvantages; ozonation; ultraviolet radiation, advanced oxidation process; water softening, membrane filtration; reverse osmosis; demineralization, defluridation, metal removal; nanotechnology applications in drinking water treatment

Unit 3: Sewage and industrial wastewater treatment [10 lectures]

Classification of wastewater treatment; primary treatment: Screening, sedimentation; secondary treatment (Aerobic and Anaerobic processes): activated sludge process; trickling filter; rotating biological contactors, Up flow anaerobic sludge blanket (UASB), stabilization ponds & aerated lagoons; tertiary treatment: removal of dissolved inorganics, ion exchange, membrane processes, reverse osmosis, ultra filtration, electro-dialysis; brief overview of removal of nitrogen and phosphorus; concept of common effluent treatment plant (CETP)

Unit 4: Sludge treatment and disposal [4 lectures]

Sludge characteristics; digestion process, composting, thickening, dewatering, drying beds, management and disposal of residues.

Suggested readings:

4. Hammer MJ and Hammer Jr MJ (2000). *Water and Wastewater Technology*. 3rd ed. Prentice Hall of India
5. Kumar R and Singh RN (2006). *Municipal Water and Wastewater Treatment*. Capitol Pub. Co., New Delhi
6. Birdie GS and Birdie JS (2010). *Water Supply and sanitary Engineering*
7. Metcalf and Eddy (2003) *Wastewater Engineering-Treatment and reuse*, Tata McGraw Hill, New Delhi
8. American Water Works Association and James Edzwald (2010) *Water quality and treatment: a handbook on drinking water*
9. Gurnham CF (2004) *Principle of Industrial Waste Treatment*. John Wiley & Sons Inc, New York.

SEMESTER – II

PAPER: EWS 1303E

SOIL BIOLOGY

CREDITS: 3 (2+1+0)

Unit 1: General introduction to the soil system [10 lectures]

Lithosphere and pedosphere, pedology and edaphology, soil formation and soil horizons, soil texture (sand, silt, clay), soil aggregates, soil micro and macro pores, soil air, soil water, soil temperature, soil organic matter, humus, soil physicochemical properties.

Unit 2: Soil biota [10 lectures]

Soil micro fauna and micro flora: bacteria, actinobacteria, algae, yeast, fungi, protozoa, roundworms, rotifers etc.; soil mesofauna: tardigrades, mites, springtails etc.; soil macrofauna: earthworms, beetles, centipedes, ants, slugs, snails etc.; soil megafauna: moles, rabbits, rodents etc.; plant roots and the rhizosphere, effect of root growth on soil physical structure and soil biota.

Unit 3: Soil ecology [12 lectures]

Food webs in soil, detritivores and detritus food chain, soil biodiversity-pattern and distribution, role of soil microorganisms-nutrient cycling, stabilization of soil structure, N mineralization, nitrification, denitrification, biological nitrogen fixation, greenhouse gas production and oxidation, plant root-soil microbe interaction, effect of root exudates on soil microbial populations, microbial action, nutrient availability and plant uptake, vesicular arbuscular mycorrhizae, phosphate solubilizing bacteria, role of

digging and burrowing soil organisms-nutrient availability, soil mixing and aeration etc.

Suggested readings:

1. Bardgett D (2005). *The Biology of Soil: A Community and Ecosystem Approach.* Oxford University Press.
2. Dion P (ed) (2010). *Soil Biology and Agriculture in the Tropics*. Springer.
3. Wall DH (ed) (2012). *Soil Ecology and Ecosystem Services*. Oxford University Press.
4. Lavelle P and Spain AV (2003*). Soil Ecology*. Kluwer Academic Publishers.
5. Paul EA (ed) (2014). *Soil Microbiology, Ecology and Biochemistry (4th edition)*. Academic Press.

SEMESTER – III

PAPER: EWS 901C

ENVIRONMENTAL HEALTH AND RISK ASSESSMENT

CREDITS: 3 (3+1+0)

Unit 1: Introduction to environmental health and toxicology [8 lectures]

Historical context of environmental toxicology; principles of toxicology; definition of xenobiotics; classification of contaminants; toxic chemicals in the environment: metals and metalloids, pesticides, solvents and vapours, radiations and radioactive materials; transport and fate in the environment (including air, water and soil); metal toxicity and metal tolerance in plants; environmental issues due to emerging contaminants

Unit 2: Toxicity-mechanism and effects [10 lectures]

Dose response relationships; biochemical effects: uptake, biotransformation, detoxification, bioaccumulation, biomagnifications; wildlife ecotoxicology; biomarkers; carcinogens and carcinogenesis; biochemical aspects of toxicity of arsenic, cadmium, lead, mercury, carbon monoxide, O_3 and PAN (Paroxy Acyl Nitrate), photochemical smog, methyl Isocyanate; pesticides

Unit 3: Disease ecology [10 lectures]

Pollution and human health; trace element deficiency and disorders; occupational health hazards: silicosis, asbestosis, bronchitis; biogeochemical factors in

environmental health; epidemiological issues-goiter, fluorosis, arsenic poisoning; transmissible diseases: symptoms, epidemiology and control of vector borne diseases-amoebiasis, trypanosomiasis, Japanese encephalitis, , malaria, tuberculosis and AIDS; coliform and others as indicator faecal pollution; waterborne diseases: jaundice and diarrhoea; waterborne diseases during flood in Assam

Unit 4: Nanotechnology: health and environmental risk [6 lectures]

Classification of nanomaterials; environmental aspects of nanotechnology; current state of nanomaterials applications; environmental cases and nanotoxicology; nanoparticles in food: intentional and accidental; risk assessment for nanotechnology

Unit 5: Environmental risk and impact assessment [14 lectures]

Definition of risk, basic steps in risk assessment – hazard identification, dose-response assessment, exposure assessment, risk characterisation, risk communication and risk management; case studies related to environmental risk assessment; human health and ecological risk assessment; origin and development of EIA (Environmental Impact Assessment); linkage between development and environment; relationship of EIA to sustainable development; EIA process; national environmental policies and guidelines in India for major projects; conditions and approach for EIS (Environmental Impact Statements) review; case studies: Hydropower projects; mining projects; oil refineries and petrochemicals.

Suggested Readings:

1. Phillip RB (1995) *Environmental Hazards and Human Health*, Lewis, Boca Raton
2. Chatterjee KD (2009) Parasitology
3. Shatkin JA (2008) *Nanotechnology Health and Environmental Risks*. Perspectives in Nanotechnology. CRC press
4. Canter LW (1996) *Environmental Impact Assessment*, second edition. McGraw-Hill, New York
5. Gilbert M (2008) *Introduction to Environmental Engineering and Science*, Pearson Education
6. Casarett and Doull's Toxicology: *The Basic Science of Poisons* (2001) edited by C. D. Klaassen, McGraw-Hill, New York
7. Richards IS (2008) *Principles and Practice of Toxicology in Public Health*. Jones and Bartlett Publishers, London

SEMESTER – III

PAPER: EWS 902C

ENVIRONMENTAL LAWS AND POLICIES

CREDITS: 4 (3+1+0)

Unit 1: Environmental Acts and Laws [24 lectures]

Pollution control through legislation in India with special reference to the Water Prevention and Control of Pollution) Act, 1974 ; The Air (Prevention and Control of Pollution) Act, 1981 as amended by Amendment Act, 1987 and Rule 1982 ; The Environmental Protection Act, 1986 ; Wild Life (Protection) Act, 1972 ; Forest Conservation Act, 1980 ; Forest Right Act 2006; Biodiversity Act 2002; Motor Vehicle Act, 1988 (environmental aspects), Public Insurance Liability Act, 1991; Waste Management Laws. Hazardous waste management and handling rules, 1989; Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016; E-Waste (Management) Rules, 2016; Ecomark, The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Convention on the Conservation of Migratory Species of Wild Animals (CMS)

Unit 2: Global environmental policies [24 lectures]

Environmental initiatives at International level: Stockholm Declaration, Earth Summit, Convention on protection of environment, Montreal Protocol, Ramsar convention on wetlands, Vienna convention and Kyoto Protocol, Agenda 21, Brundtland Commission, Environmental ethics-anthropocentric vs. ecocentric world view. Basic concepts of environmental planning; integrated land-use planning; land use patterns; urban planning-impact of population growth. Major issues related to Himalayan ecology, deserts and mangroves. Sustainable development-principles and practices in relation to economics and ecology; Clean Development Mechanisms (CDM), United Nations Framework Convention on Climate Change (UNFCCC) and REDD+

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Suggested Readings

1. Saxena KD (1993) *Environmental Planning, Policies & Programmes in India*. Shilpa publication, Delhi
2. Sands P (2003) *Principles of International Environmental Laws*, Cambridge University Press
3. Divan S and Roseneranz A (1995) *Environmental Law and Policy in India: cases, materials and statues*, Oxford University Press
4. Singh G (2005) *Environmental Laws in India*, McMillan Publisher

5. Basu DD (2003) *Introduction to the Constitution of India*, Wadhwa and Company Law Publisher
6. Choudhury SK (1996) *Environmental Legislation in India*, Oxford IBH
7. Heywood VH and Watson RT (1995) *Global Bio-diversity Assessment*, Cambridge
University Press
8. Trivedi RK (2004) Handbook of Environmental Laws, Acts, Guidelines, Compliance and Standards, Vol I & II, B.S. Publications, Hyderabad

SEMESTER – III

PAPER: EWS 903C

ENVIRONMENT AND SOCIETY

CREDITS: 4 (3+1+0)

Unit 1: Environmental Ethics [12 lectures]

Ethics for the environment; the early development of environmental ethics; some central debates: dominion and stewardship, holism, anthropocentrism and biocentrism, biocentric consequentialism, alternative theory, meta-ethical debates; environmental ethics and politics: deep ecology, feminism and the environment, disenchantment and the new animism, social ecology and bioregionalism; traditional ethical theories and contemporary environment ethics; wilderness, the built environment, poverty and politics; sustainability and climate change; environmental justice; justice and equity; the ethics of climate change.

Unit 2: Environment and Society [12 lectures]

Introduction to political ecology; political versus apolitical ecologies; conceptual and methodological challenges, challenges in ecology, social construction and explanation, dominant narratives of political ecology - degradation and marginalisation, conservation and control, environmental conflict and exclusion, environmental subjects and identities and political objects and actors with examples from India and northeastern India; gender and environment (case study of Narmada Dam project in India); environmental identity and social movements in India and across the world—chipko, silent valley, navdanya, national park movement, Aldo Leopold's land ethics, Rachel Carson and Silent Spring; role of civil society, non-governmental organisation, media, individuals, literary figures in environmental awareness and actions.

Unit 3: Ecology and economics of human societies [12 lectures]

Human ecology; demography; socio-economic transitions; ecological economics; sustainable use; markets; natural resource management; community initiatives; common property resources; incentive schemes. scope of human ecology, its importance in understanding conservation issues; human population growth and its implications for the natural environment; people of India, diversity of culture and lifestyles; different modes of resource use and differences with respect to technology, economy, social organization, ideology, and nature of ecological impact; characteristics of rural subsistence economy; role of wilderness areas in subsistence economy, and the impact of market economy

Unit 4: Ecological History [12 lectures]

Ecological history of India: A critical reading of Gadgil and Guha, *The Fissured Land (1989)* and Rangarajan and Sivaramakrishna, *India's Environmental History* (2013). Ecological history of northeast India: paleoecology and pre-historic ecology; agriculture expansion, domestication of rice and other crops; geography and geology of the region: flood, fire, climate and monsoon pattern, formation of alluvial flood plain; society: hunting, shifting cultivation, forest villages; grazing; economy: nature, commerce and mobility, tea environmental history; state and environment: the Ahom rulers and and the colonial state.

Suggested Readings

1. Saxena KD (1993) *Environmental Planning, Policies & Programmes in India*. Shilpa publication, Delhi
2. Sands P (2003) *Principles of International Environmental Laws*, Cambridge University Press
3. Divan S and Roseneranz A (1995) *Environmental Law and Policy in India: cases, materials and statues*, Oxford University Press
4. Singh G (2005) *Environmental Laws in India*, McMillan Publisher
5. Basu DD (2003) *Introduction to the Constitution of India*, Wadhwa and Company Law Publisher
6. Choudhury SK (1996) *Environmental Legislation in India*, Oxford IBH
7. Heywood VH and Watson RT (1995) *Global Bio-diversity Assessment*, Cambridge University Press
8. Trivedi RK (2004) Handbook of Environmental Laws, Acts, Guidelines, Compliance and Standards, Vol I & II, B.S. Publications, Hyderabad
9. Robbins P (2012). *Political Ecology: A critical Introduction (2nd Edition)*. Wiley-Blackwell
10. Robbins P, Hintz J and Moore SA (2014). Environment and Society (2nd Edition). Wiley-Blackwell
11. Springate-Baginski and Blaikie (eds) (2007). *Forests, People and Power: The*

Political Ecology of Reform in South Asia. Earthscan, UK and USA
12. Peet P, Robbins P and Watts MJ (eds) (2011). *Global Political Ecology*. Routledge, New York
13. Forsyth T (2003). *Critical Political Ecology: The Politics of Environmental Science*. Routledge, London and New York
14. Schutkowski H (2006). *Human Ecology: BIocultural Adaptations in Human Communities.* Springer-Verlag Berlin Heidelberg
15. Carson R (1962). *Silent Spring*. Houghton Miflin, New York
16. Baviskar A (1999). *Written on the body, written on the land: Violence and environmental struggles in Central India*. Working Paper WP02-10, Institute of International Studies, University of California, Berkeley.
17. Bryant RL and Bailey S (1997). *Third World Political Ecology*. Routledge London and New York
18. Bates DG and Tucker J (eds) (2010). *Human Ecology: Contemporary Research and Practice*. Springer
19. Verdade LM, Lyra-Jorge MC and Pina CI (eds) (2014). *Applied Ecology and Human Dimensions in Biological Conservation*
20. Karlsson BG (2011). *Unruly Hills. A Political Ecology of India's Northeast*. Berghahn Books
21. Gadgil M and Guha R (1992). *This Fissured Land, An Ecological History of India*, Oxford University Press
22. Saberwal V and Rangarajan M (eds) (2003). *Battles Over Nature, Science and the*
Politics of conservation. Permanent Black, Delhi..
23. Saikia AJ (2013). *Forests and ecological history of Assam, 1826-2000*. Oxford University Press
24. Saikia AJ (2005). *Jungles, Reserves, Wildlife: A History of Forests in Assam.* Wildlife Area Development Trust, Guwahati.
25. Rangarajan M and Sivaramakrishna (2013). *India's Environmental History: A Reader.* Orient Blackswan Private Limited.
26. Sarkar S (2012). *Environemental Philosophy: From Theory to Practice*. Wiley-Blackwell.
27. Attfield R (2014). *Environmental Ethics: An Overview for the Twenty-First Century (2nd edition).* Wiley

SEMESTER – III

PAPER: EWS 904C

ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY

CREDITS: 4 (3+1+0)

Unit 1: Introduction to Environmental Microbiology [10 lectures]

Characteristics of major groups of micro-organisms-bacteria, fungi, algae, protozoa, viruses and bacteriophages; microbial habitats; microbial interactions: microbe-microbe interactions; plants as microbial habitats; animals as microbial habitats and human microbiome

Unit 2: Microbes of environmental importance [12 lectures]

Nitrogen fixation and other related microbes; bioremoval of endocrine disruptors, petroleum hydrocarbons and their derivatives from water; anaerobic and aerobic wastewater treatment including anaerobic degradation of xenobiotics; mycorrhiza and their environmental significance; bio-indicators; microbial degradation of naturally occurring compounds-cellulose, lignin, hydrocarbons; soil microbiology-microbial interactions, decomposition and mineralization

Unit 3: Basic concepts of molecular biology and environmental biotechnology [14 lectures]

Basic of environmental biotechnology; definition and scope of biotechnology; basic concepts of molecular biology; genetic material RNA and DNA; gene structure and expression; transcription, translation and their regulation in both prokaryotes and eukaryotes; recombinant DNA technology; basic techniques in genetic engineering; DNA sequencing

Unit 4: Applications of biotechnology in environmental management [12 lectures]

Biosensors for the detection of pollutants; genetic control of industrial pollution through natural and genetically engineered micro-organisms; heavy metal pollution, bioremediation of metal contaminated soils, removal of spilled oil and grease deposits, fermentation technology (Bioreactors), biotechnology in forestry and wasteland development; gene banks, germplasm banks and their management.

Suggested Readings:

1. Sayler and Fox (1991) *Environmental Biotechnology for waste treatment*, Blackburn, James (Eds.), Planum press
2. Chan MJ, ESS and Krieg, Pelczar NR (1986) *Microbiology*, McGraw-Hill, New York
3. Atlas RM & Bastha R (1997) *Microbial Ecology: Fundamentals & Applications,* Benjamin/Cummings publ

4. Jogdanel SN (2015) *Environmental Biotechnology*
5. Ivanov V (2011) *Environmental Microbiology for Engineers,* CRC Press
6. Bertrand et al. (2011) *Environmental Microbiology: Fundamentals and Applications, Microbial Ecology*, Springer

SEMESTER – III

PAPER: EWS 905C

LABORATORY COURSE

ENVIRONMENTAL HEALTH AND RISK ASSESSMENT

CREDITS: 1 (0+0+1)

1. Determination of heavy metals toxicity by germination and seedling growth tests.
2. Estimation of microflora in soil and water through dilution plate method
3. Coliform count by MPN techniques
4. Visit to Industrial/Mining/Waste dumping sites and preparation of report
5. Study of EIA reports.

Suggested Readings:

1. Gurumani, N. (2006) *Research Methodology for Biological Sciences*, MJP Publishers, Chennai.
2. Jacobson-Kram D (2006) *Toxicological Testing Handbook: Principles, Applications and Data Interpretation*, Taylor & Francis, New York
3. Gurumani N (2006) *An introduction to Biostatistics*, MJP Publishers, Chennai.
4. Murugesan AG and Rajakumari C (2006) *Environmental Science and Biotechnology*, MJP Publishers, Chennai.

SEMESTER – III

PAPER: EWS 1401E

ECOTOXICOLOGY AND HEALTH RISK ASSESSMENT

CREDITS: 3 (2+1+0)

Unit 1: Ecotoxicology [10 lectures]

Ecotoxicology as a synthetic science; definition of xenobiotics; routes of entry of toxic substances into ecosystems – surface waters, land, atmosphere; long-range

movement and global transport of pollutants; fate of pollutants in ecosystems: biotransformation, bioaccumulation & biomagnification; dispersion and circulating mechanism of pollutants

Unit 2: Principle of Toxicity [12 lectures]

Test organisms used in bioassays; toxicity testing; aquatic toxicity test; dose–effect and dose-response relationship- frequency and cumulative response, synergism and antagonism; concept of dosimetry: lethal, sub-lethal & chronic tests, dose response curves, LC50, LD 50; toxicant effects: cellular, organismic, population; biochemical degradation of pollutants inside the cell as well as cellular interactions with the pollutants; carcinogens, mutagens and tetrogens; pharmacogenomics; cellular interaction and metabolism of xenobiotics; metabolic disorders

Unit 3: Human and ecological risk assessment [10 lectures]

Health risk assessment process: hazard identification, exposure assessment, toxicity assessment, risk characterization, risk decision making and risk management, risk communication, concept of cancer and non-cancer risk; health risk *via* to exposure to contaminated soil, air, water and food; potential ecological risk assessment: problem formulation, ecological risk based screening, ecological risk characterization; ecological risk due to heavy metals and organics in aquatic ecosystem

Suggested Readings:

1. Newman MC and Unger MA (2003) Fundametals of ecotoxicology, 2nd ed.; Lewis Publishers: Boca Raton
2. Paustenbach, DJ (2002) Human and ecological risk assessment. Theory and practice, Wiley Interscience, New York.1556 pp
3. Richards IS (2008) *Principles and Practice of Toxicology in Public Health*. Jones and Bartlett Publishers, London
4. Casarett and Doull's Toxicology: *The Basic Science of Poisons* (2001) edited by C. D. Klaassen, McGraw-Hill, New York
5. Subramanian MA (2004) *Toxicology – Principles & Methods*, MJP, Publishers, Chennai
6. Walker CH, Hopkin SP, Sibly RM and Peakall DB (2001) *Principles of Ecotoxicology*, Taylor & Francis, London

SEMESTER – III

PAPER: EWS 1402E

PLANT GROWTH HORMONES

CREDITS: 3 (2+1+0)

Unit 1: Introduction [10 lectures]

General characteristics of plant growth hormones, general mode of action of plant hormones, natural and synthetic hormones, five major classes of plant growth hormones: auxins, gibberellins, cytokinins, ethylene, abscisic acid and their biosynthesis; other known plant growth hormones-brassinosteroids, salicylic acid, strigolactones, plant peptide hormones etc.

Unit 2: Role of hormones in plant growth and development [12 lectures]

Individual roles of auxins, gibberellins, cytokinins, ethylene and abscisic acid on plant growth and development; synergistic and antagonistic effects of different hormones with reference to processes like cell division, cell elongation cell differentiation, apical dominance, lateral bud outgrowth, stomatal regulation, seed dormancy, flowering, fruiting, senescence etc., hormone signalling and cross-talks-integrated hormonal effects; impact of exogenous hormones on endogenous hormone levels and resultant effects.

Unit 3: Environmental significance of plant growth hormones [10 lectures]

Plant hormones as mediators of stress response in plants, role of hormones in counteracting abiotic stresses in plants, role of auxins, gibberellins, cytokinins, ethylene, abscisic acid, jasmonates, brassinosteroids, strigolactones etc. in abiotic stress tolerance (drought, salinity, heat, cold, flood, UV radiation etc.) in plants; role of hormones in plant defence, role of hormones in increasing crop productivity and enhancing food security.

Suggested readings:

1. Plant hormones: Biosynthesis, Signal transduction, Action, Peter J. Davis (Ed.). Kluwer Academic Publishers, 2004.
2. Plant Growth and Development: Hormones and Environment, Lalit M. Srivastava, Academic Press, USA, 2002.
3. Climate Change and Plant Abiotic Stress Tolerance, Narendra Tuteja and Sarvajeet S. Gill (Eds.), Wiley Blackwell, 2014.
4. Phytohormones and Abiotic Stress Tolerance in Plants, Nafees A. Khan et al. (Eds.), Springer, 2012.

5. Abiotic Stress Tolerance in Plants: Toward the Improvement of Global Environment and Food, A.K. Rai and T. Takabe (Eds.), Springer, 2006.

SEMESTER – III

PAPER: EWS 1403E

SOCIAL SCIENCE METHODS IN CONSERVATION

CREDITS: 3 (2+1+0)

Unit 1 Planning a research project [5 lectures]

Social science research in conservation; defining the research topic; developing the methodology; sampling

Unit 2: Methods [11 lectures]

Pre-testing, participant observation, qualitative interviews and focus groups; questionnaires; documenting local environmental knowledge and change; community workshops and the PRA toolbox; participatory mapping

Unit 3: Fieldwork with local communities [6 lectures]

Preparing for fieldwork and collecting and managing data in the field; the role of the researcher; ethical issues in research

Unit 4: Data processing and analysis [7 lectures]

Processing and analysis of qualitative data; qualitative analysis: descriptive statistics; quantitative analysis: inferential statistics

Unit 5: Writing up, dissemination and follow-up [3 lectures]

Writing up the report and dissemination and follow-up.

Suggested readings

1. Rea LM and Parker RA (2014). *Designing and Conducting Survey Research: A Comprehensive Guide, (4th edition)*. Jossey- Bass Publishers.

2. Newing H (2011). *Conducting Research in Conservation: Social science methods and practice*. Routledge London and New York.

SEMESTER – IV

PAPER: EWS 1001C

ANALYTICAL TECHNIQUES IN ENVIRONMENT AND WILDLIFE

CREDITS: 3 (2+1+0)

Unit 1: Environmental Instrumentation [12 lectures]

Principles and practices of: pH meter, Flame photometer, Colorimeter, Gas Chromatograph (GC), (Scanning Electron Microscope) SEM and Transmission Electron Microscope (TEM), High Performance Liquid Chromatography (HPLC), Mass Spectrometer (MS), Atomic Absorption Spectrophotometer (AAS), UV-Visible spectrophotometer, NMR and X-ray, Inductively Coupled Plasma (ICP)

Unit 2: Science Communication Skills [11 lectures]

Reading a scientific paper; writing different sections of a scientific paper; organizing thoughts; developing proposals; writing scientific documents (reports, papers, books, book chapters), understanding referencing (e.g., Mandalay, EndNote); writing popular articles, art of presentation (oral and posters); power of visualization; addressing an audience – posture, voice, content; simplifying the message; interacting with the media including social media; science communication through arts.

Unit 3: Photographic techniques [9 lectures]

The whats, hows, whys, and why nows of photography; framing a visual narrative; visual style and storytelling; importance of history and context in narrative and visual construction; the dilemma of the frame as a point of view; photonaturalist versus photographer; power of photography; ethics in wildlife photography.

Suggested Reading

1. Strunk Jr W and White EB (1999). *The Elements of Style (4th edition)*. Longman.
2. Hale C (2013). *Sin and Syntax: How to Craft Wicked Good Prose*. Three River Press
3. Schimel, J (2011). *Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded*. Oxford University Press
4. Reynolds G (2011). *Presentation Zen: Simple Ideas on Presentation Design and Delivery*. New Riders.

5. S. Morris (1993) *Measurement and Instrumentation Principles*, Prentice Hall of India, New Delhi
6. Olson R (2009). *Don´t Be Such a Scientist: Talking Substance in an Age of Style*. London: Island Press.
7. Skoog DA, Holler FJ, Crouch SR (2006) *Principles of Instrumental Analysis*, 6 th Edition, Thomson
8. Rouessac and Rouessac (1998) *Chemical Analysis: Modern Instrumental Methods and Techniques*, Wiley, Singapore,
9. Christian GD (1994) *Analytical Chemistry*, John Wiley and Sons
10. Kemp W (1991) *Organic Spectros*copy, ELBS Macmillan
11. Datatri S and Sreenivasan R (2016). *Ethics in Wildlife Photography*. Conservation India http://www.conservationindia.org/wp-content/files_mf/Ethics-Web.pdf
12. Sontag S (2008). *On Photography*. Penguin UK
13. Sontag S (2004). *In Regarding the Pain of Others (Reprint edition)*. Picador
14. Trivundža IT (2015). *Press Photography and Visual Framing of News*. Hermina Krajnc
15. Nixon R (2011). *Slow Violence and the Environmentalism of the poor*. Harvard University Press
16. Lesen AE et al. (2016) Science Communication Through Art: Objectives, Challenges, and Outcomes. Trends in Ecology & Evolution , Volume 31 , Issue 9 , 657 - 660

SEMESTER – IV

PAPER: EWS 1002C

LANDSCAPE ECOLOGY, GIS AND REMOTE SENSING

CREDITS: 2 (2+0+0)

Unit 1: Introduction to landscape ecology [10 lectures]

Brief introduction and overview; history of landscape ecology (impetus for its emergence; European and American versions); why is landscape ecology important to resource managers?

Unit 2: Introduction to GIS [10 lectures]

Introduction to GIS (Raster and Vector layers); Introduction to QGIS; vector data types; how to read a toposheet and digitise it; topology, basic spatial operations (measurement, classification, polygon overlay, buffering), projections and datums;

ground survey and positioning, introduction to QGIS; gathering data with mobile devices/handhelds (GPS, GLONASS); introduction to Google Earth, Web-GIS.

Unit 3: Introduction to Remote Sensing [12 lectures]

Principle and concept of remote sensing, electromagnatic specturm and reflectance of various uses; classification including visual, unsupervised, supervised; change detection and analysis. application of remote sensing in vegetation mapping, forest fire monitoring, management of water, mineral resources, wildlife and pollution monitoring.

Suggested Reading

1. Turner MG and RH Gardner (2015). Landscape Ecology in Theory and Practice: Pattern and Process (2nd Edition). Springer George Joseph (2005). *Fundamentals of Remote Sensing*, University Press
2. Lillesand, Kiefer and Chipman (2011). *Remote Sensing and Image Interpretation, Willey*
3. *Ian Heywood, S*arah Cornelius, Steve Carver (2006). *An Introduction to Geographic Information Systems*, Prentice Hall

SEMESTER – IV

PAPER: EWS 1003C

URBAN ECOLOGY

CREDITS: 3 (2+1+0)

Unit 1: Introduction to Urban Ecology [6 lectures]

Definition and goals; the analysis of cities as ecosystems; the human relationship with nature: rights of animals and plants in the urban context; Urban natural histories to urban ecologies: the growth of the study of urban nature.

Unit 2: The Urban Environment and Habitats [5 lectures]

The urban ecological environment (air, water and hydrology, soil, climate, noise, light, roads) and habitat (city forests, walls and paved surfaces, urban cliffs, landscaped parks and open spaces, wetlands and waterbodies, parks, urban contaminated land).

Unit 3: Ecosystem Services and Urban ecology [6 lectures]

Intrinsic and aesthetic values of urban nature; urban nature and human physical health; human psychological and community health; street trees and the urban environment; urban gardens and biodiversity

Unit 4: Urban Biodiversity and Animal Adaptation and Behaviour [6 lectures]

Urban plants and animals (establishment, presence of non-natives, distribution patterns, specific threats to wildlife); biotic homogenisation, impacts of urbanisation on biodiversity, urban hotspots, urban animal ecology; feral animals in the urban environment; urbanisation-related changes at levels of the individuals, populations, community and ecosystem (e.g., phenology, life history, physiology, behaviour, genetic).

Unit 5: Urban Ecology and Society [5 lectures]

Social dimension of urban conservation (nature deficit disorder, human-wildlife interactions); Mitigating strategies to combat the impacts of urbanisation (e.g., pollution and fragmentation, urban greening, urban sprawl vs densification.

Unit 6: Urban Design, planning , and management: Lesson from Ecology [4 lectures]

Multifunctional green infrastructure planning to promote ecological services in the city; building for biodiversity: accommodating people and wildlife in cities; linking social and ecological systems; building urban biodiversity through financial incentives, regulations, and targets

Suggested Reading

1. Ian Douglas, D Goode, MC Houck and Rusong Wang (2011) (eds). *The Routledge Handboon of Urban Ecology*. Routledge, London and New York
2. Parris KM (2016). *Ecology of Urban Environments*. Wiley Blackwell
3. Forman RTT (2014). *Urban Ecology Science of Cities*. Cambridge University Press
4. Niemelä J (2011) (ed). Urban Ecology: Patterns, Processes, and Applications. Oxford University Press

SEMESTER – IV

PAPER: EWS 1004C

STRESS BIOLOGY

CREDITS: 3 (2+1+0)

Unit 1: Basics of physiology and biochemistry [8 lectures]

Carbohydrates, lipids, proteins, nucleic acids, cell organelles, cell, pigments, signal transducers, neurotransmitters, electron transfer, oxidative phosphorylation, glycolysis, enzymes, hormones, photosynthesis, transpiration, respiration, xylem and phloem transport, photoperiodism and photomorphogenesis, tropisms, nastic movements, homeostasis, thermoregulation, osmoregulation, blood circulation, digestion, excretion, gene expression, immunity, growth and development, reproduction.

Unit 2: Environmental stress: definition and types [8 lectures]

Definition of stress, biotic stress: pathogens, bacteria, viruses, fungi, parasites, insects, herbivore attacks, weeds; abiotic stress: water stress, heat stress, salinity stress, photo-oxidative stress, photoperiodic stress, exposure to pollutant gases, chemicals, particulate matter, heavy metals, ozone, UV radiation etc., nutrient toxicity and deficiency.

Unit 3: Impacts of environmental stresses on organisms [8 lectures]

Effects of flooding or waterlogging in plants: anaerobiosis in roots, impact on above-ground parts, loss of soil nutrients, effect on soil animal species; drought stress: loss of crops yields, famines, habitat destruction affecting both terrestrial and aquatic wild life, mass migrations; heat stress: chilling, frost and freezing injury in plants, high temperature stress effect on pollen development, anther dehiscence and flowering, hypothermia and hyperthermia in animals; salt stress effects on plants and animals; physiological responses of plants and animals to SOx, NOx, particulate matter, ozone, UV radiation etc.

Unit 4: Stress coping mechanisms [8 lectures]

Stress avoidance and stress tolerance – two contrasting stress coping mechanisms; hormonal regulation of abiotic stress tolerance; heat shock proteins; tolerance to photo-oxidative damage and lipid peroxidation: anti-oxidative defence systems, free radical scavengers, hydrogen peroxide, superoxide dismutase etc.

SEMESTER – IV

PAPER: EWS 1005C

PRACTICAL

LANDSCAPE ECOLOGY, GIS AND REMOTE SENSING

CREDITS: 2 (0+0+2)

The field and laboratory exercise will be based on the requirement of the theory in order to understand the basic concepts of landscape ecology, GIS and remote sensing.

SEMESTER – IV

PAPER: EWS 1006C

PRACTICAL (STRESS BIOLOGY)

CREDITS: 1 (0+0+1)

Proline estimation in plants; chlorophyll estimation; nitrate reductase estimation, study of nutrient deficiency and toxicity symptoms, study of leaf stomata under water stress.

SEMESTER – IV

PAPER: EWS 1007C

PROJECT

CREDITS 6 (0+0+6)