OFFICE OF THE PRINCIPAL

# DIMORIA COLLEGE, KHETRI

P.O. KHETRI – 782403, KAMRUP(M), ASSAM

Permanently affiliated to G.U. Registered under 2(f) & 12(B) of UGC Act 1956

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From:
Dr. Biman Kumar Bhatta
Principal & Secretary

*Ref. No. . . . . Date . 12/10/2020*

To
The Registrar,
Dibrugarh University, Dibrugarh

Sub.- Modification of Syllabus (Non-CBCS) of Post Graduate Department of Eco restoration, Dimoria college, Khetri.

Sir,

With due regards, in inviting a reference to the subject cited above, I would like to inform you that – the postgraduate department of Eco restoration, Dimoria college, Khetri is offering MSc program in the Subject Eco restoration, affiliated to Dibrugarh University, which was started in the year 2008 under UGC's innovative program. This four semester MSc program was accorded - academic affiliation from Dibrugarh University and the Department of Life Science, DU is acting as the nodal department.

In this regard I would like to let you know that the syllabus of this course has not been updated since its inception and it is urgently required to update/modify the syllabus suitable to present situation in the field of Restoration of Ecology.

Hence, I am forwarding the modified/updated draft syllabus prepared by the department of Eco restoration, Dimoria college and request your necessary action.

Soliciting your kind response and needful.

Dimoria college is also thankful to Dibrugarh University and the Department of Life Science for immense support to run this course.

Thanking you

With regards

Principal
Dimoria College, Khetri

Memo No

Copy to:

1) Honb'le Vice chancellor, Dibrugarh University for his information
2) Chairman, Departmental Board of Studies, Eco restoration (Department of Life Sciences, Dibrugarh University, Dibrugarh).

Principal
Dimoria College, Khetri

# DIBRUGARH UNIVERSITY

**DIMORIA COLLEGE, KHETRI, KAMRUP(M), ASSAM, INDIA**

**DRAFT SYLLABUS( NON-CBCS MODE) of**

**POST GRADUATE DEPARTMENT OF ECO-RESTORATION**

**OUTLINE**

## Why Ecological Restoration?

The primary aim of the study of this course is to convert the liability – degraded ecosystem, into an asset - a healthy ecosystem.

A highly qualified talent pool is urgently needed for ecological restoration in present degraded ecosystem. This master's program will provide students with the critical thinking and experiential skills to be leaders and educators in the rapidly developing ecological restoration industry. The unique, shared institutional curriculum will produce Human Resources with an integrated body of knowledge, methods, and tools for advancing the practice and science of restoring degraded ecosystems.

### Rationale of the course

The program will establish a unique interdisciplinary and inter-institutional curriculum that provides students with an integrated science-based body of knowledge and skills necessary to meet the challenge of delivering effective and successful restoration programs. Given that there are so few graduate programs with this specialization in India, the proposed program will advance the knowledge and practice of ecosystem restoration in our nation and also internationally.

### The goals of the program are to provide students with the knowledge and skills to:

- Critically assess degraded ecosystems within different scales and locations (local to international) and identify primary causal factors contributing to the declining state of target ecosystems.
- Design a restoration prescription (unique to the target site and project goals) by integrating ecological principles (theoretical) and physical processes with applied restoration techniques and approaches.
- Develop and initiate detailed monitoring programs needed to assess the success of restoration programs and to identify approaches to guide the restoration process.
- Adapt and modify the restoration approach as deemed appropriate based on monitoring results within an adaptive management framework.

- Establish strong scientifically-based approaches (research skills) to enhance "reliable knowledge" (reduce uncertainties) in the field of restoration ecology (the scientific foundation of ecological restoration).
- Act as a team leader and engage in respectful community engagement and planning of ecological restoration projects.
- Operate with a historically informed and policy sensitive understanding of the cultural practices and protocols.
- Communicate effectively with all levels internal and external to their organization as required to successfully initiate and conduct restoration programs.
- Develop and apply project management guidelines for each stage of a restoration project.
- Display and encourage behavior and comportment that reflects integrity, responsibility, and the values and ethics of professional restoration practitioners.

**THE SYLLABUS.**

**I. FIRST SEMESTER *(C=Credit, M=Marks)**

| Course | Course code | Course name | C | M |
|---|---|---|---|---|
| Paper I | ER-101 | **Concepts in ecology, biodiversity and eco-restoration.** | 3 | 75 |
| Paper II | ER-102 | **Population Ecology** | 3 | 75 |
| Paper III | ER-103 | **Bio Statistics and Computer Application** | 3 | 75 |
| Paper IV | ER-104 | **Pedology** | 3 | 75 |
| Paper V | ER-105 | **Lab Practical** | 3 | 75 |
| | | **Field visit to** – study a terrestrial/grassland/ aquatic ecosystems of Northeast India. and submit report. | 1 | 25 |
| | | Total = | 16 | 400 |

**II.SECOND SEMESTER *(C=Credit, M=Marks)**

| Course | Course code | Course name | C | M |
|---|---|---|---|---|
| Paper I | ER-201 | **Traditional Societies and Environmental Issues** | 3 | 75 |
| Paper II | ER-202 | **Environmental Planning and Impact Assessment** | 3 | 75 |
| Paper III | ER-203 | **Remote Sensing, GIS and GPS** | 3 | 75 |
| Paper IV | ER-204 | **Restoration Ecology and Ethics** | 3 | 75 |
| Paper V | ER-205 | **Lab Practical** | 3 | 75 |
| | | **Field visit to**- EIA study of Industries - Paper Mill/ Sugar Mill/Brick Kilns /Coke Industries - submit report. | 1 | 25 |
| | | Total= | 16 | 400 |

**III.THIRD SEMESTER *(C=Credit, M=Marks)**

| Course | Course code | Course name | C | M |
|---|---|---|---|---|
| Paper I | ER-301 | **Agro- Ecosystem and Management** | 3 | 75 |
| Paper II | ER-302 | **Forest -Ecosystem and Management** | 3 | 75 |
| Paper III | ER-303 | **Watershed and Socio-Ecological Management** | 3 | 75 |
| Paper IV | ER-304 | **Ecological Economics and Sustainable Development** | 3 | 75 |
| Paper V | ER-305 | **Lab Practical** | 3 | 75 |
| | | **Field visit** to- Study a tropical rain forest and submit report. | 1 | 25 |
| | | Total = | 16 | 400 |

**IV. FOURTH SEMESTER *(C=Credit, M=Marks)**

| Course | Course code | Course name | C | M |
|---|---|---|---|---|
| Paper I | ER-401 | **General paper -Advances in Ecorestoration** | 4 | 100 |
| Paper II | | ***Optional Paper**<br>*Any one to be taken from the list mentioned. Each subject will comprise of two papers<br>a) WETLAND ECOSYSTEM AND RIPARIAN ZONE RESTORATION<br>b) MINE LAND RESTORATION.<br>c)GRASSLAND RESTORATION<br>d) WILDLIFE HABITAT RESTORATION. | | |
| | ERO-402A | **Optional Paper (First paper)** | 3 | 75 |
| | ERO-402B | **Optional Paper (Second paper)** | 3 | 75 |
| Paper III | ER-403 | **DISSERTATION** | 4 | 100 |
| | | Candidates will produce a dissertation to satisfy the requirements of this Masters level qualification. In doing so they will demonstrate the ability to synthesize and apply learning gained throughout the program to identify a research topic, formulate and test a hypothesis through original research and communicate outputs according to agreed scientific format. | | |

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|---|---|---|---|---|
| Paper IV | ER-404 | **Field Visit to Degraded Ecosystem** and submit report. | 1 | 25 |
| Paper V | ER-405 | **Community service on restoration process.** | 1 | 25 |
| | | Total | 16 | 400 |

## SEMESTERWISE DISTRIBUTION OF CREDITS AND MARKS

| SEMESTER | Paper I | Paper II | Paper III | Paper IV | Paper V Lab | Field Visit | Credit | Marks |
|---|---|---|---|---|---|---|---|---|
| **I** | **3** | **3** | **3** | **3** | **3** | **1** | **16** | **400** |
| **II** | **3** | **3** | **3** | **3** | **3** | **1** | **16** | **400** |
| **III** | **3** | **3** | **3** | **3** | **3** | **1** | **16** | **400** |
| **IV** | **4** | **3+3=6** | **4** | **1** | **1** | **------** | **16** | **400** |
| **Grand Total** | | | | | | | **64** | **1600** |

## FIRST SEMESTER
**Total Marks = 400**

| | |
|---|---|
| **COURSE CODE:** ER - 101 | Course name**: CONCEPTS IN ECOLOGY, BIODIVERSITY AND ECO-RESTORATION.**<br><br>**Marks: ES -60** **Total hours - 40**<br>**IS-15**<br>**Total = 75** **Credit:3** |
| | |
| Unit – I | Ecology: Definition, principles, subdivisions, structural and functional concept; Levels of ecological study; Ecosystem: terrestrial – grassland, forest, desert, tiaga and tundra; Aquatic – marine and freshwater; Energy budget and transfer productivity; Food chain and food web; Energy flow and primary productivity; Habitat& Ecological niche; Different types of ecosystems found in North East India; ecosystem engineering. **(8 hours)** |
| Unit II | Homeostasis of the ecosystem; Ecosystem health and services; succession ; Linking species and ecosystems; Optimal Foraging Theory (OFT) and consumer-resource dynamics; Metabolic Theory of Ecology (MTE); Biogeochemical cycles - Carbon, Nitrogen, Oxygen, Water, Phosphorus, Sulphur, Nutrient and Rock .<br>Linking species and ecosystems; linking behavior to population and community |

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| | dynamics; spatially extended systems - source-sinks and meta-populations; spatially explicit systems - individual, rule-based approaches.<br>**(8 hours)** |
| Unit - III | Biodiversity concept; Species, Genetic and Ecosystem diversity: Values- utilitarian, intrinsic, aesthetic, economical, social and religious; Ecological role of biodiversity ; Economic valuation of biodiversity; Measuring Biodiversity; Threats to biodiversity; Human impact; Invasion of exotic species, Pollution, Population pressure and Over exploitation (HIPPO) Dilemma; Decoding multidimensional biodiversity; Environmental DNA; Methods of sustaining biodiversity, Ecological footprint.<br>**(8 hours)** |
| Unit - IV | Biodiversity Hotspot; Eco-sensitive zones; Flagship and keystone, Prioritized, Indicator and Umbrella species; Biogeography of prioritized species of North East India -Royal Bengal Tiger, One horned rhinoceros, Arunachal Macaque,Leaf Deer, Golden Langur, Hollock Gibbon, Stump-tailed Macaque,Slow Loris, Clouded Leopard, Brow-antlered Deer ,Pygmy Hog, Gharial, Orang Sitcky Frog, Greater Adjutant, Bengal Florican, White winged wood duck, Great pied Hornbill, Atlas Moth, Blue Vanda, Lady slipper, Pitcher plant, Tea, Bamboo and cane. Global change and species interactions/distributions. Impacts of climate change on biodiversity, ecosystems and ecosystems services.<br>**(8hours)** |
| Unit – V | Ecological Restoration: Concepts, General principles and definitions; Historical perspectives; Goals & Constrains; logic; Methods & skills ; Concepts of resistance, resilience, disturbances and reference site in Ecological Restoration; Importance of Ecological Restoration in present context. Ecorestoration goals and constraints. Climate change and Environmental impact : Greenhouse effect, ozone layer depletion, acid rain. Hazards - of radioactive materials, water logging, solid wastes, biomedical wastes, industrial effluents.<br>**(8 hours)** |

**Books Recommended:**


1. Adds, Judd, Larkcom and Later. Ruth. 2004 Exchange & Transport, Energy & Ecosystems: Biology).
2. Barbour, M.G., J.H. Burk, W.D. Pitts_ 1987, Terrestrial Plant Ecology Second Edition. Benjamin Cummings Publishing Company ••Aenlo Park, California. U.S.A.
3. Bharucha, E. 2003. Biodiversity of India. The. Mapin Publishing, India.
4. Chaudhuri, A.B and Sarka', b D 2002. Biodicrersity Endangered India s Threatened-Wildlife and Medicinal Plants Jodhpur, Srd.en;ific Publishers.

5. DeAngelis,D L 1992 Dynamics of Nutrient Cyc:ingardFoou Webs Chapman and Hall, London
6. Hanski, L. 1999, Metapopulation Ecology Oxford University Press, Oxford.
7. Kormondy,E.J. 1995.Concepts of Eco.ogy. edition_ Prentice Hall, Englewood Cliffs, New Jersey.
8. Odum,E.P. 2004. Fundamentals of Ecology. Repr.nt. W_B Saunders & Co. Philadelphia, USA.
9. Pullaiah, T_ (Eds). 2003. Biodiversity India Vol. 1, Vol- 2 Regency Publisher, New Delhi.
10. Schulze,E,D., Heimanh, M , Maricson S Holland E Lloyd J Prentice. C I , and Schimel. D 2001. Global Biogeochemical cycles in the climate System, Academic Press, New York
11. Krebs, C. J. (6th Ed) 2016. Ecology: The Experimental Analysis of Distribution and Abundance. University of British Columbia, Vancouver.

| Course code: ER - 102 | Course name**: Population Ecology.**<br>**Marks: ES-60**<br>**IS-15**<br>**Total: 75 Credit 3 Total hours - 40** |
|---|---|
| Unit – I | Concept of population; Population growth : exponential, logistic, Carrying capacity, continuous and discrete time models.<br>**(7 hours)** |
| Unit – II | Population fluctuations & regulations- stability, steady state, oscillations, chaos, Age-structured populations; environmental and demographic stochasticity; Leslie Matrices; Linking species and ecosystems; spatially extended systems - source-sinks;Complex Adaptive Systems (CAS)Theory; spatially explicit systems - individual, rule-based approaches.<br>**(8 hours)** |
| Unit - III | Interactive populations, predator-prey models; competition, host-parasite interactions, symbiosis; Natural selection. **(8 hours)** |
| Unit - IV | Stability theory, perturbation experiments. theory and reality. population harvesting in varied conditions.<br>**(8 hours)** |

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| Unit - V | Fisher's theorem; Malthusian theory; Survivorship, fertility rates; Reproductive value, game theoretic modeling of interactive populations: Evolutionarily stable strategies, hostile co-evolution. **(9 hours)** |

**Books recommended:**


1. Charlesworth, B. 1980. Evolution in Age - structured Populations. Cambridge University Press, USA.
2. Evans,G.C. The Quantitative Analysis of Plant Growth Blackwell Scientific Publications, Oxford.
3. Forsyth. A. and K. Miyata. 1984. Tropical Nature. Charles Scribner's Sons, New York.
4. Hastings. A. 1997. Populations Biology. Concepts and Model. Sprnger-Verlag, New York
5. Lanade, R., Euhgen S, Saether. 2003. Stochastic Population and Dynamics in Ecology and Conservation. Oxford University Press, Oxford.
6. May,R. 1981. Theoretical Ecology : Principles and Applications. Blackwell Scientific Publishers, USA.
7. Pahl-Wostl, C. 1995. The Dynamic Nature of Ecosystems: Chaos and Order Entwined. Wiley, Chisester.
8. Svirezhev,Yu.M., and Logofet,D.O. 1983 Stability of Biological Communities. Mir Publisher, Moscow.
9. Roughgarden, J 1979 Theories of Population Genetics and Evolutionary Ecology. An Introduction. Macmillan Publisher, USA.
10. Rockwood,L.L. 2006. Introduction to Population Ecology. Blackwell Publishing, USA
11. Begon, M., Mortimer, M. and Thompson, D. 1996. Population Ecology- A Unified Study of Animals and Plants (3rd Ed). Blackwell Science, USA.

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| Course code<br>ER — 103 | Course name**: Bio-Statistics and Computer Application**<br><br>**Marks= ES 60**<br>**IS 15**<br>**Total 75 Credit 3 Total hours 40** |
| Unit — I | Measurement of central tendency and dispersion mean, median, mode, range, standard deviation, variance and standard error; Sampling- types of sampling; Concepts on probability theory, theoretical distribution - Binomial, Poisson and normal distribution .<br>**(8 hours)** |
| Unit — II | Correlation measurements and regression analysis; tests of significance based on t, chi-square and F-distributions. Application of Basic Statistics Software Tools for Environmental Data Analysis- SPSS. R, PAST, FLORA.<br>**(7 hours)** |
| Unit — III | Analysis of variance and Experimental design. Randomized Block Design, completely Randomized Design.<br>**(7 hours)** |
| Unit — IV | Introduction to computers; Operating systems Windows, Unix and Linux; Binary number systems; Data structures; Database concept; MS Word for word processing; MS Excel for spreadsheet, MS Access for database and graphics.<br>**(9 hours)** |
| Unit — V | Computer oriented statistical techniques; Introduction to web browsing software and search engines; Information Retrieval System; Basic idea of computer oriented environmental and ecological analysis; Understanding online databases; Flow chart and programming techniques. **(9 hours)** |

**Books recommended:**


1. Blissmer, H.Roberts. Introducing Computers. John Wiley & Sons Inc,, USA
2. Clavenne, J.M. ad Notredame, C 2003. Bioinformatics for Dummies. John Wiley & Sons, New Delhi
3. Davis,R.S. 1996. C++ for Dummies, Foster City, CA USA
4. Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedure for Agricultural Research. Wiley, Europe.

5. Panse V.G. and Sukhatame, P.V. 1967. Statistical Methods for Agricultural Workers, (CAR, New Delhi.
6. Snedecor,G.W. and Cochran.W.G. 1969. Statistical Methods. 6:" edition. Oxford and IBH, Publishing, New Delhi.
7. Towned 2002. Practical Statistics for Environmental & Biological Scientists. John Wiley and Sons Ltd.
8. USDA. 1990. Agricultural Statistics, United States Department of Agriculture, Washington, DC,USA.
9. Williams; E.R. Matheson, A.G. and Hardwood, C.E. 2002. Experimental Designs and Analysis for Tree Improvement. CSIRO Pub.
10. Zar, J H 1974 Biostalislical Analysis. Englewood Cliffs, New Jersey Prentice-Hall.

| **Course code ER —104** | Course name**: Pedology**<br>Marks =ES 60<br>IS 15<br>Total 75 Credit 3 (Total hours - 40) |
|---|---|
| Unit -- I | Soil genesis, soil profile development, pedagogical processes; soil horizon; Soil taxonomy; Isotopic signatures in soil development different types of soil types in India.<br>**(8 hours)** |
| Unit — II | Physical properties of soil 7 texture, particle size. grain, color, compaction, volume and mass relationships; soil porosity and aeration.<br>**(7 hours)** |
| Unit — III | Soil moisture : moisture availability. Aquifer; Movement of water: Hydro biological cycle; Effect of management practices on soil moisture regime.<br>**(8 hours)** |
| Unit — IV | Chemical properties of soil : colloidal, structure of clay minerals; Origin of the net negative charge in soils; Cat- ion exchange, base saturation and buffering capacity of soils; Soil acidity and alkalinity; Soil macro and micro nutrients in relation to plant; Soil fertility evaluation and use of fertilizer; Soil testing for N, P and K.<br>**(9 hours)** |

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| Unit — V | Biological properties of soil; Composition and distribution and decomposition of soil organic matter; The forest floor, the plow layer: Microbial populations of the soil.<br>**(8 hours)** |

**Recommended Books**


1. Brady, N.C. and R. R. Weil. 1999. Elements of the Nature and Properties of Soils. (12thedition) Prentice Hall, New Jersy. USA.
2. Bockheim, J.G. and Tarnocai,C. Handbook of Soil Science. (Eds. Surnrner,M.E. el. Al.) CRC Press Boca Raton.
3. Crossley, D.A. Jr., David C. 2003, Fundamentals of Soil Ecology. Amazon Books, USA.
4. Juma, N.G. 1999. The Pedosphere and its Dynamics. Vol. 1. Selman Productions, Edmonlon, Alberta
5. Jun. A.B.E. (eds.). 2003. Roots : The Dynamic Interlace Between Plants of the Earth Kluwer Academic Publishers, London.
6. Lavelle, P., Spain,V.A. 2001. Soil Ecology. Kluwer Academic Publishers, USA,
7. Page, A.L. 1982. Methods of Soil Analysis. Wisconsin Press, Madison, USA.
8. Richardson, J.L. and Vepraskas, M.J. 2000. Wetland Soils Genesis, Hydrology, Landscapes, and Classification. Lewis Publisher. USA.
9. White,R.E. 2005. Principles and Practice of Soil Science: The Soil as a natural resources, Blackwell Publishers, USA.
10. Yerima, P.K.B., Ranst,E.V, 2005. Introduction to Soil Science: Soils of the Tropics. Trafford Publishers, UK.

| Course code<br>ER - 105 | **Course name: Practical Paper**<br>**Marks=ES 75**<br>**IS 25**<br>**Total = 100 Credit 4**<br>**(Total hours - 4)** |
|---|---|
| | 1. Identification of prioritized native, endemic, rare and endangered plants.<br>2. Identification of prioritized (endemic and rare) fauna.<br>3. Plant community study - Qualitative Structures and quantitative structure of Plant Community<br>4. Measurement of species, genetic and ecosystem diversity by standard methods.<br>5. Estimation of standing crop biomass of a grassland ecosystem by harvest method.<br>6. Growth curve : measurement of bacterial population by turbidometry and serial dilution method: Effect of temperature, pH and carbon and nitrogen sources on its growth.<br>7. Estimation of physical characteristics (temperature, soil texture, pore size, moisture content water holding capacity, field capacity, bulk density) of soil.<br>8. Determination of soil pH and CEC.<br>9. Estimation of soil N,P,K and C using standard analytical methods.<br>10. To determine abundance and density of soil fauna. 1<br>11. Simple calculation for determining mean, median, mode, standard deviation, variance, standard error, chi-square test, correlation and regression.<br>12. Analysis of ecological data using Computer Software Packages<br>13. Writing a computer program related to ecological problem solving using R |

Recommended books:


1. Allen, S E., Grimshaw, H.M., Parkinson, J.A. and Ouarmby, C. 1974. Chemical Analysis of Ecological Materials. Blackwell Scientific Publications, Oxford
2. Black,C.A,, Evans,D D While, Ensminger,L E. and Clark,F.E. 1965. Methods of Soil Analysis. Vol 1-3, American Social, of Agronomy, Madison, USA.

3. Kerbs,C.J. 1980 Ecological Methodology. Harper and Row, USA
4. Moore, P,W, and Chapman. S.B (eds) 1986 Methods in Plant Ecology. Blackwell Scientif,c Publications, Oxford.
5. Smith,R.L. 1980. Ecology and Field Biology Harper and Row, USA

**SECOND SEMESTER**
**(Total Marks = 400)**

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|---|---|
| **Course code ER - 201** | Course name**: Traditional Societies and Environmental Issues.**<br>**Marks. ES 60**<br>**IS 15**<br>**Total 75 Credit 3 (Total hours — 40)** |
| Unit - I | Outline of indigenous communities and traditional folklore of North East India; Utilization of natural resources by indigenous communities. Agro- ecosystem types in North East India and other parts of the country<br>**(8 hours)** |
| Unit - II | Shifting cultivation: present status, cropping and yield patterns, energy budgets, weed potential, soil fertility patterns, nutrient budgets; Shifting cultivation management; Ecological impacts on ecosystem; Policies involved.<br>**(8 hours)** |
| Unit - III | Tropical agriculture : rainforest ecology; Status of tropical rain forest in North East India; Tropical agriculture and future of tropical ecosystems; Indigenous knowledge on tropical ecorestoration; Future of tropical ecosystems.<br>**(8hours)** |
| Unit - IV | Ecology of riparian zone; important biota, economic activities; Flood and its impact on wildlife, crop arid human life. Structural devices used to mitigate flood and their impact on riverine biota and ecosystem<br>**(8 hours)** |
| Unit - V | Northeast Village-system, Ecological and economic efficiencies of various traditional land-use systems; Pressure on land in hilly and riparian areas.<br>**(8 hours)** |

**Books recommended :**


1. Bakker,H. 1990. The history of Sacred Places in India as retiected in Traditional Literature. Brill Academic Publisher, USA.
2. Berkes, F. and Folke C 1998. Linking Social and ecological Systems Management Practices and Social Mechanisms for Budding Resilience. Cambridge University Press, Cambridge.
3. Bose. A., Nongbri, T. & Kumar, N (eds,) 1990 Tribal demography and development in North-East India. Delhi BR.
4. Furer-Haimendorf, C.V. 1991 Tribes of India The Struggle for Survival_ Oxford University Press, Delhi
5. Gadgit,M. and Guha,R. 1992. This Fissured Land An Ecological history of India. Oxford University Press, Delhi
6. Gomex-Pampa, A., Whitmore,T C., Hadley.M 1991. Rainforest Regeneration and Management. Parthenon Publishing Group, Paris.
7. Gosling,D. 2001 Religion and Ecology in Indian and South East Asia Routledge, London.
8. Sen, N. and Bansal, R.P.(eds.). 1978. Environmental Physiology and Ecology of Plants. Bishen Singh Mahendra Pal Singh, Dehradun.
9. Singh,J.S. and Gape', B. (eds. I 1978. Glimpses of Ecology. International Scientific Puiblisher, Jaipur 10. Whilmore,T.C. 1984. Tropical Rainforest of Far East. 2TM' edition. Claredon Press, London.

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|---|---|
| Course code<br>ER - 202 | Course name**: Environmental Planning and Impact Assessment**<br>**Marks. ES 60**<br>**IS 15**<br>**Total 75 Credit 3**<br>**(Total hours - 40)** |
| Unit — I | National Forest Policy: Wildlife Act 1972 of India; Forest Conservation Act 1981, Biodiversity Act, Environment (protection) Act 1986, Various Government Bills, Policies and Laws on Environment and Water in India. BIS and IS/ISO 9001: Environmental Management System Certification Scheme IS/ISO 14001.<br>**(9 hours)** |
| Unit — II | Environmental Education : importance and historical perspectives in India. Science, society and environmental governance, role of environmental agencies.<br>**(8 hours)** |
| Unit —III | Environmental Impact Assessment concepts, processes, screening and scoring criteria; Stages and Protocol of the EIA process. **(8 hours)** |
| Unit — IV | Environmental Impact Statement(EIS), Identification and evaluation techniques; Predicting environmental impacts; Resettlement and rehabilitation process.<br>**(8 hours)** |
| Unit — V | Decision making: decision paths, Public hearing in EIA, Participatory Rural Appraisal (PRA) in environmental impact assessment. Environmental clearance for establishing industry, Cost benefit analysis, Environmental audit and certification. **(7 hours)** |

**Books recommended:**


1. Becker,C.D. 1990. Aquatic Bioenvironmental Studies. Elsevier Publications, Netherlands.
2. Cairns, J. 1982. Biological Monitoring in Water Pollution. Franklin Book Co., USA
3. Canter, L.W. 1995. Environmental Impact Assessment. Mc-Graw Hill, New Delhi.
4. Davis,S.W and Simon, P.T. Biological Assessment and Criteria — Tools for Water Resource Planning and Decision Making. CRC Pr LIG.

5. Glasson,J., Therivel,R. and Chadwick, A. 2005, Introduction to Environmental Impact Assessment-Principles, Procedures and, Processes and Practice. Spon Press,UK.
6. izrael,Y.A.1992, Ecology and Control of Natural Environment Kluwer Academic Pub., Netherlands.
7. Morris,P., Therivel,R. 2003, Methods of Environmental Impact Assessment. Spon Press, UK.
8. Osenberg, C.W. and Schmitt. R C 1982. Detecting Ecological Impacts. Academic Press, New York.
9. Sheale, W. 1996. Environmental Impact Assessment - Law and Policy, Making an Impact
10. Westman,W.E. 1985. Ecology impact Assessment and Environmental Planning John Wiley and Sons, USA.

| **Course code**<br>**ER — 203** | Course name**: Remote Sensing and Geographical Information System**<br><br>**Marks. ES 60**<br>**IS 15**<br>**Total 75 Credit 3 (Total hours -40)** |
|---|---|
| Unit — I | Remote sensing : definitions, principles, solar radiation, electromagnetic spectrum; Vector and Raster data; Application of remote sensing, Concept of Geographical Information Services (GIS) and Global Positioning Systems (GPS); GIS and GPS in natural resources assessment, monitoring and management; Interaction between Electro Magnetic Radiation and earth surface features. **(8 hours)** |
| Unit — II | Aerial and Satellite data acquisitions: platforms and sensors, resolutions, scales, Minimum mapable unit (MMU), spectral signatures. **(7 hours)** |
| Unit — III | Imaging: Earth Resource Data Analysis System (ERDAS) Imaging software; Areas of interest (AoI) creation and image processing; image fusion, visual and digital image interpretation, multispectral and hyper spectral image processing; supervised and unsupervised image classification and mapping. **(8 hours)** |
| Unit — IV | GIS software: radiometric and geometric corrections, soil mapping; Geo-referencing; data integration using GIS; Role of GIS in ecorestoration planning; Analysis of environment using Remote Sensing and GIS. **(9 hours)** |

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| Unit — V | Remote sensing and GIS in Landscape ecological analysis and management; Incorporating other spatial attributes like topography (elevation, slope, aspect, rainfall, geology and soils); Climate and bioclimatic regime; Remote Sensing stations in India. **(8 hours)** |

**Books recommended :**


1. Agarwal,C.S. and Garg,P.K 2000. Textbook on Remote Sensing in Natural Resources Monitoring and Management. A.H.Wheeler& Co. Ltd. New Delhi
2. Burrough, P.A. 1986 Principles of Geographic Information Systems for Land Resources Assessment, Oxford University, Press, New York.
3. Colwell,R.N. (Ed.) 1983. Manual of Remote Seising, Vot-11, ed American Society of Photogrammetry, Falls Church, Vancouver, USA
4. Curran. P. J. 1985_ Principles of Remote Sensing. John Wiley & Sons, New York.
5. Goaldchild,F.M., Steyaert, T.L., parks, B.U. 2036. Environmental Modelling with GIS. Oxford University Press.
6. Joseph, G. 2003. Fundamentals of Remote Sensing. University Press. Pvt. Ltd, Hyderabad.
7. Mather,P. 1999. Computer Processing of Remotely Sensed Imagery - An Introduction, John Wiley and Sons, New York.
8. Panda,B.C. 2005. Remote Sensing Principles and Applications. Viva Books Pvt. Ltd., New Delhi
9. Rabbany,E.A. 2002. Introduction to GPS . The Global Positioning System. Artech House, Inc., USA,
10. Richards, J A. 1986. Remote Sensing and Image Analysis Springer Publisher. Berlin.

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| **Course code ER - 204** | Course name**: Restoration Ecology and Ethics**<br>**Marks= ES 60**<br>**IS 15**<br>**Total = 75 Credit 3 (Total hours -40)** |
| Unit -I | Eco-degradation : types and identification; Mining : Restoration of mining habitats; Re-vegetation in toxic waste site cleanup; Rare plant species : Reintroduction and management, Role of soil biota and restoration process. **(8 hours)** |
| Unit -II | Wildlife habitat restoration : amelioration of impacts of past excessive resource use (grazing, cutting, farming, etc.); Arid lands restoration; Water quality improvement; Evaluation of habitat restoration; Restoration following natural catastrophes; Reversal of trends in habitat loss. **(9 hours)** |
| Unit -III | System approach to ecorestoration, development of wetland and wasteland restoration in critical and vulnerable areas; Alternative _livelihood strategies; Mitigation for impacts of land development. **(8 hours)** |
| Unit -IV | Ecorestoration :Analyzing ethical dilemmas and conflicting issues; Dilemmas of humanitarian intervention; Sacred culture and beliefs in traditional societies; Genetically modified organisms and bio-piracy in ecorestoration; Right to information. **(7 hours)** |
| Unit - V | Ethics in ecorestoration : virtue, utilitarian and deontological theories; Religion and ethics; Political ecology; Ownership and intellectual property rights; Codes of conduct. **(8 hours)** |

**Books recommended :**


1. Andet. J.V, and Aronson, J. feci ) 2006. Restoration Ecology : The New Frontier. Blackwell Publishing, USA.
2. Byrne, P. 1999. The Philosophical and Theological Foundations of Ethics. 2d ed. Palgrave Macmillan, London, UK.
3. Campbell, B.C. 1996 Human Ecology. Aldine de Guiter.
4. Egan,D. and Howell, E.A. (eds.) 2001. The Historical Ecology Handbook A Restorationist's Guide to Reference Ecosystems. Island Press, Washington DC. USA.
5. Gupta, G. 2004. Eco-restoration of the Degraded Hills. Vedam Books. New Delhi.

6. Harris,J.A., Birch,P. and Palmer, J 1996. Land Restoration and Reclamation : Principles and Practice. Longman Higher Education, Harlow.
7. Middleton. A. B. 1999. Wetland Restoration, Flood Pulsing, and Disturbance Dynamics John Wiley & Sons, New York
8. Perrow, M.R. and Davy, A.J. (eds.). 2002 Handbook of Restoration Ecology, Vol.18.2 . Principles of Restoration. Cambridge University Press Cambridge.
9. Robbins,P.2004. Political Ecology: A Critical Introduction Blackwell Publishing, USA.
10. Wolters,H A., Platteeuw,M. and Schoor,M.M (eds.). 2001. Guidelines for Rehabi'itation and Management of Floodplains : Ecology and Safety Combined. NRD, Delft.

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| **Course code ER — 205** | **Paper :Practical Paper**<br>**Marks= ES 75**<br>**IS 25**<br>**Total= 100 Credit 4**<br>**(Total hours - 40)** |
| | **Field study:** EIA study of Paper Mill/Sugar Mill/Brick Kilns/ Coke Industries. |
| | 1. Assessment of aquatic habitat parameters (Temperature, pH, DO, free $CO_2$, alkalinity, turbidity/transparency, BOO, COD, $NO_3^-$, $PO_4^{3-}$, Heavy metal, phytoplankton, zooplankton, macro invertebrates, vertebrates and macrophytes).<br>2. Grassland Habitat assessment studies.<br>3. Application of capture recapture method in ecological assessment studies.<br>4. Analysis of insect population (estimation of biomass and qualitative estimation of major groups).<br>5. Ecological succession studies following anthropogenic disturbances<br>6. Estimation of canopy density of natural forest, plantation and disturbed ecosystems.<br>7. Landscape data recording using GPS and then geo-referencing it with GIS software. |

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| | 8. Analysis of satellite imageries using stereoscope.<br>9. Image processing -using ERDAS Imaging software. |

**Recommended Books:**


1. Burrough, P.A. 1986. Principles of Geographic Information Systems for Land Resources Assessment, Oxford University, Press, New York.
2. Cairns, J. 1982. Biological Monitor in Water Pollution. Franklin Book Co, USA.
3. Colwell,R.N (Ed.) 1983. Manual of Remote Sensing. Vol-II. 2' ed. American Society of Photogrammetry, Falls Church, Vancouver. USA
4. Egan,D. and Howell, E.A. (eds.) 2001. The Historical EcoogyHandbook : A Restorationist's Guide to Reference Ecosystems. Island Press, Washington DC USA
5. Osenberg, C.W and Schmitt, R C 1982 Detecting Ecological Impacts Academic Press USA


## THIRD SEMESTER

**(Total Marks = 400)**

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| **Course code ER — 301** | Course name**: Agro- Ecosystem and Management**<br>**Marks= ES 60**<br>**IS 15**<br>**Total= 75 Credit 3 Total hours - 40** |
| Unit -I | Agro-ecosystem : types & classification; Physical, economic and social factors influencing the system, Farms as Input-Output System; Plantation Farming, decision-making, scale of Operation; Case Studies of Farming . location, characteristics & production, Subsistence intensive farming; Wet rice and food crops cultivation in India, Commercial extensive and intensive farming<br>**(9 hours)** |

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| Unit -II | Land Development strategies : objectives, methods & impact on the environment; Forest clearance for shifting agriculture and plantation agriculture; Wetland reclamation Terracing Irrigation practice'<br>**(7 hours)** |
| Unit—III | Development in Agriculture: problems .in crop yields, demand, soil erosion and salination; Impact of green revolution; new seed varieties, use of chemical fertilizers and mechanization" Concept of organic farming; Soil and water conservation and other sustainable approaches in agriculture<br>**(9 hours)** |
| Unit - IV | Land use and environmental planning: land use plans, designing and classification, determining location and space requirements.<br>**(7 hours)** |
| Unit - V | Sustainable land use: suitability analysis, critical areas and regional open space, formulating policy framework, public participation, urban land use design and guidance system plan, community planning.<br>**(8 hours)** |

**Books recommended:**


1. Bennett, E. and J. Robinson. 2000. Hunting Wildlife in Tropical Forests World Bank Washington, D C.
2. Berkes, F. and Folke, C. 1998. Linking Social and ecological Systems : Management Practices and Social Mechanisms for Buildii g Resilience. Cambridge University Press, Cambridge
3. Dobson, A. 1996. Conservation and Biodiversity. New York. Scientific American Press.
4. Dragun, A.K. and Tisdell, C. 1999. (eds): Sustainable Agriculture and Environment. Globalisation and the Impact of Trade Liberalization. Edward Elgar, Cheltenham
5. Forsyth, A. and K. Miyata. 1984. Tropical Nature. New York, Charles Scribner's Sons
6. Klooster&Masera .2000. Community forest management in Mexico: Carbon mitigation and biodiversity conservation through rural development. Global Environmental Change.

7. Ryszkowski,L. (ed.) 2002. Landscape Ecology in Agroecosystem management CRC Press, USA.
8. Trewartha, G. and L. Horn. 1980 Tropical humid climates. An Introduction to Climate. New York, McGraw-Hill Book Company.
9. Whitmore, T. C. 1990. An Introduction to Tropical Rain Forests. Oxford, Clarendon Press
10. Gtiessman,S.R. 1990. Agro-ecology: Researching the Ecological Basis for Sustainable Agriculture. Ecological Studies, Springer Verlag New York.

| **Course code ER — 302** | Course name**: Forest Ecosystem and Management**<br>**Marks= ES 60**<br>**IS 15**<br>**Total= 75 Credit 3** **(Total hours - 40)** |
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| Unit — I | Principles of forest ecology and management, Historical perspectives of forest ecology in India, Role of indigenous and exotic species in forest ecosystem, Age and area hypothesis, endemism<br>**(8 hours)** |
| Unit-II | Types of forest: Forest succession; Biodiversity of rainforest; Impact of invasive weeds on ecological succession in different forest types of India.<br>**(8 hours)** |
| Unit - III | Nutrient cycling in forest ecosystem; Ecology of plant root systems; Ecology of plant microbe interactions, Successional pattern, early successional strategies Shrub and tree architecture<br>**(8 hours)** |
| Unit - IV | Landscape patterns models, disturbance in landscapes: Landscapes and ecosystem processes.<br>**(8 hours)** |
| Unit - V | Species and landscapes: Applications of landscape ecological theory, Socio-economic drivers of landscape change, Methodology sampling and experimental design in the field – case study.<br>**(8 hours)** |

**Books recommended:**


1. Farina, A 2000. Introduction to Landscape Ecology Kluwer Academic publishers. USA
2. Forman, R.T. 1995. Land Mosacs: The Ecology of Landscapes and Regtons.CambridgeUniv Press,
3. Gardner, R.H., Robert,V., O'Neill, T.irner,M.G. 2001. Landscape Ecology in Theory & Practice. Pattern and Process. Springer-Verlag, USA.
4. Jansen,M., Judas,M. and Soborowski,J. (eds.} 2002. Spatial Modelling in Forest Ecology and Management ; A Case Study Springer-Verlag, New York.
5. Kelly, M.J., Larson, B.0 and Oliver, C.D 1992. The Ecology and Silviculture of mixed - species Forests. Kluwer Academ c publishers, Dordrecht
6. Larcher, W 1983 Plant Physiological Ecology Third edition Springer- Verlag, Berlin Germany
7. Moiloch, J.L. 2001 Introduction to Landscape Design John Wiley and Sons USA
8. Ryszkowski,L. (ed.) 2002. Landscape Ecology snAgroecosyslem management CRC Press, USA
9. Ramakrishnan,P.S. Campbell,J. Demierre,L. Gyi,A. Malhotra,K.C. Mehndiratta,SRai,S N, Sashidharan,E M. 1994 Ecosystem Rehabilitation of the Rural Landscape in South and Central Asia An analysis of Issues. UNESCO Regional Office, New Delhi.
10. Tumer,M.G. & Gardner, R.H. 1994 Quantitative Methods in Landscape Ecology. The Analysis and Interpretation of Landscape Heterogeneity. Springer-Verlag, Publishers, USA.


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| **Course code ER — 303** | Course name**: Watershed and Socio-Ecological Management .**<br>**Marks= ES 60**<br>**IS 15**<br>**Total = 75 Credit 3 Total hours -40** |
| **Unit — I** | Watershed management: concepts, framework, description, scope and steps in watershed management; Land use map; Impact of deforestation and urbanization of watersheds in North East India; Trading of timber and forest products.<br>**(8 hours)** |

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| Unit — II | Soil and water conservation: importance, erosion problems, conservation technology — contour terracing, contour bunding, graded bunding, bench terracing; Run-off harvesting, storage and recycling; Fuel fodder plantation, mechanical measures for erosion control, economic evaluation.<br>**(8 hours)** |
| Unit — III | Agronomic measures in soil and water conservation: perception of humid tropical environment; choke of crops, cultural practices, mixed cropping, adoption of organic manures, green manures and bio-fertilizers, residue management; Intercropping and strip cropping.<br>**(8 hours)** |
| Unit — IV | Grassland management: selection of sites, fencing, soil moisture conservation, trenching, contour furrowing and putting, contour bonding, seeding and reseeding of grasslands; Grassland fertilization and multitier system; Grazing management; Selection of tree species and methods of cultivation.<br>**(8 hours)** |
| Unit — V | Horticulture, Agroforestry and Aquaculture : selection of suitable fruit trees; Horticulture in ravines; Agroforestry systems, silvipastoral system: Sustainable aquaculture in upland waters; Wetlands and seasonal water bodies<br>**(8 hours)** |

**Books recommended:**


1. Bakker,J P 1989 Grazing Management by Grazing and Cutting. Kluwer Publishers, Dordrecht.
2. Brooks, K. N., Folliott, P F., Gregerson, H.M. and Thames, J.L. 1991. Hydrology and the Management of Watersheds. Iowa State University Press, USA.
3. Haeuber,R.A., Dasle,V.H. (eds,). 2001. Applying Ecological Principles to Land management. Springer. VerlagPublsiher, USA.
4. Healhcote, I. W. Integrated Watershed Management: Principles and Practice. 1988. John Wiley. and Sons, Inc., New York.
5. Juergensmeyer, J.C. 1998. Land Use Planning and Control Law. Hornbook Series, USA.

6. Kusler,J. 2005. Handbook for developing Watershed — plans to restore and protect our waters. Diane Publishers, USA.
7. Lal, Ruttan. 2000. Integrated Watershed Management in the Global Ecosystem. CRC Press, NY.
8. Murthy,J.V.S. 1995, Watershed management. New Age Publishers, New Delhi,
9. Reimond, R.J., (Ed). 1998. Watershed Management: Practice, Policies, and Coordination. McGraw
10. Williams, J.E., C.A. Wood, and M P Dombeck (Ed.). 1997. Watershed Restoration: Principles and Practices. American Fisheries Society, Bethesda, MD.

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| Course code<br>ER — 304 | Course name**: Ecological Economics and Sustainable Development**<br>**Marks= ES 60**<br>**IS 15**<br>**Total= 75 Credit 3 Total hours - 40** |
| Unit — I | Ecological Economics: introduction, organizing laws and principles, Motivation and historical roots of ecological economics; Concepts and tools of economics.<br>**(8 hours)** |
| Unit II | The link between ecosystems and the economy : co-evolution and evolutionary economics; Comparative Value Theories : Classical,. neoclassical, and biophysical.<br>**(8 hours)** |
| Unit – III | Evaluation of Ecosystem Services : contingent evaluation, travel cost, hedonic pricing; Energy theory of value.<br>**(8 hours)** |
| Unit – IV | Stability indicators natural Resource Scarcity; Malthus, Ricardo, Barnet and Morse - Neoclassical approach; Welfare indicators; Multicriterial management of natural Resources.<br>**(8 hours)** |
| Unit — V | Sustainable development : historical background; Machine world paradigm; Scientific world paradigm; Machine management in entropy; Sustainable goals and |

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| | guidelines; Progress indicators; Sustainable natural resources and Policy; Forest Certification.<br><br>**(8 hours)** |

**Books recommended:**


1. Bergh, J,C.J.M, van den (ed.). 1999. Handbook of Environmental and Resource Economics. Edward Elgar Publishing, Cheltenham.
2. CommonM., Stage,S. 2005. Ecological Economics : An introduction. Cambridge University Press, Delhi
3. Constanza,R., Cumberland,J., Daly, FL, Goodland, R., Norgaard,R. 2000. An Introduction to Ecological Economics. CRC Press, USA.
4. Daley, E. H., Farley, C.J. 2004. Ecological Economics : Principles and Applications. Island Press, USA.
5. Haerison,M.E.2000. Constructing Sustainable development. University of New York Press, USA.
6. Hawkeen, P., Lovins, A. and Lovirr, L.H. 1991. Natural Capitalism: Creating the Next Industrial revolution. Little Brown and Company, Boston.
7. Pearce,D.W. 1993. Economic Values and The Natural World, Earthscan Publications, London,
8. Ramakrishnan, P.S. 1992. Shifting Agriculture and Sustainable Development - An Interdisciplinary Study from North-eastern India. Man and the Biosphere Series. Volume 10. UNESCO. Paris, and Parthenon Publishing, Carnforth.
9. Sundriyal,T.C. and Sinha.G.N. 2002. (Eds). Arunachal Pradesh Environmental Planning and Sustainable Development - Opportunities and Challenges.Bishen Singh Pal Pub, Dehradun.
10. Ramakrishnan, P.S. 2001. Ecology and Sustainable Development. National Book Trust, New Delhi.

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| **Course code ER — 305** | Course name**: Practical Paper**<br>**Marks = ES 75**<br>**IS 25**<br>**Total= 100 Credit 4**<br>**Total hours - 60** |
| | **Field visit to study the tropical rain forests and submission of report.** |
| | 1. Determination of slope using Abney's level<br>2. Identification of invasive weeds<br>3. Determination of soil salinity.<br>4. Determination of inn oration of water using infiltrometer<br>5. Determination of yield of crops in Jhum agro-ecosystem<br>6. Assessment of degraded ecosystem parameters — density, species diversity, biomass, pH, temperature.<br>7. Sampling procedures in landscape ecological studies<br>8. Experimental design in landscape ecological studies.<br>9. Establishment of a nursery of indigenous plant species.<br>10. Preparation of a mini watershed management plan.<br>11. Cost effective analysis of restoration plan of selected degraded site- case study. |

**Books Recommended :**


1. Davis, S. Wand Simon, P.T. 2001. Biological Assessment and Criteria — Tools for Water Resource Planning and Decision Making. CRC Press, USA.
2. Federer, C.A. 1995. A Simulation Model for Evaporation, Soil water, and Stream Flow, Version 3.1. Computer Freeware and Documentation. USDA Forest Service. PO Box 640, USA.

3. Kennish, M. J. 1996. Practical Handbook of Estuarine and Marine Pollution. CRC Press, New York.
4. Haan, C.T., H.P. Johnson, and D.L.Brakensiek. 1982. Hydrologic Modeling of Small Watersheds. ASAE Monograph, American Society of Agricultural Engineers, St. Joseph, Michigan.
5. Osenberg, C.W. and Schmitt, R.C. 1982 Detecting Ecological Impacts. Academic Press., New Delhi.

## FOURTH SEMESTER

**Total Marks= 400**

| **Course code**<br>**ER - 401** | Course name**: General paper: Advances in Ecorestoration**<br>**Marks=ES 80**<br>**IS 20**<br>**Total= 100 Credit 4 Total hours-50** |
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| Unit I | Ecosystems of Northeast India- wetland, grassland, forest; Historical perspectives : present status and cite condition; Reference Sites, its need, selecting procedure; Ecosystem resilience; Asserting the need of ecorestoration, Ecorestoration techniques, procedures, regulations, Case studies.<br>(10 hours) |
| Unit II | Ecology of flood plains; ecology of remnant upland, its present status; restoration issues, restoration practices; moral burden of natural resources among consumers, consumption needs and land major socio-political activities resulting in degradation of ecosystems of the country – bunds, Channels, embankments, hill cutting, forest clearing, mining, highways, railway lines, wetland filling waste disposal, its reclamation methods. (14 hours) |
| Unit III | Community participation in ecorestoration traditional sacred land restoration, water restoration its techniques, practices regulation concept of traditional knowledge and transmission and maintenance of traditional knowledge on ecorestoration over generations, ecosystem services and human well being.<br>(10 hours) |

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| Unit IV | Necessity of ecorestoration for population control, Role of Pollution Control Board , NGO's, educational and research institutions, other agencies, community restoration awareness and education, cleanup of species toxic wastes , solid waste materials.<br>(8 hours) |
| Unit V | Ecosystem reclamation – regulation, law policies ecoremediation techniques, general principles, bioremediation, phytoremediation in ecorestoration.<br>(8 hours) |

**Books Recommended:**

1 Ecological Restoration, Second Edition: Principles, Values, and Structure of an Emerging Profession (Society for Ecological Restoration) Paperback – Import, 28 February 2013 by Andre F. Clewell (Author), James Aronson (Author)

2 Old Fields: Dynamics and Restoration of Abandoned Farmland October 2007
Edited by Viki A. Cramer and Richard J. Hobbs

3 Google book: International principles and standards for the practice of ecological restoration. Second edition George D. Gann ,Tein McDonald ,Bethanie Walder ,James Aronson ,Cara R.Nelson ,Justin Jonson ,James G. Hallett ,Cristina Eisenberg ,Manuel R. Guariguata ,Junguo Liu ,First published: 04 September 2019,https://doi.org/10.1111/rec.13035

4. Ecorestoration of the coalmine degraded lands,SK Maiti - 2012 - books.google.com

5 Reclaiming nature: eco-restoration of liminal spaces, BJ Richardson - AJEL, 2015 – HeinOnline

6 Application of filamentous phages in environment: A tectonic shift in the science and practice of ecorestoration RS Sharma, S Karmakar, P Kumar… - Ecology and …, 2019 - Wiley Online Library

**7** A review on the role of soil microbial biomass in eco-restoration of degraded ecosystem with special reference to mining areas,V Dwivedi, P Soni - Journal of Applied and Natural …, 2011 - journals.ansfoundation.org

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| Course code ERO-402A | Course name **:OPTIONAL PAPER: Wetland Restoration-First paper**<br>**Marks =ES 60**<br>**IS 15**<br>**Total = 75 Credit 3 Total hours – 40** |
| Unit I | Wetland definition and classification, times; climate, conditions, landscape considerations; water at the atomic to landscape level; hydrodynamics/hydro-periods.<br>(8 hours) |
| Unit II | Geochemistry cycles in wetlands- $O_2$ and pH ,Carbon, mineral and nutrient cycling in wetland<br>(8 hours) |
| Unit III | Wetland water supply, water budget; water energy budgets, isolated island coastal and tidal wetlands, wetland soils.<br>(8 hours) |
| Unit IV | Wetland biota: micro and macrophytes, nekton and benthos organism, eutrophication and their roles, plant decomposition in wetlands<br>(8 hours) |
| Unit V | The wetland paradox with special reference to the Paradox of the Plankton, autogenic, allergenic and anthropogenic processes; wetland policies; wetland regulations delineation; Ramasar sites; wetland diversity.<br>(8 hours) |

Books Recommended :

1 Restoring Neighborhood Streams: Planning, Design, and Construction (Science and Practice of Ecological Restoration) Paperback – 23 August 2016 by Ann L. Riley (Author)
2 Wetlands Hardcover – 24 April 2015 by William J. Mitsch (Author), James G. Gosselink (Author)
3 Cherry, J. A. (2011) Ecology of Wetland Ecosystems: Water, Substrate, and Life. *Nature Education Knowledge* 3(10):16

4 Kosygin, L. 2009. Wetlands of North East India: ecology, aquatic bioresources and conservation. Akansha Publishing House, New Delhi.

5 Agrawal, A. andGopal, K. (2013). Biomonitoring of Water and Waste Water.**DOI** 10.1007/978-81-322-0864-8. Springer India.

6 Gerhardt, A. (1999). Biomonitoring of Polluted Water. Trans Tech Publications Ltd.

7 Rosenberg, D. M. and V. H. Resh, 1993: Freshwater biomonitoring and benthic macroinvertebrates. Chapman and Hall, Inc.

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|---|---|
| Course code ERO-402B | Course name **:OPTIONAL PAPER: Wetland Restoration -Second Paper**<br>**Marks= ES 60**<br>**IS 15**<br>**Total = 75 Credit 3 (Total hours - 40)** |
| Unit I | Wetlands of Northeast India – its condition absent status, natural and human disturbances Ecological impacts of dam construction, water diversion on flood plain wetland, wetland destruction with special reference to water bird population.Biomonitoring of water quality of wetland, impacts of extraction on wetland and their biota.<br>(8 hours) |

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| Unit II | Wetland interactions with adjacent uplands/riparian areas, impacts of hange on wetlands, restoring wetland water supply, artificial wetland for treatment, Flood pulse concept(FPC) in wetlands, rewatering the wetland, wet ecosystems.<br><br>(8 hours) |
| Unit III | Wetland and community role of wetlands in the rural economy community role in restoration of wetlands sacred wetlands, its nature in conservation of biodiversity role of wetland in providing economic services.<br><br>(8 hours) |
| Unit IV | Restoring prioritization, missing links in regeneration, restoration theory, guidelines, to selection criteria.<br><br>(8 hours) |
| Unit V | Philosophies and morals of underpinning of wetland restorations-wetland restoration techniques, historical perspectives, its need, integration of traditional knowledge in wetland restoration case studies of some important wetland of Northeast India and world.<br><br>(8 hours) |

Books Recommended :

1. Mitsch, W. J. and J. G. Gosselink, 2015: *Wetlands* (5th Ed.). John Wiley & Sons, Inc., Hoboken, New Jersey, pp. i-vii+736.

2. Ramsar Convention Secretariat, 2016: *An Introduction to the convention on wetlands*. Ramsar Convention Secretariat, Gland, Switzerland, pp.110.

3. Finlayson, C. M., Milton,G. R. Prentice, C. and Davidson, N. C. 2018. The Wetland Book-II: Distribution, Description, and Conservation. Springer Netherlands.

4. Keddy, P. A.2010.Wetland Ecology: Principles and Conservation(2nd Ed) Cambridge University Press.

5. Gopal, B., 2005: Does inland aquatic biodiversity have a future in Asian developing countries? *Hydrobiologia* 542: 69-75. https://doi.org/10.1007/s10750-004-5736-8

6. Gopal, B., 2003: Perspectives on wetland science, application and policy. *Hydrobiologia* 490: 1-10.

7. Gopal, B., 2013: Future of wetlands in tropical and subtropical Asia, especially in the face of climate change. *Aquatic Sciences* 75: 39-61. DOI: 10.1007/s00027-011-0247-y

8. Goswami, M. M., B. Lahon, M. Kakati, T. K. Deka, P. Sarma and P. K. Singha, 1994: Fishery exploitation system and their impact on socio – economic status of fisherman in some beels of Assam. *Journal of Inland Fisheries Societies of India* 26: 51-58.

9. Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Wetlands and water Synthesis*. World Resources Institute, Washington, DC.

10. Conner, W. H. and Day, J. W. "The ecology of forested wetlands in the southeastern United States." In *Wetlands: Ecology and Management,* eds. B. 9. Gopal, *et al.* (Jaipur, India: National Institute of Ecology and International Scientific Publications, 1982): 69–87.

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| Course code ERO-402A | Course name **:Optional paper: Mineland Restoration - First paper**<br>**Marks= ES 60**<br>**IS 15**<br>**Total= 75 Credit 3 (Total hours=40)** |
| Unit I | Mineralogy determination and identification of minerals with emphasis on one minerals. Rocks, Petrology, Structural geology internal and external geologic processes, Techniques used to find and delineate one bodies, airborne methods, geophysical and geochemical sampling and drilling.<br>(8 hours) |

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| Unit II | Mining methods and technologies, History of Mining in India, Mine types, Mining Policies Acts, Rules, and Regulation, Control of Mines.<br>(8 hours) |
| Unit III | Environmental impacts of mining on ecosystem level properties, biotic communities, biodiversity, traditional societies and rural health Soil properties of mines areas, Land degradation, Acid mine …….and changes in water quality, Impact on drinking water in mine areas.<br>(8 hours) |
| Unit IV | Hazardous wastes relating to mining, Mine water drainage, pumps, Mine gases, Mine dust, explosive, Mine fires, accident in mines, Noise in Mines, Illumination in mines, safety regulations in mining organization and testing.<br>(8 hours) |
| Unit V | Minerals and mining in Northeast India, Environment problems relating to Open cast mining in India and north-east India.<br>(7 hours) |
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| Course code ERO-402B | Course name **: Optional paper: Mineland Restoration- Second paper**<br>**Marks= ES 60**<br>**IS 15**<br>**Total= 75 Credit 3 (Total hours=40)** |
| Unit I | Surface mining and underground mining – Distinguishing features, Mining methods, Advantages and disadvantages. Pit planning and layout, Laws regarding surface and underground mines.<br>(8 hours) |
| Unit II | Environmental attributes of mined areas : air pollution, toxic matter buildup, land degradation, mitigation awareness on mined area, Environment plan of mined areas. |

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| | (8 hours) |
| Unit III | Mine wetland reclamation – principles, techniques, vegetation in mined areas, Mineland restoration, Bioremediation and phytoremediation in mine land restoration. Case studies on mine land restoration.<br>(8 hours) |
| Unit IV | Surface coal mine reclamation – regulation, practices procedures and concepts, special restoration practices adopted for coal mines, mineral mine restoration, Case studies on surface mine restoration.<br>(8 Hours) |
| Unit V | Environmental modeling and prediction of pollution and land degradation in mining areas; mine land restoration techniques; case studies of mine land restoration in different parts of the world<br>(8 hours) |
| | Books recommended:<br>1 Old Fields: Dynamics and Restoration of Abandoned Farmland October 2007<br>Edited by Viki A. Cramer and Richard J. Hobbs<br>**2** Ecorestoration of the coalmine degraded lands, SK Maiti -<br>2012 - books.google.com<br>3 Bio-Geotechnologies for mine site Rehabilitation Book-2018<br>,Edited by: Majeti Narasimha Vara Prasad, Paulo Jorge de<br>Campos Favas and Subodh Kumar Maiti.<br>4 Reclamation of Mine-Impacted Land for Ecosystem Recovery<br>Author(s): Nimisha Tripathi,Raj Shekhar Singh,Colin D. Hills<br>First published:5 February 2016<br>Print ISBN:9781119057901 \|Online ISBN:9781119057925<br>\|DOI:10.1002/9781119057925<br> |

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| | 5 Reclamation of Mine-impacted Land for Ecosystem Recovery Hardcover – 15 April 2016<br>by Raj S. Singh (Author), Colin D. Hills (Author), Nimisha Tripathi (Author) |
| Course code ERO-402A | Course name **:Optional paper: Grassland Restoration -First paper**<br>**Marks= ES 60**<br>**IS 15**<br>**Total= 75 Credit 3 Total hours=40** |
| Unit I | Grassland ecosystems – concept, type and vegetation characteristics, Different types of grasslands in the world and their distribution.<br>(8 hours) |
| Unit II | Evolution and history of Phocaea, Grass plant response to herbivore – morphology and physiology, Grass physiology - $C_3$ and $C_4$ grasses, Grassland community ecology. Herbivore adaptation to dynamics of grassland ecosystem.<br>(7 hours) |
| Unit III | Pattern of productivity grassland nutrient cycling. Importance of grassland in maintaining ecosystem reclamation.<br>(9 hours) |
| Unit IV | Grassland ecosystems prevailing in Northeast in India. Grassland based farming as a means of Ecorestoration, Benefits of grassland to village community, Utilization of grassland by rural People.<br>(8 hours) |
| Unit V | Public land grazing administration and laws relating to Grassland management in Northeast India, Pastoral people of India and the role they play in grassland use and restoration.<br>(7 hours) |

Books Recommended :

1. Hartman, H. L. and Mutmansky, J. M. 2002. Introductory Mining Engineering (2nd Ed). Jofn Wiley & Sons. Inc., Hoboken, New Jersey.

2. Barbara, F. 2016. Coal: A Human History. Basic Books.

3.Bech, J., Bini, C. and Pashkevich, M. A. 2017. Assessment, Restoration and Reclamation of Mining Influenced Soils.https://doi.org/10.1016/C2015-0-05549-6. Elsevier.

4. Maiti, S. K. 2013. Ecorestoration of the coalmine degraded lands. 10.1007/978-81-322-0851-8. Springer India.

5. Mathur, S. P. 2008. Coal Mining in India (2nd Ed). Sahyog Publishers, India.6. Prasad, M. N. V., Favas, P. J. C. and Maiti, S. K. 2018. Bio-Geotechnologies for Mine Site Rehabilitation. https://doi.org/10.1016/C2016-0-04139-6. Elsevier.

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|---|---|
| Course code ERO-402B | Course name **:Optional paper: Grass land Restoration –Second Paper**<br>**Marks= ES 60**<br>**IS 15**<br>**Total= 75 Credit 3 Total hours=40** |
| Unit I | Fire ecology, importance of fire in grassland restoration, Fire history and fire regimes fire regime condition classes and historical range of variability.<br>(8 hours) |
| Unit II | Effect of fire on soil, water, air, nitrogen, carbon, cycle, and other neutrinos in grassland ecosystems, impact of invasive species, landscape dynamics and climate change on grassland ecosystems. |

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| | Grassland microbes, Grassland mesofaunatrophic structure and function, Grassland management in relation to historical and current disturbances, mood of grassland management for ecorestoration case studies.<br>(8 hours) |
| Unit IV | Mountain food plan grassland restoration techniques, prescribed burning. its necessity, procedure production case studies.<br>(8 hours) |
| Unit V | Grassland reference conditions, Application of remote sensing and Geographical information system in grassland restoration, Necessity of grassland restoration for the threatened and rare herbivores and plants, Case studies.<br>(8 hours) |

Books recommended:


1 Project Planning & Management for Ecological Restoration August 2014 John Rieger, John Stanley, and Ray Traynor

2 Principles of Terrestrial Ecosystem Ecology Paperback – 10 September 2011 by F Stuart Chapin III (Author), Pamela A. Matson (Author), Peter Vitousek (Author), M.C. Chapin (Illustrator)

3 Plant Identification Terminology: An Illustrated Glossary Paperback – Import, 1 January 2001 by James G. Harris (Author), Melinda Woolf Harris (Author)

4 The Restoring Ecological Health to Your Land Workbook December 2011 by Steven I. Apfelbaum and Alan W. Haney

5 Human Dimensions of Ecological Restoration October 2011 Edited by Dave Egan, Evan E. Hjerpe, and Jesse

6 Restoring Disturbed Landscapes: Putting Principles Into Practice November,2010,by David J. Tongway and John A. Ludwig

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|---|---|
| Course code ERO-402A | Course name **:Optional paper: Wildlife Ecology, Management & its Habitat Restoration -First paper**<br>**Marks= ES 60**<br>**IS 15**<br>**Total= 75 Credit 3 Total hours=40** |
| Unit I | Wildlife Ecology behavior, Wildlife – concepts nature law wildlife habitats and natural communities climate and wildlife its role in distribution.<br>(8 hours) |
| Unit II | Wildlife as individuals, values of wildlife, population dynamics in wildlife natality reproductive success, mortality and longevity predation concept of carrying capacity minimum viable population.<br>(8 hours) |
| Unit III | Community and wildlife conflict, other issues its management, sacred wildlife and its concept in wildlife conservation wildlife issues and stakeholders, wildlife ethics and traditional communities' wildlife services, community awareness of wildlife management.<br>(8 hours) |
| Unit IV | Wildlife species recovery and management of wild animals in distress reintroduction, wildlife introduction and capacity building, role of Zoo's in wildlife conservation, global concern in wildlife institutions of wildlife conservation and management.<br>(8 hours) |

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| Unit V | Population math models in wildlife ecology and management, biodiversity and conservation role in wildlife ecology and management, species decline and extinction, wildlife census techniques.<br>(8 hours) |

Books recommended:

1 Wildlife Ecology, Conservation and Management, by Anthony R.E. Sinclair, John M. FryxellPaperback, 488 pages, Published January 10th 2006 by Wiley-Blackwell (first published January 1st 2006)

2 Wildlife Ecology, Conservation, and Management (Wiley Desktop Editions),**by John M. Fryxell, Anthony R. E. Sinclair Graeme Caughley**

3 Ivory, Horn and Blood: Behind the Elephant and Rhinoceros Poaching Crisis

by Ronald Orenstein Hardcover, 216 pages ,Published July 25th 2013 by Firefly Books

4 Ecology, Wildlife Conservation & Management Paperback – 1 January 2017

by TAPASHI GUPTA (Author)

5 Fundamentals of Wildlife Management Hardcover – 1 August 2011,by Rajesh Gopal (Author)

6 Wildlife Biology: An Indian Perspective Paperback – 30 August 2017, by Goutam Kumar Saha (Author), Subhendu Mazumdar (Author

7 A Naturalist's Guide to the Butterflies of India Paperback – 1 January 2016, by Peter Smetacek (Author)

8 Wildlife Restoration: Techniques for Habitat Analysis and Animal Monitoring May 2002 Michael L. Morrison

9 Restoring Wildlife: Ecological Concepts & Practice of Applications May 2009 Michael L. Morrison

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|---|---|
| Course code ERO-402B | Course name **:Optional paper: Wildlife ecology, management & its Habitat restoration - Second paper**<br>**Marks= ES 60**<br>**IS 15**<br>**Total= 75 Credit 3**<br>**Total hours=40** |
| Unit I | Wildlife Management and habitat restoration<br>Important wildlife of Northeast India (mammals, birds, amphibians) and their present status, wildlife habitats: wildlife habitat ecology, threats on wildlife, wildlife habitat restoration -case studies.<br>(8 hours) |
| Unit II | Application of population ecology in conservation of rare threatened wildlife biology in ecorestoration, role of conservation biology in wildlife habitat restoration techniques, principles- case studies.<br>(8 hours) |
| Unit III | Protected wildlife habitat of Northeast India, its present status pertaining to ecosystem degradation, need of its restoration,- case studies.<br>(8 hours) |
| Unit IV | Wildlife management – principles and techniques, legal and regulatory framework, policies- in wildlife management, wildlife health management, .management and protected area management, wildlife management working plan. |

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|---|---|
| | (8 hours) |
| Unit V | Application of computes in wildlife management visitors use in managing and interactive planning of protected areas. Geographic information system (GIS) and remote Sensing in wildlife habitat restoration- case studies. (8 hours) |

Books recommended :


1. Fryxell, J. M., Sinclair, A. R. E. and Caughley, G. 2014. Wildlife Ecology, Conservation, and Management (3rd Ed). Wiley-Blackwell.

2. Caughley, G. and Sinclair, J. 1994. Wildlife Ecology and Management. Blackwell Publishing.

3. Patton, D. R. 2019. Forest Wildlife Ecology and Habitat Management. CRC Press.

4. Sands, J. P., DeMaso, S. J., Schnupp, M. J. andBrennan, L. A. 2012. Wildlife Science: Connecting Research with Management (1st Ed). CRC Press.

5.Manning , A. and Dawkins, M. S. 2012. An Introduction to Animal Behaviour (6th Ed). Cambridge University Press.

6. Ali, S. 2003. The Book of Indian Birds.Oxford.

7. Chhapgar, B. F. 2008. Fishes of India. OUP India.

8.Das, I. and Das, A. 2017. A Naturalist's Guide to the Reptiles of India. JB Publishing.

9. Sivaperuman, C. and Venkataraman, K. 2018. Indian Hotspots- Vertebrate Faunal Diversity, Conservation and Management (Vol 1). Springer Singapore.
10. Leadlay, E. and Jury, S. 2006. Taxonomy and Plant Conservation. Cambridge University Press.

11. Ricciuti,E. R. and Gonzalez, E. E. 2019. Wildlife and Climate Change. World Book.

12. Norton,B. G., Hutchins, M., Maple,T. and Stevens, E. 1996. Ethics on the Ark: Zoos, Animal Welfare, and Wildlife Conservation (Zoo & Aquarium Biology & Conservation). Smithsonian Books.

13. Sharma, K. 2010. Human Conflict and Wildlife Conservation. Jnanada Prakashan.

14. Jani, R. 2012. Basics of Wildlife Health Care & Management. Narendra Publishing House.

15. Morrison, M. L. 2009. Restoring Wildlife: Ecological Concepts and Practical Applications (The Science and Practice of Ecological Restoration Series) (2nd Ed). Island Press.

16. S.S. Negi, S. S. 2008. Forests, Forestry and Wildlife in North East India. Indus Publishing.
17. Keller, J. K. and Smith, C. R. 2014. Improving GIS-based Wildlife-Habitat Analysis (SpringerBriefs in Ecology). Springer.

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**References**:

**1 Simon Fraser University(SFU), Burnaby, British Columbia Canada [Public University]**
**8888 University Drive, Burnaby, BC**
**Canada V5A 1S6**

The Program

**Level 1**

ECOR 9100: Concepts of ER & the Physical Environment
ECO 611: Concepts of ER & the Biological Environment
ECOR 9110: Planning and Monitoring for Ecological Restoration;

**Level 2**

ECOR 9200: Field Applications of Restoration Principles (2-week field course)
ECOR 9210: Restoration of Terrestrial Ecosystems or ECOR 9220: Restoration of Aquatic Ecosystems
ECO 621: Graduate Seminars in Research Methods
ECO 622: Project Management & Policy for Ecological Restoration

**Level 3**

Elective 1 & 2
ECO 9300: Applied Research Project 1

**Level 4**

ECO 641: First Nations & Social Perspectives of Ecological Restoration
ECOR 9400: Applied Research Project 2

## Program Details

### Class hours

The program consists of 36 credits / units or 12 courses. There will be three classes per term for the first three terms and two classes for the final term. In addition, there is a two-week field course scheduled at the end of term 2. For in-class courses, classes will be scheduled as 3-hour sessions, one day a week for 15 weeks. Most classes will be scheduled on Tuesdays, Wednesdays, and Thursdays. Exceptions are the electives, which will be delivered according to their regular schedule. Specific times when classes are scheduled will vary depending on classroom availability and instructors' schedules.

## Program delivery

The delivery methods for the M.Sc. in Ecological Restoration will be a combination of classroom-based delivery and hands-on field applications and distributed learning modes. Instruction will include group and individual projects, group activities, case studies, class presentations, guest lectures by active restoration specialists, laboratory sessions, field labs and exercises, and field research.

## Program Details

The program consists of both coursework and applied components. The use of experiential learning is a major strength of the program, with many courses offered in-class at BCIT or SFU (Burnaby) or in the field.

Through experiential learning, students integrate and apply theories, concepts, and observations firsthand. Through experiential learning, students will experience the variability and uniqueness of ecosystems, and the difficulty of applying the same concepts to all sites.

A case-based learning methodology will also be used throughout the program to provide students exposure to restoring ecosystems in other areas of the world. Case studies will illustrate how concepts can be integrated and applied to complex ecological systems. Students will be actively engaged in discussion of specific problems in complex, real-world situations. This method is student-centered and involves the exchange of ideas among participants. The instructor's role will be that of a facilitator, while students address problems collaboratively.

A key component of the Ecological Restoration degree will be the field visits to active restoration projects in the Lower Mainland and other parts of the province. The extensive ecological disturbance and damage that has occurred throughout the Lower Mainland provides real-world opportunities to apply skills in a broad range of restoration activities. Real-world scenarios in ecological restoration will be presented through assignments and team-based projects within courses. These projects will allow students to apply their knowledge from classroom and lab sessions.

## Program length

Two years, full-time.

The maximum time to complete this program is 6 years.

## Grading

Each student is required to maintain a cumulative grade point average (CGPA) of at least 3.0 out of 4.0 (75%).

The overall progress of students in the program will be monitored and evaluated by The Applied Research Committee, and a report on each student's progress will be sent to the Graduate

Program Committee once a year. If the student's progress is deemed to be unsatisfactory by the Graduate Program Committee, the student may be required to withdraw, or improve in specific ways within a defined period of time.

## Graduation and Careers

There is currently a shortage of qualified restoration biologists and practitioners trained in the techniques needed to restore terrestrial and aquatic ecosystems in British Columbia and other jurisdictions in Canada and abroad. Similarly, there are few opportunities to complete a graduate-level program in Ecological restoration in North America. This program will provide a solid foundation for students wishing to embark upon a career involving the conservation, maintenance and restoration of terrestrial and aquatic ecosystems.

Graduates will be qualified for employment with organizations whose mandates involve the restoration of natural ecosystems, particularly fish and wildlife habitats. Upon graduation, students will have the skills and knowledge to qualify for existing positions and develop rewarding careers with municipal, regional, provincial and federal government agencies, private industry, stewardship groups and other NGOs as restoration practitioners, intermediate biologists, and habitat restoration specialists.

### Accreditation

To practice as a professional biologist in British Columbia, one must be a member of the **College of Applied Biology** (the College).

To qualify for certification by the College, applicants require 25 courses (15 of which have a biology focus), three years of work experience, and completion of a professional report. For many students, the course work they completed in their undergraduate studies (if their major is strongly focused on biology), coupled with biology-based courses in this MSc program, may satisfy all academic requirements for accreditation. In addition, graduates from the M.Sc. in ER program can use their time in the program to fulfill 12 months of the three-year work-experience period needed for accreditation. Similarly, the final report for their applied research project will be considered as meeting the professional report requirements of the College of Applied Biology, if:

it is strongly focused on the biotic components of ecological restoration,

the student is responsible for the substantive content of the research project, and

it meets one of the three report evaluation criteria listed by the College

## 2 MSc (Tech) in Environmental Science & Technology , BHU, India

About the Course-

M.Sc.(Tech.) degree course (3years/six semester) in Environmental Science and Technology, conducted by the Centre for Environmental Science & Technology, Faculty of Science, BHU is unique of its kind in India that bridges the gap between "World of Knowledge and World of Work". This course shall be available to those graduates who have passed B.Sc. (Hons.)/ B.Sc. (10+2+3) or B.Sc. (Ag) or M.B.B.S. or BE/B.Tech. with a minimum of 50% marks (equivalent GPA).

Scope of the Study:

M.Sc. (Tech.) in Environmental Science and Technology provides job opportunities in industries, ministries, judiciary, research organizations, universities, colleges, multi national companies, administration & NGOs, etc. Present course is designed to meet the national and international requirements of environmental monitoring, management, environmental impact assessment, ISO certification, environmental legislations, hazards & risk management, air/water/soil pollution management, nano-science application, biodiversity conservation, natural resource management, energy resource conservation, recycling of waste materials, social issues of the environment, environmental protection and policies for sustainable development of the society. Ph.D Programme in Environmental Science and Technology is also available.

**COURSE STRUCTURE**

**SEMESTER-I : ETM101: Basics of Environmental Science & Technology [Credits: 3]** Basic concepts of environmental science & technology, major issues and challenges, Origin of earth, composition of atmosphere, lithosphere, hydrosphere, biosphere and natural resources, Ecosystem structure : air, water, soil, primary producers, consumers and decomposers, Ecosystem function : energy flow, food chains, food webs, ecological pyramids & biotic interaction, Ecosystem disturbance, resilience, decline & succession, Global environmental changes, Decline of biodiversity, its reason and consequences of loosing bio-diversity. Concepts of sustainable development, Ethics of stewardship, Scope of environmentally sound technologies.

**ETM102: Computer Application & Statistics [Credits: 3]** Basic concepts of computer, hardware, operating systems: Windows, Unix and Linux, Use of common application software in biology: word processing, spreadsheets, graphics and data base, Introduction to web browsing software and search engines, Introduction to sampling methodology,

Measures of central tendency and graphical representation of data, Contingency tables and chi-squire test, Difference between sample means: t-test, range tests, Correlation measurements and regression analysis, Simple experimental design and analysis of variance, Introduction to multivariate methods

**ETM103: Environmental Pollution and Management [Credits: 3]** Types, major sources and effects of air pollutants, air borne diseases, Technologies for air pollution management, Types, major sources and effects of water pollutants, water borne diseases, Technologies for water pollution management, Types, major sources and effects of soil pollutants, Technologies for soil pollution management, Major sources of noise pollution, effects of noise pollution on health, Technologies for noise pollution management, Types, major sources and effects of radioactive pollutants, Air, water and noise quality standards.

**ETM104: Geoinformatics [Credits: 3]** Geographic Information Systems, Map Projections, Surveying , Understanding geographic data, Global Positioning Systems, Photogrammetry Methods, Remote Sensing of environment, Digital Image Processing, Digital Cartography, Application of GIS and remote sensing in environmental monitoring and, management.

**ETM105: Lab exercises based on ETM101 & ETM102 [Credits: 4]**

**ETM106: Lab exercises based on ETM103 & ETM104 [Credits: 4]**

**ETM107M: Natural Hazards (Minor elective for the students of ES & T only) [Credits: 3]** Extent and nature of natural hazards, Nature and extent of flood; environmental effects of flooding; flood mitigation methods, Landslides: causes, prevention and correction, Coastal hazards: tropical cyclone and tsunamis; coastal erosion; sea level changes and its impact on coastal areas, hurricanes and tsunami, Earthquakes: causes, intensity and magnitude of earthquakes, geographic distribution of earthquake zones, nature of destruction, protection from earthquake, Volcanism: nature, extent and causes of volcanism, geographic distribution of volcanoes, volcanism and climate, Disaster management Technologies: pre-disaster phase, actual disaster phase, post-disaster phase, Technological assistance for disaster management, Relief camps, organization, camp layout, food requirement, water needs, sanitation, security, information administration, Role of NGOs in disaster management

**SEMESTER-II: ETM201: Environmental Monitoring Technologies [Credits: 3]** Meteorological monitoring technologies, Application of remote sensing for environmental monitoring, Vegetation mapping and monitoring of biodiversity, Optical and Molecular Spectroscopy, Non-Optical Spectroscopes, Physical and Chemical Sensors, Chromatographic and Partition Techniques, Chemical sensors, Biosensors, Biological Methods of environmental monitoring: Microbial, Screening, DNA Probes, Bioassays

**ETM202: Environmental Biotechnology [Credits: 3]** Basic techniques in genetic engineering: Nucleic acid hybridisation and polymerase chain reaction as sensitive detention methods, Introduction of clone genes into new hosts using plasmid and phage vector systems. Expression of genes in new host, Use of micro-organisms in waste treatment and methane production, Production of microbial enzymes: cellulase, proteases, amylases, Alcohol and acetic acid production, Microbial leaching of low grade mineral ores Molecular probes for organisms in mines and mine tailings, Biodegradation of petroleum pollutants, Biofiltration technologies for pollution abatement, Genetically engineered microbes and environmental risk

**ETM203: Ecological Engineering [Credits: 3]** Ecological engineering as a tool for restoration of degraded ecosystems, Ecology of Disturbed Ecosystems: disturbance and its impact on the structure and functioning of terrestrial and aquatic ecosystems., Concepts and strategies of restoration, Biological and biotechnological tools of restoration, Restoration of biological diversity: Acceleration of ecological succession, reintroduction of biota, Degradation and restoration of Forests ecosystems, Degradation and restoration of grassland ecosystems, Degradation and restoration of aquatic ecosystems, Degradation and restoration of wetlands, Restoration of wastelands and degraded soils: Restoration of contaminated soils and soil fertility, mine spoil restoration

**ETM204: Chemical Hazards & Management Technologies [Credits: 3]** Toxicity of chemicals and its dose effect relationships, Chemical hazards in air, water & soil and remedial measures, Monitoring and control of chemical hazards, Characteristics and hazards of radioactive materials, dispersion of radioactive materials, Risk assessment techniques for accidental release of toxic and inflammable materials, Occupational health hazards: Silicosis, asbestosis, bronchitis, heart disease, nasal cancer, Industrial chemical hazards and safety measures, Biochemical effects of toxic heavy metals, pesticides, carcinogens, mutagens and teratogens, Food adulteration, contaminations and related hazards, Handling and transport of hazardous materials, environmental safety, risk management and emergency preparedness

**ETM205: Lab exercises based on ETM201 & ETM202 [Credits: 4]**

**ETM206: Lab exercises based on ETM203 & ETM204 [Credits: 4]**

**ETM207M: Socio-economic Dimensions of Environmental Management (Minor elective for the students of ES & T only) [Credits: 3]** Population explosion and social factors affecting development - poverty, affluence, education, employment, child marriage and child labour, Environment and human health, human rights, value education, women and child welfare, Impact of development on environment - changing patterns of land use, land reclamation, deforestation, resource depletion, pollution and environmental degradation, Basic concepts of sustainable development and social environmental issues, Community participation and capacity building programmes for sustainable socio-economic and ecological development, Role of

NGOs in environmental awareness and management, Role of media in environmental awareness and management

**SEMESTER-III : ETM301: Waste Management Technologies [Credits: 3]** Sources of waste, types and characteristics, Sewage disposal and its management, Solid waste disposal, Biomedical waste handling and disposal, Nuclear waste handling and disposal, Waste from thermal power plants, reuse and disposal, Waste minimization in industries, recycling and disposal technologies, Role of Microbes in waste minimization, Bio-chemistry of anaerobic fermentation and design of biogas systems, Application of phytoextraction and biofilteration techniques for waste management

**ETM302: Air Monitoring and Management [Credits: 3]** Basic principles of air pollution management, Ambient concentrations of air pollutants and trace gases, Air pollution and human health, Vehicular pollution, monitoring and abatement technologies, Meteorological parameters and dispersal of air pollutants, Air pollution control equipments, Control of particulate emission, Control of sulphur oxide and nitrogen oxides, Indoor air pollution and its control, Biological abatement of air pollution

**ETM303: Water Management [Credits: 3]** Global distribution of water, hydrological cycle and water balance on earth, Physico-chemical and biological properties of fresh water and water quality standard, Major sources of water pollution and its effect on surrounding water bodies, Effects of water pollutants on primary productivity of water bodies, Treatment technologies for domestic and industrial waste waters , Biological treatment of waste waters, Ozonization of secondary treated waste water, Ground water resources and its management, Water management strategies: rain water harvesting, artificial recharging of ground water and use of domestic and industrial waste waters, Watershed development, river linking and hydro power projects

**ETM304: Mining Environment & Management [Credits: 3]** Mining types and major environmental issues, Classification and properties of rocks, Classification and properties of minerals, Metallic and non-metallic mineral deposits, Geological and geographical distribution of mineral resources, Importance of mining and mineral resources, Impact of mining activities on health, Mine waste disposal and related problems, Mitigation technologies for mining related environmental problems, Restoration of mined areas

**ETM305: Lab exercises based on ETM301 & ETM302 [Credits: 4]**

**ETM306: Lab exercises based on ETM203 & ETM304 [Credits: 4]**

**ETM307M: Bio-resource Management Technologies [Credits: 3]** (Minor elective for the students of ES & T only) Status and strategies for bioresource management, Sustainable exploitation and development, Forest resources management, social forestry and agro forestry,

Grassland management, Cropland Management, Freshwater bioresource management, Marine bioresource management, Wetlands and estuary bioresource management, Microbial resource management, Wildlife management

**SEMESTER-IV : (Any four major electives from the ETM401 - ETM406) ETM401:** Global Energy Scenarios & Non-Conventional Energy[Credits: 4] Global patterns of energy consumption, rising demand and supply, Conventional energy sources, potential and limitations, methods of harnessing and environmental consequences, Types of non-conventional energy sources, potential and limitations, methods of harnessing and their environmental consequences, Energy Conservation- efficiency in production, transportation and utilization of energy, Future sources of energy: hydrogen, alcohol, biodiesel, fuel cells

**ETM402: Climate Change & Abatement Technologies [Credits: 4]** Greenhouse gases and global warming, Drought and desertification, Acid rain and abatement technologies, Ozone layer destruction and prevention, Technologies to minimize and combat climate change

**ETM403: Environmental Legislation & Impact Assessment [Credits: 4]** Powers and functions of Central & State pollution control boards, Duties and responsibilities of citizens for environmental protection, Important legislations related with environment: Wildlife Protection Act 1972, The Water (Prevention and Control of Pollution) Act 1974. Prevention and Control of Air Pollution Act 1981, Forest Conservation Act 1981, Environment (protection) Act 1986, Hazardous waste (Management and Handling) Rules, 1989, Bio-Medical Waste (Management and Handling) Rules, 1998, Environmental Impact Assessment (EIA), Environmental impact statement (EIS), Environmental management plan (EMP) and Environmental clearance for establishing industry, Cost benefit analysis, Environmental audit, ISO 14000 standards and certification.

**ETM404: Noise Pollution & Abatement Technologies [Credits: 4]** Noise pollution sources, Ambient noise level and its monitoring, Noise standards, Biological and behavioural effects of noise pollution, Noise pollution control technologies: physical and biological approaches

**ETM405: Technologies for Restoration of Degraded Soils [Credits: 4]** Physico chemical and biological properties of soil, Soil forming factors and soil development, Land use classification, Soil Erosion, factors affecting erosion, Principles and methodologies for soil conservation and restoration

**ETM406: Biodiversity Conservation [Credits: 4]** Biodiversity trends, diversity gradients and related hypotheses methods for monitoring biodiversity trends, Mega diversity zones and hot spots, Biodiversity valuation, goods and services provided by biodiversity, Threats to biodiversity, major causes, extinctions, vulnerability of species to extinction, IUCN threat categories, Red data book, Principles and strategies of biodiversity conservation

**ETM407: Dissertation based on selected papers. [Credits: 5]**

**SEMESTER-V : ETM501: Industrial Tour (study of different kinds of industries) [Credits: 8]**

**ETM502 : Industrial Training (technical training in any industry)[Credits:10]**

**ETM503 : Presentation of Industrial Tour & Training Report [Credits: 5**]

**SEMESTER-VI : (Any two major electives from the ETM601 - ETM604) ETM601**: **International Agreements on Environment [Credits: 4]** Global organizations working on ecology and environmental issues, United Nations Conference on Human Environment - UNCHE (Stockholm, 1972)., United Nations Conference on Environment and Development - UNCED (Rio de Janeiro, 1992), World Summit on Sustainable Development - WSSD (Johannesburg, 2002), Treaties/protocols related with environment

**ETM602 : Environmental Modelling [Credits: 4]** Basic concept of environmental modeling, its scope and limitations, Air quality modeling, Surface and ground water quality modelling, Modelling of hazardous substances, Modelling for landscape and urban planning

**ETM603: Industrial Ecology [Credits: 4]** Industrial ecology and sustainable industry concept, Life Cycle Assessment, Inventory analysis and input/output techniques, applying LCA for eco labeling & solid waste management, Product design and development design for environment, Material flow analysis and dematerialization, servicizing and consumption, Environmental management systems, greening supply chains, and life cycle management

**ETM604: Environmental Economics [Credits: 4]** World environmental history and economic development, Valuation of natural resources, Sustainable agriculture and development, Cost benefit analysis and integrated economic modeling, Environmental indicators and their use in resource management AND

**ETM605 : Project Work (Project on any Environmental Issue) [Credits:10]**

**ETM606 : Seminar based on project [Credits: 4]**

**3 University of Plymouth ,Academic Partnerships,CORNWALL COLLEGE (Camborne),Programme Quality Handbook,MSc Land & Ecological Restoration,Academic Year 2019-2020; www.plymouth .ac.uk**

**DEFINITIVE MODULE RECORDS**

**Programme Title: MSc Land & Ecological Restoration**

**University of Plymouth Programme Code: FT 6343 PT 6344**

**Partner Faculty: Academic Partnerships, University of Plymouth**

**Partner Delivering Institution: Cornwall College**

**Start Date: September 2019**

**Date of Approval: April 2018**

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