PONDICHERRY UNIVERSITY
School of Life Sciences

DEPARTMENT OF ECOLOGY & ENVIRONMENTAL SCIENCES

CURRICULUM FOR
M.Sc. PROGRAM
IN
ECOLOGY
2019-20 onwards

PONDICHERRY UNIVERSITY
School of Life Sciences
Department of Ecology & Environmental Sciences

Master of Science in Ecology

PROGRAM OBJECTIVES

The objectives of the MSc Ecology are:

1. to provide students the fundamental concepts and principles of Ecology

2. to make students aware of the importance of biodiversity and its conservation

3. to introduce the modern tools and techniques available to study and understand the nature

4. to teach field techniques, data collection, mapping and analysis

5. to make students to take up interdisciplinary research and teaching in Ecology

PROGRAM OUTCOME

The students will

1. understand the concepts and principles of Ecology

2. understand the structural and functional aspects of biodiversity and the need for its conservation

3. be familiar with modern tools and techniques and their appropriate use to conduct research.

4. be aware of the suitable use of field techniques, data collection, mapping, analysis and interpretation.

5. be able to take up interdisciplinary research and teaching in Ecology

PONDICHERRY UNIVERSITY

School of Life Sciences
Department of Ecology & Environmental Sciences

Curriculum for

M.Sc. Ecology
2019-2020 onwards

Total Credit for Hard Core courses = 48
Total Credit for Soft Core courses = 24
Total Credit requirements = 72

FUNDAMENTALS OF ECOLOGY AND ENVIRONMENTAL SCIENCES

ECOL: 401 **CREDITS: 3**

COURSE OBJECTIVE: To introduce the basics of Ecology and Environmental Sciences to students coming from different background.

UNIT-I Introduction to Ecology & environmental sciences; Principles and Scope of Ecology Structure and Functions of Ecosystems- Abiotic and Biotic components, Flow of energy and cycling of materials; water, carbon, nitrogen and phosphorus, Trophic pyramids and food webs; Ecosystems Types and Diversity, Alterations of ecosystem function: acid rain, nuclear winter, global warming and ozone hole, an overview of IPCC. **(8 Hours)**

UNIT-II Diversity of life; origin of life on earth and Speciation; Human Ecology and Human Settlements, Evolution of early life and changes in earth's atmosphere. Mendelian genetics – and Darwin Wallace theory of inheritance. Five kingdoms overview; Monera, Protists, Fungi, plant and animal kingdoms. **(8 Hours)**

UNIT-III Populations and communities; Birth, death and population size, age structure; Trends in human population growth; Malthusian growth. Intraspecific interactions and density dependence, Parasitism, Prey-predator relationships, Interspecific interactions; Commensalism, mutualism, competition and predation. Species diversity, community stability and disturbance **(8 Hours)**

UNIT-IV Aquatic and terrestrial communities; rare communities; deep earth, deep sea floor, volcanoes. Primary productivity; basic concepts, Ecological succession inland, water; concepts, Invasive species and control **(8 Hours)**

UNIT-V Practical and Field Experiments using standard methods; Estimation of density and relative abundance of species using quadrats and plotless methods. Estimation of species diversity: introduction to indices. Estimation of primary productivity. Ecological adaptations of the Plant and animal species in the hydrophytes, mesophytes and xerophytes. **(8 Hours)**

Text books:

1. Smith, TM and Smith RL 2015. Elements of Ecology, Pearson Education, India.
2. Cain, ML, Bowman, WD and Hacker SD 2011. Ecology, 2nd Edition, Sinauer Associates Inc.
3. Odum, E. P. (2004). Fundamentals of Ecology, Oxford and IBH Publishing Co. Pvt. Ltd.

Reference books:

1. Singh, J.S., S.P & Gupta, S.R. 2006. Ecology, Environment and Resource conservation. Anamaya Publ., New Delhi, 688 pp.
2. Miller. G.T. 2004. Environmental Science. Thomson, California. 538 pgs.
3. Chapman, J.L.& M.J. Reiss. 1998. Ecology: Principles and Applications. Cambridge Univ. press. 2nd edition. 336 pgs.
4. Krebs, C.J. 2008. Ecology: The experimental Analysis of Distribution and Abundance (6th Edition), Benjamin Cummings Publ. 688pgs

COURSE OUTCOME: The students will understand the basics of Ecology & Environmental Sciences.

BIOSTATISTICS

ECOL: 402 **CREDITS: 3**

COURSE OBJECTIVES: To introduce the statistics for ecological and environmental data analysis.

UNIT-I Fundamentals of Biostatistics; sampling, Data collection and recording, central tendency- concept; arithmetic mean, mode, median for ungrouped and grouped data. Probability Rules and Theoretical Distributions: Basic probability rules, expectation, conditional probability; Probability distributions – Binomial, Poisson, Normal and Log-normal distributions; Fitting of probability distributions to environmental data. **(8 Hours)**

UNIT-II Sample survey**:** Need and Purpose of sampling, Sampling with and without replacement, Population and sample, Population parameters; Environmental sampling design - Methods for selecting sampling locations and times; Different techniques of sampling – simple random sampling, stratified random sampling, systematic sampling, two stage sampling, compositing and three-stage sampling; Relative advantages and disadvantages of different techniques. **(8 Hours)**

UNIT-III Sampling distribution and Test of Significance: Parameter and statistics; Sampling distribution, Standard error and its uses; Concept of t- distribution, F-distributions, Chi Square distribution without derivation and their applications; Null hypothesis and uses of t- test, F-test, X^2-tests; Test of significance of large samples. Correlation and Regression**:** Bi-variate data and scatter diagram; Simple (linear) correlation and regression; Coefficient of correlation and regression and their properties; Fitting of regression line; Multiple and partial correlations and regressions. **(8 Hours)**

UNIT IV Analysis of Variance: Different types of models used in AOV; Basic assumptions and its violation; One and two way classified data; Application of AOV to environmental data. Distribution- Normal, t and chi square test; Difference among means: f-test: 1 way ANOVA. Computer applications in environmental modeling, Computer based modeling for population and population studies. **(8 Hours)**

UNIT-V Multivariate analysis , hypothesis testing Model fitting; Biometry – principles and concepts; Matrices, simultaneous linear equations; tests of hypothesis and significance, time series analysis- moving averages (3 and 5 unit cycles); current development in the subject. **(8 Hours)**

Text books:

1 Zar, Jerrold H. (2010). Biostatistical Analysis. 5th Edition, Pearson Publication.
2 Sokal RR and Rohlf FJ (2009) Introduction to Biostatics, 2nd Edition, Dover Publications, Inc, New York.
3 Walpole, R. and R. Myres (1993). Statistics for Engineers and scientists, 5th edn. Mac Millan, N.Y.

Reference Books:

1. Wayne, R. Ott (1995). Environmental Statistics and Data analysis, CRC Press.
2. Manly (2001) statistics for environmental science and management, Chapman and Hall/CRC Press

COURSE OUTCOME: The students will be able to select appropriate statistical tool and to do statistical analysis on a proper dataset.

TERRESTRIAL ECOSYSTEMS

ECOL: 403 **CREDITS: 3**

COURSE OBJECTIVES: To understand the principles of global biome distribution, biodiversity and functional ecology of various tropical and temperate biomes and their conservation under the climate change scenario.

UNIT-I Climate, climate change scenario and distribution of terrestrial ecosystems; Distribution, climate, soil, biota, community structure and functioning, current status and conservation of following biomes: Sand dune ecosystem: formation, soil and community structure, zonation in sand dunes and functioning**. (8 Hours)**

UNIT-II Tropical scrubs and thorn forests – distribution, species composition, structure and functioning, land use change for plantations Tropical dry evergreen forests: Distribution, forest structure, composition, component interactions, human impacts and conservation**(8 Hours)**

UNIT-III Desert ecosystem: distribution - type, climate, soil, vegetation, animals of arid zones and adaptation of various biota; human interaction. Savanna woodlands: types of savannas and their distribution; structural and functional characteristics, soils, seasonality; productivity; phenodynamics; phytomass use by animals; Deciduous forests and scrubs: distribution, seasonality, vegetation; resource use by animals **(8 Hours)**

UNIT-IV Tropical rainforests: distribution, climate; stratification, floral-faunal interactions; tropical deforestation; Tundra: Tundra zone; climate and day length; soils and the process of cryoturbation, seasonality in tundra vegetation and faunal resource utilization; Taigas: distribution, climate, vegetation; serotiny; leaf litter accumulation and nutrient pools, fauna **(8 Hours)**

UNIT-V Temperate broad leaved deciduous forests- distribution, species composition and seasonal changes Temperate grasslands- distribution, species composition and functional aspects; Temperate broad-leaved Sclerophyll and rainforests: Why sclerophylly? Similarities of tropical and temperate rainforests. **(8 Hours)**

Text Books:

1. Miller.G.T., Jr. 2014. Environmental Science. 14th Edition,Thomson, California.
2. Singh, J.S., Singh, S.P. & Gupta, S.R. 2014. Ecology, Environmental Science and Conservation. S. Chand & Company Pvt. Ltd., New Delhi. 929p.
3. Archibold, O.W. 1995. Ecology of World Vegetation. Chapman & Hall, London.

References:

1. Friday, A & D.S. Ingram (Gen. Eds.) 1985. The Cambridge Encyclopedia of Life Sciences, Cambridge Univ. Press, Cambridge.
2. Ecosystems of the World Series - Nos.1,2,3,4,5,6,7,8,12,13, & 14 Elsevier, Amsterdam.

COURSE OUTCOME: Students will know about climate and distribution of global tropical and temperate biomes, their diversity, ecosystem functioning and conservation need.

BIODIVERSITY AND CONSERVATION

ECOL: 404 **CREDITS: 3**

COURSE OBJECTIVES: To gain an understanding of : (1) status of the planet's biological diversity (2) value of biodiversity and drivers of its loss (3) basic concepts and scientific principles of conservation and global patterns in biodiversity (4) current efforts to conserve biodiversity on global, national and local scales; (5) practical issues with local conservation.

UNIT–I Biodiversity: Definition, importance**,** Magnitude and global accumulation of biodiversity; diversification through geological time scale; Levels of biodiversity. Species diversity (i) tree diversity in tropical forest (ii) Diversity and ecology of lianas, (iii) Litter arthropods: sampling methods and role in nutrient cycling and (iii) small mammals in tropical forests: diversity and role in ecosystem functioning. Genetic diversity – measurement of genetic diversity, transgenic organisms, Agro-biodiversity **(8 Hours)**

UNIT–II Measurement of biodiversity – Species richness & abundances, diversity indices – Shannon, Simpson & Fisher's Alpha. Biodiversity and various ecosystem services; Valuation of ecosystems and species:. Biodiversity prospecting and indigenous knowledge systems, community biodiversity registers. Biodiversity as bio resources – use and values (consumptive and productive use values) of biodiversity as sources of food, fodder, timber, medicinal and ornamental plants**. (8 hours)**

UNIT-III Threats to and loss of biodiversity-Global deforestation rate- extinction crises. Causes for extinction: habitat loss, industrialization, hunting and bio invasions; invasive species: wiser use & management. Extinction through geological time scale: mass extinction. Current extinction trends. The theory of island biogeography; edge effect. SLOSS. **(8 hours)**

UNIT-IV Conservation strategies: *In-situ* and *ex-situ* conservation, biodiversity hot spots, hottest hot spots, mega diversity countries, centers of plant diversity and endemism. India – Biospheres, National parks and Wildlife sanctuaries, Wild life conservation projects: Crocodile Conservation, GOI-UNDP Sea Turtle project. **(8 hours)**

Unit V Overview of Conservation efforts: global protected area network. Protected areas and functions; UNESCO biosphere reserves; IUCN conservation categories-endangered, threatened, vulnerable, Red Data Books. Regulation of biodiversity: Convention on Biological Diversity, National Biodiversity Authority, WCMC, CITES. **(8 hours)**

Text Books

1. Primack, Richard B., and Anna Sher (2016). Introduction To Conservation Biology. Sinauer Associates, Incorporated, Publishers.
2. Berlatsky (2013) Biodiversity – Global Viewpoints. Gale Cengage Publishers. ISBN: 9780737769050.
3. Gary G. Mittelbach (2012) Community Ecology. Sinauer Associates, Inc.; 1 edition. ISBN: 978-0878935093.

Reference Books

1. Jase Fitzgerald 2017. Biodiversity: An Introduction. Larsen and Keller Education. ISBN: 978-1635490428

2. Peter Stiling 2015. Ecology: Global Insights & Investigations 2nd Edition. McGraw-Hill international edition
3. Krishnamurthy KV (2003) An Advanced Textbook on Biodiversity – Principles and Practice, Oxford and IBH Publishing, New Delhi.
4. Singh JS, Singh SP and Gupta SR (2014) Ecology, Environmental Science and Conservation. 4th Edition. S. Chand & Company Pvt. Ltd.
5. Primack, R. B. (2012). A Primer of Conservation Biology. Sinauer Associates is an imprint of Oxford University Press; 5 edition.
6. Anne E. Magurran, Brian J. McGill (2011) Biological Diversity: Frontiers in Measurement and Assessment. Oxford University Press. ISBN: 978-0199580675.

COURSE OUTCOME: At the end of the course the students will (1) cite the scientific evidence for biodiversity change in the modern era and detail the contemporary causes of diversity loss, (2) understand and convey the ecological, social, and economic impacts of diversity loss, and (3) apply management principles and tools that are used to conserve diversity at levels from genes to landscapes.

LAB / FIELD WORK - 1

ECOL: 405 **CREDITS: 2**

INTRODUCTION TO ECOLOGY AND ENVIRONMENTAL SCIENCES – FIELD VISIT

a. Field visit to forest patch – data collection and report preparation
b. Field visit to wetland – data collection and report preparation
c. Field visit coast - data collection and report preparation

TERRESTRIAL ECOLOGY AND BIODIVERSITY AND CONSERVATION LAB / FIELD WORK

a. Determine the required size of quadrat to study the vegetation by species area curve method.
b. Determine the required number of quadrat to study the vegetation in a given area by species area curve method.
c. Analyze the vegetation by quadrat method.
    i. Line transect method
    ii. Belt transect method
d. Biodiversity assessment of forest tree community.
e. Quantitative inventory of Liana abundance and diversity in relation to host trees.
f. Forest Biomass calculation by allometric method.
g. Determination of carbon stock of woody plant species.
h. Plant functional trait analysis: Vegetative features.
i. Reproductive trait analysis for understanding forest component interactions.
j. Nutrients cycling in forest: Soil sampling & Organic carbon analysis.
k. Belowground vegetation: Find root biomass determination.
l. Quantification of forest standing stock of litter and carbon analysis.
m. Assessment of forest disturbance for conservation aspects.

POPULATION AND COMMUNITY ECOLOGY

ECOL: 411 **CREDITS: 3**

COURSE OBJECTIVES: To gain an understanding of: (1) complex processes in population and community ecology (2) population growth and dynamics and its regulation (3) Recognise and justify the importance of ecological interactions in shaping the structure of ecological communities

UNIT-I Introduction to population ecology, A review of terms and concepts, attributes of populations, introduction to Mendelian and population genetics, Hardy Weinberg's law, genetic drift, gene flow. **(8 Hours)**

UNIT-II Demographic parameters - Mortality, fecundity and age structure. Life tables – cohorts and static. Population growth: exponential and logistic. Population regulation. Capture - Recapture sampling (closed populations & open populations) demography. Single species populations: intra-specific competition, density dependence. **(8 Hours)**

UNIT-III Community Ecology - Intra-specific competition: Competition exclusion principle and Hutchinson's rule, Gause's theory of niche, coexistence patterns of competing species. Galapagos finches as a demonstration of inter-specific competition. Predator-prey interactions: Functional responses of predator to prey. Lotka-Volterra model, co-evolution of prey-predator interactions – Red Queen hypothesis. **(8 Hours)**

UNIT-IV Plant-animal interaction: mutualisms, commensalism and competition. Host-parasite interactions, Life history strategies – r and k selection. Meta population dynamics: Types of Meta populations - Levins Meta population, Mainland-island Meta population, Population fragmentation, Population viability analysis: deterministic and stochastic models. **(8 Hours)**

UNIT-V Population estimation methods- Life tables, fecundity and survivorship schedules pre and post breeding census, field exercise in plant demography, density estimations: field and computer simulation. **(8 Hours)**

Text books

1. Rockwood LL (2015) Introduction to Population Ecology. Blackwell publishing (2nd Ed.) ISBN: 978-1-4051-3263-3.
2. Peter Stiling (2015). Ecology: Global Insights & Investigations 2nd Edition. McGraw-Hill international edition
3. Begon M, Mortimer M, Thompson DJ (1996) Population Ecology: A Unified Study of Animals and Plants, 3rd Edition. Wiley-Blackwell. ISBN: 978-0-632-03478-9.

Reference Books

1. Sudarshan KN, Trivedi KR (2011) Population and Community Ecology. Neha Publishers & Distributors. ISBN: 978-8171692804
2. Hamilton MB (2009) Population Genetics. John Wiley & Sons Ltd, UK.
3. John H. Vandermeer Deborah E. Goldberg (2013) Population Ecology: First Principles (Second Edition). Princeton University Press, ISBN: 978-0691160313.
4. Putnam R (2010) Community ecology. Springer Publications. ISBN: 978-9048140114.
5. Ranta E, Lundberg P, Kaitala V (2006) Ecology of populations. Cambridge University Press.

COURSE OUTCOME: Students will acquire a theoretical understanding of population and community ecology to apply in the current issues in ecology and critically evaluate the value of long term studies of populations and communities. Knowledge and skills to use practical and analytical techniques to examine population size and structure and quantify population dynamics

EVOLUTIONARY ECOLOGY

ECOL: 412 **CREDITS: 3**

COURSE OBJECTIVE: To provide theoretical ecological concepts to understand the evolution of different species and their interaction.

UNIT-I Introduction - Scaling and the hierarchical structure of biology, levels of approach in biology, domain of ecology, definitions and ground work; anthropocentrism, the importance of wild organisms in pristine natural environments, the urgency of basic ecological research; scientific methodology; models; multiple causality; limiting factors, tolerance limits, the principle of allocation; natural selection, self-replicating molecular assemblages; units of selection.**(8 Hours)**

UNIT-II Population Structure - Population of communities and structure ; factors affecting populations; population "cycles," cause and effect; use of space (vagility, home range, territoriality, foraging tactics); evolution of sex; sex ratio; mating systems; sexual selection; fitness and the individual's status in the population; kin selection, inclusive fitness; reciprocal altruism, parent-off spring conflict.**(8 Hours)**

UNIT-III Interaction amongst species Competition and Niche Theory: Lotka-Volterra equations and competition theory; diffuse competition; niche overlap and competition;

Niche dimensionality; niche breadth (specialization versus generalization);evolutionary consequences; laboratory and field experiments; other evidence from nature; future prospects. Predation: Theory; predator-prey oscillations; aspect diversity; "prudent" predation and optimal yield; evolutionary consequences; predator escape tactics; adaptive coloration; mimicry; warning calls; coevolution; plant-herbivore interactions and plant-appetency theory; parasitism; Darwinian medicine; selected other observations and experiments. **(8 Hours)**

Unit-IV Evolution of Communities Phylogenetic systematics, independent contrasts, the comparative method, evolutionary Eco morphology, recovering the history of the vanishing book of life on Earth Macro descriptors; compartmentation in communities (trophic levels, guild structure, and food webs); connectance; pyramids of numbers, biomass, and energy; energy flow and ecological energetics; secondary succession and transition matrices; community matrix; saturation with individuals and with species; species diversity; diversity of low landrain forest trees; community stability; types of stability; chaotic attractors; evolutionary convergence and ecological equivalents; evolution of communities; pseudo-communities. **(8 Hours)**

Unit-V Biogeography - Distribution of communities and island biogeography; examples.**(8 Hours)**

Text Books:

1. Cockburn, A, 2001. An Introduction to Evolutionary Ecology, 2nd Edition, Wiley-Blackwell.
2. Mayhew, PJ 2006, Discovering Evolutionary Ecology, Oxford University Press.

Reference Books:

1. Fox, CW, Roff, DA Fairbairn 2001 Evolutionary Ecology: Concepts and Case studies, Oxford University press.

COURSE OUTCOME: Students will be equipped to understand the evolutionary background and its importance.

AQUATIC ECOLOGY

ECOL: 413 **CREDIT: 3**

COURSE OBJECTIVE: To give a broad outline and deep understanding of different aquatic systems, components and interactions.

UNIT-I Introduction– Biosphere – hydrosphere – hydrological cycle – aquatic systems-subdivisions – abiotic and biotic factors- Freshwater - Wetlands - Estuarine and marine ecosystems. **(8 Hours)**

UNIT-II Freshwater ecosystem – lentic water bodies – pond - lakes –-types based on origin-based on thermal stratification- reservoirs; lotic water bodies — streams-springs- major Indian rivers – abiotic parameter- biotic communities. **(8 Hours)**

UNIT-III Marine and resourceful coastal ecosystems– fauna and flora diversity - ecological characteristics -perspectives- Wetlands-brackish water-estuary- mangroves - inter tidal-coral reefs - sea grasses – seaweeds – pelagic- deep sea- hydrothermal vents. Economic and pharmacological important bio-resources - drugs from marine plants and animals. **(8 Hours)**

UNIT IV- Ecological adaptations of aquatic fauna and flora - kinds of adaptations –primary and secondary aquatic adaptations- freshwater –estuarine -pelagic –inter tidal and deep sea. Marine Biodiversity conservation programmes – World Marine Bio-Reserves – Great Barrier Reef Programme -IUCN- Marine Bio-reserves in India. **(8 Hours)**

UNIT-V Aquatic system study – measurement of water temperature-light transmission in the water column -water transparency - dissolved oxygen-Collection and identification of hydrophytes-wetland plants-report writing. **(8 Hours)**

Text Books:

1. Olandao Martin. (2017). Aquatic Ecology and Biodiversity. Publisher: Callisto ISBN: 9781632398215, 1632398214.
2. Vincent Jennings, (2016). Aquatic Ecology. Publishing House Syrawood, ISBN: 9781682866153, 1682866157
3. Verma & Agarwal (1995). Environmental Biology (Principles of ecology) Chand & co.,New Delhi

Reference Books:

1. Walter Dodds and Matt Whiles. (2010). Freshwater Ecology -Concepts and Environmental Applications of Limnology 2nd Edition eBook ISBN: 9780080884776: Academic Press
2. Nybakkan J.N. (1997). Marine Biology-An ecological approach. AdditonWesley, Eduational publication Inc.
3. Boaden.PJ.S. 1997. An introduction to coastal ecology, NPH, Delhi 1995.

COURSE OUTCOME: Students will know the different types of aquatic environment, interaction of living and non-living things and adaptations.

LAB / FIELD WORK - 2

ECOL: 414 **CREDITS: 2**

POPULATION AND COMMUNITY ECOLOGY – FIELD WORK

a. Analyze the population structure of tree species in a given area.
b. Estimate the standing forest floor litter.
c. Estimate the fine root biomass up to 15 cm depth by hand picking method.
d. Estimate the litter arthropod diversity by a trap method.
e. Estimate the biomass and carbon stock of woody vegetation by non-harvest method.
f. Assess the population size by capture and recapture technique
g. Mini Project – Preparation of co-harts life table

AQUATIC ECOLOGY - LAB / FIELD WORK

a. Water quality analysis
b. Biological Oxygen Demand
c. Chemical Oxygen Demand
d. Collection of flora from wetland and diversity analysis
e. Collection of fauna from wetland and diversity analysis

REMOTE SENSING AND GIS

ECOL: 501 **CREDITS: 3**

COURSE OBJECTIVE: To make students understand the fundamental principles, sensors characteristics and applications of different types of remote sensing. To introduce students the importance of spatial mapping and modeling in GIS for natural resources management.

UNIT I: Principles of Remote Sensing: Concepts of Remote Sensing, Electromagnetic spectrum; effects of atmosphere, Principle of scanner and CCD array, Spectral reflectance of earth's surface features in different wavelength region of electromagnetic spectrum: spectral characteristics of surface features (soil, vegetation, water). (a) Thermal remote sensing: Basic principles, Radiation laws, Sensing radiant energy, Thermal sensors, characteristics of image and their uses. (b) Microwave remote sensing: Basic definitions and principles, advantages, Types of microwave systems - RADAR, SLAR, SAR. **(8 Hours)**

UNIT II: Satellite and Sensors - Landsat, SPOT, IRS, NOAA, Seasat, ERS, RADARSAT, INSAT, IKONOS; Orbital characteristics, Data products. General characteristics, spectral resolution spatial resolution, temporal resolution and radiometric resolution; Digital Image Processing- Principles, Image rectification and restoration, Image enhancement and Mosaicing. Image classification - Supervised, Unsupervised, Ground truth data, Classification accuracy assessment. **(8 Hours)**

UNIT III: Air borne and space borne data: Fundamentals of photogrammetry, aerial cameras, planning of aerial photography, principles of stereo-photography, parallax; characteristics of aerial photographs; Elements of image interpretation - visual interpretation of aerial photographs and satellite imageries, instruments used in interpretation. Satellite data availability – United States Geological Survey (USGS), Bhuvan, India, European Space Agency (ESA), National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA). **(8 Hours)**

UNIT IV: Geographical Information System (GIS): Basic principles, components and terminologies, Raster and vector data structure, attribute data, Map projection, Digital cartography, elements of map, thematic map, proximity analysis, overlay analysis, GIS software – commercial and open source, Global Positioning System (GPS) - Basic principles, satellite constellation, control segment and user segment, AGPS and DGPS and applications. **(8 Hours)**

UNIT V: Applications of Remote Sensing and GIS: Forest resources - forest type mapping, forest density mapping, change analysis, matrix analysis; water resources - mapping surface waterbody, flood and inundation mapping; agriculture – crop area and yield estimation, damage detection, plant disease detection; disaster mapping – forest fire, fire frequency mapping, fire trend analysis, landslide, land use and land cover mapping, land cover dynamics. **(8 Hours)**

Text books

1. Emery W. and Camps A., (2017) Introduction to Satellite Remote Sensing 1st Edition Atmosphere, Ocean, Land and Cryosphere Applications, Elsevier Publications
2. Rees W.G (2013) Physical Principles of Remote sensing (3 rd edition), Scott polar, Research Institute, University of Cambridge, New York.

3. George Joseph (2008) Fundamentals of Remote Sensing (2 nd edition), Universities press, Hyderabad.
4. Lillies T. M. and Kiefer R.W (2003) Remote Sensing and Image Interpretation, John Wiley and Sons.

Reference books

1. Raizer, V (2017) Advances in Passive Microwave Remote Sensing of Oceans 1st Edition CRC Press
2. Solimini, D., (2016) Understanding Earth Observation: The Electromagnetic Foundation of Remote Sensing (Remote Sensing and Digital Image Processing) 1st Edition, Springer;
3. Estes J. E., and Senger, L.W. (1973), Remote Sensing Techniques for Environmental Analysis, John Wiley and Sons New York.
4. Fischer, and Nijkamp, P (1993). Geographic Information Systems – Spatial Modeling and Policy Evaluation, Springer – Verlag.

COURSE OUTCOME: At the end of the course, students will know about the different types of remote sensing data available and its application in mapping and monitoring the natural resources, Students will also know the potential applications of GIS mapping and modeling in natural resources management.

BEHAVIORAL ECOLOGY

ECOL: 502 **CREDITS: 3**

COURSE OBJECTIVE: To make students know the behavioral ecological concepts and models to understand the animal behavior.

UNIT–I Introduction to Behavioural Ecology: evolution and natural selection, fitness and adaptation, proximate and ultimate causes of behavior, fixed action patterns, imprinting, associate and non associate learning. Intelligence: its components and attributes, case studies of intelligence behaviour in coots, crows and chimpanzees. **(8 Hours)**

UNI–II Evolutionarily Stable Strategies (ESS),types of ESS, Game theory and contests: hawk-dove, prisoners's dilemma, sex ratios, Evolution of social behaviour, inclusive fitness, evolution of altruism: kin selection and reciprocal altruism. Social insect colonies as superorganisms, haplodiploidy, division of labour and castes. Case studies. **(8 Hours)**

UNIT–III Foraging ecology, search and handling time, optimization, generalization and specialization, territoriality, group foraging, selfish herd concept, interspecific mutualisms. **(8 Hours)**

UNIT–IV Overview on reproductive behaviour, Red Queen hypothesis and the evolution of sexual behaviour, belloid rotifers and asexual organisms. Different types of breeding systems in plants and animals. Mate choice and mating systems in plants and animals. Cooperative breeding in birds and mammals. Brood parasitism in cuckoos and other birds. **(8 Hours)**

UNIT–V Overview of research methods in sampling sex ratios and mat choice; time Budgets and foraging ecology; designing behavioural studies, seminars. **(8 Hours)**

Text Books:

1. Singh, J.S., Singh, S.P & Gupta, S.R. 2006. Ecology, Environmental and Resource Conservation. Anamaya Publ., New Delhi. 688Pp.
2. An introduction to behavioural ecology. 1993. J.R. Krebs. Blackwell Publishing.
3. Behavioural Ecology: an evolutionary approach.1984. J. R Krebs and N.B. Davies (eds) Sinauer Associates.

References Books:

1. Krishnamurthy, K. V. 2004. An advanced textbook on Biodiversity: Principles and practice. Oxford and IBH. Publ. Co. New Delhi.260Pp.
2. Mabberley, D.J.2005. The Plant-Book. A portable of dictionary of the vascular plants. 2nd ed. Cambridge University Press.
3. Behavioural ecology. E.S. Morton and B. Stutchbury.2001. Academic Press.

COURSE OUTCOME: At the end of the course, students will know the different model in behavioral ecology and its significance.

CLIMATE CHANGE AND ECOSYSTEM RESILIENCE

ECOL: 503 **CREDITS: 3**

COURSE OBJECTIVE: To make students aware of scenario of climate change and to provide exposure on resilience of species in nature.

UNIT – I A simple example of global change: stratospheric ozone depletion – impacts and policy responses; A complex example of enhanced greenhouse effect- fundamentals of the climate system – changing composition of the atmosphere from human population growth & activities – climate variability in the last millennium and the recent climate record – future emissions and future climate. **(8 Hours)**

UNIT – II Impacts on earth system and society; Impact- regional, national, global; ecosystems; agriculture and food security; sea level rise; acid rain; ocean acidification, coral bleaching; human health; Forestry and Fishery. **(8 Hours)**

UNIT – III Understanding Vulnerability: Key concepts of Sensitivity and Vulnerability – Adaptive capacity, Resilience and Coping ranges and Critical Thresholds; Determinants of vulnerability and adaptive capacity; Variations among regions and sectors; Conceptual framework for assessing vulnerability to climate change; Necessity for adaptation to climate variability; Adaptation types and forms- planned versus autonomous adaptation; No-regrets adaptation options. **(8 Hours)**

UNIT – IV Assessing Impacts and Vulnerabilities: Climate change scenarios and Vulnerability; Methods of Vulnerability Assessment; Indicators of vulnerability and livelihood; Climate sensitivity analysis; Uncertainties in prediction and detection; Vulnerabilities and adaptation practices in forestry, agriculture, soil & land, water resources; Measures for heat waves, coastal inundation – cities – critical infrastructure; Global Policy on Climate and Adaptation. **(8 Hours)**

UNIT – V Resilience: Introduction, why resilience, resilience and stability of ecological systems, resilience of terrestrial ecosystems, regime shift, resilience and biodiversity in ecosystem management Case studies – 1. Catastrophes, phase shifts, and large scale degradataion of a Caribbean coral reef, 2. Sea otters and kelp forests in Alaska: generality and variation in a community ecological paradigm. **(8 Hours)**

Text Books

1. Rathinasamy, M, Chandramouli S. Phanindra K.B.V.N. Uma Mahesh 2018, Resources and Environmental Engineering II: Climate and Environment
2. Parry, ML et al. Climate change 2007: Impacts, Adaptation and Vulnerability, Cambridge University Press.
3. Patt, A et al. 2009 Assessing Vulnerability to global environmental change: making research useful for adaptation decision making policy, Earth scan London.

Reference Books

1. Gunderson, LH, Allen CR and Holling, 2012, Foundations of Ecological Resilience, Island Press.

2. Climate Change and Biodiversity; By Thomas E. Lovejoy, Lee Jay Hannah Published by Yale University Press, 2006 ISBN 0300119801, 80300119800 418 pages.
3. William H. Schlesinger. 1997. Biogeochemistry: An Analysis of Global Change. Academic Press, San Diego, CA. 2nd edition. Available at the Bay Tree Bookstore.
4. Global Environmental Change: Research Pathways for the Next Decade, National Research Council, 1999.
5. Our Common Journey: A Transition toward Sustainability, National Research Council, 1999.

COURSE OUTCOME: Students would be able to address climate change and species' resilience.

LAB / FIELD WORK - 3

ECOL: 504 **CREDITS: 2**

REMOTE SENSING AND GIS - LAB

a. Satellite data downloading from Repository
b. Layer stacking
c. False color composite preparation
d. Unsupervised classification
e. Supervised classification
f. Head-up interpretation
g. Accuracy assessment
h. Map composition

CLIMATE CHANGE AND ECOSYSTEM RESILIENCE - FIELD WORK

a. Data collection,
b. Analysis, and
c. Report preparation