

# BIOLOGICAL SCIENCES (BIOL)

## Degrees Offered: Ph.D., M.S.

*This program is offered in Durham.*

The Biological Sciences Graduate Program offers M.S. and Ph.D. degrees in Biological Sciences, with options in Integrative and Organismal Biology and Marine Biology.

### Integrative and Organismal Biology (IOB)

This option offers a home to students interested in basic organismal biology in all of its diverse aspects (physiology, neurobiology, behavior, cell biology, genetics, evolution, ecology, systematics, etc.), in both terrestrial and aquatic environments. Modern biology employs approaches and tools ranging from molecular to ecological levels to gain a deep understanding of organismal functions and adaptations. Students in IOB approach their studies with a focus on organisms, and apply whatever tools are necessary to answer thematic and specific questions. Students interested in combining hands-on biological projects with research on teaching and learning biology at the post-secondary level should choose this option.

### Marine Biology (MB)

This option is intended for students interested in marine, coastal, and estuarine ecosystems, and the organisms that inhabit them, at all levels of inquiry. Some faculty at UNH use marine organisms, ranging from microbes to fish, invertebrates, and macroalgae to study physiology, molecular phylogeny, and species interactions; others focus on the structure and function of marine ecosystems. Faculty interests range from basic research on marine organisms and systems to applied areas such as aquaculture and fisheries# many combine the two.

### Related programs

Students interested in fields such as agriculture and animal science should review programs available through the [Department of Agriculture, Nutrition, and Food Systems](#); those interested in molecular biology and genomics should review programs in the [Department of Molecular, Cellular and Biomedical Sciences, including Genetics and Molecular & Evolutionary Systems Biology](#); those interested in ecosystems, wildlife and forestry should review programs in the [Department of Natural Resources and the Environment](#), including [Natural Resources and Earth Systems Science \(NRESS\)](#).

## Admission Requirements

Applicants ordinarily will have completed an undergraduate major in biology or a related field. A basic array of courses including general biology, development, ecology, genetics, morphology, and physiology is recommended# applicants should have completed organic chemistry and a semester each of calculus and physics. Applicants whose preparation does not meet these criteria can be admitted to the program, but may need to remedy any deficiencies via courses that do not give graduate credit.

All applicants are strongly encouraged to communicate with potential advisors as part of the application process. Identifying an advisor is normally a prerequisite for admission. To contact a potential advisor in the [Marine Biology](#) or [Integrative Organismal Biology](#) option, please see the lists of faculty.

## Research and Facilities

The Biological Sciences graduate program is enhanced by research in other departments and institutes across the University.

These include the [School for Marine Sciences and Ocean Engineering](#) and its associated programs and facilities:

- [N.H. Sea Grant Program](#);
- the Institute for the [Study of Earth, Oceans, and Space \(EOS\)](#);
- [the UNH Center for Coastal and Ocean Mapping/Joint Hydrographic Center](#); and (CCOM);
- [the Ocean Processes Analysis Laboratory \(OPAL\)](#).

There are four aquatic laboratories:

- [Jackson Estuarine Lab](#),
- [Judd Gregg Marine Research Complex](#),
- the Aquaculture Research Center (ARC), and
- the [Shoals Marine Laboratory \(SML\)](#).

[The Center for Freshwater Biology \(CFB\)](#) jointly administers (with the UNH Cooperative Extension) the [Lakes Lay Monitoring Program](#), which is dedicated to the preservation and sound management of lakes through citizen-based monitoring and research.

[The University of New Hampshire Collection of insects and other arthropods](#) is the largest arthropod depository and research collection in Northern New England (700,000 specimens and growing). Over 12,000 species are represented from different regions of New England, featuring many specimens collected from the White Mountains.

In addition, research in plant biology and agriculture is carried out in the [Macfarlane Research Greenhouses](#), the [Hodgdon Herbarium](#), and [UNH's agricultural facilities](#).

[The Hubbard Center for Genomic Studies](#) provides training and research in comparative and environmental genomics, with a special emphasis on novel model species. It provides expertise in constructing DNA libraries, DNA sequencing, fragment analysis, and the analysis of gene expression.

<https://colsa.unh.edu/biological-sciences>

## Programs

- [Biological Sciences: Integrative and Organismal Biology \(Ph.D.\)](#)
- [Biological Sciences: Marine Biology \(Ph.D.\)](#)
- [Biological Sciences: Integrative and Organismal Biology \(M.S.\)](#)
- [Biological Sciences: Marine Biology \(M.S.\)](#)

## Courses

### Animal Sciences (ANSC)

**ANSC #801 - Physiology of Reproduction**

**Credits: 4**

Comparative aspects of embryology, anatomy, endocrinology, and physiology of reproduction. Lab.

**Grade Mode:** Letter Grade

**ANSC 808 - Ruminant Nutritional Physiology****Credits:** 3

Anatomy of the ruminant gastrointestinal tract, physiological factors related to rumen function, and microbial and whole-body metabolism of carbohydrates, protein, and lipids. Prereq: general microbiology or equivalent.

**Grade Mode:** Letter Grade**ANSC 810 - Dairy Nutrition****Credits:** 4

Feeding and related management of dairy cows, nutrients and their use, digestive anatomy, physiology, energy systems, forage quality and conservation methods, metabolic disorders, ration balancing. Prereq: principles of nutrition; nutritional biochemistry or equivalent, permission.

**Grade Mode:** Letter Grade**ANSC 815 - Physiology of Lactation****Credits:** 4

Examines the biological and biochemical influences of the lactation process. Emphasis on the physiological effects of environments, hormones, and nutrition on milk synthesis and secretion, mammary physiology, and maternal response. Prereq: physiology of reproduction, permission.

**Grade Mode:** Letter Grade**ANSC 827 - Advanced Dairy Management I****Credits:** 4

Advanced management evaluation of milking procedures, reproduction, nutrition, mastitis, and calf and heifer management. Prereq: principles of nutrition, permission.

**Grade Mode:** Letter Grade**ANSC 828 - Advanced Dairy Management II****Credits:** 4

Advanced management evaluation of dairy cattle, housing, milking equipment, milk quality, record keeping, herd health, financial, personnel management, environmental issues. Visits to farms in the area to provide critical assessments of dairy farm businesses. Prereq: advanced dairy management I, permission. Special fee.

**Grade Mode:** Letter Grade**ANSC 895 - Investigations****Credits:** 1-4

Investigations in genetics, nutrition, management, diseases, histology, equestrian management/agribusiness, physiology, cell biology, microbiology, dairy management, or teaching experience. Prereq: permission.

**Repeat Rule:** May be repeated for a maximum of 4 credits.**Grade Mode:** Letter Grade**ANSC 899 - Master's Thesis****Credits:** 1-6

Master's students must enroll for a total of 6 credits of this course. Students may enroll in 1-6 credits per semester. Cr/F.

**Repeat Rule:** May be repeated for a maximum of 6 credits.**Grade Mode:****ANSC 995 - Non-thesis Investigations in Animal Science****Credits:** 1-4

Advanced investigations in a research project, exclusive of thesis project. Elective only after consultation with the instructor. Offered both fall and spring semesters.

**Repeat Rule:** May be repeated for a maximum of 4 credits.**Grade Mode:** Letter Grade**ANSC 999 - Doctoral Research****Credits:** 0

Cr/F.

**Grade Mode:**

## Biology (BIOL)

**BIOL 801 - Plant Physiology****Credits:** 4

Knowledge about principles of plant physiology is critical to understand how plants work and what happens between planting a seed and picking up a flower or a fruit. This course focuses on fundamentals of plant physiology and metabolism using lecture and laboratory investigations. Lecture topics include: plant-water relations, mineral nutrition, photosynthesis and respiration, plant metabolism, signaling and hormones, growth and development, and plant-environment interactions. Labs will be project-based and students will conduct experiments to explore basic plant processes. Prereq: Knowledge of plant biology and chemistry (introductory plant biol/botany and college level general or organic chemistry); or permission.

**Equivalent(s):** PBIO 801**Grade Mode:** Letter Grade**BIOL #802 - Lab Techniques in Plant Physiology and Biochemistry****Credits:** 4

The course provides a hands-on experience with instrumentation and experimental procedures for analysis of plant growth and metabolism. Experiments demonstrate the regulation of plant growth and development in response to environmental and chemical factors, analysis of cellular contents and processes, and use of modern instrumentation and analytical tools for physiological and biochemical studies.

Experiments deal with plant water relations, photosynthesis, plant hormones, enzyme kinetics, use of spectrophotometry and fluorometry, aseptic procedures, and liquid and thin-layer chromatography. Special lab fee. Prereq: BIOL 411, BIOL 412, BIOL 701/801 or permission of instructor.

**Equivalent(s):** GEN 802**Grade Mode:** Letter Grade**BIOL 804 - Plant-Microbe Interactions****Credits:** 3

Microbes and plants have developed intriguing strategies to encourage, resist or profit from their coexistence. The primary objective of the course is to provide students with a comprehensive overview of the various ways in which microbes interacts with plants, the outcomes of that interplay, and applications of these interactions and explore how these interactions impact ecosystem function. Prereq: BIOL 411 and BIOL 412, BMS 503 and BMS 504 or GEN 604.

**Grade Mode:** Letter Grade**BIOL 805 - Molecular and Cellular Neurobiology****Credits:** 4

The overarching goal of this course is to examine the molecular and cellular mechanisms underlying neuronal function. This course builds on fundamental knowledge in neuroscience. Students will be exposed to primary literature regarding the most advanced techniques in neuroscience, with emphasis in cellular and molecular processes. Students will learn how different model organisms have been used to understand neurons. Graduate students should have a strong background in chemistry, biochemistry and cell biology, and must obtain permission to register.

**Grade Mode:** Letter Grade

**BIOL 806 - Data Science with R for the Life Sciences****Credits:** 4

Introduces students to the basic data analysis and programming tools commonly used throughout the life sciences. Students will become proficient in R programming, data wrangling and cleaning, the principles of open and reproducible science, SQL database management, version control via Git/Github, building maps, and Bash command lines. Data sets and case studies from across the life sciences will be used throughout the course. The class culminates with a small group project.

**Grade Mode:** Letter Grade**BIOL 809 - Plant Stress Physiology****Credits:** 3

Plants cannot move in order to avoid challenging environmental conditions. Hence, plants developed other mechanisms that allow them to cope with stress. This course focuses on the mechanisms deployed by plants to respond to stressful conditions, some responses being nothing short of chemical and biological warfare. Biotic and abiotic stresses covered include pathogens, herbivores, drought, salinity, temperature, UV radiation, and heavy metals. Agricultural and ecological implications are discussed.

**Equivalent(s):** PBIO 809**Grade Mode:** Letter Grade**BIOL 811 - Experimental Design & Analysis****Credits:** 4

Design and analysis of biological and ecological research experiments. "Real world" studies used to discuss the identification of hypotheses, appropriate experimental design, and the application of statistical analyses including ANOVA, ANCOVA, correlation and regression, cluster analysis, classification and ordination techniques. Theoretical statistical concepts tailored to consider students' own thesis and dissertation research, allowing statistical problems to be addressed at various stages of the research process. Common computer packages used for analyses include Excel, JMP, Systat and R.

**Grade Mode:** Letter Grade**BIOL 812 - Experimental Design Seminar****Credits:** 2

Explore the experimental design of your own and your classmates' current or proposed graduate research projects. Learn to recognize the difference between good and bad experimental designs by analyzing recently published studies in your field of interest. Learn the secrets of statistical reviewers and how to avoid mistakes that will prevent your work from being published. Prereq: BIOL 811 or upper level stats course.

**Grade Mode:** Letter Grade**BIOL 814 - Model Organisms in Biological and Medical Research****Credits:** 2

Animals, plants, and microbes serve as powerful tools for both basic and biomedical research. This course integrates historical, philosophical, sociological, and biological perspectives to examine how models are chosen and used, and how to evaluate their strengths and weaknesses. Students will study particular model species in depth, and address general epistemological questions about the choice and use of model organisms. This course is designed for graduate students and advanced undergraduates interested in research.

**Grade Mode:** Letter Grade**BIOL 820 - Plant-Animal Interactions****Credits:** 4

Animals and plants engage in a range of interactions, from plant-pollinator and plant-ant mutualisms to plant-herbivore and carnivorous plant antagonisms. This course will explore the consequences of a variety of interactions on the evolution of traits in both animals and plants, considering implications for both conservation and agriculture. Weekly recitation. Prereq: BIOL 412.

**Grade Mode:** Letter Grade**BIOL 827 - Animal Communication****Credits:** 4

This course examines the principles underlying how animals communicate with each other and why they communicate the way they do by using perspectives drawn from a broad range of disciplines including physics, chemistry, ecology, psychology, economics, and behavioral ecology. Students will explore the primary literature, and work in teams to conduct independent research. The course is intended for advanced undergraduate or graduate students interested in neuroscience and behavior, evolution, wildlife and conservation biology, or zoology. Prereq: BIOL 412.

**Grade Mode:** Letter Grade**BIOL 828 - Marine Bioacoustics****Credits:** 3

Marine bioacoustics is a highly interdisciplinary field of science that requires knowledge of marine biology, oceanography, physics, and engineering. This course provides an introduction to the role of acoustics in aquatic biological systems and how acoustics is used to study biological processes and ecosystem dynamics. Topics include: marine animal hearing; sound production; behavior; echolocation; remote sensing; research methods; and the impacts of sounds on marine animals. It is suggested that students have a strong background in biology. College level physics and calculus is suggested.

**Grade Mode:** Letter Grade**BIOL #829 - Agricultural Waste Management****Credits:** 4

The management of agricultural wastes is crucial in the development of sustainable agricultural practices. This course covers principles of managing, handling, treating, and applying animal manures and organic byproducts from an agricultural system perspective. Topics include waste characterization, descriptions of systems and technology, utilization of wastes as resources (land application, composting electricity generation, fertilization, etc.), land application principles, preparations of waste management plans, and potential impacts to the environment. Prereq: SAFS 502 or permission of instructor.

**Grade Mode:** Letter Grade**BIOL 852 - New England Mushrooms: a Field and Lab Exploration****Credits:** 4

This is a hands-on field, lab and lecture course in the identification, classification, life histories, and ecology of mushrooms and other macrofungi. Lectures focus on macrofungal ecology and systematics. Laboratory instruction emphasizes morphological, microscopic, and molecular identification techniques, plus the use of smart-phone field note recording and on-line resources. Several field trips are required in addition to the weekly laboratory. Previous experience with fungi is not required. Grades are based on a collection, a project, and presentations. Prereq: Intro course in Biology or Plant Biology, or permission.

**Equivalent(s):** PBIO 852**Grade Mode:** Letter Grade

**BIOL 855 - Biological Oceanography****Credits:** 4

Biological processes of the oceans, including primary and secondary production, trophodynamics, plankton diversity, zooplankton ecology, ecosystems and global ocean dynamics. Field trips on R/V Gulf Challenger and to the Jackson Estuarine Laboratory. Prereq: One year of biology or permission of the instructor. Special Fee.

**Equivalent(s):** ESCI #850, ZOO 850**Grade Mode:** Letter Grade**BIOL 873 - Physiology of Fishes****Credits:** 4

Investigates the physiological processes responsible for maintaining homeostasis in fishes. Focuses on the function and regulation of the major organ systems during stress and environmental adaptation. Topics include reproduction, osmoregulation, digestion, endocrinology, and sensory perception. Special Fee.

**Equivalent(s):** ZOO 873**Grade Mode:** Letter Grade**BIOL 895 - Advanced Studies****Credits:** 1-4

Advanced research or seminar, supervised by a faculty member.

**Grade Mode:** Letter Grade**BIOL 899 - Master's Thesis****Credits:** 1-10

Master's thesis research. Cr/F.

**Repeat Rule:** May be repeated for a maximum of 10 credits.**Grade Mode:****BIOL 901 - Introductory Graduate Seminar****Credits:** 2

This seminar provides an introduction to the Biological Sciences Graduate Program, offering students an overview of program structure and requirements, introducing faculty research and campus resources, and helping participants develop skills and strategies useful in graduate school. Requirements include preparation of a written research proposal and a brief oral presentation. Cr/F.

**Equivalent(s):** ZOO 901**Grade Mode:****BIOL 902 - Writing and Publishing Science****Credits:** 2

Participants in this seminar (1) make significant progress on one or more of their current academic writing projects; (2) increase their understanding of the genres, protocols, and mechanisms of scientific writing and publishing; and (3) develop strategies and skills for getting professional writing done efficiently and well, in graduate school and beyond. Cr/F.

**Repeat Rule:** May be repeated for a maximum of 6 credits.**Grade Mode:****BIOL #903 - Graduate Research Techniques****Credits:** 2

Introduction to a range of research approaches in biology and to research skills needed for success in graduate school and beyond. Topics include scientific methods and experimental design, research techniques, and instrumentation available for graduate research. Cr/F. Offered every spring.

**Grade Mode:****BIOL 950 - Scientific Communication****Credits:** 2

Professional success in science depends on the ability to communicate, both by publishing in professional journals and by explaining the implications of research to a broad audience. This course covers a wide range of topics related to scientific communication. Students work on multiple forms of communication, practice communicating science to the public, strengthen peer reviewing skills, explore online scientific communities, and enhance awareness of relevant economic, legal, and ethical issues.

**Equivalent(s):** LSA 950**Grade Mode:****BIOL #997 - Graduate Seminar in Biology****Credits:** 1-2

Current topics in biological sciences; discussion of literature in the field, and student research. Topics span a wide range of biological disciplines (agricultural sciences, marine biology, integrative and organismal biology, etc.), and vary to reflect the faculty and student interests.

**Repeat Rule:** May be repeated for a maximum of 8 credits.**Grade Mode:****BIOL 999 - Doctoral Dissertation Research****Credits:** 0

Doctoral dissertation research. Cr/F.

**Grade Mode:**

## Marine, Estuarine and Freshwater Biology (MEFB)

**MEFB 817 - Lake Ecology****Credits:** 4

Introduction to the ecology of freshwater systems with emphasis on lakes. Origins of lakes and the effects of watersheds on lake chemistry and nutrient cycling are explored. Other topics include the impact of human disturbances on productivity and aquatic food webs and methods used for the management and restoration of lakes. Comparisons are made of the structure and functions of lake ecosystems found in temperate, tropical and arctic regions. Prereq: general biology.

**Equivalent(s):** PBIO 817, ZOO 817**Grade Mode:** Letter Grade**MEFB 819 - Field Studies in Lake Ecology****Credits:** 4

Ecology of lakes and other freshwater habitats examined through field studies. Emphasizes modern methods for studying lakes, analysis and interpretation of data, and writing of scientific papers. Seminars on research papers and student presentations of class studies. Field trips to a variety of lakes, from the coastal plain to White Mountains; investigate problems, such as eutrophication, acidification, biodiversity and biotoxins. Capstone experiences include interaction with state agencies, lake stakeholders and the submission of written manuscripts for publication. Prereq: introductory biology. Special fee. Lab.

**Equivalent(s):** PBIO 819, ZOO 819**Grade Mode:** Letter Grade

**MEFB 825 - Marine Ecology****Credits:** 4

Marine environment and its biota, emphasizing intertidal and estuarine habitats. Includes field, laboratory, and independent research project.

Prereq: general ecology; permission. Marine invertebrate zoology, oceanography, and statistics are desirable. Special fee. (Not offered every year.)

**Equivalent(s):** PBIO 825, ZOOL 825**Grade Mode:** Letter Grade**MEFB #832 - Lake Management****Credits:** 4

Lectures and seminars on interpreting lake water quality, developing a natural history inventory for lakes, the process of creating a lake management plan, and resolution of conflicting uses of lakes. Students develop lake management plans in cooperation with governmental agencies and lake associations. Guest speakers from State agencies and non-governmental organizations. Introduction to and use of GIS (Geographic Information Systems) methods for the analysis of lakes and watersheds. Presents lake management issues from scientific and social science points of view. Open to students from all disciplines. Special fee. Lab.

**Equivalent(s):** PBIO 832, ZOOL 832**Grade Mode:** Letter Grade**MEFB 847 - Aquatic Plants in Restoration/Management****Credits:** 4

A field-intensive class focusing upon freshwater and marine vascular plants with an emphasis on species commonly associated with ecological restoration, the identification and conservation of rare species, and the adaptations and management of invasive species of aquatic habitats in New England. Field trips emphasize the flora of various wetland habitats, including open water and vegetated fresh water wetlands, as well as coastal and estuarine habitats. Lectures and readings examine the current trends in research and management focusing upon specific taxa and pertinent facets of their taxonomy, physiology, and natural history. Prereq: BIOL 566 or permission. Special fee.

**Equivalent(s):** PBIO 847**Grade Mode:** Letter Grade**MEFB 872 - Fisheries Biology: Conservation and Management****Credits:** 3

Globally, many fished populations are declining, but 3.2 billion people eat fish and the average human eats >40 pounds of fish a year. This course identifies what biological characteristics are important to management and how they are measured. The course also explores quantitative methods describing fishery-population interactions and other management tools. Lastly, students will learn about the impacts of fishing on ecosystems. Prereq: BIOL 411 and BIOL 412 or equivalent.

**Equivalent(s):** ZOOL 872**Grade Mode:** Letter Grade**Natural Resources (NR)****NR #801 - Ecological Sustainability and Values****Credits:** 4

Deeper more fundamental philosophical questions, including spiritual values questions, are being asked concerning the ecological/ environmental challenge of our time; its causes and resolution. Aspects of this challenge—environmental education, energy, food, agriculture, and natural resources—analyzed with ethics and values approaches. Students develop ways of responding to problem identification and resolution.

**Equivalent(s):** EC 802**Grade Mode:** Letter Grade**NR 803 - Watershed Water Quality Management****Credits:** 4

Principles of land use as they relate to water quality and quantity. Lectures focus on biogeochemical cycles and the watershed approach to land and water resource management. Labs and field trips focus on methods of water sampling and analysis. One year of chemistry is recommended. Prereq: freshwater resources or watershed hydrology, or permission. Special fee. Lab/field trips.

**Equivalent(s):** WARM 803**Grade Mode:** Letter Grade**NR 806 - Soil Ecology****Credits:** 4

Examines the ecological relationships between soil microorganisms and their biotic and abiotic environment, with emphasis on the role of soil microorganisms in biogeochemical cycling. Specific objectives are to examine the biodiversity present in soil systems, factors controlling microbial community composition and diversity, and linkages between soil microbial communities, soil physical properties, and soil organic matter and nutrient cycling dynamics. Prereq: Introduction to principles of biology, general chemistry or equivalent, or permission. Lab. Special fee.

**Equivalent(s):** SOIL 806**Grade Mode:** Letter Grade**NR 807 - Environmental Modeling****Credits:** 4

Environmental Modeling introduces students to a range of key mathematical and computer modeling concepts and the ways they can be used to address important scientific questions. The course is divided into four topical sections: Population and Community Ecology, Hydrology, Biogeochemistry, and Ecosystems. In each section, modeling concepts and skills are presented together with environmental information to emphasize the linkage between quantitative methods and relevant scientific results. Prereq: MATH 425. (Also listed as EOS 807.)

**Equivalent(s):** EOS 807**Grade Mode:** Letter Grade**NR #811 - Wetland Ecology and Management****Credits:** 4

Analysis of the natural resources of coastal and inland wetlands and environmental problems caused by human use and misuse of these ecosystems. Groups will collect field data to summarize the structure and function of four wetland types within a management context. Special fee. Lab. Prereq: general ecology; watershed water quality management;/ or permission. Special fee. Lab/field trips.

**Equivalent(s):** FOR 811, FORS 811, WARM 811**Grade Mode:** Letter Grade



**NR 812 - Mammalogy****Credits:** 4

Evolution, ecology, behavior, physiology and diversity of mammals. The focus of the course is on conceptual issues, such as the relation of structure, function, physiology and ecology of species; reproductive physiology and life history strategies; and the evolution of mating systems and social structure. Familiarity of mammalian groups to the family level and identification of local fauna to species will be required. Prereq: BIOL 411 and BIOL 412 or equivalent. Lab. (Not offered every year.) Special fee.

**Grade Mode:** Letter Grade**NR #818 - Law of Natural Resources and Environment****Credits:** 3

Federal and state environmental statutory and administrative law, its application, strengths and weaknesses, and options for future amendment.

**Equivalent(s):** EC 818**Grade Mode:** Letter Grade**NR 820 - International Environmental Politics and Policies for the 21st Century****Credits:** 4

Students examine policies for managing human activities to sustain the health of regional ecosystems and planetary life-support systems. Selected problems of the international commons (oceans, marine resources, atmosphere, migratory species); global and regional carrying capacity (population, resource consumption), internationally shared ecosystems (trans-boundary watersheds, water-bodies, tropical forests); and the relevant international institutions and politics for policy formation, conflict resolution, and implementation. Using a policy-analytic framework, students develop case studies to assess international policies and institutional arrangements to achieve the objectives of Agenda 21–Earth Summit Strategy to Save the Planet. Prereq: permission.

**Equivalent(s):** EC 820**Grade Mode:** Letter Grade**NR 824 - Resolving Environmental Conflicts****Credits:** 4

Theories and practices of environmental dispute settlement. Roles of public, non-governmental and governmental organizations. Effectiveness of public participation initiatives in influencing public policy decisions and/or resolving environmental conflicts. Alternative approaches to consensus (policy dialogues, joint problem solving; strategic planning; negotiation, mediation) as well as litigation. Specific cases are critiqued and evaluated; conflict resolution skills are developed. Students observe and/or participate in ongoing local decision processes. Prereq: permission. Lab. Special fee.

**Equivalent(s):** EC 824**Grade Mode:** Letter Grade**NR 829 - Silviculture****Credits:** 4

The science and art of establishing, growing, and tending forests to meet multiple objectives. Basics of forest stand dynamics applied to the problems of timber management, wildlife habitat, water quality, and carbon sequestration. Prereq: NR 425 and NR 527 or permission. Special fee.

**Grade Mode:** Letter Grade**NR 830 - Terrestrial Ecosystems****Credits:** 4

Processes controlling the energy, water, and nutrient dynamics of terrestrial ecosystems; concepts of study at the ecosystem level, controls on primary production, transpiration, decomposition, herbivory; links to Earth-system science, acid deposition, agriculture. Prereq: forest ecology and introduction to botany or principles of biology, or permission.

**Equivalent(s):** EOS 830**Grade Mode:** Letter Grade**NR 834 - Tropical Ecology****Credits:** 4

This course introduces students to the ecology of different tropical ecosystems, and involves students in analyzing and interpreting ecological field data and remotely sensed data. An important emphasis is to understand patterns and processes across scales - from individual plants to ecosystems and landscapes. The also addresses important global issues in the tropics, including climate change, land use change, diverse ecosystem services, and sustainable resource management.

**Equivalent(s):** FOR 834**Grade Mode:** Letter Grade**NR 840 - Inventory and Monitoring of Ecological Communities****Credits:** 4

Provides an introduction to the major concepts associated with monitoring change in ecological communities. Students develop an appreciation for such issues as: identification of appropriate baselines for comparison; use of indicator species; the tools used to inventory common, rare, and secretive species; how trend data are analyzed; and the implications of failing to detect an indicator species. Restricted to senior wildlife majors others by permission. Special fee. Lab.

**Grade Mode:** Letter Grade**NR 843 - Ecology and Society in a Changing Arctic****Credits:** 4

Students will gain an in-depth understanding of the effect of climate change on ecology and people in the Arctic, which is experiencing rapid climate change. As a team, students will tackle a research project and contribute new knowledge in the form of a peer-reviewed publication, policy brief, outreach product, or other technical document. Graduate students are expected to be leaders in this inquiry-based course, particularly in the statistical analysis in R and writing of products.

**Grade Mode:** Letter Grade**NR 844 - Biogeochemistry****Credits:** 4

Examines the influence of biological and physical processes on elemental cycling and geochemical transformations from the molecular to the global scale, involving microorganisms, higher plants and animals and whole ecosystems; factors that regulate element cycles including soils, climate, disturbance and human activities; interactions among the biosphere, hydrosphere, lithosphere, and atmosphere; transformations of C, N, S, and trace elements. Prereq: one semester biology and two semesters chemistry or permission. (Also offered as EOS 844.)

**Equivalent(s):** EOS 813, EOS 844**Grade Mode:** Letter Grade**NR 845 - Forest Management****Credits:** 4

Forest land ownership; management objectives; forest inventory regulation and policy; forest administration; professional responsibilities and opportunities. Restricted to Natural Resources majors. Lab. Special fee.

**Equivalent(s):** FOR 845**Grade Mode:** Letter Grade

**NR 849 - Forest Inventory and Modeling****Credits:** 4

Applied sampling and statistical techniques for assessing current forest conditions and predicting future growth, yield, and structure. Topics include plot and point sampling, ecological inventory, and evaluation of site quality and stand density. Prereq: MATH 420 and BIOL 528. Special fee.

**Grade Mode:** Letter Grade**NR 851 - Aquatic Ecosystems****Credits:** 4

Energy flow and nutrient cycling in streams, rivers and lakes, with an emphasis on understanding the control of primary productivity, decomposition and community structure by both hydrologic and biotic drivers. Role of aquatic ecosystems in carbon and nitrogen budgets at watershed, regional, and global scales. Impacts of environmental changes such as global climate change and suburbanization on aquatic ecosystems. Lab. Prereq: General Ecology.

**Grade Mode:** Letter Grade**NR 857 - Remote Sensing of the Environment****Credits:** 4

Practical and conceptual presentation of the use of remote sensing and other geospatial technologies for mapping and monitoring the environment. This course begins with the use of aerial photographs (photogrammetry, and photo interpretation) and includes measures of photo scale and area, parallax and stereo viewing, object heights, flight planning, photo geometry, the electromagnetic spectrum, camera systems and vegetation/land cover mapping. The course concludes with an introduction to other geospatial technologies including digital image analysis, global positioning (GPS), and geographic information systems (GIS). Conceptual lectures are augmented with practical homework assignments and hands-on lab exercises. Prereq: algebra. Special fee. Lab.

**Equivalent(s):** GEOG 757**Grade Mode:** Letter Grade**NR 859 - Digital Image Processing for Natural Resources****Credits:** 4

Introduction to digital remote sensing, including multispectral scanners (Landsat and SPOT) radar, and thermal imagery. Hands-on image processing including filtering, image display, ratios, classification, registration, and accuracy assessment. GIS as it applies to image processing. Discussion of practical applications. Use of ERDAS image-processing software. Knowledge of PCs required. Prereq: NR 857 or equivalent and permission.

**Grade Mode:** Letter Grade**NR 860 - Geographic Information Systems in Natural Resources****Credits:** 4

This course in geographic information systems (GIS), covers advanced theory, concepts, and applications of GIS for natural resource and related disciplines. Discussion of database structures, data sources, spatial data manipulation/analysis/modeling, data quality and assessment. Students conduct a project of their design exploring aspects of GIS most useful to them. Lecture emphasizes concepts and applications through a text and selected peer-reviewed articles. Lab uses the latest version of ArcGIS software and provides hands-on experience. Prereq: introductory GIS course. Permission required.

**Grade Mode:** Letter Grade**NR 861 - Environmental Soil Chemistry****Credits:** 4

Chemical transformations in soils are the basis for soil fertility and plant productivity in natural and managed ecosystems, and also influence key ecosystem processes including soil organic matter turnover and soil-atmosphere exchange of trace gases. This class will explore soil chemistry processes and transformations related to soil nutrient cycling, plant nutrient acquisition, and other critical environmental services. Prereq: a course in soil science or instructor permission.

**Grade Mode:** Letter Grade**NR 882 - Forest Health****Credits:** 4

Forests cover over 30% of the land surface of the Earth and are incredibly important ecologically, economically, and to the health of the planet. While forests show great capacity to withstand disturbance, these ecosystems are increasingly threatened worldwide by climate change, native and introduced insects and disease, poor management practices, land clearing, drought, fire, and pollution. This course offers an overview of the dominant threats to forests, their causes and consequences, and options for monitoring, management, and mitigation. Special fee.

**Grade Mode:** Letter Grade**NR 887 - Advanced Topics in Sustainable Energy****Credits:** 4

This course will engage students in advanced topics in sustainable energy. Course reviews basic structure of our energy system, energy markets and economics, and the environmental, economic and technological of our energy landscape. Focus will be on electricity and building use with introductions to the transportation system. Students will gain the knowledge to evaluate innovations in technology, policy and financing necessary to implement sustainable energy goals from conservation and efficiency to renewables and energy storage. Prereq: NR 507 or CHE 410 or POLT 444.

**Grade Mode:** Letter Grade**NR 899 - Master's Thesis****Credits:** 1-10

Usually 6 credits, but up to 10 credits when the problem warrants. Cr/F.

**Repeat Rule:** May be repeated for a maximum of 10 credits.**Grade Mode:****NR #902 - Ecological Ethics and Values****Credits:** 4

Increasingly fundamental philosophical questions, including spiritual values questions, are posited concerning the ecological/environmental challenge of our time, its causes, and its resolution. Examination of these questions, put forth with ethics and values approaches. Students work to develop responses to both problem identification and resolution.

**Grade Mode:** Letter Grade**NR 903 - Approach to Research****Credits:** 2

Provides incoming graduate students with an overview of the scientific method, peer review, and various research approaches and methods. Ethics, institutional and individual responsibilities, and effective communication are also addressed in a seminar and discussion format. Cr/F.

**Grade Mode:**

**NR 905 - Grant Writing****Credits:** 2

The ability to secure financial support for research and outreach activities is becoming increasingly important. This course is intended for graduate and post-graduate level students who need to write proposals for their graduate work or to gain external funding from government agencies. Students will gain in-depth understanding of the proposal writing process through class discussions, insights shared by UNH faculty, and by writing a research proposal following the entire process.

**Equivalent(s):** SOIL 905, WARM 905**Grade Mode:****NR 907 - Genomes to Phenomes Seminar****Credits:** 1

This seminar-style class examines linkages between genotype, phenotype and fitness in natural populations through readings of the primary literature. Topics covered include organismal adaptation, evolutionary ecology, adaptive capacity, resilience to climate change, environmental genomics, microbiome evolution, and environmental DNA monitoring. Students will gain an appreciation for the role of genomics ecological, evolution, and conservation science.

**Repeat Rule:** May be repeated for a maximum of 2 credits.**Grade Mode:****NR 908 - Landscape Genetics****Credits:** 3

This course provides interdisciplinary training and overview of landscape genetics – the application of genetic and genomic tools to the study of organismal connectivity, dispersal and gene flow across the landscape. The course caters to graduate students in both basic and applied ecology and ecological genetics/genomics. Through a combination of online lectures distributed across multiple participating institutions and in-class seminar-style format, students learn from international experts and discuss papers with local peers.

**Grade Mode:** Letter Grade**NR 909 - Analysis of Ecological Communities and Complex Data****Credits:** 4

This course introduces you to a suite of tools appropriate for analyzing and interpreting multivariate data arising from agroecological (and other ecological) research. In this course we cover a variety of multivariate analyses, including clustering, ordination (principle components analysis, nonmetric multidimensional scaling, correspondence analysis), group comparisons (multi-response permutation procedures, PerMANOVA, indicator species analysis, discriminant analysis, mantel test), and other hypothesis-driven techniques, including structural equation modeling.

**Grade Mode:** Letter Grade**NR #910 - Forest Stand Dynamics****Credits:** 4

Discussion and presentation on forest dynamics to include soil-site quality evaluation, individual tree growth, stand growth and yield, stand and forest management, and related resource politics. (Not offered every year.)

**Equivalent(s):** FOR 910**Grade Mode:** Letter Grade**NR #912 - Sampling Techniques****Credits:** 2-4

Techniques of sampling finite populations in environmental sciences; choice of sampling unit and frame, estimation of sample size, confidence limits, and comparisons of sample designs. Prereq: Applied statistics or equivalent. (Not offered every year.)

**Equivalent(s):** NR 812**Grade Mode:** Letter Grade**NR 947 - Ecosystem Science: Theory, Practice, and Management Applications for Sustainability****Credits:** 4

This course is designed for graduate students to explore in detail the fundamental principles and practical application of ecosystem science. Emphasis will be placed on understanding historical context as well as the most recent peer-reviewed literature. Writing assignments will emphasize local, regional, and international applications of ecosystem science to address environmental sustainability.

**Grade Mode:** Letter Grade**NR 965 - Community Ecology****Credits:** 4

This course investigates how community properties – species richness, and abundance distribution – are influenced by evolutionary history, landscape phenomena such as dispersal and migration, and local factors such as the physical environment, disturbance, competition, predation, and positive interactions. Mechanistic models of community dynamics, including succession, are discussed. The influence of species diversity on ecosystem function is discussed, and all aspects of the course are related to conservation science.

**Equivalent(s):** NR 865**Grade Mode:** Letter Grade**NR 993 - Natural and Environmental Resources Seminar****Credits:** 1 or 2

Presentation and discussion of recent research, literature, and policy problems in the natural and social sciences influencing resource use. Cr/F.

**Grade Mode:****NR 995 - Investigations****Credits:** 1-4

Investigations in Natural Resources may include topics in environmental conservation, forestry, soil science, water resources, and wildlife management. Permission required.

**Grade Mode:** Letter Grade**NR 996 - Natural Resource Education****Credits:** 2

Responsibilities include set-up, teaching, and grading of one lab section per week or equivalent lecture experience. Meets the teaching requirement for M.S. degree students. Cr/F.

**Grade Mode:****NR 998 - Directed Research****Credits:** 1-4

Student designs and conducts original research that culminates in a paper of publishable quality. Alternative to NR 899 for those choosing non-thesis degree option. Cr/F. IA (continuous grading).

**Repeat Rule:** May be repeated for a maximum of 4 credits.**Grade Mode:****Plant Biology (PBIO)****PBIO 899 - Master's Thesis****Credits:** 1-10

May be repeated up to a maximum of 10 credits. Cr/F.

**Repeat Rule:** May be repeated for a maximum of 10 credits.**Grade Mode:**



**PBIO #995 - Investigations****Credits:** 1-6

Supervised projects in selected areas of plant biology. A) Systematic Botany; B) Physiology; C) Pathology; D) Anatomy; E) Morphology; F) Ecology; G) Phycology; H) Mycology; I) Cell Biology; J) Cell Physiology; K) Microtechnique; L) Cell and Tissue Culture; M) Genetics; N) Crop Management; O) Developmental Plant Biology; P) Scientific Writing; Q) History of Botany; R) Teaching in Plant Biology; S) Plant Growth Research and Modeling. Prereq: permission.

**Grade Mode:** Letter Grade

## Zoology (ZOOL)

**ZOOL 810 - Sharks and Bony Fishes****Credits:** 4

Some fish swimming today are hundreds of years old, whereas others complete their life cycle in two months! This course provides an introduction to the diversity of fishes found across the globe, including elasmobranchs (sharks, skates, and rays) and teleosts (bony fishes). Particular attention will be paid to fishes local to New Hampshire and New England. Students will learn about fish anatomy, physiology, and ecology. Prereq: BIOL 411, BIOL 412, or equivalent. Lab. (Offered in alternative years.) Special Fee.

**Grade Mode:** Letter Grade**ZOOL 833 - Behavioral Ecology****Credits:** 4

Behavioral ecology is the evolution of animal behavior played out on the stage of ecology—why might a certain behavior be adaptive in a certain context? In this course, we will pursue in-depth, high-level explorations of the central topics of animal behavior, all through the lens of evolution. We will also focus heavily on improving reading, writing, and presentation skills.

**Grade Mode:** Letter Grade**ZOOL 836 - Genes and Behavior****Credits:** 4

Genes and behavior examines the genetic underpinnings of animal behavior, and how behavior evolves on a genetic level. The course primarily relies on readings from the primary literature, using examples from laboratory model organisms, animals in their natural habitats, and humans. Topics include aggressiveness, social behavior, personality, parental care, communication, mating behavior, novelty seeking behavior, and foraging. This interdisciplinary course examines these behaviors at multiple levels, including genomics, population genetics, molecular genetics, epigenetics, endocrinology, and neurobiology. Prereq: GEN 604 and ZOOL 613 or equivalent.

**Grade Mode:** Letter Grade**ZOOL 877 - Neuroethology: The Neural Basis of Animal Behavior****Credits:** 4

Students taking this course will discover how some of the most remarkable behavioral adaptations in animals can be understood by examining specialized sensory systems and neural circuits. By exploring the complex interactions between animal behavior, neural systems, evolutionary relationships, anatomy, physiology and ecology, students will be better equipped to understand the neural basis of behavior. A culminating writing project will help sharpen students' scientific writing skills, and the ability to understand the primary neuroethology literature. Prereq: BIOL 411 and BIOL 412, or permission. Physiology (ZOOL 625), or another introductory neurobiology course, also desirable.

**Grade Mode:** Letter Grade**ZOOL 895 - Advanced Studies****Credits:** 1-4

Independent study in various areas, including but not limited to: animal behavior; departmental biology; ecology; electron microscopy; evolution; genetics; histology; history of biology; invertebrate biology; neurobiology and behavior; physiology; teaching practices; underwater research; vertebrate biology; biological techniques. Course sections for advanced work, individual or group seminar. May include reading, laboratory work, organized seminars, and conferences. Prereq: permission of department chairperson and staff concerned.

**Grade Mode:** Letter Grade**ZOOL 899 - Master's Thesis****Credits:** 1-10

Prereq: permission of department chairperson and prospective supervisor. Cr/F.

**Repeat Rule:** May be repeated for a maximum of 10 credits.**Grade Mode:****ZOOL #997 - Seminar****Credits:** 1-2

Reports on recent zoological literature. Subject fields are those listed under ZOOL 895 and ZOOL 896; not all areas available every semester. Cr/F.

**Grade Mode:****ZOOL #998 - Seminar****Credits:** 1-2

Reports on recent zoological literature. Subject fields are those listed under ZOOL 895 and ZOOL 896; not all areas available every semester. Cr/F.

**Grade Mode:****ZOOL 999 - Doctoral Research****Credits:** 0

Cr/F.

**Grade Mode:**

## Faculty

<https://colsa.unh.edu/biological-sciences/people>