Bulletin of
Duke University

Nicholas School of the Environment
2014-2015
The information in this bulletin applies to the academic year 2014-2015 and is accurate and current, to the greatest extent possible, as of August 2014. The university reserves the right to change programs of study, academic requirements, teaching staff, the calendar, and other matters described herein without prior notice, in accordance with established procedures.

Duke University does not tolerate harassment of any kind. Sexual harassment and sexual misconduct are forms of sex discrimination and prohibited by the university. Duke University has designated Dr. Benjamin Reese, vice-president for institutional equity, as the individual responsible for the coordination and administration of its nondiscrimination and harassment policies. The Office of Institutional Equity is located in Smith Warehouse, 114 S. Buchanan Blvd., Bay 8, Durham, NC 27708. Dr. Reese's office telephone number is (919) 684-8222 and his e-mail address is ben.reese@duke.edu.

Questions or comments about harassment or discrimination can be directed to the Office for Institutional Equity, (919) 684-8222. Additional information, including the complete text of the harassment policy and appropriate complaint procedures, may be found by contacting the Office for Institutional Equity or visiting its website at: www.duke.edu/web/equity/.

Duke University recognizes and utilizes electronic mail as a medium for official communications. The university provides all students with e-mail accounts as well as access to e-mail services from public clusters if students do not have personal computers of their own. All students are expected to access their e-mail accounts on a regular basis to check for and respond as necessary to such communications, just as they currently do with paper/postal service mail.

Information that the university is required to make available under the federal Clery Act is available by visiting the Records Division, Duke University Police Department, 502 Oregon Street, Durham, NC 27708, or by calling (919) 684-4602. See http://duke.edu/police/news_stats/clery/index.php for more details.

The Family Educational Rights & Privacy Act (FERPA), 20 U.S.C § 1232g; 34 CFR Part 99, is a federal law that guides the release of students’ education records, of which disciplinary records are a part. For additional information about FERPA, see http://www.ed.gov/policy/gen/guid/fpco/ferpa/index.html.

Duke University is accredited by the Commission on Colleges of the Southern Association of Colleges and Schools to award baccalaureate, masters, doctorate, and professional degrees. Contact the Commission on Colleges at 1866 Southern Lane, Decatur, GA 30033-4097 or call (404) 679-4500 for questions about the accreditation of Duke University.

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The Mission of Duke University

James B. Duke’s founding Indenture of Duke University directed the members of the university to “provide real leadership in the educational world” by choosing individuals of “outstanding character, ability and vision” to serve as its officers, trustees and faculty; by carefully selecting students of “character, determination and application;” and by pursuing those areas of teaching and scholarship that would “most help to develop our resources, increase our wisdom, and promote human happiness.”

To these ends, the mission of Duke University is to provide a superior liberal education to undergraduate students, attending not only to their intellectual growth but also to their development as adults committed to high ethical standards and full participation as leaders in their communities; to prepare future members of the learned professions for lives of skilled and ethical service by providing excellent graduate and professional education; to advance the frontiers of knowledge and contribute boldly to the international community of scholarship; to promote an intellectual environment built on a commitment to free and open inquiry; to help those who suffer, cure disease and promote health, through sophisticated medical research and thoughtful patient care; to provide wide ranging educational opportunities, on and beyond our campuses, for traditional students, active professionals and life-long learners using the power of information technologies; and to promote a deep appreciation for the range of human difference and potential, a sense of the obligations and rewards of citizenship, and a commitment to learning, freedom and truth.

By pursuing these objectives with vision and integrity, Duke University seeks to engage the mind, elevate the spirit, and stimulate the best effort of all who are associated with the university; to contribute in diverse ways to the local community, the state, the nation and the world; and to attain and maintain a place of real leadership in all that we do.

Adopted by the Board of Trustees on February 23, 2001
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Megan Hayes, Student Representative
Sara Lindenfeld, Student Representative
Academic Calendar 2014-15

The Nicholas School

**Summer 2014**

- **February 17**: Monday—Registration begins for all summer sessions
- **May 14**: Wednesday—Term I classes begin. The Monday class meeting schedule is in effect on this day. (Therefore, all summer classes meet this day.) Regular class meeting schedule begins on Thursday, May 16; Drop/add continues
- **May 15**: Thursday—Regular class meeting schedule begins
- **May 16**: Friday—Drop/add for Term I ends
- **May 26**: Monday—Memorial Day holiday. No classes are held
- **June 23**: Monday. Term I classes end
- **June 24**: Tuesday—Reading period
- **June 25**: Wednesday—Term I final examinations begin
- **June 26**: Thursday—Term I final examinations end
- **June 30**: Monday—Term II classes begin
- **July 2**: Wednesday—Drop/add for Term II ends
- **July 4**: Friday—Independence Day holiday. No classes are held
- **August 7**: Thursday—Term II classes end
- **August 8**: Friday—Reading period (until 7 p.m.)
- **August 8**: Friday—Term II final examinations begin, 7 p.m.
- **August 10**: Sunday—Term II final examinations end

**Fall 2014**

- **August 18**: Monday—New graduate student orientation begins
- **August 20**: Wednesday—4 p.m. Convocation for graduate and professional school students
- **August 25**: Monday—8:30 a.m. Fall semester classes begin; Drop/add continues
- **September 1**: Monday—Labor Day. Classes in session
- **September 5**: Friday—Drop/add ends
- **September 19**: Friday—5:30 p.m. Founders’ Day Convocation
- **September 21**: Sunday—Founders’ Day
- **October 10**: Friday—7 p.m. Fall break begins
- **October 15**: Wednesday—8:30 a.m. Classes resume
- **November 5**: Wednesday—Registration begins for Spring 2014
- **November 19**: Wednesday—Registration ends for Spring Semester, 2014
- **November 20**: Thursday—Drop/add begins for Spring 2014
- **November 25**: Tuesday—10:30 p.m. Thanksgiving recess begins
- **November 25**: Tuesday—Graduate classes end
- **December 1-8**: Monday-Monday—Graduate reading period
- **December 9**: Wednesday—Drop/add begins for Spring 2014
- **December 14**: Sunday—10 p.m. Final examinations end

**Spring 2015**

- **January 7**: Wednesday—8:30 a.m. Spring semester begins. The Monday class meeting schedule is in effect on this day; Regular class meeting schedule begins on Thursday, January 9; Classes meeting in a Wednesday/Friday meeting pattern begin January 10; Drop/add continues
- **January 8**: Thursday—Regular class meeting schedule begins
- **January 19**: Monday—Martin Luther King, Jr. Day holiday. Classes are rescheduled on Wednesday, January 8
- **January 21**: Wednesday—Drop/add ends
- **February 16**: Monday—Registration begins for Summer 2014
- **March 6**: Friday—7 p.m. Spring recess begins
- **March 16**: Monday—8:30 a.m. Classes resume
- **April 1**: Wednesday—Registration begins for Fall 2014; Summer 2014 registration continues
- **April 10**: Friday—Registration ends for Fall 2014; Summer 2014 Registration continues
- **April 11**: Saturday—Drop/add begins for Fall 2014
- **April 15**: Wednesday—Graduate classes end
- **April 16-26**: Thursday-Sunday—Graduate reading period
- **April 27**: Monday—Final examinations begin
- **May 2**: Saturday—10 p.m. Final examinations end
- **May 8**: Friday—Commencement begins
- **May 10**: Sunday—Graduation exercises; conferring of degrees

The dates on this calendar are subject to change. Past, current, and future academic calendars can be found online at http://registrar.duke.edu/academic-calendar.
Introduction

Headquartered in the heart of the Duke University campus, the Nicholas School of the Environment—not Environmental Sciences, or Environmental Studies, but the Environment—strives for a new paradigm, one that views and attempts to understand the earth and the environment including humans as an integrated whole. And one that advances a more sustainable future by strategically focusing its resources on addressing the major environmental issues of our times and by training a new and environmentally-informed generation of global leaders.

To achieve this vision, the Nicholas School has assembled a unique and talented faculty of world-class researchers and educators spanning all of the relevant physical, life, and social sciences, steeped and actively engaged in their respective disciplines, but also committed to the multi- and interdisciplinary lines of inquiry and collaborations that are at the core of many environmental issues.

The Nicholas School’s mission, to create knowledge and global leaders of consequence for a sustainable future, is informed by Duke University’s theme of knowledge in the service of society and motivated by the need to restore and preserve the world’s environmental resources while adapting to a changing climate and a growing population with aspirations for rising standards of living. We strive to fulfill this mission by:

• Creating Knowledge through basic, applied, and multidisciplinary research in the relevant physical, life, and social sciences designed to expand our understanding of the Earth and its environment;
• Creating Global Leaders through:
  • an undergraduate academic program designed to spread understanding of the Earth and the environment
to a new cadre of Duke graduates;
  • a professional masters program that trains a new breed of environmental professionals working in the
  public, private, and non-profit sectors with the skills needed to devise and implement effective environ-
  mental policies and practices; and
  • a Ph.D. program dedicated to adding to a new generation of world-class scientists, researchers, and educa-
    tors in the environment;
• Forging a Sustainable Future by strategically focusing the intellectual resources and capital amassed in
  research and education to address three of the most challenging environmental issues confronting society:
  • climate and energy
  • terrestrial and marine ecosystems
  • human health and the environment

Graduate Professional Degrees
Most students entering the Nicholas School seek graduate professional degrees, preparing for careers as expert
environmental problem-solvers after two years of study. The master of environmental management (MEM) degree
trains students to understand the scientific basis of environmental problems, as well as the social, political, and
economic factors that determine effective policy options for their solution with an eye toward forging a sustainable
future. Mid-career environmental professionals can also earn the MEM degree through the Duke Environmental
Leadership (DEL) program. Through a combination of traditional and distance learning formats, students focus on
environmental management and leadership development. The master of forestry (MF) degree develops experts in
sustainable management of forested ecosystems. Students enrolling at the Nicholas School also have the opportunity
to seek concurrent degrees with The Fuqua School of Business (MBA), Duke Law School (JD), the Sanford School of
Public Policy (MPP), the Pratt School of Engineering (MEMP), and the master of arts in teaching (MAT) through
The Graduate School.

Doctoral Degrees
The traditional PhD, which is offered to Nicholas School students through The Graduate School, provides the
opportunity for students to pursue in-depth interest in a more narrowly focused field in preparation for a career in
teaching and/or research. Doctoral students work with faculty in each of the Nicholas School’s three divisions:
environmental sciences and policy, earth and ocean sciences, and marine science and conservation.

Undergraduate Degrees
The Nicholas School cooperates with the Trinity College of Arts & Sciences in awarding four undergraduate
degrees: the AB in environmental science and policy, the BS in environmental sciences, and the BA and BS in earth
and ocean sciences. In addition, minors are offered in both environmental sciences and policy and earth and ocean
sciences. Certificate programs are offered in energy and the environment and marine science and conservation
leadership. Courses for the majors are taught by more than sixty Duke professors in twenty cooperating departments
and schools. The Department of Biology offers a BS with a concentration in marine biology that is fulfilled by a
semester in residence at the Duke University Marine Laboratory—a major facility of the Nicholas School.

History of the Nicholas School
The Nicholas School of the Environment at Duke University, represents the joining of three programs whose
histories are almost as old as the university itself: the School of Forestry and Environmental Studies and the Duke
University Marine Laboratory, both formed in 1938, and the Department of Geology, founded in 1936.
In 1932, forestry instruction was first offered to undergraduate students, and in 1938 the School of Forestry was
established as a graduate professional school under the direction of Dean Clarence F. Korstian. Dr. Korstian had
joined the faculty in 1931 as the first director of the Duke Forest. Brought to Durham by Dr. William P. Few,
president of Duke at the time, Dr. Korstian set out to develop a demonstration and research forest that would serve as
a model for owners of small tracts of timber in the South.
The master of forestry and doctor of forestry degrees were offered initially, and later the AM, MS, and PhD were offered through The Graduate School. The school’s forestry program has been fully accredited by the Society of American Foresters since 1939.

Growing national concern with natural resources and environmental problems led to a new teaching and research emphasis in ecology in the 1970s. In 1974, the school’s name was changed to the School of Forestry and Environmental Studies, and a new degree was added: the master of environmental management (MEM).

The Duke University Marine Laboratory also had its beginnings in the 1930s, when Dr. A.S. Pearse and colleagues from Duke were attracted to Pivers Island and its surrounding abundance of marine life for their summer field studies. The island afforded an excellent location for a field station. Through the subsequent efforts of Dr. Pearse and others, the land was acquired, and the first buildings of the Duke University Marine Laboratory were built in 1938. Originally, the Marine Lab served only as a summer training and research facility. Today, it operates year-round to provide training and research opportunities to nearly 10,000 people annually.

In 1991, the School of Forestry and Environmental Studies was combined with the Duke University Marine Laboratory to form the School of the Environment. The new school represented an unprecedented university commitment to interdisciplinary education and research in environmental science, policy, and management. It was the only private graduate professional school of its type in the country. The school became the Nicholas School of the Environment in 1995 after a generous gift from Duke graduates Peter and Ginny Nicholas.

In 1997, the Division of Earth and Ocean Sciences was created when the former Department of Geology, previously a part of Trinity College of Arts & Sciences, joined the school. This department also dates from the 1930s when Dr. Willard (Doc) Berry was hired as the first geologist at Duke University. By the 1960s, the Department of Geology had established itself as a center for the study of sedimentary geology. Today, as the Division of Earth and Ocean Sciences, it focuses on a number of areas at the intersection of earth and environmental sciences.

In the spring of 2014, the school celebrated the opening of Duke Environment Hall, a 70,000-square-foot facility designed to meet or exceed the criteria for LEED Green Building platinum certification, the highest level of sustainability.

Divisions

The school is composed of three divisions, which serve graduate professional, doctoral, and undergraduate students:

Earth and Ocean Sciences
With focal areas in climate change, energy, solid earth processes and surficial processes, this division is headquartered in the Levine Science Research Center on Duke’s West Campus. The EOS faculty conduct research all over the world, from the 3,200-meter-deep Hess Deep trench in the Pacific Ocean to the 4,000-meter altitudes of the South American Altiplano.

Environmental Sciences and Policy
With focal areas in ecosystem science and management, environmental health, wetlands, and environmental economics and policy, ESP is headquartered in the Duke Environment Hall. Faculty with training in the biological, physical, chemical, and social sciences work on applied and basic environmental research problems. The division stresses interdisciplinary approaches to environmental problem solving.

Marine Science and Conservation
The mission of the Division of Marine Science and Conservation is education, research, and service to understand marine systems, including the human component, and to develop approaches for marine conservation and restoration. The MSC division is headquartered at the Duke University Marine Laboratory in Beaufort, North Carolina. Faculty research interests include biological and physical oceanography, marine biology and conservation, marine environmental health, marine biotechnology, and marine policy and management.
Location

Duke University is situated in Durham, a city of more than 273,000 inhabitants in the central piedmont region of North Carolina. The Appalachian escarpment lies approximately one hundred miles to the west of Durham, and the coastal plain is but a short distance to the east. The Duke University Marine Laboratory is located 180 miles to the southeast of Durham, on Pivers Island, adjacent to the historic town of Beaufort, North Carolina. The Nicholas School is thus ideally situated near areas of ecological and topographic diversity that offer many opportunities for study as well as recreation.

Piedmont North Carolina is characterized by a rolling, forested topography interspersed with small farms and rural communities in addition to the state’s largest cities. The climax forests of the piedmont are hardwoods; however, human disturbance has resulted in the establishment of many forests of native southern pines. To the west, the Appalachian Mountains contain magnificent hardwood forests, giving way to spruce-fir forests at higher elevations. The region hosts a large percentage of the rich biodiversity of the southeastern United States.

The coastal plain of North Carolina, well known for its agricultural production, is used extensively by many of the nation’s forest industries for plantations of native pines. Coastal wetlands and estuaries, now recognized as one of the nurseries of world fisheries, offer abundant and valuable natural resources. The barrier islands of North Carolina’s Outer Banks serve to protect these coastal waters. The rapidly increasing population and development in this region make proper management of its natural resources particularly important to the nation.

Because of the school’s central location near these regions of vital ecological importance and rapid human population growth, students are afforded the opportunity to study many current environmental problems in the field. Both the opportunity and the challenge exist to analyze these pressing problems and to develop sound approaches to their management.

History of Duke University

Duke University traces its roots to 1838 in nearby Randolph County, where local Methodist and Quaker communities joined forces to support a permanent school that they named Union Institute. After a brief period as Normal College (1851-59), the school changed its name to Trinity College in 1859 and became a liberal arts college affiliated with the Methodist Church. The college moved to the growing city of Durham in 1892 when Washington Duke provided financial assistance and another local businessman, Julian S. Carr, donated land. In December 1924, the trustees graciously accepted the provisions of James B. Duke’s indenture creating the family philanthropic foundation, The Duke Endowment, which provided for the expansion of Trinity College into Duke University.

As a result of the Duke gift, Trinity underwent both academic and physical expansion. The original Durham campus became known as East Campus when it was rebuilt in stately Georgian architecture. West Campus, Gothic in style and dominated by the soaring tower of the Duke Chapel, opened in 1930.

In 1972, the men’s and women’s colleges merged into the Trinity College of Arts & Sciences. Academic expansion of the university throughout its history has also included the establishment of graduate and professional schools. Duke now is composed of ten schools, including The Graduate School, Duke Divinity School, the School of Medicine, the School of Nursing, the School of Law, the Pratt School of Engineering, The Fuqua School of Business, the Nicholas School of the Environment, and the Sanford School of Public Policy, along with international outposts, including one in Kunshan, China.

Today, Duke embraces a diverse community of learners, including approximately 6,500 undergraduates and 7,500 graduate and professional students from a multiplicity of backgrounds. For more historical information, visit http://library.duke.edu/rubenstein/uarchives.

Facilities

The Nicholas School of the Environment is headquartered in Environment Hall at 9 Circuit Drive located on Duke’s West Campus and linked by a walkway to the A Wing of the Levine Science Research Center (LSRC), its former home. The 70,000-square-foot, five-story glass-and-concrete building incorporates state-of-the-art green features and technologies inside and out. The hall houses five classrooms, a 105-seat auditorium, 45 private offices, 72 open office spaces, a 32-seat computer lab, an outdoor courtyard and an environmental art gallery, as well as conference rooms, shared workrooms and common areas. It also is home to the Division of Environmental Sciences and Policy. Green features range from rooftop solar panels and innovative climate control and water systems, to special windows that moderate light and heat, to an organic orchard and sustainably designed landscaping.
The Division of Earth and Ocean Sciences, which currently has laboratories in the Old Chemistry building on the West Campus, will relocate in spring 2015 to the A wing of the LSRC, which is undergoing renovations. The division maintains state-of-the-art facilities for geochemical analysis and climate modeling studies. The A wing will also house Nicholas School student services.

Duke University Marine Laboratory is home to the third division of the Nicholas School, the Marine Science and Conservation division. Situated on Pivers Island on the coast of North Carolina, the Marine Lab is Duke’s coastal campus. Its facilities are described in detail later in this chapter.

Duke Forest

The Duke Forest comprises more than 7,000 acres of land in Alamance, Durham, and Orange counties and has been managed for teaching and research purposes since the early 1930s. A variety of ecosystems, forest cover types, plant species, soils, topography, and past land use conditions are represented within its boundaries. In terms of size, diversity, accessibility, and accumulated long-term data, the Duke Forest is a resource for studies related to forest ecosystems and the environment that is unmatched by any other university.

Academic use of the Duke Forest ranges from class instruction to long-term research projects and includes studies on vegetation composition, landscape ecology, remote sensing, invertebrate zoology, atmospheric science, and global climate change. A large volume of information is available to support teaching and research efforts including data on soils, topography, and forest inventory, as well as historic and current management records.

In addition to leading educational tours and field laboratory exercises, Duke Forest Staff are available to assist faculty, students, teachers, and researchers in project development—from site selection and logistics to utility hook-ups and stand management. To initiate or lead academic activities in the Duke Forest, please contact the Office of the Duke Forest at dukeforest@duke.edu. More information can also be found online at www.dukeforest.duke.edu.

Duke University Marine Laboratory

General Information

The Duke University Marine Laboratory is a campus of Duke University and a unit within the Nicholas School of the Environment. Its mission is education, research, and service to understand marine systems, including the human component, and to develop approaches for marine conservation and restoration. The Marine Laboratory campus serves year-round resident Duke faculty in the Division of Marine Science and Conservation who, together with research and administrative staff, provide training, educational, and research opportunities to about 10,000 people annually. Duke academic programs served by the Marine Laboratory campus include undergraduate students, graduate degree students, and doctoral students. Students and post-graduates from other colleges may enroll for one or more semesters or summer sessions. Visiting student groups use the Laboratory’s dormitory and laboratory facilities and scientists come from North America and abroad to conduct research on the campus. A weekly seminar/lecture series features distinguished scientific speakers from across the nation and abroad.

Location and Natural Environment

The Marine Lab is situated on Pivers Island, near the historic town of Beaufort. Beaufort is the third-oldest town in North Carolina and is surrounded by fishing, agricultural, and leisure-tourism communities. The area is well known for its historic and scenic attractions as well as being a seaside resort. Cape Lookout National Seashore and the Rachel Carson Estuarine Research Reserve are within easy boating distance.

The laboratory is within range of both temperate and tropical species of marine biota. The edge of the Gulf Stream oscillates between thirty and forty miles offshore, with reefs on the wide continental shelf and habitat for marine vertebrates. The coastal region of North Carolina is a system of barrier islands, sounds, and estuaries rich in flora and fauna, and other diverse habitats, including rivers, creeks, mud flats, sand beaches, dunes, marshes, peat bogs, cypress swamps, bird islands, and coastal forests. It is a haven for both nature lovers and those interested in the pursuit of marine science.

Two other university laboratories, federal and state laboratories, plus a museum, and an aquarium in the Beaufort--Morehead City area collectively house one of the highest concentrations of marine scientists in the nation. These are the University of North Carolina's Institute of Marine Sciences (IMS), the North Carolina University's Center for Marine Science and Technology (CMAST), the North Carolina State University Seafood Laboratory, the
National Oceanic and Atmospheric Administration's (NOAA) Beaufort Laboratory, the North Carolina Divisions of Marine Fisheries and Coastal Management, the North Carolina Maritime Museum, and the North Carolina Aquarium at Pine Knoll Shores. This concentration of marine scientists provides a critical mass for the pursuit of science, conservation, and education.

Teaching and Research Facilities

The Marine Lab campus features dormitories, a dining hall, a student center, classrooms, laboratories, and research buildings. The Marguerite Kent Repass Ocean Conservation Center, the Marine Lab's first LEED-certified building. The Orrin Pilkey Research Laboratory was dedicated in 2013 and houses state-of-the-art molecular biology research laboratories and a teaching lab where faculty and students can apply advanced genetic tools and techniques toward understanding marine systems and marine ecosystems. The Pilkey Laboratory was designed with sensitivity to the changing coastal environment—including site design utilizing prevailing winds and sunlight, geothermal heating and cooling systems, and recycled and regional materials—and is designed for LEED certification.

In addition to modern analytical facilities, the Marine Lab operates a variety of seawater systems and tanks for experimental work. The Marine Lab also maintains modern computer facilities and IT services, including state-of-the-art video conferencing and telepresence facilities. The Pearse Memorial Library at the Marine Lab is a component of the Duke University Library System. Computer and library facilities are described in further detail in the sections highlighting the Computer and Library Resources of the Nicholas School and Duke University. The Marine Lab now features a new, fully equipped and state-of-the-art shared-use Marine Conservation Molecular Facility in the Bookhout Research Laboratory. This laboratory enables a range of genetic studies from genomics to populations genetics and forensics. The Marine Lab operates the R/V Susan Hudson, a 57-foot fully equipped coastal oceans research vessel; the R/V Richard T. Barber, a 30-foot aluminum vessel, used mostly for faculty and student research; and a fleet of small skiffs, kayaks, and canoes for research and teaching.

Computer Resources

The Nicholas School of the Environment's Information Technology (IT) department provides IT support to students, faculty and staff in all divisions. Resources such as multipurpose classrooms, instructional and public computer labs, specialized software, data storage, scanners, and network printers are available at each location. The Nicholas School provides access to ArcGIS software and is the main source of training and support. Laptops, tablets, cameras, conference phones and digital projectors may be reserved for short-term loans.

The Nicholas School is unique with its daily interactions between the Durham campus and the Marine Lab campus in Beaufort. Therefore, video conferencing is a frequently employed tool, which enables faculty, staff, and students to remotely attend meetings and classes and collaborate effectively. The units range from ones that accommodate one or two people to full size technology enabled classrooms with multi-screen teleconferencing, which offer students global access to guest lecturers and professors.

Additional IT services used at the Nicholas School are provided by central organizations, including the Office of Information Technology (OIT), Center for Instructional Technology (CIT), and Research Computing. Examples include: Physical and Virtual Computer Labs, Microsoft Office365 and Calendar, Sakai, Duke Capture, Duke Wiki, WordPress, site licensed software, and web conferencing. Duke also has a computer store located on West campus along with Duke Computer Repair only a couple of miles away.

Since technology is frequently changing, visit http://www.nicholas.duke.edu/it for the most up-to-date Nicholas School offerings. For more information on Duke centralized resources see http://www.oit.duke.edu.

Regional Resources

Research Triangle Park

Numerous industrial and governmental organizations have established research facilities in the Research Triangle Park, ten miles from the Duke campus. Government facilities include a major research laboratory of the Environmental Protection Agency, the Forestry Sciences Laboratory of the United States Forest Service, and the National Institute of Environmental Health Sciences (NIEHS). These laboratories provide opportunities for student research and internships in some of the nation's most advanced research facilities.
Neighboring Universities

Through a reciprocal agreement, Duke students may supplement their education in forestry and the environmental sciences by taking courses in related fields at The University of North Carolina at Chapel Hill, North Carolina State University in Raleigh, and North Carolina Central University in Durham. Graduate students of Duke University and The University of North Carolina at Chapel Hill are granted library loan privileges in both universities.

Forest History Society

Founded in 1946, the Forest History Society is a nonprofit, nonadvocacy organization committed to balanced and objective investigations of human interaction with the forest environment. In 1984, it became affiliated with Duke University and moved its headquarters to Durham. The Forest History Society copublishes the quarterly journal Environmental History and maintains a large collection of archival materials, including records from the American Forestry Association, American Forest Institute, National Forest Products Association and the Society of American Foresters. These valuable resources and the services of the society’s reference staff are available to Nicholas School students. The society also provides the F. K. Weyerhaeuser Fellowship for a graduate student studying forest conservation history (see Financial Aid sections in chapters for professional degree and doctoral students in this bulletin) and cosponsors the Lynn W. Day Distinguished Lectureship in Forest & Conservation History with the Nicholas School and the Department of History. Internet: www.foresthistory.org; (919) 682-9319.

Carolina Population Center

The Carolina Population Center is a community of outstanding scholars who promote population research and education at The University of North Carolina at Chapel Hill. The CPC offers classes and seminars and supports its own library as well as an online catalog of resources. The Nicholas School collaborates with the Carolina Population Center as a member of its Integrative Graduate Education and Research Training (IGERT) grant from the National Science Foundation. Internet: http://www.cpc.unc.edu.

Center for Sustainable Enterprise

Based at the Kenan-Flagler School of Business at The University of North Carolina at Chapel Hill, the Center for Sustainable Enterprise has provided over a decade of vision and impact creating leaders for the world we envision using business to innovate for global change. The CSE world class curriculum (twenty-one sustainability-related classes this fall), real world applications and relevant research help students and companies succeed with sustainable strategies. Nicholas School students with interests in business and the environment, industrial ecology and sustainable business practices frequently enroll in courses offered by this center. Internet: http://www.kenan-flagler.unc.edu/sustainable-enterprise.

Organization for Tropical Studies at Duke

The Organization for Tropical Studies (OTS) is a nonprofit consortium that has grown to include sixty-three universities and research institutions from the United States, Latin America, and Australia. In the early 1960’s, scientists from US universities forged working relationships with colleagues at the Universidad de Costa Rica in the interest of strengthening education and research in tropical biology. Intense interest both in the United States and Costa Rica led to the founding of OTS in 1963. OTS was founded to provide leadership in education, research, and the responsible use of natural resources in the tropics. To address this mission, OTS conducts graduate and undergraduate education, facilitates research, participates in tropical forest conservation, maintains three biological stations in Costa Rica and conducts environmental education programs. Internet: http://www.ots.duke.edu/.

Campus Resources

Libraries

Duke University Libraries, which rank among the top ten private research libraries in the United States, include the libraries of the Perkins Library System — Perkins Library, Bostock Library, the Rare Book, Manuscript, and Special Collections Library, Lilly Library, the Music Library, and the Marine Lab Library — and the libraries affiliated
with Duke Divinity School, The Fuqua School of Business, Duke Law School, and the Medical Center. Duke University Libraries also include the Library Service Center (LSC), an off campus, state-of-the-art high density repository designed to maintain optimal temperature and humidity levels that has the capacity to store fifteen million volumes. Library patrons can search our more than six million volume collection, search over 180,000 electronic resources, and print articles on demand or download them to their computer or smartphone. Through a single interface, they can search the catalogs of our Triangle Research Libraries Network partners (UNC-Chapel Hill, NCSU, and NCCU) and have a book from our combined collection of more than fifteen million volumes delivered within twenty-four hours. They can ask a Duke librarian a question from anywhere in the world by e-mail, phone, or IM. Last year, Duke University librarians made 635 presentations to more than 8,000 students and answered more than 118,000 questions in person, by phone, live chat, or IM.

The Pearse Memorial Library on the Beaufort campus of Duke University's Marine Laboratory is a satellite branch of Duke's Perkins Library System. It provides access to print and electronic resources that support interdisciplinary education and research with a primary focus on the marine environment. The library subscribes to a limited number of print research journals, has access to the full complement of journals in electronic format, and maintains holdings of approximately 28,000 volumes. The Pearse Library is connected electronically to the Duke University Libraries online catalog, providing access to holdings information and full-text e-resources, as well as its robust collection of full-text and citation databases. Pearse Library actively participates in interlibrary loan and document delivery services in cooperation with regional and national academic institutions and research centers.

Student Life

Housing

Most undergraduates live in dormitories on the Duke campus, and first-year undergraduates are required to do so. Dormitories are also available for students attending the Duke University Marine Laboratory. On-campus housing for graduate students is extremely limited so most graduate students in the Nicholas School of the Environment live off-campus. Housing is plentiful and varied, both in Durham and in Beaufort. The perimeter of the West Campus is densely developed with apartment complexes, and the East Campus is adjacent to a neighborhood of large, early 20th-century homes, some of which have been converted to apartments. Free and frequent bus service is available between the two campuses and between Duke and The University of North Carolina at Chapel Hill.

The Duke Community Housing Office maintains listings of apartment openings, house rentals, and roommates wanted. The off-campus housing service does not rate the quality of apartments, houses or landlords, nor does it arrange viewings. Similarly, the Nicholas School maintains an electronic bulletin board where students may list apartments and seek housing or roommates. The Office of Academic and Enrollment Services sends housing information to all entering professional degree students in the late spring.

Services for Students

Student Disability Access Office

Duke University and the Nicholas School of the Environment are committed to equality of educational opportunities for qualified students with disabilities. The Student Disability Access Office (SDAO) is charged with the responsibility of exploring possible coverage and reasonable accommodations for undergraduate, graduate, and professional students for purposes of the Americans with Disabilities Act (ADA) of 1990 and Section 504 of the Rehabilitation Act of 1973. The mission of the Student Disability Access Office (SDAO) is to provide and coordinate accommodations, support services, and auxiliary aids for qualified students with disabilities.

Services and accommodations are provided to students with a variety of disabilities, including but not limited to attention deficit hyperactivity disorders, learning disabilities, psychological disabilities, or physical disabilities such as visual impairments, hearing impairments, chronic health disorders, and mobility impairments. Students who wish to be considered for reasonable accommodations at the Nicholas School must identify themselves to the Duke University Student Disability Access Office. A comprehensive website at [www.access.duke.edu/students/requesting/index.php](http://www.access.duke.edu/students/requesting/index.php) provides complete policy and procedural information for students requesting to be considered for reasonable accommodations.
For questions about documentation, eligibility, and accommodations, please contact the director of the Student Disability Access Office at 402 Oregon Street, Suite 102, Box 90142, Durham, NC 27708 or at (919) 668-1267. For information about specific Nicholas School program requirements, please contact Cynthia Peters, assistant dean, Academic and Enrollment Services, Nicholas School of the Environment at Box 90330, Duke University, Durham, NC 27708 or at cynthia.peters@duke.edu at (919) 613-8070.

Communications
Upon entrance to the Nicholas School, each student is issued an e-mail address. E-mail is recognized as an official means of communication within the university. Students are encouraged to check their e-mail frequently.

Medical Care
The Duke Student Health Center, the primary care clinic for Duke students, is located within the Duke Clinic in the sub-basement Orange Zone, Duke South Hospital and Clinics, with an entrance off Flowers Drive. Emergency transportation, if required, can be obtained from the Duke campus police. The Duke Student Health Center is not a Walk-In Clinic and priority is given to students with scheduled appointments. Internet: http://www.studentaffairs.duke.edu/studenthealth.

The student health fee is nonrefundable after the first day of classes. Students may be covered during the summer for an additional charge. Dependents and family members are not covered at any time.

The resources of the medical center are available to all students and their spouses and children. Charges for all services received from the medical center are the responsibility of the student, and students must carry health care insurance to cover these costs.

The university has a Student Medical Insurance Plan available for full-time students. Although participation in this plan is voluntary, the university expects all graduate students to be financially responsible for medical expenses above those covered by the student health service. Students who have medical insurance or wish to accept the financial responsibility for any medical expense may elect not to join the Student Medical Insurance Plan by registering their insurance provider with the university online. Each full-time student in residence must purchase Duke's student health insurance or indicate the alternative arrangement that is equal in coverage to Duke's plan. All F-1 and J-1 visa students must purchase the Duke plan.

The Student Medical Insurance Plan is in effect twenty-four hours a day during the twelve-month term of the policy. Students are covered on and off the campus, at home, while traveling, and during interim vacation periods. For additional fees, a student may obtain coverage for a spouse and children. The annual term of the policy begins on the opening day of classes each fall.

Coverage and services are subject to change as deemed necessary by the university.

Counseling and Psychological Services (CAPS)
CAPS provides a comprehensive range of counseling and psychological services to assist and promote the personal growth and development of Duke students. The professional staff is composed of clinical social workers, psychologists, and psychiatrists experienced in working with young adults. Among services provided are personal, social, and academic counseling. A number of short-term seminars or groups focusing on skills development and special interests such as coping with stress and tension, fostering assertiveness, enriching couples ‘communication, and dealing with separation and divorce are also offered.

A policy of strict confidentiality is maintained concerning each student’s contact with the CAPS staff. Student health fees cover individual evaluation and brief counseling/therapy as well as skills development seminars. There are no additional charges to the student for these services.

Appointments may be made by calling (919) 660-1000 or visiting CAPS, 214 Page Building.

Career and Professional Development
The Nicholas School of the Environment operates its own Career and Professional Development Center (CPDC) for MEM/MF students and alumni.

Vision: To be the leading career experts for the environmental and natural resource profession.

Mission: To work with students, alumni, and employers to achieve the vision of a sustainable future a reality.

Fostering our vision and mission through
• Coaching/Counseling assists individual students to identify their strengths and create strategies for connecting their academic training and career goals to professional opportunities;
• **Training Programs** that increase knowledge and teach techniques to create student confidence in communicating qualifications in resumes, employer correspondence, interviewing and networking situations;

• **Experiential Learning** opportunities that are integral to broadening one’s career connections, skill and professional development; internships, client-based experiences and career field trips;

• **Employer Relationships** that build stronger ties to qualified candidates and the academic institution.

The CPDC professional staff offers high quality services, training programs, and promotes career opportunities that are academically relevant and positively contribute to a student’s professional development and career preparation. The CPDC staff helps students and alumni make the most of their Nicholas education, available resources, and connections to develop and deepen career interests and values.

The University Career Center at Duke ([http://career.studentaffairs.duke.edu](http://career.studentaffairs.duke.edu)) provides career services of the highest standard to Trinity College undergraduates and graduate students in The Graduate School. The center’s goal is to assist with exploration of career options to post-graduation employment preparation and opportunities that match an individual’s special interests, training, and expertise gained from an undergraduate education or PhD credential. The Career Center has numerous services, resources, programs, and events to help students choose careers or further training and education.

**International Advisor**

The Duke University Visa Services Office handles governmental matters for students from abroad, including statements of attendance for home governments, issuance of United States immigration forms for reentry into the country after a temporary absence and required yearly extensions of time. Any new student who is not a citizen of the United States should report with passport to the international advisor immediately upon arrival. The Visa Services Office is located at Smith Warehouse, Bay 7, first floor.

**Other Services**

The Bryan Center houses an information desk, two drama theaters, a film theater, stores for books and supplies, meeting rooms, lounges, snack bars, and other facilities. A barbershop, hairdresser, postal services, and various bank ATMs are also located in the Bryan Center and in the nearby West Campus Union.

**Student Activities and Organizations**

**Sports**

Students are welcome to use recreational facilities such as the swimming pools, tennis courts, golf course, track, jogging course, handball and squash courts, gymnasiums, weight room, and playing fields. Intramural programs provide an opportunity to participate in informal and competitive physical activity. A variety of clubs for gymnastics, scuba diving, sailing, cycling, badminton, karate, rugby, soccer, and crew are also active. Students studying at the Duke Marine Laboratory in Beaufort, North Carolina will receive a free student membership to the local gym in Morehead City.

**Cultural Activities**

Concerts, recitals, lectures, plays, films, and dance programs are presented frequently on campus. Information on major events is available at Page Box Office or the Bryan Center information desk. The Nasher Museum of Art, located near West Campus, features an excellent permanent collection as well as popular visiting exhibitions.

**Religious Services**

Interdenominational services are conducted on Sunday mornings in Duke Chapel. Roman Catholic masses are offered daily on campus. Several Protestant denominations have student centers on campus. The Divinity School conducts other chapel services and religious and social activities. There is also a Hillel group that meets regularly, and the Freeman Center hosts Jewish student life activities. Duke is one of a very few academic institutions to have on staff a Muslim imam for the benefit of Muslim students.

**Duke Environmental Law and Policy Forum**

Students from the Nicholas School work with students of the Duke University School of Law to produce the biannual journal *Duke Environmental Law and Policy Forum* as an outlet for scholarly work in environmental law, policy, economics, and science. Recent issues of the journal have dealt with climate change, environmental justice, and land use.
Duke Environmental Leadership (DEL) Program

The Duke Environmental Leadership (DEL) Program at the Nicholas School of the Environment provides an online master’s degree and executive education courses to advance knowledge in environmental management topics. Residential MEM students have the opportunity to register for most DEL-MEM courses (900-999) during spring semesters. These courses are primarily held online and allow residential students the opportunity to study with mid-career environmental professionals in the DEL-MEM program. Inquire about permission numbers and course logistics at del@nicholas.duke.edu.

In addition, while executive education courses are intended for a professional audience, there are opportunities for students to participate in these offerings, per DEL policy guidelines and permission.

The DEL program offers paid student assistantships and/or work study opportunities for assisting in the social media and marketing projects, including graphic design work and possible video projects. Please contact the DEL office for more information and to volunteer with local schools at del@nicholas.duke.edu.

Student Organizations

**AFE (Association for Fire Ecology)** is an organization of students interested in promoting knowledge of fire ecology and its economic, social, political, and ecological implications to its members, peers, and the public.

**Coastal Society** (Duke Chapter) plans events in Beaufort and Durham to raise either money or awareness in an effort to help solve issues facing the coasts. Best known for the Triathlon in Beaufort every fall.

**Duke University Greening Initiative (DUGI)** is a project-based, primarily graduate student organization that focuses on projects that will further the institutionalization of sustainability at Duke. Recognizing that in a volunteer organization, equal ownership is vital, DUGI operates on a nonhierarchical, consensus basis. Learn more at www.duke.edu/greening/mission.html.

**Duke University USGBC Student Group** serves as a forum for graduate and undergraduate students across disciplines to work together to learn about and implement the best sustainable design and construction practices.

**DukeFish** (American Fisheries Society chapter) helps bring awareness on sustainable seafoods and fisheries conservation issues, and holds fly-fishing trips and volunteer events on the coast.

**EIF (Environmental Internship Fund)** is a group who raises money to help fund students’ summer internships. The group arranges Veggies Sales, sale of Nicholas School T-shirts and sweatshirts, and other fundraising activities.

**The Energy Club** is a group focused on learning about all things related to energy through roundtable discussions, movie nights, field trips, and various independent student projects.

**Environmental Law Society** is a group interested in the legal/policy side of environmental issues.

**Farmhand** is a group of students who volunteer on local farms and host events geared to educate and raise awareness of the importance of local farms.

**FOREM (Forestry and Environmental Management)** is a Nicholas School professional student organization that coordinates the school’s social functions, community service and intramural team participation. Annual activities of the club include a holiday party, Field Day and a year-end banquet.

**Green Devils Intramurals.** The Green Devil Intramural team provides opportunities for students to participate in various sports, competing against teams from other schools at Duke. Some students participate in a more competitive team and others choose to participate in a recreational team.

**Grey Devils** focuses on students over thirty (or getting there), who may be having a hard time getting back into the world of homework and classes, need advice on juggling family life and school, or just want to get to know their fellow students who are dealing with similar challenges.

**Marine Technology Society.** This group is interested in the application of available technology to marine conservation and exploration. Members will have the opportunity to develop hands-on experience with equipment, abilities, learn about new technologies, and engage in networking opportunities with professionals in this field.

**NAEP (National Association of Environmental Professionals)** works on professional development for the MEM students. The organization sponsors speaker panels of working professionals, introducing students to career options, etc.

**Nicholas School Alumni Council** members visit Durham throughout the year to speak with current MEM and MF students, providing a glimpse into professional life after the Nicholas School. Council members also communicate with Nicholas administrators on the state of the MEM and MF programs, and welcome input from current students.
SAF (Society of American Foresters) is a group for everyone interested in forestry and forestry issues (non-MFs included). The Nicholas School’s student chapter of SAF is very active in promoting modern forestry.

SCB (Society for Conservation Biology). The Triangle chapter of the prominent international conservation research society, for all students interested in conservation issues.

Nicholas School Student Council (NSSC), an elected student group in the Nicholas School, meets regularly with the dean and faculty and staff representatives to discuss courses and curriculum, programs, and long-range goals of the school.

Student International Discussion Group (SIDG), a nonprofit student discussion group at the Nicholas School, provides opportunities for students to integrate international issues into their graduate education. Although the group’s main interests are environmental issues, it also explores sustainable development and societal concerns. SIDG also offers grants to students who would like to study abroad and co-organizes an annual conference on environmental and sustainability issues with the Working Group for Environment in Latin America.

Students for Sustainable Living is a joint graduate-undergraduate group paid by the Sustainability Office to plan environmental awareness events on campus.

Working Group for Environment in Latin America (WGELA) sponsors student and professional talks for the purpose of furthering knowledge about recent trends and activities in environmental research in Latin America, as well as allowing students to investigate opportunities for research and employment. With the Student International Discussion Group, WGELA cosponsors an annual conference on environmental and sustainability issues.

Professional and Scientific Societies

Student chapters of national societies at the Nicholas School create a forum where students with similar interests can share professional information and learn from practicing professionals. Speaker programs, information sessions with employers, and seminars serve to increase the value of the Nicholas School education. Recognizing the importance of active participation in student organizations and encouraging attendance at national conferences and symposia, the Nicholas School makes a limited amount of funding available for student attendance or presentations.

Student chapters of the Society of American Foresters, the Coastal Society, the Society for Conservation Biology, the National Association of Environmental Professionals, the Society of Environmental Toxicology and Chemistry and the American Water Resources Association are active in the Nicholas School.
Undergraduate Degrees

The Nicholas School of the Environment collaborates with the Trinity College of Arts & Sciences in awarding four undergraduate degrees: the bachelor of arts in environmental sciences and policy, the bachelor of science in environmental sciences, the bachelor of arts in earth and ocean sciences, and the bachelor of science in earth and ocean sciences. In addition, minors are offered in both environmental sciences and policy and earth and ocean sciences. Courses for the majors and minors are taught by Nicholas School faculty and professors in cooperating departments and schools within Duke University. Information about these majors and minors is available through the undergraduate office in 103A Old Chemistry Building; undergrad@nicholas.duke.edu, or through the program website at http://www.nicholas.duke.edu/programs/undergrad/.

All applications for undergraduate studies at Duke University are submitted to the Office of Undergraduate Admissions, and admission is offered by Trinity College of Arts & Sciences or the Pratt School of Engineering. All applicants should contact the Office of Undergraduate Admissions or visit their website at http://www.admissions.duke.edu.
Environmental Sciences and Policy (ENVIRON)

Rebecca Vidra, Lecturer and Director of Undergraduate Programs

Environmental Sciences and Policy (AB Degree)

The undergraduate major in environmental sciences and policy is offered within the bachelor of arts degree to students interested in the interdisciplinary study of environmental issues. The major permits students to combine studies in the natural sciences and engineering with courses in social sciences and humanities around general focus areas and themes. This major is designed for students with career objectives such as environmental law, policy, science, management, or planning that require in-depth understanding of environmental issues that cross disciplinary boundaries. The prerequisites for the AB degree stress a firm foundation in basic natural, environmental, and social science areas. An intermediate core course focuses on local, regional, and global case studies taught by interdisciplinary teams of faculty. Upper-level focus courses are selected in consultation with advisors to match a specific environmental theme or career objective. The upper-level curriculum includes a course in probability and statistics, a policy course, and an independent study, internship, or field experience. At least two courses in the upper-level curriculum must be selected from approved lists in each of the social sciences/humanities and sciences/engineering areas.

Corequisites

The following courses or their equivalents (for example, Advanced Placement credit) are required. Approval to substitute courses taken at other universities must be obtained from the director of undergraduate studies in the department offering the course. Some of these courses are prerequisite to some upper-level courses in this major.

- Environment 102 (Introduction to Environmental Sciences and Policy)
- Biology 201L or 202L (Gateway to Biology)
- Chemistry 101DL (Advanced General Chemistry), or equivalent
- Economics—either Economics 101 (Economic Principles); Political Science 145 (Introduction to Political Economy), or equivalent
- Earth and Ocean Sciences 101 (The Dynamic Earth); or Earth and Ocean Sciences 102 (The Dynamic Oceans) (C-L: Biology 157)
- Mathematics 111L (Introductory Calculus), or equivalent (e.g. Mathematics 25L and 26L)

Major Requirements

1. Core Course: Environment 201 (Integrating Environmental Sciences and Policy)
2. Ecology/Biodiversity course. One of the following or approved substitution: Environment 210D (Conserving the Variety of Life on Earth); or Biology 205 (Marine Megafauna) (C-L Environment 205); Biology 206L (Organismal Diversity); Biology 207 (Organismal Evolution); Biology 209 (Ecology for a Crowded Planet); Biology 330L (Anatomy of Vertebrates); or Biology 340L (Plant Diversity); or Biology 377LA (Marine Invertebrate Zoology) (C-L: Environment/Earth and Ocean Sciences 377LA)
3. Environmental Policy course. One of the following or approved substitution: Environment 212/Public Policy Studies 275 (United States Environmental Policy); Environment 216S (Environment and Conflict: The Role of the Environment in Conflict and Peacebuilding) (C-L: Political Science 152S; Public Policy 167S); Public Policy 274/Political Science 260D Environmental Politics and Policies in the Developing World); Environment 286A (Marine Policy); or Environment 533A (Marine Fisheries Policy)
4. Probability and Statistics. One course from the following or approved substitution: Statistics 101 (Data Analysis and Statistical Inference); Statistics 102 (Introductory Biostatistics); Statistics 103 (Statistics in the Courtroom); Statistics 111 (Probability and Statistical Inference); Statistics 130 (Probability and Statistics in Engineering); Psychology 201 (Introduction to Statistical Methods in Psychology); Sociology 333 (Quantitative Analysis Sociology); Biology 281LA (Research Methods in Tropical Biology); Political Science 471L (Quantitative Political Analysis); Economics 208D (Introduction to Econometrics); Evolutionary Anthropology 381 (Biometry)
5. Focused Study. Five upper-level courses proposed by students in consultation with their advisors to fit a particular theme or career objective. Courses are generally selected from approved lists in each of the social sciences/humanities and sciences/engineering areas, available at [http://www.nicholas.duke.edu/programs/undergrad/masterlist.pdf](http://www.nicholas.duke.edu/programs/undergrad/masterlist.pdf). Students will submit to their advisor, usually at the beginning of their junior year, a written rationale for the courses selected, including the title of their focus study theme.
Independent Study/Internship/Field Experience

Students complete an approved independent study, internship, or field experience that may or may not include course credit toward upper-level requirements. The Duke Career Center maintains information on available internships. Field experiences may include a semester or summer session at the Duke University Marine Laboratory or participation in field-oriented study abroad programs. Independent study typically involves a supervised research experience (see [www.nicholas.duke.edu/programs/independent-study](http://www.nicholas.duke.edu/programs/independent-study)).

Environmental Sciences (BS Degree)

The undergraduate major in environmental sciences is offered within the bachelor of science degree to students interested in a scientific perspective on environmental issues. The major is designed to encourage breadth in the physical and life sciences and depth in a chosen area of scientific concentration. This major is designed for students with career objectives in environmental or related sciences, industry or management that require a strong scientific background, or for students intending to pursue graduate degrees in environmental sciences. The major also meshes well with premedical requirements. The prerequisites for the BS degree stress a firm foundation in the physical and life sciences and mathematics. The major requirements include five core courses selected from six course options that focus on the biosphere, the atmosphere, the hydrosphere, the solid earth, chemical cycling, and the interface between humans and the environment. The major also includes a course in probability and statistics. The focused study consists of three upper-level natural science, engineering, or mathematics courses proposed by the student in consultation with their advisor to form a concentration area.

Corequisites

The following courses or their equivalents (for example, Advanced Placement credit) are required. Approval to substitute courses taken at other universities must be obtained from the director of undergraduate studies in the department offering the course. Some of these courses are prerequisites to upper-level courses in this major.

- Biology 201L or 202L (Gateway to Biology) or equivalent
- Chemistry 101DL (Advanced General Chemistry) and either Chemistry 210DL or 201DL or equivalents.
- Physics 161L (Introductory Physics), or equivalent
- Mathematics 111L and 112L (Introductory Calculus), or equivalent
- Environment 102 (Introduction to Environmental Sciences and Policy); or Earth and Ocean Sciences 101 (The Dynamic Earth); or Earth and Ocean Sciences 102 (The Dynamic Oceans) (C-L: Biology157)

Major Requirements

1. Five Core Courses selected from the following six courses or course lists:
   - Earth and Ocean Sciences 202 (Ocean and Atmosphere Dynamics)
   - Environment 360 (Environmental Chemistry and Toxicology) or Environment 537 (Environmental Health)
   - Earth and Ocean Sciences 204L (The Evolving Earth and Life)
   - Earth and Ocean Sciences 323 (Landscape Hydrology)
   - One course from an approved list of ecology courses. Approved course list includes:
     Biology 205 (Marine Megafauna)
     Biology 209 (Ecology for a Crowded Planet)
     Biology 261S (Ecosystem Ecology)
     Biology 273LA/Environment 273LA (Marine Ecology) (Beaufort)
     Biology 280LA (Fundamentals of Tropical Biology)
     Biology 369LA/Environment 369LA (Biological Oceanography) (Beaufort)
     Biology 272A/Environment 272A (Analysis of Ocean Ecosystems)
     Environment 217 (Restoration Ecology)
     Environment 361LS (Terrestrial Field Ecology)
   - One course from an approved list of courses that focus on the interface between humans and the environment. Approved course list includes:
     Environment 201 (Introduction to Environmental Sciences and Policy)
     Environment 210D (Conserving the Variety of Life on Earth)
     Environment 214S (Ethical Challenges in Environmental Conservation)
     Environment 212/Public Policy Studies 275 (United States Environmental Policy)
     Environment 216S (Environment and Conflict)
     Environment 253S (Urban Environmental Restoration and Design)
Environment 281A (Cons/Mgt Protected areas S. Africa)
Environment 282A (Environmental Science and Politics of the Tropics)
Environment 350S (Capstone: Marine Science and Conservation Leadership)
Biology/Environment 270A (Conservation Biology and Policy) (Beaufort)
Biology 571A (Urban Tropical Ecology) (Beaufort)
Economics 439/Environment 363 (Economics of the Environment)
Philosophy 215 (Applied Environmental Ethics)
Political Science 344 (Environmental Politics in the US)

2. Statistics 101, 103, 111, or equivalent

Focused Study. Three upper-level natural science, engineering, or mathematics courses proposed by the student in consultation with his or her advisor to form a concentration area. A list of approved courses is available from the undergraduate website at http://nicholas.duke.edu/programs/undergrad/co-requisites-for-the-a.b.-degree-in-environmental-sciences-and-policy. The student will submit to his or her advisor, usually at the beginning of their junior year, a written rationale for the courses selected.

The Minor
Environmental Sciences and Policy

Requirements: Five courses: two core courses (Environment 102 and Environment 201); the remaining three courses selected from 200-level or above environment courses, which may include one substitution of a course in another department. Students with AP credit must select an additional environment course in place of Environment 102 to equal five courses.

Graduation with Distinction

The environmental sciences and policy and environmental sciences majors both offer a Graduation with Distinction option. Interested students with a 3.0 grade point average overall and 3.2 grade point average in the environmental sciences/policy major should apply by the beginning of their senior year. The application should include a written request to the director of undergraduate studies describing the proposed research project, and identifying a primary faculty advisor who has agreed to supervise the research. Participants write a substantial paper describing their completed research, which is evaluated by the faculty advisor. The student will also make an oral presentation to students and faculty of the program before the end of classes of the student's final semester. For additional information and an application form, contact the director of undergraduate programs or visit http://nicholas.duke.edu/programs/graduation-distinction.

Note: Students may not use more than six professional school course credits toward the bachelor of arts or bachelor of science degree. This six-course restriction applies to all courses offered through The Fuqua School of Business, Duke Divinity School, Duke Law School, the School of Medicine, Pratt School of Engineering, and any environment courses at or above the 500-level in the Nicholas School of the Environment.

Earth and Ocean Sciences (EOS)

Alex Glass, Lecturer and Director of Undergraduate Studies

Two majors are offered, leading to either the bachelor of arts degree or the bachelor of science degree in earth and ocean sciences within the Trinity College of Arts & Sciences. A minor in earth and ocean sciences also is offered.

Courses for the major include introductory and advanced courses in climatology, coastal processes, geology, hydrology, geochemistry, geomorphology, oceanography, paleontology, petrology, marine geology, and energy and the environment. A bachelor of science degree is offered for those students wishing to pursue further studies in the earth and ocean sciences, or for those who intend to work professionally in earth sciences. A bachelor of arts degree is offered for students who wish to understand more fully local and global earth and environmental issues. The majors are administered by the Nicholas School of the Environment.

For the AB Degree

The AB degree in earth and ocean sciences is designed as a flexible major for students interested in understanding how the earth, atmosphere, and oceans work. The major is intended to provide a general knowledge of scientific issues that shape and control the environment in which we live.

Required courses include Earth and Ocean Sciences 101 or 102, followed by six earth and ocean sciences courses of which five must be 200-level or higher, and three additional 200-level or higher courses in either earth and ocean sciences or related fields (physics, mathematics, statistics, biology, chemistry, evolutionary anthropology, environment), as approved by the director of undergraduate studies.
Concentration in Natural History. Students may elect to complete the requirements in the area of natural history; intended for students interested in an integrative study of topics selected from ecology, botany, zoology, anthropology, history, hydrology, geology, oceanography, and the environment. For more information on this area of concentration see the director of undergraduate studies.

For the BS Degree

The BS degree provides a background for subsequent graduate work for those who wish to follow an academic or professional career track in the earth and ocean sciences.

Prerequisites: Earth and Ocean Sciences 101 and 102; Chemistry 101DL and either Chemistry 210DL or 201DL, or equivalents; Mathematics 111L and 112L; Physics 141L; Biology 202L.

Major requirements. Earth and Ocean Sciences 201L, 202, 203S, and 204L, plus five additional earth and ocean sciences courses at the 200 level, including one field-oriented class. Up to two courses from a related field (biology, chemistry, physics, environment, evolutionary anthropology, mathematics, or statistics) may be substituted with the approval of the director of undergraduate studies.

The Minor

The Division of Earth and Ocean Sciences offers an option for a minor in earth and ocean sciences.

Minor Requirements. Earth and Ocean Sciences 101 or 102, and four additional earth and ocean sciences courses, three of which must be 200-level or higher.

Graduation with Distinction

The Division of Earth and Ocean Sciences through Trinity College offers Graduation with Distinction through successful completion of a student research project. A candidate for Graduation with Distinction in the earth and ocean sciences must have a divisional grade point average of 3.2 at the beginning of the project to qualify for nomination. The student will apply for consideration for Graduation with Distinction by the beginning of his or her senior academic year by submitting an application to the director of undergraduate studies describing the project. The student must solicit a faculty advisor who will review the student’s record and decide to admit or reject the application and oversee the project. The student will normally do the work as part of independent study courses (Earth and Ocean Sciences 393, 394) completed during one academic year. The project will consist of an original piece of scientific research which will be summarized by a written report in the style of a scientific publication. The student will also make an oral presentation to students and faculty of the division before the end of classes of the student’s final semester. The decision on granting Graduation with Distinction will be made by a vote of the student’s project committee, with a majority in favor needed for Graduation with Distinction.

Marine Science and Conservation Leadership (Undergraduate Certificate)

Professor Brian Silliman, Certificate Director

A certificate, but not a major, is available in this program.

This certificate program offers all undergraduates at Duke University the opportunity to supplement their majors with studies of leadership in marine science and conservation. The program is designed to expand the academic breadth of Duke undergraduates who wish to pursue graduate degrees in biology, environmental science, social science, and policy, as well as professional careers in medicine and other disciplines. It seeks to stimulate interdisciplinary studies, including the human dimension, using marine systems as a model. It also fosters leadership skills in communication, management, values, and ethics. Students apply biological and ecological principles to the study of marine organisms and develop and evaluate solutions to conservation challenges. They are encouraged to think reflectively about their roles as citizens and leaders and the philosophical, ethical, and practical positions they will face in these roles.

The certificate program requires a residential component at Duke’s Marine Laboratory in Beaufort, North Carolina, for one full academic semester (fall or spring) or both summer terms. All certificate students thus become Marine Lab Scholars and are eligible to become Rachel Carson Scholars. These scholars programs offer additional resources and research and service opportunities for undergraduate students. Marine Lab residence features opportunities that bring Duke undergraduates together with local, regional, national, and international leaders in formal and informal settings, as well as special training sessions on leadership skills.
Course of Study

The Marine Science and Conservation Leadership Program is rooted in marine science and conservation, but includes studies in a variety of disciplines—biology, earth and ocean sciences, economics, engineering, environmental sciences and policy, markets and management studies, philosophy, political science, public policy, religion, and theater studies. The introductory course on environmental sciences and policy introduces students to the integration of natural and social sciences and a means of evaluating an environmental issue and developing an effective solution. A capstone course is required of all students during the spring semester of their senior year.

Certificate Requirements

The certificate requirements are: 1) a total of six courses: one introductory course (Environment 102 or Environment 201 with permission, for students who place out of Environment 102), one leadership, ethics, management, or communication course, two marine science courses (one natural science and one social science), one marine conservation course, and one capstone course taken during spring of the senior year; 2) no more than three courses may originate in a single department; and 3) no more than two courses that are counted toward the marine science and conservation leadership certificate may also satisfy the requirements of any major, minor, or other certificate program. Appropriate courses may come from the list included here: www.nicholas.duke.edu/marinelab/programs/certificate.html or may include other courses as approved by the director. Acceptance into the certificate program does not guarantee enrollment in electives, with the exception of the Capstone Course.

Program Enrollment

All students are eligible to enroll in the program. Enrollment must be done via the Duke Marine Laboratory website at www.nicholas.duke.edu/marinelab/programs/certificate.html.

Energy and the Environment (Undergraduate Certificate)

Josiah Knight and Emily M. Klein, Co-Directors

A certificate, but not a major, is available in this program. The certificate in energy and the environment is designed to provide Duke undergraduates with an understanding of the breadth of issues that confront our society in its need for clean, affordable, and reliable energy. An expertise in energy will expand the students' career options in the private, nonprofit, government, and academic sectors. In addition to integrative core and capstone courses, the certificate will expose students to the three key disciplines in the study of energy and the environment: markets and policy; environmental impacts and resources; and energy technology. The goal of the certificate is to develop innovative thinkers and leaders who understand the energy system as a whole and the important interconnections among policy, markets, technology, and the environment.

Beyond traditional coursework, the certificate in energy and the environment will offer a variety of activities intended to provide students with a real-world perspective and hands-on experiences. These include field trips, guest speakers such as visiting executives and practitioners, research opportunities, and internships. Additional information may be obtained from the Undergraduate Programs Office for the Nicholas School. Additional information is available at http://gendell.pratt.duke.edu/academics/undergraduate-certificate.

Course of Study

The certificate requires a total of six courses, no more than three of which may originate in a single department. No more than two courses counted toward the certificate in energy and the environment may also satisfy the requirements of any major, minor, or other certificate program. AP credit may not fulfill certificate requirements.

Energy use is a multifaceted problem, which draws upon the perspectives and expertise of a variety of disciplines. The certificate in energy and the environment is therefore similarly interdisciplinary. The following requirements apply to students who declare their intent to pursue the certificate in Fall 2013 or thereafter. Students who declared prior to Fall 2013 will follow the previous requirements, or may petition to follow the new requirements.

One introductory course:
• Earth and Ocean Sciences/Environment/Energy330 (Energy and the Environment)

One elective course from each of the following three areas:
• Markets and Policy;
• Environment; and
• Energy Science and Technology (see approved courses below)
One additional elective course:
- selected from elective course list below, or approved independent study

One Capstone Project Course (choose one):
- Environment 452L (for Trinity students)/Engineering 424L (for Pratt students) (Energy and Environment Design)
  Teams of students explore the feasibility of a new or modified energy resource, technology, or approach. An integrative design course addressing both creative and practical aspects of the design of systems related to energy and the environment.
  Or with prior approval of the certificate codirector, the following may serve as the capstone project course if taken during the student’s junior or senior year. Alternatively, students may take the following as their fourth elective course for the certificate.
- Energy 595/596. (Connections in Energy: Projects)
  Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore, and develop solutions to pressing energy issues. Teams may also include postdoctoral fellows, visiting energy fellows, and other experts from business, government, and the nonprofit sector. A team’s work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Instructor consent required.

Electives (one from each area)
Three elective courses are required, with one from each area (markets and policy, environment, and energy science and technology) taken from the below list. The most up-to-date version of the list can be found at the program’s website at http://gendell.pratt.duke.edu/academics/undergraduate-certificate.

Markets and Policy
Civil and Environmental Engineering
315. Engineering Sustainable Design and the Global Community
Economics
119. Introduction to Political Economy
431S. Research Methods: Energy Markets/Environmental Impacts
439. Economics of the Environment
Environment
212. United States Environmental Policy
345. Environmental Politics in the United States
363. Economics of the Environment
365. Engineering Sustainable Design and the Global Community
544S. Collective Action, Property Rights, and the Environment
577. Environmental Politics
583S. Energy and U.S. National Security
Political Science
145. Introduction to Political Economy
344. Environmental Politics in the United States
549S. Collective Action, Property Rights, and the Environment
665S. Energy and U.S. National Security
Public Policy Studies
211. Engineering Sustainable Design and the Global Community
275. United States Environmental Policy
281. Environmental Politics in the United States
577. Environmental Politics
583S. Energy and U.S. National Security
Environment
Chemistry
91. Chemistry, Technology, and Society
Civil and Environmental Engineering
461L. Chemical Principles in Environmental Engineering
462L. Biological Principles in Environmental Engineering
Earth and Ocean Sciences
351S. Global Environmental Change
355. Global Warming
364S. Changing Oceans
514 Energy and Ecology
544S. Geoengineering
Environment
102. Introduction to Environmental Sciences and Policy
245. The Theory and Practice of Sustainability
362S. Changing Oceans
Energy Science and Technology
Note: in selecting the elective course in energy science and technology, it is important to consider which course will provide optimal preparation for the student’s capstone project course. Students should discuss their selection of this elective with a co-director of the program.

Chemistry
590. Special Topics in Chemistry

Energy
310. Introduction to Energy Generation, Delivery, Conversion and Efficiency
630. Transportation and Energy

Energy Engineering
310. Introduction to Energy Generation, Delivery, Conversion and Efficiency
490. Special Topics in Energy Engineering

Environment
630. Transportation and Energy
631. Energy Technology and Impact on the Environment

Mechanical Engineering and Materials Science
461. Energy Engineering and the Environment
490. Special Topics in Mechanical Engineering

Physics
137S. Energy in the 21st Century and Beyond

Study at the Duke University Marine Laboratory
All undergraduate students at Duke, no matter what their major, have the opportunity to study at the Duke University Marine Laboratory in Beaufort, North Carolina. Academic programs include a fall semester, a spring semester and two 5-week summer terms. The fall and spring semesters include Beaufort Signature Travel Courses with extended field trips to Puerto Rico or Ascension Island, Bahamas; the Gulf of California; and Panama. The academic programs integrate classroom lectures and laboratories with direct field and shipboard experiences. For more information, visit the Duke Marine Lab website at [http://www.nicholas.duke.edu/marinelab/](http://www.nicholas.duke.edu/marinelab/).

A semester or summer term of coursework at the Duke Marine Laboratory is a core requirement of the BS major in biology with a concentration in marine biology. For more information see [http://www.biology.duke.edu/undergrad/requirements/concentrations/marine.html](http://www.biology.duke.edu/undergrad/requirements/concentrations/marine.html)

Advising
Students choose or are assigned to a faculty advisor based on students’ general areas of interest. The program encourages close relationships between faculty and students with convergent interests.

The Nicholas School of the Environment maintains an Office of Undergraduate Programs in 107 Old Chemistry Building (e-mail: undergrad@nicholas.duke.edu). The office provides useful information pertaining to major requirements and extracurricular opportunities relating to environmental sciences and policy and earth and ocean sciences. The office also maintains a website with up-to-date information about major requirements at [http://www.nicholas.duke.edu/programs/undergrad/](http://www.nicholas.duke.edu/programs/undergrad/).

Financial Aid
The Duke Undergraduate Financial Aid Office handles all financial aid matters, and the Bulletin of Undergraduate Instruction includes information about scholarships available to Duke undergraduates as well as loans and tuition payment plans.

Marine Lab Scholarships
The following scholarships are available to undergraduates wishing to study at the Duke University Marine Laboratory.

Summer Tuition Scholarships
Duke Marine Lab Summer Tuition Scholarships are available to all students enrolled in marine science summer courses. The criteria used in review of scholarship applicants are academic excellence, scope of preparation, professional goals, and need. A student may receive only one summer tuition scholarship per summer. The precondition for review of a scholarship application is admission to a specific summer course. Admission to courses does not automatically imply award of a scholarship; separate reviews are conducted. Please notify the Duke Marine Lab Enrollment Office at ml_enrollment@nicholas.duke.edu if you would like to apply for a summer tuition scholarship. You are required to submit a letter of recommendation from academic faculty and a brief statement of purpose, i.e., the reason for taking the particular course and demonstrate a need for the scholarship. Details are available online at [www.nicholas.duke.edu/marinelab/programs/summeraid](http://www.nicholas.duke.edu/marinelab/programs/summeraid). Deadline is April 1.
**Bookhout Research Scholarship**

The Bookhout Research Scholarship is offered for students interested in research related to the invertebrate zoology of marine animals. Support includes a full tuition scholarship to take Research Independent Study during Summer Session I or Summer Session II. A student may receive only one summer tuition scholarship per summer. The only requirement for the research project is that it involves some aspect of the biology of invertebrate animals. The scholarship recipients will be assigned to a faculty sponsor based upon their stated interests or the recipients may request a specific faculty advisor. Details are available at [www.nicholas.duke.edu/marinelab/programs/summeraid](http://www.nicholas.duke.edu/marinelab/programs/summeraid). Deadline is April 1.

**Undergraduate Scholarships in Marine Science**

Two scholarships are available during both fall and spring semesters for non-Duke undergraduates covering tuition & fees, room and board, books, travel to Beaufort, and full support for participation in one Beaufort Signature Travel Course. Undergraduate scholars will enroll in Duke courses taught in Beaufort, where there is emphasis on the biology and physiology of marine organisms, marine molecular biology, marine policy, and coastal socio-ecological issues. Eligible students must be currently enrolled as a sophomore, junior, or senior in college (non-Duke) and be a U.S. citizen or hold a permanent resident visa. Other factors considered in the evaluation process include whether an applicant identifies with a group that is racially/ethnically underrepresented in marine science; has demonstrated interest in marine science and its impact on society; anticipates pursuing a PhD in marine science; and submits a compelling personal statement and strong letters of recommendation. Details are available at [www.nicholas.duke.edu/marinelab/programs/undergraduate/fellowship](http://www.nicholas.duke.edu/marinelab/programs/undergraduate/fellowship).

**The Stanback Conservation Internship Program**

The Nicholas School offers paid summer conservation internship opportunities to any currently enrolled Duke undergraduate student through the Stanback Conservation Internship Program. Made possible by the support of Mr. and Mrs. Fred Stanback, the program provides students with significant work experience in grassroots conservation, advocacy, applied resource management, or environmental policy. More information is available at [http://www.nicholas.duke.edu/career/stanback](http://www.nicholas.duke.edu/career/stanback).

**Academic Recognition**

**The Sara LaBoskey Award** is given annually by the Nicholas School to a graduating senior in environmental science/policy in recognition of personal integrity and academic excellence. The award was established by Vicki and Peter LaBoskey in memory of their daughter, Sara LaBoskey.

**The Thomas V. Laska Memorial Award** is given annually by the Division of Earth and Ocean Sciences of the Nicholas School to a graduating senior in recognition of outstanding achievement and promise for future success in earth and ocean sciences. The award was established by Andrew J. and Vera Laska in memory of their son, Thomas Vaclav Laska.

**Teacher Certification**

Students pursuing environment or earth and ocean science majors who are interested in teaching in secondary schools are encouraged to earn a comprehensive science-teaching certificate in addition to the bachelor's degree. The teaching certificate, which is earned by fulfilling requirements prescribed by the state of North Carolina, is generally accepted in most of the fifty states by reciprocal agreement. In addition to completion of any of the major tracks, the requirements for the comprehensive science teaching certificate include coursework in biology, chemistry, and physics, an appropriate course in psychology, and several courses in education. The last semester of the senior year is devoted to a student-teaching program, including two special accelerated courses and ten weeks of full-time teaching and observation in local schools, working with a certified teacher and with Duke faculty.

Students considering secondary school teaching should contact the Program in Education for more information on this option and its requirements.
The Cooperative College 3-2 Program
(Combined Undergraduate and Master's Degrees)

The Cooperative College Program (3-2 program) allows qualified students to receive an undergraduate and master's degree by spending three years at a cooperating undergraduate institution (including Duke) and two years at the Nicholas School of the Environment. Students can pursue either of two master's degrees: the master of environmental management (MEM) or master of forestry (MF). Although the program is designed to accommodate a wide range of undergraduate backgrounds, it is best suited to majors in one of the natural or social sciences, pre-engineering, business, natural resources, or environmental science.

The baccalaureate degree is awarded by the undergraduate school after the student has spent at least two full-time semesters at Duke and earned enough units to satisfy the requirements of the undergraduate institution. After four semesters at Duke, during which a minimum of 48 course credits is earned, students will earn one of the professional master's degrees.

A student interested in entering the Cooperative College Program should attend one of the participating undergraduate schools, a list of which is available from the Office of Academic and Enrollment Services. Students should design their three years of undergraduate coursework to include prerequisite courses for the Nicholas School as well as undergraduate requirements. Students from the cooperative colleges may also enter Duke after completing a baccalaureate degree. In all cases, applicants from cooperative institutions are evaluated on the same basis as other applicants to the school.
The Nicholas School of the Environment offers two professional graduate degrees—the master of environmental management and the master of forestry, which prepare students for careers in a wide variety of employment settings, including government agencies, private industry, consulting, nonprofit organizations, and international organizations.

The Distinction between Professional and Doctoral Degrees

Professional graduate programs such as the master of environmental management (MEM) (including the Duke Environmental Leadership MEM) and master of forestry (MF) differ from traditional MS/PhD programs both in terms of the career goals of students and in terms of curricula. The MEM and MF are normally considered “terminal” degrees, equipping graduates to begin or advance in a professional career related to environmental policy and management. Most MEM and MF graduates hold management and staff positions in which they are expected to compile, analyze, and interpret natural and social science information and then use it to formulate a plan for action.

The MEM and MF curriculum reflects these employment goals. The emphasis is on coursework that provides a strong scientific and analytical foundation for management-oriented decision making. A master's project supplements the coursework by allowing students to demonstrate their organizational and analytical skills in solving an environmental management problem in their areas of specialization.
Although the MEM and MF degrees are not designed as precursors to the PhD degree, students who later choose to enter PhD programs suffer no disadvantage from taking a professional master's degree first.

Students desiring to concentrate their study and research within a well-defined subject area and planning for careers primarily in university teaching and research are encouraged to pursue the doctoral (PhD) degree. The PhD emphasizes disciplinary research, and all Nicholas School faculty train doctoral students at Duke. Prospective PhD students should consult the chapter in this bulletin on doctoral degrees as well as the bulletin of The Graduate School of Duke University (http://registrar.duke.edu/university-bulletins/graduate-school). For more detailed information, visit The Graduate School website at http://www.gradschool.duke.edu.

Professional Master's Degrees

The master of environmental management degree is designed to help students develop expertise in the management of the natural environment for human use with minimum deterioration of ecosystem stability. MEM degree candidates choose one of these programs of study:

- Coastal Environmental Management
- Ecosystem Science and Conservation
- Ecotoxicology and Environmental Health
- Energy and Environment
- Environmental Economics and Policy
- Global Environmental Change
- Water Resources Management

Students pursuing the master of forestry (MF) focus their studies on sustainable forest management. The MF is accredited by the Society of American Foresters.

The Duke Environmental Leadership (DEL) program also offers a master of environmental management degree for mid-career environmental professionals. The MEM program offered through the DEL program is primarily taught via distance learning technology, but requires students to attend five place-based sessions over the course of study. Applicants for the DEL-MEM program must have a minimum of five years relevant professional environmental experience. Students who successfully complete the DEL-MEM program are awarded the master of environmental management degree. Specific program requirements can be found below.

Program Requirements

Each of the Nicholas School’s professional programs requires the completion of 48 course credits (please see the section on Special Tracks for Practicing Professionals – Duke Environmental Leadership—Master of Environmental Management below for specific program requirements related to the master of environmental management degree offered through the Duke Environmental Leadership program). These units are distributed among a set of core courses required by each program, quantitative courses, electives, a master’s project, and seminars relevant to the program’s objectives. More specific information about requirements for any one of the programs may be obtained from the Office of Academic and Enrollment Services. With advisor approval, students may count up to 6 course credits of coursework related to their area of focus at the 200-499-level with a grade of at least B toward their degree requirements. Any requests to reduce credits, or waive course requirements, minimum semesters of tuition, or in-residence requirements must be made before half of the total course credits are completed for the student’s degree program.

Prerequisites

All programs require a semester each of college calculus and applied statistics as prerequisites. Most programs require additional prerequisites, as described later in this chapter. Any course submitted in fulfillment of a prerequisite must be taken for graded credit, a final grade of at least a B- must be earned and the course must be submitted on an official transcript from the accredited institution where the course was taken.

Major (Core) Courses

Each program requires a series of core courses that provide essential background training relevant to the program’s objectives, as outlined in the program descriptions below. All students are required to complete successfully the one credit Environment 800 (Professional Communications) during the fall term of their first year.
Quantitative and Analytical Courses

All programs require 6 to 12 course credits stressing quantitative and analytical methods.

Elective Courses

Elective courses are available to give the student flexibility in developing his or her course of study. Most programs use some of these courses to add depth to the major area of study or to develop a second area of expertise. Students who select the Environmental Economics and Policy program must use at least three of their elective courses to broaden their understanding of environmental science.

Master's Project

A master's project constituting 4 to 6 course credits is required. These projects take the form of individual or small-group analysis of a problem in natural resource management, offering alternative solutions for better management of the environment. The results of the master's project are presented orally in a symposium held near the end of each semester and in a written document that is presented to the student's advisor before graduation and uploaded into a world-wide searchable database.

Seminars

All students are required to participate in seminars in their program area each semester that results in a total of one unit of credit at the end of their program. These seminars prepare students for the master's project and other activities.

Certificates

Certificate programs allow students to achieve an area of special expertise by completing a series of courses and projects. At present, the Nicholas School offers certificates in geospatial analysis, sustainable systems analysis, environmental entrepreneurship and innovation, and in community-based environmental management. In addition, Nicholas School students sometimes complete certificate programs in other schools or departments, such as the International Development Policy certificate offered by the Sanford School of Public Policy or in global health from Duke’s Global Health Institute.

Experiential Learning

To complement academic coursework, the Nicholas School also offers experiential learning in environmental management. This includes short courses, field trips, and practical learning experiences guided by practicing environmental professionals from the energy industry, from forestry and from conservation. These practical learning experiences tie more traditional classroom learning to the work environments that professional degree students will be entering.

Professional Skills Development

In addition to regular courses and seminars, the Nicholas School of the Environment offers a series of optional lectures and workshops to prepare students for professional employment. Topics for these modules include field and laboratory techniques, project organization and management and teamwork skills. The director of professional studies makes the schedule and detailed information concerning the series available to students during the academic year. A modest matching fund is available to help students defray the cost of skills training offered outside the school, such as the certificate in nonprofit management offered by the Duke Continuing Studies department.

Professional Programs

Coastal Environmental Management

The Coastal Environmental Management program provides a scientifically rigorous understanding of global, national, and local physical and biological coastal environments and processes and the human behaviors and policies that affect, and are affected by, those environments and processes. The specific aim of the program is to train scientifically informed professionals to fill coastal policy and management, research or advocacy positions in federal, state, and local agencies, industry, consulting firms, and nonprofit organizations. The program also provides a firm foundation for future PhD studies.
The first year of the program is spent on the Durham campus fulfilling the required courses in areas such as natural resource economics, general environmental policy, ecology, oceanography, and methodological skills. The second year is usually spent in residence at the Duke University Marine Laboratory in Beaufort, taking courses in the natural, social, and policy sciences specific to the coastal and marine environment, and focusing on the production of the master's project. The marine lab provides an ideal setting for the study of natural and social scientific phenomena associated with coastal and marine environments, and for interaction with coastal and marine constituencies and policymakers in the application of science to policy. Potential opportunities for participation in the policymaking process are emphasized throughout the program.

**Prerequisites:** calculus, statistics, introductory microeconomics (or general economics that focuses on microeconomics rather than macroeconomics).

For more detailed information about this program, including specific prerequisites and degree requirements, visit [http://nicholas.duke.edu/programs/coastal-environmental-management](http://nicholas.duke.edu/programs/coastal-environmental-management).

### Ecosystem Science and Conservation

The Nicholas School offers one overarching ecological program that focuses on the natural science, policy, and management issues that relate to the stewardship of our natural resources. Conservation and ecosystem science are becoming ever more integrated as conservation planning moves to increasingly larger scales and addresses a wider range of resources, from biodiversity to watershed function. For curriculum planning purposes, the program is defined to provide a diversity of alternative perspectives on natural resource ecology and management. The defining feature of the program is a two-dimensional structure, consisting of a focal concentration area and an approach. The concentration defines a topical area or disciplinary specialization. The approach defines a methodological perspective and toolkit. In combination, these choices define a career track and a planning matrix for coursework and research experience for the MEM degree.

**Prerequisites:** calculus, statistics, principles of ecology

For more detailed information about this program, including specific prerequisites and degree requirements, see [http://nicholas.duke.edu/programs/ecosystem-science-and-conservation](http://nicholas.duke.edu/programs/ecosystem-science-and-conservation).

### Ecotoxicology and Environmental Health

The program in Ecotoxicology and Environmental Health (EEH) emphasizes interactions among human/environmental health and ecological processes. The concentration is concerned with the fates, effects, and risks of pollutants to natural ecosystems and human users of those systems both within the United States and internationally. A multidisciplinary program, EEH incorporates the concepts, information bases, and methodologies of toxicology, environmental chemistry, risk assessment, and ecology. This program stresses risk assessment attendant to actions/processes that affect human/environmental health and provides a scientific approach to environmental management. By instilling in the student a science-based approach combining integrated assessment for humans, biota, and natural resources, EEH seeks to produce scientists and environmental managers with a solid foundation in the principles underlying pollutant fates and impacts on ecology and environmental health, as well as a firm grasp of state-of-the-art approaches for evaluating specific instances of environmental contamination and for making management decisions based upon quantitative analysis.

**Prerequisites:** calculus, statistics, biology including human or animal physiology, chemistry; organic chemistry and ecology recommended.

For more detailed information about this program, including specific prerequisites and degree requirements, see [http://nicholas.duke.edu/programs/ecotoxicology-and-environmental-health](http://nicholas.duke.edu/programs/ecotoxicology-and-environmental-health).

### Energy and Environment

The Energy and Environment (EE) program aims to provide students with the skills and knowledge necessary to effectively address energy and environmental challenges. Over the course of the program, students will gain a broad perspective on the current energy system and future alternatives; a fundamental understanding of science and technology as it relates to energy and environment; background in the economics, policy and business of energy; first-hand exposure to the energy sector and energy leaders; critical skills in data analysis and modeling; and experience with communication, facilitation, project management, and teamwork.

Energy use is one of the most complex and multi-faceted problems influencing the future of the environment. Students wishing to complete the energy and environment concentration will need to complete coursework that
addresses energy across multiple disciplines, covering science and technology, economics, business, policy, and law. The concentration is organized along four broad themes: science and technology, markets and policy, tools, and energy electives. The curriculum requires students to take a core course, courses in science and technology; markets and policy; tools; energy and general electives; and the master’s seminar and project.

**Prerequisites:** calculus, statistics, introductory microeconomics (or general economics that focuses on microeconomics rather than macroeconomics).

For more detailed information about this program, including specific prerequisites and degree requirements, see [http://nicholas.duke.edu/programs/energy-and-environment](http://nicholas.duke.edu/programs/energy-and-environment).

**Environmental Economics and Policy**

The Environmental Economics and Policy (EEP) program is designed to train decision-makers, those who offer them expert advice, and those who try to influence policy through the political process. The program emphasizes the basic methods needed for analyzing how households and businesses react to existing and proposed environmental and resource policies. The program is highly analytical and is oriented toward the analysis of contemporary national and international environmental problems.

Understanding the effects of markets and institutions on people and the environment requires mastery of three broad areas of knowledge: the basic sciences pertaining to a natural resource or an environmental phenomenon; the relevant disciplines in the social sciences; and the quantitative and qualitative tools required for using knowledge from the physical, biological, and social sciences to arrive at informed decisions. Students choose one of three areas of emphasis: environmental policy analysis, environmental and resource economics, or business and the environment. Four major elective courses and three quantitative courses support the area of emphasis. Three science courses develop a resource area for applying social science analysis, e.g., conservation or water resources.

**Prerequisites:** calculus, statistics, microeconomics (or general economics that focuses on microeconomics rather than macroeconomics).

For more detailed information about this program, including specific prerequisites and degree requirements, see [http://nicholas.duke.edu/programs/environmental-economics-and-policy](http://nicholas.duke.edu/programs/environmental-economics-and-policy).

**Global Environmental Change**

The program in Global Environmental Change (GEC) trains students to analyze environmental changes that occur on a variety of temporal and spatial scales and to anticipate and respond to management and policy issues that arise from these changes. Global environmental change includes global climate change, but it also includes widespread changes in the world’s terrestrial environments, oceans, and coastlines. These changes, in turn, are affecting the well-being of human populations and of biological components of the global system. The GEC program provides an integrated package of fundamental environmental science, analytical skills, and management and policy training. Graduates of the program will be well equipped to serve as environmental analysts and managers bridging the gap between advances in the science of global change and the policy initiatives needed to manage the consequences of global change. The program is designed to provide the necessary background for a student to develop a career in public, private, or nonprofit sectors, or to pursue further studies in environmental science and policy. The program has particular strengths in global climate change, biodiversity, coastal environmental change, and earth surface processes, with faculty participating in a wide range of activities in these areas. Students couple study of basic earth system science with an understanding and analysis of national and international policy options that might be brought to bear on these global environmental problems.

**Prerequisites:** calculus, statistics; earth science, and biology recommended.

For more detailed information about this program, including specific prerequisites and degree requirements, see [http://nicholas.duke.edu/programs/global-environmental-change](http://nicholas.duke.edu/programs/global-environmental-change).

**Water Resources Management**

The program in Water Resources Management (WRM) enables students to understand the physical, chemical, and biological processes—as well as the social contexts—affecting freshwater environments. The program concentrates on problems that span the natural divisions of the biosphere, soil, plants, lakes, watersheds, groundwater, and the atmosphere, and teaches quantitative techniques, including measurement and modeling methods used by environmental managers.
The core coursework and training in the WRM program cover basic physical, chemical, and biological processes relevant to hydrologic sciences, methods of quantitative and statistical analysis, and methods of management and decision-making. Quantitative analysis techniques include mathematical and statistical methods, probabilistic and deterministic models, spatial analysis and modeling, and optimization and simulation methods. Methods for assessing human beliefs, attitudes and behavior, including survey design and analysis, and qualitative methods for analyzing documents and interview transcripts are also useful for water resources management.

Graduates of the program will acquire the skills required to practice as analysts, consultants, regulators, or entrepreneurs concerned with the management and protection of water resources. These employers include government agencies, public utilities, consulting firms, fuel and resource extraction companies, and hydrologic, atmospheric, or environmental research centers, and not-for-profit organizations. Within the WRM program, students can use their course selection to develop expertise toward a career in: Water Science, Water Management, and International Water.

**Prerequisites:** calculus, statistics, general economics; introductory physics and chemistry recommended.

For more detailed information about this program, including specific prerequisites and degree requirements, see [http://nicholas.duke.edu/programs/water-resources-management](http://nicholas.duke.edu/programs/water-resources-management).

**Master of Forestry**

The Master of Forestry degree integrates forest ecology and management within an educational program that emphasizes related environmental fields. The program builds knowledge in basic forest ecology and ecological management of forests for a variety of uses, including nontraditional forest products and conservation. This distinctive approach is brought about by coordinating a core set of forestry courses in sampling, measurement, dendrology, silviculture and ecology—combined with electives in resource-oriented courses (such as soils, hydrology, air quality, water quality, biological conservation, and physiology); statistical analysis and modeling; and resource economics and policy. The Duke Forest serves as an outdoor laboratory in many of these courses.

The focus of the Master of Forestry is problem solving in complex ecological and management systems. Within the program, students may acquire skills that qualify them for positions in industry, conservation organizations, government agencies, nonprofit organizations, and other groups involved with the use and conservation of forests. The MF program is accredited by the Society of American Foresters, which is recognized by the Council on Higher Education Accreditation as the specialized accrediting body for forestry educational programs in the United States. Students can develop additional credentials for employment by concurrently completing the MF degree and a master of environmental management degree in the Nicholas School of the Environment or other concurrent degree programs (i.e., business, law, or public policy) at Duke, as described in the section that follows.

**Prerequisites:** statistics, calculus, principles of ecology, microeconomics (or general economics that focuses on microeconomics rather than macroeconomics).

For more detailed information about this program, including specific prerequisites and degree requirements, see [http://nicholas.duke.edu/programs/master-of-forestry](http://nicholas.duke.edu/programs/master-of-forestry).

**Special Tracks for Practicing Professionals**

The Nicholas School of the Environment offers two options for environmental professionals who wish to receive a professional degree:

**The Senior Professional Program (SPP)** allows students to receive a master of environmental management or master of forestry degree in a compressed program with at least one semester spent on campus. SPP students choose one of the program areas available to all traditional MEM and MF students.

**The Duke Environmental Leadership Master of Environmental Management (DEL-MEM)** is for mid-career professionals with a leadership focus. The DEL-MEM program is primarily held online and thus requires minimal time on campus (five place-based sessions over the two-year program are required), making it feasible for professionals to pursue the degree while working full-time.

**Senior Professional Program**

The Senior Professional Program is a special master’s degree track for candidates with at least five years of work experience in an environmental field. Those who qualify may be admitted to the Nicholas School to complete a master of environmental management or master of forestry degree with reduced credit and residency requirements.
The Senior Professional Program may not be combined with any other degree programs. All students admitted to the Senior Professional Program must complete all prerequisites (school-wide and program area specific) prior to matriculation.

These professional degree candidates must spend at least one semester at Duke enrolled in regular graduate-level courses. Up to 15 course credits are taken during this semester. The remaining course credits required for the MEM or MF degree (usually 15 additional course credits) may be earned through another semester in residence or through available for-credit executive education courses offered through the DEL program, independent study, and the master’s project. Candidates have five years from the date of acceptance to complete the degree requirements.

The student’s advisor—upon evaluation of the individual’s previous education, work experience and career goals—establishes specific degree requirements for students in the Senior Professional Program, including required courses and the number of academic units necessary to complete the degree. At least 30 course credits are required.

**Duke Environmental Leadership—Master of Environmental Management**

The Duke Environmental Leadership Master of Environmental Management Program (DEL-MEM) is a two-year, four-semester, 30-course-credit program designed for mid-career professionals with a minimum of five years’ environmentally related experience. The DEL-MEM focuses on interdisciplinary and global themes, strategic approaches to environmental management, communication, and effective leadership. The DEL-MEM degree is offered primarily via distance learning technologies, and is complemented with five short place-based sessions. The online format allows professionals to pursue a master of environmental management while maintaining a commitment to job and family.

**Program Format**

The DEL-MEM combines distance-learning courses and short, intensive on-campus sessions. The five required on-campus sessions give participants an opportunity to experience the campus environment, meet fellow MEM students, interact directly with faculty, and participate in leadership development activities. Including orientation, students are required to come to the Duke campus five times during their studies. One of these sessions, includes the hallmark DC Leadership Module in which students convene in Washington, DC, and meet with prominent leaders in all sectors. Between campus visits, and to complement the face-to-face sessions, students complete individual and group coursework online through web-conferences, discussion boards, Skype, e-mail, and other advanced interactive technologies.

**Prerequisites:** Five years of relevant professional environmental experience is a prerequisite for the program. No specific courses are required to apply.

**Major (Core) Courses.** Core courses are offered in ecosystems science and management, making environmental decisions, economics of environmental management, environmental law and policy, and program management for environmental professionals. Other required components include: five place-based intensive sessions (varying from three to six days), a professional writing skills course for first-year students, and a master’s project.

**Elective Courses.** Elective courses, developed around more specialized themes, are offered in the spring semesters and alternate each year. Independent studies and projects and one-credit intensive short courses may also be taken.

**Master’s Project.** A master’s project constituting 4 course credits is required. These projects take the form of individual or small-group analysis of a problem in natural resource management, offering alternative solutions for better management of the environment. A project related to the student’s current employment is recommended, but not required. The results of the master’s project are presented orally on campus and in a written document that is approved by the student’s advisor before graduation.

For more details on curriculum requirements, see [http://www.nicholas.duke.edu/del/delmem/](http://www.nicholas.duke.edu/del/delmem/).
Contact Information

For more information about the DEL-MEM program, contact the DEL Program Office at (919) 613-8082, e-mail del@nicholas.duke.edu, or visit http://www.nicholas.duke.edu/del/delmem.

The Cooperative College (3-2) Program

The Cooperative College Program (3-2 program) allows qualified students to receive an undergraduate and master’s degree by spending three years at a cooperating undergraduate institution and two years at the Nicholas School of the Environment. Students can pursue either of two degrees, the master of environmental management (MEM) or master of forestry (MF). See the chapter Undergraduate Degree Programs on page 30, for more details about the program. Application procedures are described in the chapter "Academic Information for Professional Degree Students" on page 44.

Concurrent Degrees

The most current information on all concurrent degree programs can be found here: http://nicholas.duke.edu/programs/concurrent-degree-programs.

Master of Environmental Management and Master of Forestry

With careful planning of their curriculum, students can earn both the MEM and the MF degrees concurrently. The requirements for earning both degrees are as follows:

1. The student must qualify for either the MEM or MF degree by earning 48 course credits under the requirements set forth in the previous section.
2. For the second degree, the student must complete an additional 24 course credits of study that, in combination with courses taken for the first degree, meet the substance of the requirements for the second degree. Two additional semesters in residence are normally required, although, with careful planning, the student may complete both professional degrees in a total of five semesters.
3. One master’s project should combine the two areas of study.

Determination of eligibility for the degrees will be made on an individual basis and will consider the educational background and objectives of the student.

Master of Business Administration

The techniques of management science are applied with increasing frequency in the management of natural resources, and they are also now commonly used in the analysis of environmental and corporate sustainability challenges. To train students in the integration of management and environmental sciences, the Nicholas School of the Environment and The Fuqua School of Business offer concurrent business degrees. At least three years of study are required to earn the combined degrees of master of environmental management/master of business administration or master of forestry/master of business administration. At least 36 course credits within the Nicholas School are required to receive the MEM or MF degree; these include 4 to 6 course credits for the master’s project. A typical program sequence would involve spending the first year in the Nicholas School followed by a year in The Fuqua School of Business, and concluding with the final year of combined work in both schools.

These concurrent degrees stress analytical reasoning and the basic methodologies of management science, while providing the student with knowledge of current problems in the natural resource industries, industrial ecology, and sustainable business practices. The study of managerial economics, resource economics, organization theory and management, resource management, the legal environment, and the public policy aspects of resource industries form a substantial component of each degree.

Because of the academic demands of these degrees, those entering without the necessary analytical skills or life science background may be required to take additional work beyond that specified.

Students who wish to undertake both the master of environmental management or master of forestry and master of business administration degrees submit one application through The Fuqua School of Business that is reviewed by each school. Notification of admission status will be transmitted separately by each school. Students electing to pursue the MEM or MF concurrently with the MBA must complete the requirements for both degrees before either degree will be awarded. For information on the master of business administration degree, the prospective student should write to The Fuqua School of Business, Admissions Office, Duke University, Box 90104, Durham, NC 27708-0104, or visit http://www.fuqua.duke.edu. Detailed information on the MEM/MBA program and requirements can be found at http://nicholas.duke.edu/programs/mem-or-mf-mba.
Master of Public Policy

As issues concerning natural resources and the environment have become increasingly significant to the nation, a corresponding need has developed for well-trained policy analysts who can provide timely and appropriate information and analysis to resource policy makers. Students interested in a professional degree in environmental policy at Duke have three options: 1) the master of environmental management (MEM) degree in the environmental economics and policy program of the Nicholas School, described above; 2) a master of public policy (MPP) degree from the Sanford School of Public Policy; or 3) concurrent MEM/MPP degrees from the Nicholas School and the Sanford School. Doctoral candidates in the Nicholas School are also eligible to undertake the master of public policy.

The concurrent MEM/MPP degree provides training in the politics and economics of resource and environmental policymaking. Emphasis is placed on understanding the social and political forces involved, developing facility with quantitative and logical methods of forecasting and evaluating policy consequences. Knowledge of the uses and limitations of policy analysis and an awareness of the ethical dimensions of policy choice are also stressed.

The concurrent degree takes three years to complete. Typically, the first year is devoted to study in the Sanford School of Public Policy, the second year is spent in the Nicholas School of the Environment and the third year combines work in both the Nicholas School and the Sanford School. At least 36 course credits within the Nicholas School are required to earn the MEM or MF degree. A summer internship with a resource or environmental agency, or with a related legislative, judicial, or interest group, is required for the policy degree. Students in this concurrent degree program have the option of doing two separate master's projects (MP), or one combined MP. Concurrent degree students working in a group MP in the Nicholas School must choose the two-MP option. Students electing to pursue the MEM concurrently with the MPP must complete requirements for both degrees before either degree will be awarded.

Students must apply to and be accepted by both the Nicholas School of the Environment and the Sanford School of Public Policy. For detailed information on the public policy degree, write to the Director of Graduate Studies, Sanford School of Public Policy, Duke University, Box 90243, Durham, NC 27708-0243, or visit the Sanford School of Public Policy website at http://www.sanford.duke.edu.

Juris Doctor in Environmental Law and Juris Doctor/MA Option

Environmental and natural resource issues increasingly require legal and regulatory knowledge for resolution. There is a growing demand for resource managers and scientists who have legal credentials; similarly, attorneys are facing more situations in which knowledge of natural resources and the environmental sciences is critical to the resolution of disputes. To satisfy these demands, the Nicholas School of the Environment and the Duke University School of Law have developed a cooperative arrangement to allow pursuit of concurrent master of environmental management (or master of forestry) and juris doctor degrees.

For students in the concurrent MEM (or MF)/JD program, the Nicholas School requires 36 course credits, including a master's project. The School of Law requires 84 course credits in law, 12 course credits of which may be satisfied through courses taken in the Nicholas School.

Typically, a student will complete the first year of study in the Duke Law School and the second in the Nicholas School. During the third and fourth years, the student will take a combination of courses in both schools. Students electing to pursue the MEM concurrently with the JD must complete requirements for both degrees before either degree will be awarded.

MEM/JD candidates must apply to and be accepted by both the Nicholas School of the Environment and the Duke Law School. For information on the law degree, prospective students should write to the Duke University School of Law, Admissions Office, Duke University, Box 90393, Durham, NC 27708-0393, http://www.law.duke.edu.

Additionally, the Duke University School of Law offers a unique program whereby students enrolled in the Duke Law School may concurrently pursue a master of arts degree in a variety of subject areas, including environmental studies. Students who intend to focus their careers on law but who wish to supplement their legal education with continuing study of the environment may find this program of interest. Students pursuing the MA are governed by the regulations of The Graduate School but take their coursework alongside professional degree students.
Applicants to this program must file an application with the Duke Law School at [http://law.duke.edu/admis](http://law.duke.edu/admis). The application is also reviewed by faculty in the Nicholas School, and admission is offered by the Duke Law School and The Graduate School.

The JD/MA program requires that students begin their studies in the summer and continue through the following six academic semesters. During that time students will earn 30 course credits in The Graduate School, of which twenty-four must be graded, and 72 course credits in the Duke Law School. MA students complete an oral comprehensive examination in the Nicholas School but are not required to complete a master's project. Further information is available from the director of graduate studies of the Nicholas School.

**Master of Arts in Teaching**

Over the past several decades, international concern for protecting our ecosystems has led to an increased need to educate citizens on the challenges facing our environment. Numerous education programs are now aimed at K-12 students as well as the general population. Environmental education is of increasing importance to those who prepare to teach, particularly in the sciences. Duke's concurrent degree program between the Nicholas School of the Environment and The Graduate School allows students to meet this challenge by earning a master of environmental management (MEM) and a master of arts in teaching (MAT) degree.

In this concurrent degree program, to earn the MEM degree students must complete 36 course credits in the Nicholas School, including a master's project. For the MAT degree, students will complete 30 course credits, including a full-year teaching internship and all requirements for the North Carolina teaching licensure in comprehensive science at the high school level. Competencies required by the state will be met through undergraduate courses taken prior to admission to Duke, science courses taken as part of the MAT or courses taken as part of the MEM.

Students will normally enroll in the MAT program during the summer and then complete an academic year of student teaching and MAT coursework prior to enrolling in the MEM program for three semesters. Students electing to pursue the MEM concurrently with the MAT must complete requirements for both degrees before either degree will be awarded.

Students must apply to and be accepted by both the Nicholas School of the Environment and The Graduate School of Duke University, citing the master of arts in teaching program. Students admitted to the MAT program in comprehensive science must hold an undergraduate degree in one of the natural sciences with significant undergraduate preparation in biology and chemistry. Organic chemistry is required.

Questions concerning the MAT degree should be addressed to the Director of the Master of Arts in Teaching Program, Duke University, Box 90093, Durham, NC 27708-0093; (919) 684-4353, [http://duke.edu/web/MAT](http://duke.edu/web/MAT).

**Master of Engineering Management**

Duke's concurrent degree program between the Nicholas School of the Environment and the Pratt School of Engineering provides a broad perspective to blend the master of engineering management (MEMP) students' engineering backgrounds and the master of environmental management (or master of forestry) students’ training in natural and social environmental sciences, resulting in graduates with a strong mix of technical and contextual knowledge and tools well suited to careers in several environmental sectors, particularly energy and environment, environmental health, and water resources. Students wishing to pursue the MEM in a concurrent arrangement with the MEMP should plan on two to three years of study.

Students must complete 36 course credits in the Nicholas School, including a master's project. An additional 24 course credits must be taken in the Pratt School of Engineering, including a required summer internship.

Prior to enrolling in the fall, students fulfill their required engineering internship in the summer preceding the fall term. During the first year, courses are split evenly between engineering and environment with an emphasis on core engineering courses. The second year includes elective credits in the Pratt School of Engineering and key core courses in the Nicholas School. During the third year students will complete their master’s projects for the Nicholas School; they may be able to finish in one additional semester or may require the full year to complete remaining credits and the master’s project.

Students must apply to and be accepted by both the Nicholas School of the Environment and the Pratt School of Engineering. Students electing to pursue the MEM or MF concurrently with the MEMP must complete requirements for both degrees before either degree will be awarded. Questions concerning the MEMP should be addressed to the Master of Engineering Management Program, Duke University Pratt School of Engineering, 3120 Fitzpatrick Center (FCIEMAS), Box 90300, Durham, NC 27708-0300; Phone: (919) 660-5455; [www.memp.pratt.duke.edu/](http://www.memp.pratt.duke.edu/).
Concurrent Degrees with Other Universities

With the special permission of the education committee and the dean of the Nicholas School of the Environment, students are permitted, on an individual basis, to establish concurrent degree programs with certified graduate degree programs either within or outside of Duke University. In the past, students have designed such programs with law schools, business schools, and graduate engineering programs. As with the other concurrent degrees, the student must be enrolled in the master of environmental management or master of forestry degree program for at least 36 course credits and be in residence for three semesters.

To receive permission to pursue a specially designed concurrent degree, the student must show an official acceptance from another certified graduate degree program. For additional information concerning special concurrent degrees, applicants should consult the Office of Academic and Enrollment Services.
Admissions

Requirements and Prerequisites

The Nicholas School of the Environment welcomes applications from domestic and international students of all backgrounds who seek an intellectually challenging education designed to prepare them for leadership in a wide variety of natural resource and environmental careers. Admission to the master of environmental management (MEM) and the master of forestry (MF) is open to students who hold a bachelor’s degree from an accredited college or university or who have completed at least three years of study in an institution participating in the Cooperative College Program described later in this chapter. Admission as a nondegree student may also be granted under appropriate circumstances.

Students enrolled in the Duke Environmental Leadership Master of Environmental Management Program (DEL-MEM) are subject to all of the same requirements, responsibilities, and policies as set forth for residential MEM students, except where specifically differentiated (i.e., admissions requirements, credit requirements, program format, and curriculum requirements). Admission to the DEL-MEM is open to students who hold a bachelor’s degree
Academic Information for Professional Degree Students

from an accredited college or university and have a minimum of five years of professional environmental experience. The DEL-MEM program is a 30-course credit, two-year, four-semester master of environmental management degree-granting program utilizing distance learning technologies.

**Prerequisites**

All students admitted to the school are expected to have had the following (The DEL-MEM program does not have any course prerequisite requirements; however five years of professional environmental experience is required):

- Some previous training in the natural sciences or the social sciences related to their area of interest in natural resources and environment.
- At least one college semester of calculus.
- A college statistics course that includes descriptive statistics, probability distributions, hypothesis testing, confidence intervals, correlation, and simple linear regression.

Each program area requires additional courses or recommends additional preparation, as follows:

- Coastal Environmental Management: microeconomics (or general economics that focuses on microeconomics)
- Ecosystem Science and Conservation: principles of ecology; microeconomics (or general economics that focuses on microeconomics) is recommended
- Ecotoxicology and Environmental Health: biology (including human or animal physiology), chemistry; organic chemistry recommended
- Energey and Environment: microeconomics (or general economics that focuses on microeconomics)
- Environmental Economics and Policy: microeconomics (or general economics that focuses on microeconomics)
- Forest Resource Management: microeconomics (or general economics that focuses on microeconomics); principles of ecology
- Global Environmental Change: earth science and biology recommended
- Water Resources Management: economics; undergraduate training in chemistry and physics recommended
- Duke Environmental Leadership Program: minimum of five years professional environmental-related experience.

All courses taken to fulfill a prerequisite must be full-semester courses, be taken for a graded credit and a final grade of B- or better must be earned in the course. Official transcripts must be submitted to the Office of Academic and Enrollment Services.

Although students lacking the level of preparation described above may be accepted for admission, deficiencies should be made up prior to enrollment in the Nicholas School. It is especially important for concurrent degree students and students planning to study at the Duke University Marine Laboratory in their second year to complete all prerequisites prior to enrollment. A limited number of deficiencies may be made up during the first year of residence; however, these courses will not count toward the 48 course credits required for the MEM or MF degree.

**Interviews**

An interview with a member of the admissions committee is not required but may be helpful to the applicant as well as to the school. Consequently, those applicants who can visit the Nicholas School are encouraged to do so. The visit presents an excellent opportunity for the applicant to ask questions and gain insights about the school. Applicants are encouraged to allow sufficient time to visit classes, meet students and faculty and tour the university.

In general, visits can be scheduled on weekdays throughout the academic year by contacting the Office of Academic and Enrollment Services at least two weeks in advance of the desired visit. Although visits during the summer months are possible, they should be scheduled well in advance since no summer classes are taught at the Durham campus of the Nicholas School of the Environment, and faculty are frequently away from campus. Formal visitation programs are hosted by the Office of Academic and Enrollment Services of the Nicholas School of the Environment on-campus in the fall semester and through two virtual visitations conducted online.

Each year, representatives of the Nicholas School travel throughout the country to visit undergraduate schools, participate in graduate school fairs, and attend relevant professional conferences. Applicants interested in meeting with a representative of the school should write or call the Office of Academic and Enrollment Services, or visit www.nicholas.duke.edu/programs/professional for a schedule of on-campus visits and open house events.

In addition, it is sometimes possible to arrange an interview with an alumnus, particularly where distance precludes travel to Durham. For further information or to arrange a school visit, applicants may contact the Office of Academic and Enrollment Services by e-mail admissions@nicholas.duke.edu, or by calling (919) 613-8070.

Applicants to the DEL-MEM program are required to participate in an interview, upon request. For questions about the DEL-MEM program, e-mail del@nicholas.duke.edu, or call (919) 613-8082.
Admissions Criteria

Admissions criteria for the Nicholas School of the Environment are designed to ensure that admitted students will perform well while they are at Duke and after they graduate. Academic performance as an undergraduate, scores on the Graduate Record Examination and work experience are the primary factors considered in the application review process. Letters of recommendation, the applicant’s statement of educational goals, extracurricular activities and other information requested on the application also provide a basis for selection.

The Admissions and Awards Committee evaluates each candidate for his or her academic potential, professional promise and ability to benefit from and contribute to the goals of the school. Individuals with prior relevant work experience are especially encouraged to apply.

The admissions criteria for the DEL-MEM program include a minimum of five years relevant professional environmental experience. Academic performance as an undergraduate, professional environmental work experience, leadership experience and/or potential, letters of recommendation, applicant essays, and an applicant interview are the primary factors considered in the application review process. Extracurricular activities and other information requested on the application also provide a basis for selection.

Application Procedures

Application for admission to the residential master of environmental management and the master of forestry degrees is made through the Office of Academic and Enrollment Services of the Nicholas School of the Environment by submitting an electronic application. All correspondence should be addressed as follows: Office of Academic and Enrollment Services, Nicholas School of the Environment, Duke University, Box 90330, Durham, NC 27708-0330.

The application deadline is January 15 preceding the fall in which admission is desired. Because the school processes applications from more qualified students than it can admit, early submission of applications is recommended. Applications received after the January 15 deadline are held until all on-time applications have been considered. Admissions decisions on late applications are made on an individual basis according to the availability of student spaces and financial assistance.

No applicant will be considered until the completed application form, statement of objectives, and all related documents described below are received by the Office of Academic and Enrollment Services. All paper-based materials should be submitted together.

1. **Application Form.** Electronic application is available at the Nicholas School website at [http://www.nicholas.duke.edu/programs/professional/apply](http://www.nicholas.duke.edu/programs/professional/apply). The Admissions and Awards Committee attaches considerable weight to the statement of educational objectives submitted by the applicant. This statement should reflect well-defined motivation to pursue graduate study. The school is particularly interested in applicants who show leadership potential in the broad field of natural resources and the environment. Applicants are expected to demonstrate the maturity and sense of purpose essential to a demanding educational experience, including an understanding of the value of professional education to the applicant’s career plans and expectations.

2. **Official Transcripts.** One copy of the official transcripts from each undergraduate and graduate school attended should be sent to the Office of Academic and Enrollment Services in sealed envelopes that have been signed across the flap by the registrar of the institution attended. If the original transcript is not in English, the applicant must also provide a certified English translation. If not included on the transcript, students must provide proof of the degree prior to enrollment. If the undergraduate institution uses SCRIP-SAFE International (or similar agent) for the delivery of official transcripts, the applicant may request that their registrar forward an official transcript to admissions@nicholas.duke.edu.

3. **Letters of Recommendation.** Each applicant is required to submit three letters of recommendation, electronically. If electronic submission is not possible the recommender may submit a recommendation on a form available from Academic and Enrollment Services, which may also be attached to the recommender’s letterhead. These letters should be sent in sealed envelopes that have been signed across the flap by the writer. Recommendations provide the Admissions and Awards Committee with evaluations of the applicant’s past performance in academic and employment situations. Although recommendations from any source are acceptable, it is preferable that as many as possible come from college instructors.

4. **Graduate Record Examination (GRE) scores.** All applicants for degree programs must provide official scores on the general test (verbal, quantitative, and writing assessment) of the Graduate Record Examination. Subject tests are not required. For scores to be considered, the GRE must have been taken within five years of
the date of application. The GRE is administered by the Educational Testing Service at locations throughout the world. Applicants are urged to take the exam at the earliest convenient date. Scores on tests taken later than December may not reach the school until after the January 15 priority deadline. Scores should be reported to Duke University code number 5156. Registration forms may be obtained online at http://www.takethegre.com/. Applicants may send copies of their reports to the Nicholas School's Office of Academic and Enrollment Services, but official reports from the Educational Testing Service are required before admission decisions can be made.

5. Application Fee. A nonrefundable application fee of $75 is required of all applicants. A personal check, money order, or cashier's check made payable to Duke University is acceptable. Applicants who submit their applications electronically may pay the fee via credit card. Applications will not be processed until the required fee has been paid.

6. Undergraduate dean’s approval for students applying through the Cooperative College Program. (See below for additional information.)

Application for admission to the DEL-MEM program is made through the Duke Environmental Leadership Program office by submitting an electronic application. All correspondence should be addressed as follows: Duke Environmental Leadership Program, Box 90328, North Building, 304 Research Drive, Suite 324, Durham, NC 27708-0328. All application requirements are outlined at http://www.nicholas.duke.edu/del/del-mem.

DEL-MEM students are admitted at the beginning of the fall term. The application deadline is February 1 preceding the fall in which admission is desired. The DEL-MEM program only has one admission period. Applications received after the February 1 deadline are held until all on-time applications have been considered. Admissions decisions on late applications are made on a case-by-case decision.

No applicant will be considered until the completed application form, letters of recommendation, employer support letter, and all related documents described are received by the Duke Environmental Leadership program. International applicants to the DEL-MEM should review specific requirements and other information at http://www.nicholas.duke.edu/del/del-mem.

Additional Procedures for International Students

Each year the Nicholas School of the Environment welcomes a number of international students among its professional degree candidates, including the Duke Environmental Leadership program. Applicants from other countries must meet the same criteria as applicants from the United States, including a four-year bachelor's degree or its equivalent. All academic transcripts and other documents in support of admission must be accompanied by an official translation if the original document is not in English. The nonrefundable application fee must accompany the application.

Test of English as a Foreign Language (TOEFL)

Applicants must have a fluent command of oral and written English. No allowance is made for language difficulty in arranging course schedules or in evaluating performance. If the native language is not English, the applicant must submit scores on the Test of English as a Foreign Language (TOEFL) to be considered for admission. All arrangements for taking the TOEFL must be made directly with the Educational Testing Service at http://www.ets.org/toefl/. In cases in which an applicant's TOEFL score is low, the applicant may be accepted on the provision that he/she completes an intensive English language program in the United States prior to enrollment. Official acceptable scores on the International English Language Testing System (IELTS) may be submitted in lieu of the TOEFL.

In addition to TOEFL scores, international applicants whose native language is not English may be interviewed remotely (Skype) to evaluate English proficiency prior to acceptance in the program.

Proficiency exams in written and spoken English will be given to nonnative speakers during orientation week. Students found to lack the proficiency in English needed to do well at Duke will be required to enroll in additional English language instruction. Students should be prepared to assume all costs for being tutored in English and may need to reduce their course or research program while being tutored. If more than one English language course is required, MEM and MF students may count one English course toward their degree; otherwise, English language instruction does not count toward credit hours required for the MEM or MF degree. (This paragraph is not applicable to students in the DEL-MEM program).
Proof of Funding

The visa-granting authority in the student’s country of origin, ordinarily the United States Embassy, requires proof that sufficient funds are available to the student to cover the expenses of all academic years of study before a visa can be granted. Foreign students are not eligible for federal and state loans, although they may qualify for certain educational loans through private United States agencies. Current immigration laws make it difficult for the foreign student to find summer employment and permanent employment in the United States after graduation. Merit-based financial assistance, if it is offered, is not sufficient to cover all of the costs associated with studying at the Nicholas School. International students should expect to demonstrate other sources of support in order to obtain a visa.

Specific information for international students in the DEL-MEM program should review the requirements at http://www.nicholas.duke.edu/del/del-mem/.

Admission through the Cooperative College (3-2) Program

The Cooperative College Program (3-2 program) allows students to receive an undergraduate and master’s degree by spending three years at a participating undergraduate institution and two years at the Nicholas School of the Environment. Students can pursue either of two degrees, the master of environmental management (MEM) or master of forestry (MF).

A student interested in entering the Cooperative College Program should attend one of the participating undergraduate schools, a list of which is available from the Office of Academic and Enrollment Services. Students should apply for admission to the Nicholas School by January 15 of their third undergraduate year. Applicants from the participating schools are considered regular applicants for admission and are judged by the same criteria; therefore, students should submit application forms, transcripts, letters of recommendation, and results of the Graduate Record Examination. In addition, students applying to this 3-2 program must also submit a letter from the undergraduate dean approving the application.

Admission to the Senior Professional Program

Applicants for either the master of environmental management or master of forestry degree through the Senior Professional Program follow the same application procedures as regular students in the school. Applications should be submitted by January 15 for the fall term. Normally, degree candidates in the Senior Professional Program take the required semester in residence during the term following admission. Any student admitted to the Senior Professional Program must complete all prerequisites prior to matriculation.

Admission with Nondegree Status

Persons wishing to enter the Nicholas School of the Environment as nondegree students must submit a special application form requesting nondegree status along with an application fee of $25. The applicant must have completed a bachelor's degree from an accredited college or university and must submit an official transcript of all previous coursework. Taking the Graduate Record Examination is not required, although GRE scores are helpful in the admissions process. The student must have one letter of recommendation; this letter should indicate why the applicant should be allowed to undertake nondegree study at Duke. The application itself requires a brief statement of purpose in which the applicant should state his or her reasons for such study at Duke.

Admission as a nondegree student does not guarantee future admission to the MEM or MF degree. Nondegree students who complete an application for the professional degree and are offered admission may transfer a limited number of appropriate credits from their nondegree status at Duke into the MEM (or MF) degree. The student's program chair will determine which if any credits may be counted toward the degree. Applying credits taken as a nondegree student does not reduce the number of semesters required for the degree or the tuition required. The DEL-MEM program does not accept transfer credits.

Offers of Admission

When admission is approved, the applicant will receive an offer of admission and an acceptance form. Offers of admission for the fall semester, including financial aid awards, are sent to accepted students in mid-March. Offers of admission for the fall semester within the DEL-MEM program are sent to accepted students beginning in mid-April. A nonrefundable tuition deposit is required with acceptance of the offer. The admission process is not complete until the acceptance form and the tuition deposit have been returned to the Office of Academic and Enrollment Services or to the Duke Environmental Leadership program, respectively. Failure to respond by the stated deadline may result in cancellation of acceptance.
Deferred Admission

Applicants are admitted only to the class for which they have applied and should not apply until they are prepared to undertake professional studies. Applicants with substantial reasons for deferring the start of graduate work must send a request to the Admissions and Awards Committee in care of the Office of Academic and Enrollment Services, or the Duke Environmental Leadership program, as appropriate, as soon as possible after receiving an offer of admission. Offers of financial assistance are cancelled upon deferral of admission, and students must be reconsidered for financial aid.

Financial Information

Tuition and Fees

Estimated Expenses for the Academic Year

The following approximate costs, applicable in 2014-2015, are indicative of costs that can be expected by MEM and MF candidates; PhD students should consult the bulletin of The Graduate School for similar data.

<table>
<thead>
<tr>
<th>Expense</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuition ($16,450 per semester)</td>
<td>$32,900</td>
</tr>
<tr>
<td>Student health fee ($342 per semester)</td>
<td>$684</td>
</tr>
<tr>
<td>Graduate student activity fee ($17 per semester)</td>
<td>$34</td>
</tr>
<tr>
<td>Recreation fee ($120 per semester)</td>
<td>$240</td>
</tr>
<tr>
<td>Transcript fee (first semester only)</td>
<td>$40</td>
</tr>
<tr>
<td>Housing</td>
<td>$7,763</td>
</tr>
<tr>
<td>Food</td>
<td>$4,561</td>
</tr>
<tr>
<td>Books and supplies</td>
<td>$1,240</td>
</tr>
<tr>
<td>Transportation</td>
<td>$1,646</td>
</tr>
<tr>
<td>Motor Vehicle Registration and Parking Automobile</td>
<td>$100-$1,200</td>
</tr>
</tbody>
</table>

In addition to these fixed expenses, the student may incur other expenses, which will depend to a large extent upon individual tastes and habits. All students are required to carry major health insurance either through Duke's comprehensive medical insurance plan or by providing proof that other health insurance provides equal coverage. The average Duke student, however, can plan on a budget in the range of $50,000 to $55,000 for the academic year. Students with spouses and children, naturally, will have higher expenses.

Specific tuition information for the Duke Environmental Leadership program can be found at [http://www.nicholas.duke.edu/del/del-mem/](http://www.nicholas.duke.edu/del/del-mem/).

Flat-rate Tuition

Professional degree students in the Nicholas School pay a flat rate of tuition per semester (excluding the summer session) (see “Flat-rate Tuition—Duke Environmental Leadership Program” on page 49 below for the DEL-MEM program). Students enrolled in the regular two-year MEM or MF degree program are required to pay the flat rate tuition for a minimum of four semesters. Students in concurrent degree programs at Duke pay a flat rate to the university throughout their concurrent degree program that is split proportionately between the two programs regardless of where the student is taking courses in a particular semester; the tuition rate for the Nicholas School is equivalent to three semesters. Students in the concurrent MEM/MF program must enroll full-time for at least five semesters and pay the flat-rate tuition for a minimum of five semesters.

The flat-rate tuition allows master of environmental management and master of forestry degree candidates to register for 9 or more course credits for a fixed tuition payment per semester. The normal full-time enrollment is expected to be 12 course credits per semester, although course credits may vary from 9 to 15 depending upon the student’s academic and assistantship requirements. Permission is required to register for fewer than 9 or more than 15 course credits in a semester.

If the student is permitted to be enrolled part time (fewer than 9 course credits), he or she will be charged per course credit ($1,600 per unit for the 2014-2015 academic year). Students who are approved for part-time enrollment status are not eligible for school or federal financial aid. The per credit rate is available to professional degree students only after the minimum number of semesters’ of tuition have been paid (three, four or five semesters depending on the degree program/s).

Students who wish to earn additional credits during the summer will be charged at the part-time rate per course credit. Payment for summer session courses is in addition to the required four semesters at the flat tuition rate.
Students who have completed the required semesters in residence and all course requirements except the master's project will be charged a minimum registration fee ($350 for 2014–2015) each semester until the degree is completed.

All students are expected to be registered in residence, to be approved for a leave of absence or to pay a minimum registration fee for each semester until their degree is completed.

Flat-rate Tuition—Duke Environmental Leadership Program

Professional degree students in the Nicholas School DEL-MEM program pay a flat rate of tuition per semester (excluding the summer session). Students in the two-year DEL-MEM program will pay the flat-rate tuition for four semesters.

The DEL-MEM program is a minimum 30-course-credit program that must be completed in four semesters over two years. The flat-rate tuition allows master of environmental management degree candidates to register for courses for a fixed tuition payment per semester. To complete the DEL-MEM program within the required amount of time, students typically take between 6 and 9 course credits per semester. Permission is required to register for fewer than 6 course credits or more than 9 course credits in a semester. Students must be enrolled with at least 6 course credits to be considered a full-time student and to receive federal financial aid, if eligible. Students registering for fewer than 6 course credits per semester are not eligible to receive federal financial aid.

Students who have completed the required four semesters and all course requirements, except the master's project, will be charged a minimum registration fee ($350 for 2014-2015) each semester until the degree is completed.

All students are expected to be registered, to be approved for a leave of absence, or to pay a minimum registration fee for each semester until their degree is completed.

Payment of Accounts

Invoices for tuition, fees, and other charges are sent electronically by the Office of the Bursar and are payable by the invoice due date. As a part of the agreement of admission to Duke University, a student is required to pay all invoices as presented, unless other arrangements are made in advance. Students interested in arranging a payment plan should contact Tuition Management Services by calling (800)722-4867 or visiting http://www.afford.com/duke.

Late Payment Charge

If the total amount due on the student invoice is not received by the invoice due date, a penalty charge will be accrued from the billing date and applied to the past due balance. The past due balance is defined as the previous balance less any payments and credits received during the current month. Student loan payments, already accepted and in process in the system, will not cause a late payment charge.

Restrictions

If the total amount due on the student invoice is not received by the due date, the student will be considered in default and will not be allowed to register for classes, receive a copy of the academic transcript, have academic credits certified, be granted a leave of absence or receive a diploma at graduation. In addition, an individual in default may be subject to dismissal from the university.

Tuition Refund Policy

In case of withdrawal from the university, Title IV federal financial aid received by students enrolled for the first time at Duke will be refunded on a pro rata basis. The pro rata formula is calculated by multiplying the total school charges by the remaining fraction of the enrollment period for which the student has been charged, rounded downward to the nearest 10 percent, less any unpaid charges owed by the student. The pro rata refund policy does not apply to any student whose withdrawal occurs after the 60 percent point in the period of enrollment. Sample refund calculations are available from the academic and enrollment services office.

If the student receives federal financial aid but is not attending the university for the first time or if the student does not receive federal financial aid, tuition will be refunded or carried forward as a credit for later study according to the following schedule:

<table>
<thead>
<tr>
<th>Withdrawal</th>
<th>Refund</th>
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</tbody>
</table>
Late Registration

Students who register at a date later than that prescribed by the university must pay a late registration fee at the Office of the Bursar.

Audit Fee

Students registered for a full course load may audit courses without charge. Otherwise, audit fees are $550 per course credit.

Transcripts

Transcripts are available upon request from the Duke University Office of the University Registrar. During their first semester in residence, students are charged a fee that covers all future requests for transcripts. The Nicholas School of the Environment cannot issue transcripts.

Parking

Students who wish to operate or park motor vehicles on campus must obtain a permit from the Parking and Transportation Office. Parking fees vary according to location and type of vehicle. Duke University has a WeCar sharing service and offers carpool coordination for students, faculty, and staff to use as needed. Bicycle commuters, once registered with Parking and Transportation, are provided with a limited number of daily parking passes at no other cost.

Student Health Fee

All students are assessed a fee for the Student Health Service. This fee is distinct from health insurance and does not provide major medical coverage.

Medical Insurance

All resident students are billed for health insurance in the fall semester unless proof of other insurance is provided. Family plans are available through the university’s insurance vendor for an additional fee. All international students will be registered automatically for the Duke health insurance policy. International students are required to carry health insurance for a spouse or children living in Durham.

Students enrolled in the DEL-MEM program are exempt from the health insurance fee. However, DEL-MEM students opting to be enrolled in the Duke health insurance plan can do so by contacting the university’s insurance vendor.

Tuition and Fees for the Summer

Very few summer course offerings are available on the Durham campus of the Nicholas School. MEM and MF students who wish to take additional credits during the summer should expect to do so through other departments in the university or at the Duke University Marine Laboratory in Beaufort. Students should consult with their advisors to make sure the courses are appropriate for their program of study. Tuition and fees for summer study depend on the department. Professional degree students who wish to study at the Duke Marine Lab during the summer may enroll for credit in graduate level Marine Lab courses in the second summer session during the summer prior to their first fall semester at no additional tuition charges, though they will pay for housing on-campus. Students choosing to study at the Marine Lab during the summer are still required to pay four full semesters of tuition and be in residence for at least three semesters in the pursuit of their degree. Information on fees, housing, policies, and procedures related to the Duke University summer session is available at http://summersession.duke.edu/.

Summer session coursework cannot be considered a substitute for the required semesters in residence during the academic year, nor does it reduce the flat rate tuition for the academic year. Summer study is not an option for students in the DEL-MEM degree program.

Recreation Fee

A mandatory fee will be charged to all registered students for usage of campus recreational facilities. Students’ spouses or domestic partners are eligible to use the facilities for an additional fee. Students enrolled in the DEL-MEM program are not assessed this fee. Local DEL-MEM students wishing to use campus recreational facilities may do so for a fee.
Athletic Events

Students are admitted free of charge to all regularly scheduled university athletic events held on campus during the academic year, with the exception of basketball. Students who wish to attend home basketball games must enter the student ticket lottery and pay for tickets if selected.

Financial Assistance

Financial assistance in the form of scholarships, fellowships, or assistantships is available for qualified students. Funds to support these merit awards are limited. As a result, students must expect to have other financial resources. For many students, the federal loan programs provide a large portion of the funds necessary to cover the cost of attendance. Students in the DEL-MEM program are also eligible for financial assistance; awards are determined by the Duke Environmental Leadership program.

All professional degree students must file the Free Application for Federal Student Aid (FAFSA) to be considered for student loans and work-study. A separate application must be filed for each academic year. Applicants may obtain a FAFSA from a college or university counseling and placement center or financial aid office or from the Office of Academic and Enrollment Services. The form is also available online at http://www.fafsa.ed.gov. Professional degree applicants must also complete the financial aid section of the Application for Admission.

Scholarships and assistantships are granted from school funds, which are in limited supply. Consequently, only well-qualified students can expect to receive awards. Scholarships and assistantships are awarded on the basis of demonstrated outstanding academic ability and a high degree of professional promise.

Fellowships are obtained from foundation grants, private industry, or individual donors. Donors of fellowship funds sometimes place restrictions on the use of the funds as well as on the amount of awards.

Research assistantships are obtained primarily from grant and contract funds awarded to various faculty in the school. University-funded assistantships are available for students who have sufficient experience to contribute to one or more ongoing research or academic programs.

Pursuant to the Tax Reform Act of 1986, students performing any services (whether degree-related or not) required by their scholarship, fellowship, or assistantship must have income taxes withheld. However, if the student anticipates no tax liability at the end of the calendar year, he or she can note “exempt” on the state and federal withholding forms, and no taxes will be withheld. Income tax information is reported to the student by the university in January.

In all instances, admission to the Nicholas School is a prerequisite for the award of assistance in any form. If offered financial assistance, professional students normally will receive the award for two years of study; it is expected that they will complete their degree within this period of time. However, the school has the right to examine the progress of each student to determine eligibility for continuation of awards beyond the first year. Students not in good standing (with regard to academics or honor code) are not eligible for any new awards from the Nicholas School (e.g., scholarships, fellowships, recognitions without monetary component) whether academic performance is an eligibility criterion or not.

No student will receive financial aid while on probation unless an appeal is approved by the director of professional studies and the assistant dean for academic and enrollment services.

In no case may the amount of financial aid awarded to a student from all sources in a given year exceed the estimated annual costs of attending the Nicholas School as determined by the school.

Eligibility for Financial Assistance

A significant portion of the financial assistance for students in the Nicholas School of the Environment is provided by federal, Title IV funds. To qualify for such funding, usually in the form of loans, students must meet federal eligibility requirements including the maintenance of satisfactory academic progress. Professional degree students must complete at least 18 course credits with at least 6 course credits of B and/or A grades during the first full year of study and may not receive a grade of F in any course to be eligible for federal financial aid for their second year.

Although professional degree students, including DEL-MEM students, have five years from the first date of matriculation in the school to complete their degree requirements, they are eligible for federal financial assistance for the equivalent of four full-time semesters only. Students who fail to meet the satisfactory academic progress requirements or need federal financial assistance for more than the equivalent of four semesters may appeal to the Admissions and Awards Committee.
Fellowships for MEM/MF Students

Merit-based awards depend on the generosity of donors. Students receiving merit-based awards may be supported from one of the following endowments. Currently, DEL-MEM students are not eligible for these endowments.

Alumni Fellowship. Established by graduates of the Nicholas School, the Alumni Fellowship Endowment provides fellowships to minority students and to rising second-year students to support master's project research.

Lawrence E. Blanchard Society of Scholars and Fellows. Established by Charles and Bernard Blanchard, this fund provides scholarships to undergraduates and fellowships to graduate students studying at the Duke University Marine Laboratory.

Norman L. Christensen Jr. Fellowship. Established by alumni and friends in honor of the founding dean of the Nicholas School, this fellowship provides full tuition to candidates pursuing the master of environmental management degree.

William Cleveland Fellowship. Established by William Cleveland, this fellowship provides financial assistance to Nicholas School students.

Timothy J. and Anne G. Creem Scholarship. Established by Tim Creem, this fellowship is for candidates pursuing the master of forestry degree.

Cummings Family Fellowship. Established by Bruce and Myrna Cummings, this fellowship supports Nicholas School students.

Barbara L. Dannenberg Fellowship. Established by Richard Dannenberg, this fellowship is for Nicholas School students with a preference for the field of ecology.

Kathryn M. Deane and Walter L. Deane Fellowship. Established by Walter Deane and Kathryn Deane, this fellowship provides financial assistance to African American students during the summer session at the Marine Lab.

Field Fellowship Fund. Established by Marshall Field and Jamee Field, this fund provides fellowships for Nicholas School students.

Virlis L. Fischer Student Recognition Endowment. Established by Mrs. Bernice Fischer, this fund provides fellowships to second-year professional degree students at the Nicholas School and provides an award to the master of environmental management graduate with the highest academic achievement.

Forestry and Environmental Studies Fellowship. Established by the Cordelia S. May Trust, this fellowship provides financial support to Nicholas School students.

Friends of the Earth. Established by F. Daniel Gabel, Jr. T ’60, this fund provides fellowships to Nicholas School students with a preference given to students who are associated with Friends of the Earth International or students with an interest in creative environmental advocacy.

LeRoy George Scholarship. Established by the LeRoy George Children's Nature Museum Inc., this fund provides fellowships to Nicholas School students, with preference given first to students from Haywood and Buncombe Counties and Hendersonville in North Carolina. Second preference will be given to students from the Southern Appalachian region.

Verne Lester Harper Fellowship. Established by Verne Lester Harper, this fellowship provides financial support to Nicholas School students.

Charlotte and Robert Hay Fellowship. Established by Charlotte and Robert Hay, this fellowship provides support to Nicholas School students.

Richard Heintzelman Family Fellowship. Established by Richard Heintzelman, this fellowship is for Nicholas School students, with first preference given to those studying forestry or environmental economics.

Richard E. Hug Fellowship. Established by Richard Hug, this fellowship provides financial support to Nicholas School students.

International Paper Corporation Fellowship. Established by the International Paper Corporation, this fellowship is for Nicholas School students.

Thomas W. Keesee Jr. Fellowship. Established by Thomas Keesee Jr., this fellowship is for Nicholas School students.

LG-SP Fellowship Fund. Established by an anonymous donor, this fund provides fellowships to graduate professional Nicholas School students.

Carolyn Odom Little School of the Environment Scholarship Fund. Established by Terry H. Little, provides scholarships for Nicholas School students.

Melanie Lynn Memorial Scholarship. Established by Peter Lynn and David Lynn, this fellowship is for graduate students studying at the Marine Lab, with first preference to female students.

The Masselink Family Fellowship Fund. Established by Mark D. and Priscilla P. Masselink, this fund provides fellowships to graduate professional Nicholas School students.

Andrew W. Mellon Fellowship. Established by the Andrew W. Mellon Foundation, this fellowship provides financial support for research experience at the Nicholas School.

Muchnic Foundation Fellowship. Established by the foundation, this fellowship provides financial support to Nicholas School students.

Mary Wade Myers and William D. Myers Scholarship Fund. Established by Mary Wade and William Myers, this fund provides scholarships to professional Nicholas School students.

Nicholas School Professional Student Fellowship. Established by Sally S. Kleberg, this fellowship provides financial support to Nicholas School students.

Orvis Fellowship. Established by the Perkins Charitable Foundation, the Orvis-Perkins Foundation, and the Leigh H. Perkins Charitable Lead Trust, this fellowship is offered to Nicholas School students.

Orrin Pilkey Fellowship. Established by friends of Orrin Pilkey, this fellowship is for Nicholas School students applying research to human uses of the coastal zone.


Robert W. Safrit Jr. Fellowship. Established by Robert W. Safrit, this fellowship is for graduate students at the Marine Lab.

Gary H. Salenger Fellowship. Established by Gary Salenger, this fellowship is for Nicholas School students.

W. Schlesinger Scholarship. Established by friends of William H. Schlesinger, this fund provides scholarships to graduate professional Nicholas School students.

Truman T. and Nellie Semans Scholarship Fund. Established by Truman and Nellie Semans, this fund provides fellowships for Nicholas School students.

Bartow Shaw Family Fellowship. Established by Bartow Shaw, this fellowship is for Nicholas School students, with preference given to students pursuing a master of forestry degree.

Syngenta Crop Protection Inc. Fellowship. Established by the company, this fellowship is for Nicholas School students, with preference given to students studying environmental toxicology or environmental risk assessment.

Yasuomi Tanaka Memorial Fellowship. Established by Frances Tanaka, this fellowship is given to Nicholas School students, with preference given to international students.
Thorensen Foundation Fellowship Fund. Established by Paul O’Connell, this fund provides fellowships for Nicholas School students.

Wade Family Fund. Established by Charles B. Wade, Jr. T ’38, this fund provides scholarships for Nicholas School students studying at the Marine Lab.

Frederick K. Weyerhaeuser Forest History Fellowship. Offered by the Forest History Society, this fellowship is given annually to a Duke University graduate student who wishes to study broadly in the area of forest and conservation history. The fellowship consists of a cash prize and office space at the FHS.

Dr. Larry R. Widell Memorial Fellowship. Established by Christopher M. Widell, this fund provides scholarships to graduate professional Nicholas School students, with a preference given to doctoral students.

Zirkle Fellowships. Established by Sara and Lewis Zirkle, this fellowship is offered to Nicholas School students.

Assistantships
Assistantships may be awarded to a select number of professional degree students during their first year of study to assist faculty and staff with teaching, research, professional, and other projects. It is expected that students will work for eight hours a week on their assigned project. Assistantships require a regular work schedule to be arranged between the student and the faculty or staff member to whom he or she is assigned.

Students who receive assistantships are paid by the Nicholas School on the monthly payroll. For the 2014-15 academic year, the award for eight hours per week of assistance is $3,000. Normally, assistantships are available only for the academic year and require full-time enrollment in the school. If a student completes the assistantship in full and makes adequate progress toward the degree during the first year, the student will receive the assistantship funds as scholarship applied directly to their bursar account toward their tuition for the second year.

Work-Study
Work-study funds for professional degree students are administered through the Office of Academic and Enrollment Services. At the beginning of the academic year, students are made aware of work-study opportunities and informed of the application procedures. Interested students must file the Free Application for Federal Student Aid (FAFSA) in order to determine eligibility. Currently, students enrolled in the DEL-MEM program are not eligible for work-study funds.

Application for Awards for the Entering Student
Application for financial aid is made concurrently with the application for admission. Applicants should initiate the necessary action early to ensure that the required documents are filed with the school’s Office of Academic and Enrollment Services on or before January 15 (February 1 for DEL-MEM students) prior to fall term enrollment. Completed applications received after the January 15 deadline (February 1 for DEL-MEM students) will be considered if vacancies occur at a later date.

Notification and Acceptance of Awards
Recipients of awards usually are notified at the time of admission. Scholarships, fellowships, and the various categories of assistantships provide the basis for professional/graduate student support. Once offered by the university or the school, funds are committed to one student and are therefore unavailable to others. As a consequence, it is the policy of the Nicholas School that all awards offered may be declined prior to April 15 without prejudice. However, offers accepted and left in effect after April 15 are binding for both the student and the school.

Loans
Federally insured student loans are often necessary and useful in helping a needy student afford the graduate program of his or her choice. Students considering federal loans should consider the nature of the loan and the positive and negative aspects of future loan payments and should also investigate all other forms of financial assistance.

Federal law requires all students to have completed a Free Application for Federal Student Aid (FAFSA) to determine financial need. The FAFSA form may be obtained online at http://www.fafsa.ed.gov or by contacting a college or university financial aid office or the Office of Academic and Enrollment Services. No loan application will be processed without the FAFSA form having been submitted to the central processor. In addition, in some cases federal law requires verification of income and other information.
Federal Stafford Loans

Federal Stafford loans of up to $20,500 (unsubsidized) are available for eligible graduate/professional students. For loans made to new borrowers, interest is calculated at a fixed annual rate of 6.8 percent. Interest on unsubsidized loans must be paid by the student during enrollment or capitalized to the principal at the borrower's request.

Students who borrow through the federal Stafford program will be given entrance and exit interviews concerning the projected and actual costs of their loans. They will also be provided with information on loan consolidation, should this repayment option be desired or needed.

Graduate Plus Loan Information

The Deficit Reduction Act of 2005 allows graduate and professional students to borrow under the Federal PLUS loan program beginning with the 2006-07 aid year. The PLUS (Parent Loan for Undergraduate Students) was previously available only to the parents of dependent undergraduate students. Beginning July 1, 2006, that availability was expanded to graduate/professional students.

Students must be graduate/professional students enrolled at least half-time in a matriculated program; they must complete a current FAFSA; they must first apply for the maximum loan eligibility in Stafford loan before the PLUS can be awarded; parents of graduate students will not be eligible to borrow the loan.

PLUS Loan borrowers are required to pass a basic credit check. The borrower may borrow the difference between the total cost of the student’s education (including books, fees, and personal expenses) minus any financial aid the student will receive.

Repayment begins within sixty days after the final disbursement of each loan. The maximum repayment period is ten years, and the minimum monthly payment is $50. Students may be eligible to defer payments as long as they maintain at least half-time enrollment. A loan fee of 4 percent will be charged and will be deducted proportionately from each loan disbursement. In addition, some loan guarantee agencies charge a 1 percent guarantee fee, which will also be deducted from disbursements. The interest rate will be fixed at 7.9 percent.

Federal Perkins Loans

Loans through the federal Perkins program are administered through the university for students who qualify under federal guidelines. The student must qualify as needy by the terms of the FAFSA form and must be in need of assistance beyond the maximum federal Stafford allocation. The interest rate is 5 percent, with payment on interest and principal deferred until nine months following graduation. The maximum Perkins loan is currently $6,000 for an academic year.

Federal Grant Programs

Students with only three years of study at one of the institutions in the Cooperative College Program may be eligible for undergraduate state and federal grant programs. Such students should consult their undergraduate financial aid officers, state loan agencies, or federal granting agencies for applications and information about requirements and restrictions.

Academic Regulations

Course Planning

Each of the professional programs has required courses or required areas of study, and responsibility for meeting these requirements before graduation rests with the student, with the assistance of the coursework advisor. During orientation, each student is assigned a faculty coursework advisor. Early in the first semester, the student and advisor should fill out a course planning form outlining four semesters of coursework that will meet program course and credit requirements. This form can be amended at any time before the last semester of a student’s program, provided the plan still meets all requirements for graduation. Prospective students interested in specific advisors should include the faculty member’s name in their application statement; it is not necessary to contact potential advisors before orientation.

It is usually possible to change coursework advisors, with the approval of both the current and prospective advisors, and it is common to have as a master’s project advisor someone other than the coursework advisor. It is also usually possible to change programs through the end of the third semester (out of four required semesters of enrollment), provided that the student has met prerequisites for the new program and provided that it is still possible for the student to meet all requirements of the new program before graduation. A student changing
programs will usually be assigned a new coursework advisor, and the student must complete a new course planning form showing how program requirements will be met. The student is responsible for ensuring that all degree requirements have been met. Faculty coursework advisors and staff in Academic and Enrollment Services are available to advise and assist students but the final responsibility rests with the student.

Students in the DEL-MEM program have the majority of their required coursework planned for them. Students work directly with the assistant dean of DEL to ensure they are meeting these requirements before graduation; however, the responsibility rests with the students to successfully manage their coursework. DEL-MEM students will be assigned a master’s project advisor during their second semester.

Language Testing
Proficiency exams in written and spoken English will be given to non-native English speakers regardless of citizenship during the week prior to orientation week. Students found to lack the proficiency in English needed to do well at Duke will be required to enroll in additional English language instruction. Students should be prepared to assume all costs for being tutored in English and may need to reduce their course or research program while being tutored. If more than one English language course is required, MEM and MF students may count one English course toward their degree; otherwise, English language instruction does not count toward course credit required for the MEM or MF degree. Non-native English speakers applying to the DEL-MEM should consult with that program for specific requirements beyond the TOEFL, [http://Nicholas.duke.edu/del/application-materials-del-mem-online](http://Nicholas.duke.edu/del/application-materials-del-mem-online).

Registration
Entering students who enroll in the Master of Environmental Management or Master of Forestry, or DEL-MEM degree program, will receive instructions from the Nicholas School of the Environment about registering for courses. Registration for new students should be completed during the orientation period. Students in residence register for succeeding semesters at times scheduled in the university calendar.

Registration is approved by the advisor and completed by the student using an online registration system. Registration is required in order to take courses for credit or audit. To establish eligibility for university and other loans, for the student health service, and for study and laboratory space, a student must be registered. All tuition and fee payments and any indebtedness must be settled before registration can be completed.

Course Credits
Candidates for the professional degrees are considered fully registered when they enroll full-time for the number of semesters required in their individual degree programs (for example, four semesters for the MEM or MF degree). Students normally register for 12 course credits per semester, although a variation from 9 to 15 course credits is common. Students must have the permission of their advisor to register for more than 15 course credits in a semester, and all students who wish to enroll for fewer than 9 course credits must make a formal request to the education committee to study part-time.

The DEL-MEM program is a minimum 30-course credit degree program.
To complete the DEL-MEM program within the required amount of time, students typically take between 6 and 9 course credits per semester. Permission is required to register for fewer than 6 credits or more than 9 course credits in a semester. Students must be enrolled with at least 6 course credits to be considered a full-time student and to receive federal financial aid, if eligible. Students registering for fewer than 6 credits per semester are not eligible to receive federal financial aid.

Late Registration
All students should register at the times specified by the university. The charge for late registration is significant.

Drop/Add
The period for dropping and adding courses ends on the tenth calendar day of the fall and spring semesters. During the summer, dropping, or adding of courses is limited to the first three days of the term. Students are advised to make all class changes on the first day of class if at all possible.
Reciprocal Agreements with Neighboring Universities

Students enrolled full-time in the Nicholas School or in The Graduate School during the regular academic year may enroll for 6 course credits (two course maximum) per semester at The University of North Carolina at Chapel Hill, North Carolina State University, North Carolina Central University, or any other university participating in the Interinstitutional Agreement provided that they are also registered for at least 6 course credits at Duke during the same semester. Similarly, graduate students at these universities may take up to 6 course credits per semester at Duke. In the summer, students may take courses interinstitutionally provided that they are enrolled at Duke for at least the same number of hours they wish to take at the other school(s); graduate students are limited to two summer courses at other institutions. This agreement does not apply to contract programs such as the American Dance Festival. The student must pay any special fees required of students at the host institution and provide his or her own transportation. A bus service sponsored by the Robertson Scholars Program travels between Duke and UNC every thirty minutes during the academic year and is free to all students and staff of both universities. The reciprocal agreements with neighboring universities do not apply to distance learning programs. Online or distance learning courses are not part of the interinstitutional agreement.

Immunization Requirement

North Carolina law requires students entering a college or university in the state to be immunized against measles, rubella, tetanus, pertussis, diphtheria, and in some cases, polio. Each entering student is required to present proof of these immunizations in accordance with the instructions contained in the Student Health Services form provided with the student’s matriculation material. This form should be completed and returned to Student Health Services prior to the student’s first day of classes. Duke University cannot permit a student to attend classes unless the required immunizations have been obtained. Students who fail to meet the immunization requirements will be withdrawn from the university. DEL-MEM students are exempt from this requirement.

Courses

Course Descriptions

Courses offered by the school are described in the final section of this bulletin. However, courses are subject to change. Prior to registration for a given term, the Office of Academic and Enrollment Services prepares a list of courses to be offered as well as schedules of courses offered in other departments at Duke and at neighboring universities. These lists are made available online and in hard copy.

Independent Study

All professional degree students have the opportunity to pursue independent study with individual faculty members. After discussing the potential for an independent study with a faculty member students register to take independent study credit under Environment 593 (Environment 997 for DEL-MEM students).

Master’s Project

All students must complete a master’s project of 4 to 6 course credits. The project should be identified during the second term of study, initiated during the summer between academic years and completed during the third and fourth terms. No student will be permitted to register for the fourth term of study until a project proposal has been approved by the student’s advisor and received by the school’s Office of Academic and Enrollment Services. During the final two terms, major emphasis should be placed on the project. In completing the project, the student applies theoretical and analytical training acquired during the two years of study to actual natural resource or environmental problems. Students may use summer internships as the basis for master’s projects and may consult closely with a supervisor outside the school, as well as with their faculty master’s project advisor, to complete their work. For most program areas, master’s project advisors are assigned by faculty committee, taking into account subject matter, experience, interest, as well as equitability of advising responsibilities. Students should maintain close contact with their advisors during the development and writing of the master’s project. Projects should reach final stages of completion by midterm of the final semester in residence. A complete draft of the project must be delivered to the advisor prior to October 1 for those graduating in December and prior to March 1 for those graduating in May. The advisor is responsible for critical assessment and grading. Detailed descriptions and dates for the master’s project process are available here: http://www.nicholas.duke.edu/people/students/advising/masters-projects. Many students in the MEM and MF programs complete collaborative, or group, master’s projects. In group master’s projects, teams
of three to five students take on a real-world challenge facing a client. Students work directly with the client, under the supervision of a faculty advisor, to address the challenge. These projects begin in the spring of the first year but are completed during the second year of study; some group master’s projects include summer work as well. Further information on group master’s projects may be found at http://www.nicholas.duke.edu/people/students/advising/masters-projects/client-centered/. All completed master’s projects are required to be uploaded to Duke Library’s DukeSpace website and are searchable across the Internet. If the MP contains sensitive information (e.g., from the client’s point of view, in terms of future publication elsewhere, or sensitivity for commercial ventures) an embargo of up to two years may be requested. Requests should include specific justification for the embargo for the specific period of time and should be sent to the assistant dean for academic and enrollment services.

Master’s Project—DEL-MEM Students

All DEL-MEM students must complete a master’s project of 4 course credits. The project should be identified during the second term of study, initiated during the summer between academic years and completed during the third and fourth terms. During the final two terms, major emphasis should be placed on the project. In completing the project, the student applies theoretical and analytical training acquired during the two years of study to actual natural resource or environmental problems. DEL-MEM students are encouraged to use current professional career interest and projects as the basis for master’s projects and may consult closely with a supervisor outside the school, as well as with their faculty master’s project advisor, to complete their work. Students should maintain close contact with their advisors during the development and writing of the master’s project. Projects should reach final stages of completion by midterm of the final semester in residence. A complete draft of the project must be delivered to the advisor prior to October 1 for those graduating in December, prior to March 1 for those graduating in May, and prior to July 1 for those graduating in September. The advisor is responsible for critical assessment and grading.

Auditing

Students registered for a full course load may audit courses free of charge. Otherwise, the audit fee is $1,500 per course. In classes in which enrollment is limited, students enrolled for credit will receive priority. Audited courses are recorded without grade on the student’s permanent record. Regular attendance is expected. Changes from audit to credit are not permitted after the Drop/Add period. Audited courses may not be used to fulfill program requirements. Audited courses may not be counted toward the number of credits required for graduation. Students must obtain written permission of the instructor to audit a course.

Executive Education Short Courses

Short courses are offered through the Nicholas School’s Duke Environmental Leadership Executive Education Program. For the short courses, students may register during the semester two weeks prior to the first day of the course as space permits and with the permission of the DEL program. Students may not register for more than two short courses in a semester without permission of their advisor and the DEL executive education program coordinator. Students who wish to drop a short course must do so based on the course cancellation policies. Detailed registration requirements for executive education short courses are available through the DEL Program. Enrollment policies are subject to change. For more information, visit http://nicholas.duke.edu/del/upcoming-executive-education-courses.

Retaking Courses

Courses required as a part of the program elected by the student or required by the advisor must be retaken if failed. Courses prerequisite to more advanced courses the student wishes to take must be retaken if failed. Elective courses may be retaken if the student wishes to do so. See the section on grades below for additional information.

Class Attendance

It is expected that students attend class every time the course meets. It is understood that on occasion the student may need to miss class due to illness. Whenever possible, as a courtesy to the instructor, the student should be in communication with the instructor in advance of the absence. If the absence is unexpected due to illness, the student should alert the instructor as soon as possible. If a medical condition or extended illness causes the student to miss more than one class meeting, a doctor’s note should be provided to Academic and Enrollment Services. If a medical condition or extended illness causes absence from a test, mid-term, or exam, the instructor may arrange an alternate test date, at the instructor’s discretion. If such is the case the student must provide a doctor’s excuse to Academic and Enrollment Services. DEL-MEM students should contact the assistant dean within the DEL program.
Grades

Grading System

The grading system used in the Nicholas School and The Graduate School is as follows: A (exceptional); B (good); C (satisfactory); F (failing); I (incomplete); Z (continuing). Plus (+) and minus (-) notations are permitted. Course instructors are unable to change grades once final grades have been submitted unless there has been an error in calculation.

The grades of P (pass) and F (fail) are used in the Nicholas School for seminars, master’s projects, program area seminars, and modular courses. At the instructor’s option, the grades of P or F or regular letter grades are used for intensive courses and independent projects. If a student wishes to take a regularly letter-graded course on a Pass/Fail basis, permission for the Pass/Fail option must be obtained in writing from the instructor prior to registration for the course. Regularly graded courses taken on a Pass/Fail basis may not count toward graduation or fulfill programmatic requirements.

The grade of Z is assigned for an independent project or a master’s project that extends over a period of more than one semester; a final grade is given upon completion of the project.

Incomplete Grades

A grade of I indicates that some portion of the student’s work is lacking, for an acceptable reason, at the time grades are reported. Requirements of all courses in which an instructor assigns a grade of Incomplete must be fulfilled within one calendar year following the date of the assignment of the incomplete grade.

In exceptional circumstances, upon recommendation of the professor who assigned the grade of Incomplete, the dean of the Nicholas School may extend the time for completion of the course requirements. If, in the judgment of the professor and the student’s advisor, completion of the requirements is not a reasonable alternative for the student, the student may petition the Education Committee to allow the grade of I to stand permanently on his or her record. No student will be allowed to graduate with an Incomplete unless permission has been granted for it to stand permanently on the record.

Failure

Failing a course may leave a student short of credits for graduation or lacking program curriculum requirements. If the failed course is not necessary to complete program curriculum requirements, the student may substitute another course to make up the lost credit, with the advisor's approval. If the failed course is necessary to complete program curriculum requirements, the student must retake either that course or an acceptable substitute, with the advisor's approval. Both the original failing grade and the grade received for the retaken or substitute course will appear on the student’s transcript.

Failure of a course also subjects the student to dismissal.

Probation and Dismissal

Any of the following situations will result in probationary status for the following semester:

- Failing one or more courses
- Two or more C (C-, C, C+) grades in a semester
- Failing to maintain a cumulative average of at least B-

A student on probation must meet jointly with his/her advisor and one additional regular-rank faculty member selected by the student and his/her advisor before the end of Drop/Add (preferably before the beginning of the semester) to discuss what is going wrong and how to remedy it. These faculty committees or the Education Committee have the discretion to suggest that a student take a leave of absence for a semester if they judge that to be the best way for the student to improve academic performance. A student on probation must meet again with the advisor and second faculty member a month after the first meeting to review academic progress.

Any student who does not meet academic standards at the end of the probationary semester will be subject to dismissal from the Nicholas School. The Education Committee will make decisions on dismissal.

In addition, students must have at least 48 course credits (30 course credits within the DEL-MEM program) with a grade point average of B- or better to graduate. Students who fail to meet that standard during their final semester must take additional Duke credits to meet the standard before they can graduate. Any exceptions are at the discretion of the Education Committee.

For students placed on probation, the Nicholas School’s policy regarding awards from the school (e.g., merit-based financial aid, fellowships, scholarships, recognition awards with no monetary component) is as follows:
1. Students not in good standing (with regard to academics or honor code) are not eligible for any new awards from the Nicholas School (e.g., scholarships, fellowships, school-supported internships, and recognitions without monetary component) whether academic performance is a criterion or not.

2. Students holding scholarships or other awards when they are put on probation may be allowed to keep them for one semester if the student’s petition to do so is approved by the director of professional studies and the assistant dean for academic and enrollment services. Any student not released from probation after one semester will not be eligible to retain the scholarship/fellowship.

Students who are dismissed for honor code or other serious violations must relinquish any awards.

**Honor Code**

The Nicholas School of the Environment advocates the highest standard of professional ethics and academic integrity. Students and faculty have developed an honor code for the school that is distributed to all students prior to matriculation and then discussed and signed during orientation. The Nicholas School uses the Community Standard, below, as its basis:

**The Duke Community Standard**

Duke University is a community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community commit to reflect upon and uphold these principles in all academic and nonacademic endeavors, and to protect and promote a culture of integrity.

**The Pledge**

Students affirm their commitment to uphold the values of the Duke University community by signing a pledge that states:

- I will not lie, cheat, or steal in my academic endeavors;
- I will conduct myself honorably in all my endeavors; and
- I will act if the Standard is compromised.

A more complete explanation of the application of this standard in the Nicholas School may be found at [http://www.nicholas.duke.edu/people/students/advising/general-advising-information/nicholas-school-honor-code](http://www.nicholas.duke.edu/people/students/advising/general-advising-information/nicholas-school-honor-code).

**Harassment Policy**

Harassment of any kind is not acceptable in the Nicholas School of the Environment or at Duke University. It is inconsistent with the university’s commitments to excellence and to respect for all individuals.

Harassment is described by Duke University as the creation of a hostile or intimidating environment, in which verbal or physical conduct, because of its severity and/or persistence, is likely to interfere significantly with an individual’s work or education or affect adversely an individual’s living conditions on campus. Sexual coercion is a form of harassment with specific distinguishing characteristics. It consists of unwelcome sexual advances, requests for sexual favors, or other verbal or physical conduct of a sexual nature, when submission to such conduct is made either implicitly or explicitly a term or condition of employment, or when submission to or rejection of such conduct by an individual is used as the basis for employment or educational decisions affecting the individual.

Members of the Nicholas School of the Environment community who have questions about the policy or how to deal with a suspected violation can obtain a copy of the policy and options for resolution from the Office of the Vice-President for Institutional Equity.

**Academic Irregularities**

All cases falling outside the regular policies and procedures of the school are referred to the Education Committee for decision. The committee reviews and makes decisions regarding course requirements for graduation, student probation and dismissal, student petitions for waivers of degree requirements and all actions that deviate from established academic regulations. Any waiver requests to reduce credits, course requirements, minimum semesters of tuition, or in-residence requirements must be made before half of the total credits are completed for the student’s degree program.

A student who desires to petition the committee should do so by writing to its chair. A precise statement of the reason for the request is required. The student will be notified in writing of the decision of the committee by the chair.
Transcripts of Credit

A student who is registered for a course and who successfully completes the requirements as prescribed by the instructor receives credit on university records. A transcript fee, charged to all students during their first semester in residence, covers all future transcript requests. Only the Office of the University Registrar issues transcripts of credit. Requests for transcripts, sent directly to the registrar, should state clearly the full name under which the work was taken, the dates of attendance, and to whom the transcripts are to be sent. The student must sign the request for release of a transcript. No transcripts will be issued for students who fail to clear all financial obligations to the university upon graduation.

Length of Study

For a full-time student, and for DEL-MEM students, the normal time for completing a professional master’s degree is four semesters. Students enrolled in the Senior Professional Program must be in residence for one semester (typically the first semester) and have five years from the term of admission in which to complete the degree requirements. All degree requirements for the MEM or the MF must be completed within five years of the first term of admission.

Leave of Absence or Withdrawal

Occasionally, special circumstances require a student to leave the university for one or two semesters at a time. If the reason for the departure is considered an emergency, the student may request a leave of absence for a period not to exceed one year. If the reason is to study elsewhere in a combined degree program, a leave will be granted for the length of study. If the student plans to do field studies or an internship, he or she must maintain university enrollment by paying a registration fee each semester of the academic year until full-time study is resumed.

Under all circumstances, the student must request the leave for a specific length of time prior to departure from the university. Extensions must be requested if they are required for a maximum of two semesters, except as indicated above. Failure to request a leave or an extension of leave may result in a penalty charge and/or dismissal from the university. A student is eligible to request a leave of absence only after having completed at least one semester of study.

A student who wishes to withdraw from the university must make a written request to do so. For refunds upon withdrawal, see the section on financial information above.

Graduation

Even if degree plans are tentative, a candidate for a degree must register for graduation at the designated time for each semester. The registration is valid only for the semester in which it is filed. If the student does not receive the degree as expected, he or she must register again at a later time.

All candidates are urged to attend the commencement exercises at which their degrees are to be awarded. A student who is unable to attend is required to seek permission from the assistant dean for academic and enrollment services no later than four weeks prior to commencement to receive the degree in absentia.

Debts

Students are expected to meet all financial obligations to the university prior to completion of the degree. Failure to pay all university charges by the due dates specified by the university will bar the student from registration, class attendance, receipt of transcripts, certification of credits, leave of absence, or graduation until the account is settled in full. Further, an individual in default may be subject to dismissal from the university.

Career and Professional Development

The Nicholas School of the Environment recognizes the importance of blending rigorous academic study with professional development and career opportunities. The Nicholas School has its own career and professional development center to provide a wide variety of services, programs, and resources to enhance a student’s professional preparation and career opportunities.

The Career Center website (http://nicholas.duke.edu/career/welcome-career-services) provides up-to-date information about environmental internship and employment opportunities, relevant fellowships and scholarships and research grants as well as career advice integral to a successful job and internship search. The Career Center staff assists students with exploring career options, developing individualized strategies for finding internships and
permanent employment and making contacts with alumni and employers. The Career Center provides Nicholas School students with many services, including individual counseling and job search assistance, internship panels with experienced students, workshops and critiques for interviews, resume and cover letter writing, and employment and salary statistics for negotiating offers.

The Career Center publishes an annual Resume Book that highlights and promotes the professional qualifications and experiences of our graduating class. The Resume Book is mailed to more than 700 potential employers and is made available to employers online at http://nicholas.duke.edu/career/annual-resume-book.

The Duke Nicholas School of the Environment uses the LinkedIn group function as our alumni career network. LinkedIn is a robust social media resource for networking with practicing professionals. The group is managed and members are vetted to ensure they are a member of the Nicholas community (student, alumni, faculty, or staff) before being admitted to the group. Alumni are available to give advice on internship and job searching and to offer insights on the knowledge, skills, and abilities needed by today’s environmental professionals. The Career Center staff offers training for developing a strong LinkedIn profile and techniques for mastering the search features.

The Career Center schedules job fairs, employer information sessions, and on-campus recruiting events throughout the academic year to allow students to meet employers and broaden their knowledge of the environmental profession and career opportunities.

Nicholas School alumni in career transition may use the Career Center at any time for resume review and critique, salary data for effective negotiations, job search strategies, and information regarding employment opportunities.

**Internship Opportunities**

Practical experience is integral to the Nicholas School’s educational process and even more important to employers seeking qualified candidates. The Career Center staff helps students identify internships to meet professional development goals or research interests. Internships are opportunities for students to explore specific career fields, enhance career experiences, learn or apply new skills, establish networks of practicing professionals and gain perspective on environmental issues in various regions or countries. Ninety-eight percent of all Nicholas School students have completed internships or summer research projects during their MEM or MF program.

Each year Nicholas School students participate in summer internships throughout the United States and around the world. Students work with nonprofit conservation organizations, government agencies, consulting firms, business, industry, and international organizations to supplement career training or research interests. Most students pursue internships during the summer between academic years of study, although internships may be secured at other times and for longer durations. In addition, internships may serve as the foundation for a master’s project or open doors to new career interests and employment options.

**Internship Funds**

The Career Center staff is committed to assisting students to find paid internships or secure small grants for unpaid summer projects. Most recently, Nicholas School students were successful in securing more than $650,000 from grant resources available from the Nicholas School and Duke University as well as external funding sources to support professional student internships or research projects. The list below highlights internship grant opportunities specifically for Nicholas School students. Grant awards are made annually, with award amounts determined by the amount of endowment income generated each year.

**David R. Brower Internship Fund.** Established by Dan and Bunny Gabel, the David R. Brower Fund provides summer support for Nicholas School students interested in working as interns in grassroots environmental organizations that exemplify David R. Brower’s uncompromising commitment to preserving natural ecosystems, opposing technological fixes and upholding the spirit of conservation represented by the strong environmental laws of the 1970s.

**The Whitney Chamberlin Internship Endowment Fund.** Established by the family and classmates of Whitney Lawson Chamberlin, a first-year student at the Nicholas School in 1996, this fund supports international internship-related travel for Nicholas School students interested in pursuing meaningful internship experiences that address or explore community-based business and environment interactions with a preference for Latin America.
Environmental Internship Fund (EIF). EIF is a student-run fundraising organization within the Nicholas School that awards supplemental grants to Nicholas School students with internships that are under-funded. EIF student volunteers gain fundraising experience by coordinating and hosting fundraising events and managing the annual grant application, review, and award process. The number of EIF grant awards is determined by the amount of money raised each year by the Nicholas volunteers.

Kuzmier-Lee-Nikitine Endowment Fund (KLN Fund). Established by family and friends to perpetuate the philosophy and ideals demonstrated by the work of three members of the class of 1992: Kerrie Hamilton Kuzmier, Stephen Farrow Lee, and Pavlik André Nikitine. The KLN Fund provides internship seed grants for Nicholas School students pursuing an international internship project. Preference is given to international projects that include development of human capital; promotion of sustainable/efficient use of natural resources; maintenance of local cultural integrity; preservation of biodiversity; or improvement of the local quality of life.

Nicholas School Fund for International Summer Internships or Research Projects. A competitive grant process open to current MEM/MF students only, the fund supports international internship/research projects. Must be in-country for minimum of six to eight weeks to apply (eight-plus weeks desirable). The amount of available funding is determined by a review and award committee based on quality projects identified. The average award is $1,000-$3,500.

Stanback Conservation Internship Program. The Stanback Internship Program is made possible by the generous support of Mr. and Mrs. Fred Stanback. The program is a partnership between the Nicholas School and targeted conservation organizations. Its purpose is to provide students with a significant paid summer work experience in grassroots conservation, advocacy, applied resource management or environmental policy. Each year more than 150 internship projects with more than fifty conservation organizations are offered to Nicholas School and Duke University students. This includes any continuing or entering Duke professional, doctoral, or undergraduate student. Students who have one full semester remaining as a Duke student following the internship are eligible to compete for these internships. Graduating students are not eligible.

Summer Legislative Fellowship Fund. The Summer Legislative Fellowship Fund provides support to continuing MEM or MF student(s) enrolled in the Nicholas School who have secured an internship with the legislative branch of the United States federal government. Students must work on Capitol Hill.

Employment Trends and Statistics

The variety and geographic distribution of organizations that employ Nicholas School graduates demonstrate the value and relevance of the Master of Environmental Management and the Master of Forestry programs. Our graduates’ career success confirms the marketability of a professional/graduate degree from Duke.

The following employment statistics are based on data collected for the Nicholas School class of 2012.

Of the 169 graduates, 164 (97 percent) responded to the employment survey sent six months following graduation. Not all respondents answered all questions. Therefore, statistics were calculated on the available data for each question.

Of the respondents, 81 percent are employed. Of these 95 percent are employed in positions that are directly or closely related to their MEM or MF degrees. Four percent are pursuing an additional advanced degree and 15 percent continue to seek employment.

Salaries

Salaries vary widely depending upon the type of employer, job location, individual qualifications and previous experience. MEM/MF graduates reported salaries ranging from $30,000 to over $100,000. For 2012 graduates, the median salary was $57,500.

Average Salary by Type of Employer

<table>
<thead>
<tr>
<th>Employer Type</th>
<th>Salary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business/Industry/Legal</td>
<td>$62,500</td>
</tr>
<tr>
<td>Consulting</td>
<td>$57,500</td>
</tr>
<tr>
<td>Education</td>
<td>$47,500</td>
</tr>
<tr>
<td>Federal Government</td>
<td>$57,500</td>
</tr>
<tr>
<td>Non-profit/NGO</td>
<td>$42,500</td>
</tr>
<tr>
<td>Research Institute/Think Tank</td>
<td>$30,000</td>
</tr>
<tr>
<td>State/Local Government</td>
<td>$47,500</td>
</tr>
</tbody>
</table>
Salary Distribution by Program Area

<table>
<thead>
<tr>
<th>Program Area</th>
<th>Range</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal Environmental Management</td>
<td>$30,000-$87,500</td>
<td>$47,500</td>
</tr>
<tr>
<td>Ecosystem Science and Conservation</td>
<td>$30,000-$100,000</td>
<td>$42,500</td>
</tr>
<tr>
<td>Energy and the Environment</td>
<td>$30,000-$100,000</td>
<td>$62,500</td>
</tr>
<tr>
<td>Environmental Economics and Policy</td>
<td>$30,000-$82,500</td>
<td>$52,500</td>
</tr>
<tr>
<td>Ecotoxicology and Environmental Health</td>
<td>$30,000-$100,000</td>
<td>$57,500</td>
</tr>
<tr>
<td>Global Environmental Change</td>
<td>$32,000-$67,500</td>
<td>$50,000</td>
</tr>
<tr>
<td>Water and Air Resources</td>
<td>$52,500-$77,500</td>
<td>$65,000</td>
</tr>
<tr>
<td>Forest Resource Management (MF)</td>
<td>$32,500-$72,500</td>
<td>$55,000</td>
</tr>
<tr>
<td>MEM/MBA</td>
<td>$57,500-over $100,000</td>
<td>$100,000</td>
</tr>
</tbody>
</table>

Sector and Geographic Distribution

<table>
<thead>
<tr>
<th>Sector</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business/Industry</td>
<td>38%</td>
</tr>
<tr>
<td>Consulting</td>
<td>22%</td>
</tr>
<tr>
<td>Education</td>
<td>11%</td>
</tr>
<tr>
<td>Federal Government</td>
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<tr>
<td>Non-Profit/NGO</td>
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<td>Deloitte</td>
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<td>Marstel-Day</td>
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<td>McKinsey &amp; Company</td>
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<td>Navigant</td>
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<td>Pace Global Energy Services</td>
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<td>PricewaterhouseCoopers LLP</td>
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<td>TetraTech Inc.</td>
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<td>Raftelis Financial Consultants</td>
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<td>URS Corporation</td>
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<tr>
<td>WRA Environmental Consultants</td>
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<tr>
<td>WSP Environment &amp; Energy</td>
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<tr>
<td>West</td>
<td>24%</td>
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Selected employers of recent Nicholas School graduates (as of 1/2013)

**Consulting Firms**
- ABT Associates
- Accenture
- ACE Energy
- ARCADIS
- BCS, Incorporated
- Booz, Allen and Hamilton
- Camp Dresser & McKee
- Chemrisk
- Climate Focus
- Deloitte
- ERG, Inc.
- EcoVadis
- Ecological Services & Markets, Inc.
- EEE Consulting
- Efficiency
- Emerging Energy Research
- ENTRIX, Inc.
- ENVIROX International Corporation
- ERM
- Geo-Marine, Inc.
- Hitachi Consulting
- ICF International
- Marstel-Day
- McKinsey & Company
- Navigant
- Pace Global Energy Services
- PricewaterhouseCoopers LLP
- Project Performance Corporation
- SAIC
- Stratus Consulting
- TetraTech Inc.
- Trinity Consultants
- Raftelis Financial Consultants
- URS Corporation
- WRA Environmental Consultants
- WSP Environment & Energy

**Federal Government**
- Bureau of Land Management
- Bureau of Oceans Energy Management
- Energy Information Administration
- FEMA
- Federal Energy Regulatory Commission
Solar City
Southeast Energy Efficiency Alliance
STEM
Sustainable Apparel Coalition
United Technologies Corporation
VWR International, Inc.
Walt Disney
W.L. Gore & Associates
Waste Management Company
World Wildlife Fund

Other Government
Atlantic States Marine Fisheries Commission
California Public Utilities Commission
Hawaii Department of Land and Natural Resources
Massachusetts Water Resources Authority
New England Fisheries Management Council
NC Department of Emergency Management
NC Wildlife Resources Commission
North Pacific Fishery Management Council
UNEP
UNDP
UN Institute for Training and Research (UNITAR)
Virgin Island Coastal Zone Management
Washington Department of Natural Resources
The Nicholas Institute for Environmental Policy Solutions improves environmental policymaking worldwide through objective, fact-based research to confront the climate crisis, clarify the economics of limiting carbon pollution, harness emerging environmental markets, put the value of nature’s benefits on the balance sheet, develop adaptive water management approaches, and identify other strategies to attain community resilience.

The Nicholas Institute is part of Duke University and its wider community of world-class scholars. This unique resource allows the Nicholas Institute’s team of economists, scientists, lawyers, and policy experts not only to deliver timely, credible analyses to a wide variety of decision makers, but also convene these decision makers to reach shared understandings regarding this century’s most pressing environmental problems.

Tim Profeta serves as director of the Nicholas Institute, which is composed of the following six programs—Climate and Energy, Ocean and Coastal Policy, State Policy, Environmental Economics, Water Policy and Ecosystem Services.

The institute is housed on Campus Drive on the Duke campus, but also has staff in Duke’s Washington, DC, office and the Duke Marine Lab in Beaufort, North Carolina.
Working with Students

The Nicholas Institute provides a number of opportunities for Nicholas School doctoral and professional graduate students, as well as students from other Duke units and universities to engage in research projects. Students may also have the opportunity to work with the Nicholas Institute through the Nicholas School assistantship program as well as through its own internship program.

In early 2006, Nicholas School doctoral students initiated the Nicholas Institute Graduate Liaisons (NIGL) to facilitate communications between the Nicholas Institute and the Duke student body. A member of NIGL joins the institute for regular meetings to learn about current Nicholas Institute activities and opportunities for students.

In 2013, the Nicholas Institute created the Duke Environmental Economics Doctoral Scholars Program, a competitively funded fellowship to foster dynamic intellectual exchange between the Nicholas Institute, Duke doctoral students in environmental economics, and Duke University faculty. The DEEDS program offers support to doctoral students working with, and being mentored by a Duke faculty member in collaboration with the Nicholas Institute and the University Program in Environmental Policy (UPEP).

To learn more about our offerings for students, visit http://nicholasinstitute.duke.edu/education.

Publications, Events, and Project Details

The Nicholas Institute has always offered a safe neutral environment for stakeholders to discuss complex policy topics without a pre-determined outcome or advocacy position. Our research, time and time again, has demonstrated the value of bringing close-to-the-ground decision makers into dialogue with one another in a data-rich environment to hone policy fluency through interdisciplinary engagement. That logic underpins ongoing projects and events across our programs. Learn about our work at www.nicholasinstitute.duke.edu.
The PhD degree prepares students for careers in academia. Doctoral students emphasize scholarly research as a major part of their degree programs. An active research program is a vital component of the Nicholas School of the Environment, and most of the research projects in the school utilize PhD candidates as research assistants. The Nicholas School does not normally consider applications for the MS degree, although some students may be awarded an MS as part of a doctoral program.

A majority of faculty in the Nicholas School are members of the faculty of The Graduate School and are actively involved in the training of doctoral (PhD) students in the fields of earth and ocean, marine science and conservation, and environmental sciences. Prospective students should contact individual faculty mentors prior to applying to the doctoral program to ensure mutual interests in research topics. Policies and procedures for admission and registration, academic regulations and requirements for the PhD degree are given in detail in the bulletin of The Graduate School and not repeated in detail here.

Doctoral students are admitted to work with Nicholas School faculty by four pathways: 1) direct application to the subject areas environment, earth and ocean sciences, or marine science and conservation within The Graduate School; 2) application to the University Program in Integrated Toxicology (UIT), with an advisor chosen from within the Nicholas School faculty; 3) application to the University Program in Ecology (UPE), with an advisor chosen from within the Nicholas School faculty; or 4) application to the University Program in Environmental Policy (UPEP), with an advisor chosen from within the Nicholas School faculty.
Doctoral Study at the Duke University Marine Laboratory

Marine Science and Conservation doctoral students typically spend two semesters taking graduate classes on the Durham campus before moving to Beaufort to complete their research; however, residence in Durham is not a requirement. Although residency of the advisor is not necessary to study at the Marine Lab, some sources of funding are contingent upon having an advisor from the Marine Lab’s resident faculty.

Cooperative University Programs

Integrated Toxicology and Environmental Health Program (ITEHP)

The Integrated Toxicology and Environmental Health Program (ITEHP) prepares students for research careers in environmental health and toxicology. Interdepartmental and multidisciplinary, a PhD degree is awarded through the Nicholas School of the Environment with the ITEHP certificate granted by the program upon graduation. Upon completion of doctoral studies, these students are experienced in the design, execution, and interpretation of current research in environmental toxicology and chemistry, and environmental health. Completion of this training at the doctoral level provides career opportunities in academia, industry, and government, including positions involved in research, risk assessment, and policy.

Research directed by Nicholas School faculty covers a broad array of studies in the areas of environmental chemistry and toxicology. Current studies are concerned with chemical exposures to humans, particularly children, and to ecosystems, molecular mechanisms of toxicity, aquatic toxicology, and interconnections between human and ecosystem health. Environmental pollutants of concern in these studies include nanomaterials, flame retardants, aromatic hydrocarbons, pesticides, metals and metalloids, and endocrine disrupters.

There are several avenues possible for prospective students interested in applying for admission to the ITEHP. Students may seek admission directly into this PhD program and its NIEHS-funded T-32 Training Grant by filing an application with The Graduate School. This first option is only available to US citizens or Legal Permanent Residents. A second avenue for admission permits both domestic and international students to apply for entry via one of Duke’s participating departments, such as the Nicholas School. Finally, a certificate option is available to graduate students who have been admitted to Duke and are affiliated with a participating Duke department and who wish to pursue the additional coursework leading to certification. Interested prospective students will find complete program details and contact information at [http://sites.nicholas.duke.edu/envhealth/](http://sites.nicholas.duke.edu/envhealth/).

University Program in Ecology (UPE)

Duke hosts strong research programs in ecology, with highly productive faculty from a number of departments working at all levels of biological organization—from the organism to the ecosystem. Areas of special strength include global change ecology, evolutionary ecology, and forest and marine ecology. In the disciplinary category “ecology, evolution, and behavior” the National Research Council rated Duke in 1993 as one of the top three programs in the nation.

The University Program in Ecology was formed in 2000 to provide a common home for students who are pursuing doctoral studies in ecology in various departments across the University, including many students in the Nicholas School.

Students are admitted for doctoral work in the University Program in Ecology through The Graduate School. Departments participating in the ecology program guarantee that any student admitted is automatically admitted for PhD study in the home department of the student’s major professor.

The University Program in Ecology admits students with the promise of two years of financial support from the program, followed by support from the department of the student’s selected major advisor. Students are normally supported for up to five years of doctoral study if they maintain satisfactory progress toward their degree.

Students seeking admission to the University Program in Ecology should file an application with The Graduate School, specifying consideration by the UPE or one of the participating departments. Direct inquiries to ecology@duke.edu or to Graduate Studies, University Program in Ecology, Box 90328, Duke University, Durham, NC 27708. Find more information at [http://www.ecology.duke.edu](http://www.ecology.duke.edu).
University Program in Environmental Policy (UPEP)

The University Program in Environmental Policy was established in 2009 and is jointly administered by the Nicholas School and the Sanford School of Public Policy. It is the first and only PhD program in the United States jointly administered by a school of the environment and a school of public policy. It is a multidisciplinary, research-focused five-year doctoral degree, intended to prepare candidates for positions in applied academic departments and professional schools (e.g., environment and natural resources, public policy, public administration, international affairs), domestic and international public agencies, and environmental organizations, research institutes, and policy-consulting firms. Although the program is multidisciplinary, it is designed to ensure that students have strength in a particular social science discipline. Students designate their concentration when applying and currently may select either environmental economics or environmental politics.

The University Program in Environmental Policy provides a focal point for faculty and graduate students in the Nicholas School and Duke University’s Sanford School of Public Policy who are interested in environmental policy. It draws on the intellectual resources of not only the two schools but also related disciplinary departments (economics and political science) and other professional schools (Duke Law School, The Fuqua School of Business, Pratt School of Engineering) at Duke. Faculty in the program conduct research on economic and political aspects of a wide range of topics, including air and water quality, biodiversity conservation, climate change, community resource management, corporate sustainability, ecosystem services, energy, environmental health, fisheries, forests, and freshwater and marine resources, in both US and international contexts. Applicants are encouraged to contact faculty members with related interests to learn more about their current research projects and interest in accepting new doctoral students.

Students seeking admission to the University Program in Environmental Policy should file an application with The Graduate School, specifying consideration by the UPEP. Direct inquiries to Meg Stephens (meg.stephens@duke.edu) Graduate Studies, University Program in Environmental Policy, Box 90328, Duke University, Durham, NC 27708. Further information on the University Program in Environmental Policy can be found at http://nicholas.duke.edu/programs/university-phd-program-environmental-policy.

Qualification of Students

Students seeking admission to The Graduate School must have earned an AB or BS degree (or the equivalent in the case of foreign students) from an accredited institution. Usually the student should have majored in the area of intended graduate study or one closely related to it. Because research is such an integral part of doctoral education in the Nicholas School, the student’s undergraduate record must evidence the capability, motivation, and commitment to conduct independent study and research at an advanced level.

Admission

Applicants for the PhD degree must use The Graduate School’s electronic application, available at http://www.gradschool.duke.edu/admissions. An individual faculty member in the Nicholas School (or the Sanford School, in the case of the University Program in Environmental Policy) must accept responsibility to advise an applicant before admission can be offered; thus, students applying to the doctoral programs are strongly encouraged to correspond with prospective faculty advisors and visit the campus. Brief summaries of individual faculty research interests are given with the faculty listing in this bulletin.

Graduate School Registration

Students in PhD degree programs initiate course registration through the directors of graduate studies of the Nicholas School (in earth and ocean sciences, environment, University Program in Ecology, University Program in Environmental Policy, and University Program in Integrated Toxicology) and/or their advisor/s. Registration for courses is completed through the student online registration system (ACES). Registration requirements and procedures are described in the bulletin of The Graduate School, the department/program websites and in consultation with faculty advisor(s).
Fellowships and Assistantships for Doctoral Students

Students in all of the doctoral programs are normally supported for up to five years of study if they maintain satisfactory progress toward their degree. Some students receive fellowships to support their studies, while others are employed as teaching assistants, receiving a stipend and fellowship that cover tuition and fees. Other students are employed as research assistants, with funding derived from research grants managed by their major professor. In recent years, a significant fraction of the doctoral students have also been successful in national competition for graduate fellowships from the National Science Foundation, National Aeronautics and Space Administration National Oceanic and Atmospheric Administration, Environmental Protection Agency, and other agencies.

Normally, students are supported on teaching assistantships for only two or three years of their graduate study, the balance by research assistantships and/or fellowships. Students supported on teaching or research assistantships may also receive support for up to three summer months from research funding.

Fellowships Offered through the Nicholas School

W. D. Billings Fellowship. The University Program in Ecology awards the W. D. Billings Fellowship to an entering doctoral student who plans to specialize in some area of plant ecology. The award covers all tuition and fees and provides a full stipend for the first year of graduate study. The fellowship was established by Shirley M. Billings in honor of her husband, the late W. Dwight Billings, a physiological plant ecologist at Duke for more than thirty years who was renowned for his work in arctic and alpine environments.

Rachel Carson Fellowship. Established by William C. Powell, Thomas E. Powell Jr. and friends, the Carson Fund provides fellowships to PhD candidates who use the Rachel Carson Sanctuary site in Beaufort, North Carolina, as a major component of their research. First consideration will be given to PhD students in residence at the Duke University Marine Laboratory.

Robert W. Safrit Jr. Fellowship. Established by Robert W. Safrit, this fellowship is for students at the Duke University Marine Laboratory.

Harvey W. Smith Graduate Fellowship. Established by Evelyn Chadwick Smith, the Harvey W. Smith Graduate Fellowship Endowment provides fellowships to doctoral candidates in marine science.

Dr. Larry Widell Memorial Fellowship. Established by Christopher M. Widell, this endowment provides fellowships to Nicholas School students, with preference given to doctoral candidates.

Fellowships Offered through the Graduate School

The Graduate School offers a number of campus-wide competitive fellowships and scholarships. The James B. Duke Fellowships and University Scholars Program are available to incoming doctoral students in all departments. Advanced students may apply for the Katherine Stern Fellowship, which provides dissertation-year support. They are also eligible for conference travel awards and for a variety of other special internships or fellowships. The Graduate School also provides a number of awards for international research travel for doctoral students.

Minority doctoral students may receive support from the Dean’s Graduate Award Fellowships and Presidential Fellowships or through the National Consortium for Graduate Degrees for Minorities in Engineering and Science Inc.

The Frederick K. Weyerhaeuser Forest History Fellowship is given annually by the Forest History Society to a Duke University graduate student who wishes to study broadly in the area of forest and conservation history.

For detailed information about campus-wide financial aid opportunities for doctoral students, including application procedures, please consult the bulletin of The Graduate School.

National, Regional, and Foundation Awards

In addition to those awards available through the Nicholas School or the university, students are urged to compete for national and foundation awards for graduate study. Of particular interest to doctoral students in the Nicholas School are National Science Foundation Graduate Fellowships and Minority Fellowships, NASA Doctoral Fellowships in Global Change and Earth System Science, and EPA STAR Fellowships. The websites of these agencies offer details on applying for these fellowships.
Teaching Assistantships

Each year a selected number of PhD candidates may be offered a financial aid package consisting of full tuition plus a monthly stipend. The monthly stipend ($2,397 per month in 2013-14) requires up to 19.9 hours of work per week during the nine-month academic year. Students receiving these stipends are assigned by the director of graduate studies to serve as teaching assistants for various faculty or courses.

Research Assistantships

Funded from grant and contract research under the direction of various members of the faculty, research assistantships provide support during the course of study of the PhD candidate. Typically, the research assistant completes one or more phases of a research project under the direction of the principal investigator, a member of the faculty. Normally, the research completed forms a substantial component of the requirements of the PhD dissertation. However, in some instances students may pursue dissertation research in an unrelated area of study.

The academic year stipend is salary for research involving up to twenty hours per week. A regular schedule of research under the direction of the principal investigator must be maintained; therefore, some research assistantships require full-time service during the summer.
Research centers in the Nicholas School of the Environment are by design and intent flexible, multidisciplinary units. A major aim is to bring together specialized groups of scholars and professionals from many disciplines to focus their attention on current natural resource and environmental problems. The centers are headed by a director and staffed by an interdisciplinary faculty from Duke, neighboring universities and a variety of public and private research organizations. Depending on the level of funding, the centers may also employ research assistants and other support staff. The centers do not offer courses or degrees; rather, they offer students, scientists, and other professionals an opportunity to participate in research through collaboration with affiliated faculty.

**Center on Global Change**

**Faculty Director:** Robert B. Jackson, Professor of Earth and Ocean Sciences, Division of Earth and Ocean Sciences

Duke University created the Center on Global Change (CGC) in 2001 as a university-wide initiative to foster innovative, interdisciplinary research, and graduate education in global change science. The goals of the center are to advance scientific understanding, provide new educational and outreach opportunities, and attract additional funding from public and private entities. The center’s main emphasis is the intersection of climate change, energy, and the global carbon and water cycles. Current efforts examine the environmental footprint of energy use, including hydraulic fracturing and thermoelectric power, and the consequences of long-term droughts on land use and greenhouse gas emissions. The center also supports efforts by faculty and students to create new collaborations, on a range of topics relevant to global change.
Previous initiatives include the Climate Change Policy Partnership, established in 2005 by the CGC, Nicholas School of the Environment, and the Nicholas Institute for Environmental Policy Solutions. This initiative examined climate change and energy policy research in partnership with corporate sponsors. The CGC also established and directed the Department of Energy’s National Institute for Climate Change Research for the southeastern United States (2005-2012). Under this program, the CGC administered a five-year, $10 million climate change research program.

Other activities at the CGC include interdisciplinary working groups of Duke and non-Duke scientists; a visiting speaker seminar series; symposia and workshops held in collaboration with other units at Duke; and the provision of space and support for visiting scholars in residence. Find more information at [http://www.nicholas.duke.edu/cgc](http://www.nicholas.duke.edu/cgc).

**Center for Tropical Conservation**

**Director:** John Terborgh, Research Professor Emeritus of Environmental Science, Division of Environmental Sciences and Policy, Nicholas School of the Environment

The Center for Tropical Conservation (CTC) was established to focus the activities of Duke faculty and students who share a common concern for tropical biodiversity. The goal of the center is to unite biological and scientific inquiry with sound political economic analysis and conservation advocacy. The CTC serves to gather and disseminate pertinent information and to promote and coordinate research relevant to biodiversity and the sustainable development of natural resources.

The research and training agenda of the center focuses on the integration of environmental science and environmental policy and the processes by which policies can be adapted to reflect new scientific findings. Development of methods for managing natural resources is coupled with economic analysis to suggest policy reforms that promote the sustainable use of natural resources such as land, water, forests, and biodiversity.

Dr. John Terborgh operates Cocha Cashu Biological Station in Manu Biosphere Reserve, Peru. Located in the remote Peruvian Amazon, Cocha Cashu has hosted researchers from all over the world in a variety of fields. Investigators from a variety of disciplines have produced an impressive body of work, resulting in more than 300 publications. Find more information at [http://www.duke.edu/web/ctc](http://www.duke.edu/web/ctc).

**Duke River Center**

**Co-Directors:** Martin Doyle, Professor of River Science and Policy, Division of Environmental Sciences and Policy, Nicholas School of the Environment; Brian McGlynn, professor of watershed hydrology and geosciences, Division of Earth and Ocean Sciences; James Heffernan, assistant professor of ecology, Division of Environmental Sciences and Policy, Nicholas School of the Environment; and Emily Bernhardt, associate professor of biogeochemistry, Division of Environmental Sciences and Policy, Nicholas School of the Environment, and Director of Graduate Studies, Ecology PhD program (UPE)

The River Center was formed in 2011 as an intellectual community of faculty, postdocs, students and technical staff who share a common passion for the study of rivers and their watersheds. The group consists of four Duke research labs (Doyle, McGlynn, Heffernan and Bernhardt) that have an interest in advancing river science. Current research in the multidisciplinary labs spans watershed hydrology, ecology, biogeochemistry and environmental policy. Researchers in these labs also seek to inject the best possible science into ongoing discussions about protecting, managing, and restoring river ecosystems.

The physical home of the River Center is located in the Duke Water Science Laboratory and Research Center, a state-of-the-art facility containing shared lab space and a shared analytical facility. Find more information at [http://dukerivercenter.weebly.com](http://dukerivercenter.weebly.com).

**Duke University Wetland Center**

**Director:** Curtis J. Richardson, Professor of Resource Ecology, Division of Environmental Sciences and Policy, Nicholas School of the Environment

The goal of the Duke University Wetland Center is to provide sound scientific knowledge that will lead to sustainable wetland ecosystem functions and services locally, nationally, and globally. The center works toward this goal by conducting, sponsoring, and coordinating research and teaching on critical wetland issues, especially wetland and stream restoration, climate change effects on wetland nutrient cycling, carbon sequestration, invasive species, and the role of wetlands in improving water quality and retention on the landscape.
Perhaps no single environmental issue has so polarized public opinion as the protection of wetlands. Part land, part water, wetlands are ecosystems in which water level and low oxygen support a unique ecological habitat conducive to the development of specific plant and animal species. Wetlands improve water quality, provide flood control, supply habitat for fish, and are a vital link between surface water and groundwater. They also store over 30 percent of the world's carbon. Unfortunately, much of the public, not knowing about these functions and services, believe wetlands are of low value and should be drained or developed. As a result, the United States has lost over 50 percent of its wetlands.

By bringing together scientists, educators, and professionals, the Duke University Wetland Center is able to focus attention on wetland issues of regional, national, and international scale. Core researchers for the center are the director, faculty, visiting scholars, and graduate students. As part of a professional school within a private university, the Duke University Wetland Center works independently on wetland issues without the political pressures often brought to bear upon public institutions. Find more information at http://www.nicholas.duke.edu/wetland.

Superfund Research Center

**Director:** Richard Di Giulio, Professor of Environmental Toxicology, Division of Environmental Sciences and Policy, Nicholas School of the Environment

It is increasingly recognized that early life stages of humans and other organisms are particularly sensitive to environmental stressors such as pollutants. The Superfund Research Center unites researchers from the Nicholas School of the Environment, the Pratt School of Engineering, and the Duke University Medical Center in examining the effects of selected chemicals that are widespread in the environment, including Superfund sites. Of particular concern are effects on wildlife and human development, later life consequences of early life exposures, and new strategies for remediating heavily polluted areas such as Superfund sites. The center is supported by the National Institute of Environmental Health Sciences (NIEHS).

The goal of the center is to elucidate exposures, mechanisms of toxicity, health consequences in humans and ecosystems, and remediation strategies for specific toxic chemicals selected based upon their potential importance as developmental toxicants. Of particular interest are selected pesticides that affect development of the nervous system, hydrocarbons that impact development of the cardiovascular system, flame retardants that perturb endocrine systems and emerging nanomaterials for which information is very limited. In addition to conducting basic research in these areas, the center's key activities include undergraduate, graduate, and post-doctoral training in the environmental health sciences and engineering, and the translation of basic research findings into useful information for health professionals, government agencies, community leaders and the public. Find more information at http://sites.nicholas.duke.edu/superfund/.
Core Faculty

Abbreviations Key
- ESP – Division of Environmental Sciences and Policy
- EOS – Division of Earth and Ocean Sciences
- MSC – Division of Marine Science and Conservation
- * = holds a secondary appointment in the Nicholas School of the Environment, with primary appointment elsewhere at Duke University.

*John D. Albertson, Professor of Civil and Environmental Engineering; BS, Civil Engineering, State University of New York, Buffalo; MBA, Finance, University of Hartford; MES, Hydrology, Yale University; PhD, Hydrologic Science, University of California, Davis
  E-mail: john.albertson@duke.edu

Dr. Albertson works in the field of land-atmosphere interaction, which is centered on the connection between surface hydrology and meteorology in terrestrial ecosystems. The discipline seeks to develop a comprehensive theory to describe the exchange of mass (e.g. water and CO₂), energy and momentum between the land and atmosphere over a wide range of spatial and temporal scales. The ultimate goal is to provide the theoretical framework and tools needed to quantify spatially integrated land surface fluxes over large regions of complex terrain. (ESP)
Elizabeth Albright, Assistant Professor of the Practice of Environmental Policy and Methods; BA, the College of Wooster, MS/MPA, Indiana University; PhD, Duke University
E-mail: elizabeth.albright@duke.edu
Dr. Albright's area of focus is environmental policy; adaptation and resilience to extreme climatic events; decision analysis; stakeholder participatory processes; river basin management. (ESP)

Paul A. Baker, Professor of Geochemistry; BA, Geology, University of Rochester; MS, Geology, Pennsylvania State University; PhD, Earth Sciences/Marine Geology, Scripps Institution of Oceanography, University of California, San Diego
E-mail: pbaker@duke.edu
Dr. Baker's major focus is on understanding climatic and oceanographic history of the tropics as preserved in the sedimentary records of lakes, paleolakes, rivers, and the ocean. His work involves field, as well as laboratory, study. Analytical methods that he employs include stable isotopic and elemental geochemistry as well as all types of traditional geological and geophysical methods. (EOS)

*Ana Barros, Professor of Civil and Environmental Engineering; PhD, University of Washington.
Email: barros@duke.edu
Dr. Barros studies the physics of water cycle processes in mountainous regions with a focus on cloud formation and precipitation; remote sensing of the environment; long-range predictability and risk analysis of natural hazards; and computational environmental fluid mechanics.

Xavier Basurto, Assistant Professor of Sustainability Science; BS, Marine Resource Management, ITESM Campus Guaymas, Mexico; MS, School of Natural Resources, University of Arizona; MPA, School of Public Administration and Policy, University of Arizona; PhD, Management with a minor in Cultural Anthropology, University of Arizona
E-mail: xavier.basurto@duke.edu
Dr. Basurto's experience lies in the governance and theory of common-pool resources, community-based management, and institutional analysis of social-ecological systems, especially in the context of coastal marine environments and protected areas in rural Latin America. (MSC)

Lori Snyder Bennear, Associate Professor of Environmental Science and Policy; AB Economics and Environmental Studies, Occidental College; MA, Economics, Yale University; PhD, Public Policy, Harvard University
E-mail: lori.bennear@duke.edu
Dr. Bennear's areas of specialization are environmental and natural resource economics, applied microeconomics, and empirical methods. Her research focuses on estimating the effect of different regulatory innovations on measures of facility-level environmental performance, such as pollution levels, chemical use, and technology choice. Her recent work has focused on measuring the effectiveness of management-based regulations, which require each regulated entity to develop its own internal rules and initiatives to achieve reductions in pollution, as well as the effectiveness of regulations that mandate public reporting of toxic emissions. (ESP)

*Emily Bernhardt, Associate Professor; BS, University of North Carolina at Chapel Hill; PhD, Ecology and Evolutionary Biology, Cornell
Email: Emily.bernhardt@duke.edu
The core of Dr. Bernhardt's interests are in watershed biogeochemistry, and in understanding how the ways in which people live on and use the landscape alters the structure, function and chemistry of receiving streams and wetlands. (ESP)

Alan E. Boudreau, Professor of Geology; BA, Geology, University of California, Berkeley; MS, Geology, University of Oregon; PhD, Geology, University of Washington
E-mail: boudreau@duke.edu
Dr. Boudreau's research has focused on understanding the crystallization of large layered intrusions, with particular attention to the Archean Stillwater complex in Montana. Besides the intriguing problems proposed for the crystallization of magmas, these intrusions are host to important mineral reserves. Much of Dr. Boudreau's recent work has investigated the degassing history of these intrusions and the role of volatiles in the formation of platiniferous ore zones in South Africa. Another fundamental problem involves the mechanisms by which igneous
layering may develop. Dr. Boudreau has worked on models that challenge the conventional “two magma” mixing models often called upon to explain such features. The search for new observations to constrain and test these and other hypotheses is a major focus of his studies. (EOS)

**Lisa M. Campbell**, Rachel Carson Associate Professor of Marine Affairs and Policy, Director of Graduate Studies (Marine Science and Conservation); BA & Sc., Arts and Sciences, McMaster University, Canada; MA, Geography and Environmental Studies, University of Toronto; PhD, Geography, Cambridge University

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Dr. Campbell’s research focuses on policies designed to reconcile wildlife (and other resource) conservation with socioeconomic development, primarily in rural areas of developing countries. She studies the process of policymaking, the transition from policy to practice, and the impacts of (and responses to) implementation at the local level. At the policymaking stage, she examines how the interaction of science and other values, and how negotiations among stakeholders (local people, bilateral agencies, NGOs and experts) inform the process. A major research focus has been on marine turtle conservation policy and its implementation in Latin America and the Caribbean. Dr. Campbell is more generally interested in research methodology, including qualitative methods, interdisciplinary research and ethics. (MSC)

**Nicolas Cassar**, Associate Professor of Biogeochemistry, BS, McGill University; PhD, Oceanography, University of Hawaii

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Cassar’s experience lies in biogeochemistry and isotope biogeochemistry, marine productivity and carbon cycling, and algal ecophysiology. (EOS, MSC)

**William L. Chameides**, Nicholas Professor of the Environment; BA, SUNY Binghamton; MS, PhD, Yale University

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Dr. Chameides’s research focuses on the atmospheric sciences, elucidating the causes of and remedies for global, regional, and urban environmental change and identifying pathways toward a more sustainable future. Specifically his research helped lay the groundwork for our understanding of the photochemistry of the lower atmosphere, elucidated the importance of nitrogen oxides emission controls in the mitigation of urban and regional photochemical smog, and the impact of regional air pollution on global food production. (EOS)

**Charlotte Clark**, Assistant Professor of the Practice in Sustainability Education, and Director of Undergraduate Programs; AB, MEM and PhD, Duke University

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Dr. Clark’s primary interest is environmental education, specifically in the area of decision-making by the general public on issues of environmentally-related behavior. (ESP)

**James S. Clark**, Nicholas Professor of Environmental Science, Professor of Biology, Professor of Statistics; BS, Entomology, North Carolina State University; MS, Forestry and Wildlife, University of Massachusetts; PhD, Ecology, University of Minnesota

E-mail: jimclark@duke.edu

Dr. Clark’s research focuses on how global change affects forests and grasslands. Current projects include studies of plant migrations, the effects of recurrent drought on vegetation cover and fire in the Northern Plains and the effects of aridity and fire on North American temperate and boreal forests during recent millennia. He is also developing approaches to forecast ecosystem change. Analyses of forest successions at Duke University’s Free Air CO2 Experiment (FACE) are being used to assess how changing atmospheric chemistry is affecting the trajectory of change in modern forests. Dr. Clark has authored more than one hundred scientific articles and edited the book *Sediment Records of Biomass Burning and Global Change* (Springer, 1997). (ESP, EOS)

**Richard T. DiGiulio**, Professor of Environmental Toxicology; BA, Comparative Literature, University of Texas at Austin; MS, Wildlife Management, Louisiana State University; PhD, Wildlife Biology, Virginia Polytechnic Institute and State University

E-mail: richd@duke.edu

Dr. DiGiulio’s research is concerned with mechanisms of contaminant metabolism, adaptation and toxicity, and the development of mechanistically based indices that can be employed in biomonitoring. Of particular concern are

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mechanisms of oxidative metabolism of aromatic hydrocarbons, mechanisms of free radical production and antioxidant defense, and mechanisms of chemical carcinogenesis, developmental perturbations and adaptations to contaminated environments by fishes. The goals of this research are to bridge the gap between research and the development of tools for environmental assessment, and to elucidate linkages between human and ecosystem health. Dr. DiGiulio serves as director of Duke University’s Integrated Toxicology Program and the Superfund Basic Research Center. (ESP, MSC)

**Martin Doyle**, Professor of River Science and Policy; BS, Harding University; MS, University of Mississippi; PhD, Purdue
E-mail: martin.doyle@duke.edu
Dr. Doyle’s experience lies in river science including hydrology, geomorphology, and engineering. (ESP)

**Lee Ferguson**, Associate Professor, Civil & Environmental Engineering; BS, University of South Carolina; PhD, Stony Brook University
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Dr. Ferguson’s research centers around the application of high-performance mass spectrometry techniques to problems in environmental toxicology and chemistry. Active areas of investigation include development of methods for broadband qualitative and quantitative analysis of polar organic contaminants in the environment, as well as the use of proteome analysis techniques for investigating mechanisms and biomarkers of chemical stress in aquatic organisms. (ESP)

**Richard B. Forward Jr.**, Research Professor of Zoology and Bass Fellow; BS, Biology, Stanford University; PhD, Biology, University of California, Santa Barbara
E-mail: rforward@duke.edu
Dr. Forward investigates the physiological ecology of marine crustaceans and fishes. His studies focus on sensory physiology and behavioral responses to environmental (e.g. light, temperature, salinity) and chemical cues and biological rhythms. In recent studies, Dr. Forward has applied results to vertical migration and selective tidal stream transport of these organisms. (MSC)

**Deborah Rigling Gallagher**, Associate Professor of the Practice of Resource and Environmental Policy and Director of the Duke Environmental Leadership Program; BS, Chemical Engineering, Northwestern University; MPP, Harvard University; PhD, Public Policy, University of North Carolina at Chapel Hill
E-mail: deb.gallagher@duke.edu
Dr. Gallagher’s research focuses on public policies related to the interaction of business and the environment. Sustainable strategic management and the professionalization of sustainability is a particular focus of her work. In addition, she has examined business-government partnerships for environmental protection, such as brownfields redevelopment and the devolution of environmental public policy implementation to the private sector. (ESP)

* **Alan E. Gelfand**, James B. Duke Professor of Statistics and Decision Sciences and Professor of Environmental Sciences and Policy; BS, Mathematics, City College of New York; M.S and PhD, Statistics, Stanford University
E-mail: alan@stat.duke.edu
Dr. Gelfand’s major research focus is on stochastic modeling of complex systems. In particular, he works on applications in ecology, environmental science, and atmospheric science. A key feature of nearly all of this work is that the system under investigation can be viewed as a space-time process leading to the use of spatio-temporal modeling tools. Hierarchical specifications provide the framework for this effort, enabling convenient synthesis of knowledge about the behavior of the system with available data sources. (ESP)

**Alex Glass**, Lecturer, Invertebrate Paleontology and Science Education, and Director of Undergraduate Studies (EOS); PhD, University of Illinois
E-mail: alex.glass@duke.edu
Dr. Glass’ experience lies in paleontology, evolution, fossil echinoderms, geology, nature of science, and science education. Glass has a strong interest in the relationship between science and religion, particularly the public’s debate over creation and evolution. (EOS)
Jay Golden, Associate Professor of the Practice for Sustainable Systems Analysis; PhD, Cambridge University
E-mail: jay.golden@duke.edu
Dr. Golden studies firm and product sustainability, sustainability supply chain, sustainable energy, urban systems and climate, urban heat island, and energy-water nexus. (EOS)

Peter K. Haff, Professor of Geology and of Civil and Environmental Engineering, and Director of Graduate Studies (Earth and Ocean Sciences); BA, Physics, Harvard University; PhD, Physics, University of Virginia
E-mail: haff@duke.edu
Dr. Haff works on earth surface processes such as the effects of erosion, weathering and soil creep, typically using cellular automata models. Recently, he has become interested in neogeomorphology, the study of the change of the earth's surface as a result of human activity. A second area of interest is the changing technological environment and the human implications of the difference in rate of change between the technological sphere and the natural sphere. Dr. Haff is also interested in the philosophy and practice of modeling and prediction, specifically the extent to which limitations on our predictive abilities lie in the models we make of earth systems versus in the nature of earth surface processes themselves. (EOS)

Patrick N. Halpin, Associate Professor of Marine Geospatial Ecology; BA, International Studies, M.P.A., International Management, George Mason University; PhD, Environmental Sciences, University of Virginia
E-mail: phalpin@duke.edu
Dr. Halpin's research interests are in landscape ecology, GIS and remote sensing, and conservation management. His research activities include spatial analysis of environment and vegetation patterns, Geographic Information Systems analysis, ecological applications of remote sensing and terrestrial and marine protected area management. Dr. Halpin has conducted research on the international impacts of global climate change in montane environments. He is currently a principal investigator in research projects involving the spatial analysis of environmental change in urban environments, spatial analysis of forest structure and conservation applications of GIS. Dr. Halpin has a special interest in the application of GIS and spatial analyses to environmental problem solving in terrestrial and marine research and management problems. (MSC, ESP)

James Heffernan, Assistant Professor of Ecohydrology and Ecosystem Ecology. BA, Cornell; PhD, Arizona State University
E-mail: james.heffernan@duke.edu
Dr. Heffernan's experience lies in nutrient cycling in wetlands and aquatic ecosystems; disturbance and resilience; ecology of urban environments; and ecosystem restoration. Current study sites include spring-fed rivers of North Florida, and the wetlands of the Florida Everglades. (ESP)

James L. Hench, Assistant Professor of Oceanography; BS, Civil Engineering, North Carolina State University, MS, Civil Engineering, Stanford University; PhD, Physical Oceanography, University of North Carolina at Chapel Hill
E-mail: jim.hench@duke.edu
Dr. Hench is a physical oceanographer with research interests in shallow-water circulation characterized by unsteadiness, strong advective accelerations, and frictional boundary layers that occupy much or all of the water column. He also is interested in the effects of stratification on shallow flows. Currently he is working on several projects, including wave-driven circulation and exchange in coral reef, lagoon, and pass systems; understanding the effects of rough bottoms such as corals on circulation and scalar mixing; and the impact of stratification on circulation and tidal exchange in a freshwater tidal river.

He also has a strong interest in interdisciplinary problems that have a significant physical component, such as larval fish transport, small-scale shear effects on phytoplankton, selective tidal-stream transport, sponge excurrents, and the effects of wave forcing on corallivory. (MSC)

David E. Hinton, Nicholas Professor of Environmental Quality; BS, Zoology, Mississippi College; MS, PhD, Anatomy, University of Mississippi
E-mail: dhinton@duke.edu
Dr. Hinton's research is focused on the development and growth of fishes in normal health and in the case of toxicant-induced disease. His areas of interest include the development and application of biomarkers of exposure, the examination of adverse effects and sensitivity to studies of early life stages of fishes, and the long-term consequences of early life stage toxicant exposure to adult structure and function. (ESP, MSC)
*Heileen Hsu-Kim, Assistant Professor of Civil and Environmental Engineering; BS Massachusetts Institute of Technology; MS, PhD., University of California, Berkeley E-mail: hsukim@duke.edu

Dr. Kim’s research areas include aquatic chemistry and geochemistry, trace element environmental chemistry, nanogeoscience, mercury biogeochemistry, metal-sulfide colloids, voltammetric methods and electrochemistry. (ESP)

Dana Hunt, Assistant Professor of Microbial Ecology; BA, Rice University; PhD, MIT
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Dr. Hunt’s research lies in the area of microbial ecology, specifically the drivers of bacterial diversity and dynamics in the marine environment. Bacterial adaptation to emerging pollutants. (MSC)

*Marc Jeuland, Assistant Professor of Public Policy; MS, PhD, UNC-Chapel Hill
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Dr. Jeuland’s areas of research include environment and energy, environmental law, regulation and policy, and global health. (ESP)

Dr. David Johnston, Assistant Professor of the Practice of Marine Conservation Ecology; PhD, Duke University
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Dr. Johnston is a marine conservation ecologist who focuses on the foraging ecology and habitat needs of marine animals in relation to pressing conservation issues. (MSC)

Timothy Johnson, Associate Professor of the Practice, PhD, Carnegie Mellon University
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Dr. Johnson’s work examines the social and environmental consequences of technology change across the energy system. In addition to technology-specific assessments, he looks at long-range scenarios of energy system evolution; the economic, social, and technical forces driving this change; and their social and environmental impacts. (EOS)

Zackary Johnson, Arthur P. Kaupe Assistant Professor of Biological Oceanography and Marine Biotechnology; BS, Civil and Environmental Engineering, Massachusetts Institute of Technology; PhD, Botany, Duke University E-mail: zij@duke.edu
Dr. Johnson's research currently focuses on 1) developing marine algae as a source of biofuels and 2) studying the diversity, structure and biogeochemistry of marine microbial ecosystems using Prochlorococcus as a model marine microbe. (MSC)

Prasad Kasibhatla, Professor of Environmental Chemistry, and Senior Associate Dean; BS, Chemical Engineering, University of Bombay; MS, PhD, Chemical Engineering, University of Kentucky
E-mail: psk9@duke.edu
Dr. Kasibhatla’s research is focused on the development of a fundamental and quantitative understanding of the factors that determine the chemical composition of the atmosphere. He is particularly interested in delineating natural and anthropogenic impacts on the chemical composition of the atmosphere, and in exploring the potential for these impacts to affect natural ecosystems. His research involves the use of numerical models in conjunction with remote and in situ measurements of atmospheric composition. (ESP)

Gabriel Katul, Theodore S. Coile Professor of Hydrology and Micrometeorology; BE, Civil Engineering, American University of Beirut; MS, Civil Engineering, Oregon State University, PhD, Civil Engineering, University of California, Davis
E-mail: gaby@duke.edu
Dr. Katul’s work is focused on developing an understanding of the cycling of water, carbon, and energy within the soil-plant-atmosphere continuum. His approach is based on the application of fluid mechanics to quantify the net exchange of carbon dioxide, water, heat and momentum between ecosystems and the atmosphere. His work spans from below the root zone in the soil to the lower layers of the atmospheric boundary layer. While studies of this domain include the traditional disciplines of surface hydrology, terrestrial ecology and boundary layer meteorology, the basic principles of fluid mechanics provide the integration across this natural continuum and thus the most logical basis for developing a comprehensive, robust theory in land-atmosphere interaction research. (ESP)
*Richard Kay,* Professor of Biological Anthropology and Anatomy and of Geology; BS, Anthropology and Zoology, University of Michigan; MPhil, PhD, Geology and Geophysics, Yale University
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Dr. Kay’s current research interests center on the evolutionary history of the primates. He is especially interested in further documenting the fossil history of neotropical monkeys, whose history is poorly known. Another focus of his research has been the use of quantitative methods to understand the dietary adaptations of the teeth of living primates. Dr. Kay is chairman of Duke’s Department of Biological Anthropology and Anatomy. (EOS)

**Emily M. Klein,** Professor of Geology; BA, English, Barnard College; MS, PhD, Geology, Columbia University
E-mail: ek4@duke.edu

Dr. Klein’s research focuses on the geochemistry of oceanic basalts, using diverse tools of major, trace and isotopic analyses. The goals of her research are to understand the processes that lead to the creation of the ocean crust, including the physical and chemical characteristics of the sub-ridge mantle. Through these studies, Dr. Klein examines how the Earth evolves chemically through geologic time. Her research involves sea-going expeditions to sample and map the ocean floor. (EOS)

**Randall A. Kramer,** Professor of Resource and Environmental Economics, and Associate Director for Strategy, Duke Global Health Institute; BA, Economics, University of North Carolina at Chapel Hill; ME, Economics, North Carolina State University; PhD, Agricultural Economics, University of California, Davis
E-mail: kramer@duke.edu

Dr. Kramer’s research has focused on ecosystem valuation, water resource economics and the economics of biodiversity and natural resource management in developing countries. Current projects in Indonesia focus on biodiversity economics, such as the effects of human population growth and migration on the sustainable use of coastal resources and the examination of how public and community-based fisheries management affects economic activity. Another set of studies is focused on the economics of protected areas in Indonesia, with an emphasis on nature-based tourism, agricultural, and forest extraction in buffer zones and watershed protection benefits. In North Carolina, Dr. Kramer studies public attitudes toward water quality protection and the economic and ecological criteria for selecting sites for wetlands restoration. (ESP, MSC)

**Mukesh Kumar,** Assistant Professor of Watershed Hydrology; BS, Indian Institute of Technology; PhD, Civil and Environmental Engineering, Pennsylvania State University
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Dr. Kumar’s research interests lie in Watershed Hydrology, Groundwater-Surface Water-Atmosphere Interactions, Numerical Modeling of Snow and Hydrologic Processes, GIS-Model Coupling, High Performance Computing Applications and Optimization Methods. (ESP)

**Wenhong Li,** Assistant Professor of Climate. BS, Meteorology, Peking University; M.S., Atmospheric Sciences, Chinese Academy of Meteorological Sciences; PhD, Earth and Atmospheric Sciences, Georgia Institute of Technology
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Dr. Li’s research interests focus primarily on the climate and terrestrial ecosystem interaction, hydrometeorology, climate and modeling. Her current research is to understand how the hydrological cycle changes in the current and future climate and their impacts on the ecosystems, and future climate over tropical lands. Her work has covered both diagnostic and modeling studies. (EOS)

*Ryke Longest,* Clinical Professor of Law, and Director, Environmental Law and Policy Clinic; BA and JD, University of North Carolina at Chapel Hill. (ESP)

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**M. Susan Lozier,** Ronie-Richele Garcia-Johnson Professor of Physical Oceanography and Bass Fellow; BS Chemical Engineering, Purdue University; MS, Chemical Engineering, PhD, Physical Oceanography, University of Washington
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Dr. Lozier’s research lies in the field of physical oceanography with an emphasis on evaluation of the ocean as a reservoir for climate signals. By understanding the rapidity and extent to which climatic anomalies spread from their source region, she aims to determine the effectiveness of the deep ocean as a climatic reservoir for heat. A particular focus is on answering how climatic signals are transmitted throughout the global ocean, especially the North
Atlantic basin. Dr. Lozier also studies cross-frontal mixing mechanisms in the ocean. Currently, she is studying the dynamics of shelfbreak flow in an effort to understand how properties such as heat, sediment, and nutrients are transported from the shelf to the open ocean. (EOS, MSC)

**Lynn A. Maguire**, Professor of the Practice of Environmental Decision Analysis; AB, Biology, Harvard University; MS, Resource Ecology, University of Michigan; PhD, Ecology (Wildlife Science), Utah State University

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Dr. Maguire uses methods from decision analysis, environmental conflict resolution, and social psychology to study environmental decision making. She focuses on collaborative decision processes in which both public and stakeholder values must be considered along with technical analysis to determine management strategies. These studies evaluate both the substance of environmental decisions—how well the resulting management actions reflect public values and available science—and the process—how well the mechanisms used to involve the public achieve social justice goals. Dr. Maguire and her students have applied these approaches to collaborative decision processes for public land management and for water quality management in North Carolina and elsewhere. (ESP)

**Marco Marani**, Professor of Ecohydrology and Civil and Environmental Engineering; BA, PhD, University of Padova

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Dr. Marani's research interests include bio-geomorphology of tidal environments; Remote Sensing in Hydrology and tidal biogeomorphology; Fluvial geomorphology and theory of the hydrologic response; Models and analysis of space-time precipitation; Hydrometeorology; Climatology. (EOS)

*Frederick (Fritz) Mayer*, Professor of Public Policy and Political Science; AB, MPP and PhD, Harvard University.

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Dr. Mayer works in the areas of narrative politics; globalization and governance; international trade policy; climate politics; and international negotiations. (ESP)

*David McClay*, Professor of Biology; BS, Zoology, Pennsylvania State University; MS, Zoology, University of Vermont; PhD, Zoology, University of North Carolina at Chapel Hill

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Dr. McClay studies the events of morphogenesis that mold the embryo at gastrulation. As the embryo establishes three germ layers and organizes the basic body plan, cells rearrange in highly predictable ways. Dr. McClay studies the mechanisms by which cells are specified during cleavage to become mesoderm or endoderm, the mechanisms employed by cells to rearrange during gastrulation and the function of several specific proteins in the morphogenetic process. (MSC)

**Brian McGlynn**, Professor of Watershed Hydrology and Biogeosciences, and Division Chair, Earth and Ocean Sciences; BA, History and Environmental Science, Gettysburg College; MS and PhD, Watershed Hydrology, SUNY College of Environmental Science and Forestry

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Dr. McGlynn studies watershed hydrology (streamwater sources, flowpaths, and age), land-atmosphere CO₂, H₂O, and energy fluxes, watershed biogeochemistry, and hydrological / biogeochemical / ecological implications of landuse change. His lab employs methods that include source water tracing, physical hydrology, eddy-covariance, and landscape analysis techniques. (EOS)

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*Meg McKeen*, Research Professor; BA, Political Science and Asian Studies, University of California at Berkeley; MA, Harvard University; PhD, University of California, Berkeley

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Dr. McKeen specializes in Japanese politics and environmental and resource politics. Recently she has been working on the relationship between property rights and environmental outcomes, and on the management of common-pool resources in Japan and elsewhere. (ESP)
Joel N. Meyer, Associate Professor of Environmental Toxicology, and Director of Graduate Studies (Environment); BA, Environmental Studies and Peace and Conflict Studies, Juniata College; PhD, Environmental Toxicology, Duke University
   E-mail: joel.meyer@duke.edu
   Dr. Meyer studies the effects of genotoxic agents on human and wildlife health. He is interested in understanding the mechanisms by which environmental agents cause DNA damage, the molecular processes that organisms employ to protect prevent and repair DNA damage, and genetic differences that may lead to increased or decreased sensitivity to DNA damage. Mitochondrial DNA damage and repair are a particular focus. He studies DNA repair and other responses to DNA damage via PCR-based analysis of DNA damage and repair, gene expression and systems biology approaches, and organismal-level responses. (ESP)

Megan Mullin, Associate Professor of Environmental Politics; BA and MA, Political Science, Bowdoin College; PhD, Political Science, University of California, Berkeley.
   Email: megan.mullin@duke.edu
   Dr. Mullin’s work is in the field of American politics, focusing on governmental processes and applied policy outcomes. (ESP)

A. Brad Murray, Professor of Geomorphology and Coastal Processes; BA, Journalism, BIS, General Science, MS, Physics, PhD, Geology, University of Minnesota
   E-mail: abmurray@duke.edu
   Dr. Murray is interested in earth surface processes and patterns, focusing on rivers and desert, arctic and alpine geomorphology. His recent efforts have focused on coastal and nearshore processes. The nearshore environment is a spatially extended system that exhibits complex, dynamic spatial patterns, including the arrangement of bars and channels, waves and often an array of alongshore and cross-shore currents. He approaches such systems with the perspective and techniques developed in the study of nonlinear dynamics and complex systems, looking for possibly simple, large-scale interactions that could explain complex behaviors. He uses relatively simple, cellular-automata models to test such hypotheses, applying the methods to beach and surf-zone problems as well as offshore currents and shoreline features. (EOS)

Brian Murray, Research Professor and Director for Economic Analysis, Nicholas Institute for Environmental Policy Solutions; BS, Economics and Finance, University of Delaware; MS, Resource Economics and Policy, Duke University; PhD Resource Economics and Policy, Duke University
   E-mail: brian.murray@duke.edu
   Dr. Murray's research is in the area of environmental economics, climate change, ecosystem services, land use, forests and agriculture. (ESP)

Richard G. Newell, Gendell Professor of Energy and Environmental Economics, and Director of the Duke Energy Initiative; BS, Materials Engineering, BA, Philosophy, Rutgers University; MPA, Public Policy, Princeton University; PhD, Public Policy, Harvard University
   E-mail: richard.newell@duke.edu
   Dr. Newell's research centers on the economics of markets and policies for energy and related technologies, particularly the cost and effectiveness of alternatives for reducing greenhouse gas emissions and achieving other environmental and energy goals. Economic analysis of market-based policies, technology policies, and the influence of markets and policy on technology innovation and adoption are important themes in his work. He has published in major economics journals, including the Quarterly Journal of Economics, the Journal of Environmental Economics and Management, the Journal of Industrial Economics, and the American Journal of Agricultural Economics. He recently served as the Senior Economist for energy and environment on the President’s Council of Economic Advisers. (ESP, EOS)

Douglas Nowacek, Repass-Rogers University Associate Professor of Conservation Technology and Associate Professor of Electrical and Computer Engineering; BA, Ohio Wesleyan University; PhD, Biological Oceanography, Woods Hole Oceanographic Institute of Technology
   E-mail: doug.nowacek@duke.edu
   Dr. Nowacek's research is focused on the link between acoustic and motor behavior in marine mammals, primarily cetaceans and manatees, specifically, how they use sound in ecological processes. (MSC)
*Michelle Nowlin*, Lecturing Fellow and Supervising Attorney, Environmental Law and Policy Clinic; BA, University of Florida; JD/MA, Duke University. (ESP)

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**Ram Oren**, Nicholas Professor of Earth System Science; BS, Forest Resource Management, Humboldt State University; MS, Forest Ecology, PhD, Physiological Ecology, Oregon State University

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Dr. Oren's research quantifies the components of water flux in forest ecosystems and the influence of certain biotic and abiotic factors on water flux. Climate variability, including elevated atmospheric carbon dioxide, affects the patterns and amounts of water used by forest ecosystems, and their spatial distributions. Using a local mass-balance approach and detailed measurements of water flux and driving variables in the soil, plants and atmosphere, Dr. Oren evaluates the likely responses of different forest ecosystems to environmental change. He also works to quantify the carbon and water balance in forests under current atmospheric CO\textsubscript{2} concentration and projected future concentration, and to evaluate the effect of soil fertility on carbon sequestration and water yield in pine forests. (ESP)

**Sari Palmroth**, Associate Research Professor; MSc, Silviculture, PhD, Forest Ecology, University of Helsinki, Finland

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Dr. Palmroth's research interests are in the general area of forest carbon dynamics with emphasis on physical-physiological modeling of canopy radiative transfer and photosynthesis. Her recent work also deals with empirical modeling of ecosystem respiration, where she is examining gas exchange in leaves, stems, and soils. (ESP)

**William Pan**, Assistant Professor of Environmental Health; BA, Boston College; MPH, Emory University; MS, PhD, UNC-Chapel Hill

E-Mail: wkp@duke.edu

Dr. Pan's primary research interests are to foster a deeper understanding of demographic processes, human health and environmental change using a combination of quantitative tools from biostatistics, geography, and economics. (ESP)

**Dalia Patino-Echeverri**, Gendell Assistant Professor of Energy Systems and Public Policy; BS, University of Andes, Colombia; MS University of Andes, Colombia; PhD, Carnegie Mellon University

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Dr. Patino-Echeverri’s research focuses on public policy design for energy systems, with a particular emphasis on managing the risks arising from the uncertainties influencing the outcomes of government actions. Much of her current work focuses on the policies that affect capital investment decisions within the electricity industry, and the corresponding costs to society of electricity and air-emissions levels. (ESP)

**Subhrendu Pattanayak**, Professor of Public Policy and Environmental Economics; BA, Economics, University of Delhi; MS, Economics, Purdue University; PhD, Duke University

E-mail: subhrendu.pattanayak@duke.edu

Dr. Pattanayak measures resource and environmental values and models economic behavior under environmental constraints for analysis of environmental policy. His recent research has focused on nonindustrial private forestry, urban land use dynamics, benefits of safe drinking water and benefits transfer methodology. (ESP)

**Alex Pfaff**, Associate Professor of Public Policy Studies, and Director of Graduate Studies (University Program in Environmental Policy); BS, Applied Math/Economics, Yale University; PhD, Massachusetts Institute of Technology

E-mail: alex.pfaff@duke.edu

Dr. Pfaff’s expertise is in environmental and natural resource economics, and he is interested in the interplay among the environment, resources, and economic development—with the goal of making certain that interventions both have their intended impacts on the environment and resources and benefit the people they are designed to help. (ESP)

**Stuart L. Pimm**, Doris Duke Professor of Conservation Ecology; BA, Zoology, Oxford University; PhD, Ecology, New Mexico State University

E-mail: stuartpimm@aol.com
Dr. Pimm is committed to the study of the scientific issues behind the global loss of biological diversity, including the reasons why species become extinct, how fast they do so, the global patterns of habitat loss and species extinction, the role of introduced species in causing extinction and, importantly, the management consequences of this research. Current work includes studies of endangered species and ecosystem restoration in the Florida Everglades and setting priorities for protected areas in the Atlantic Coast forest of Brazil, one of the world’s hot spots for threatened species. Dr. Pimm has written more than 150 scientific papers and four books including his recent global assessment of biodiversity’s future, *The World According to Pimm: A Scientist Audits the Earth.*

*William (Billy) Pizer,* Associate Professor of Public Policy, Economics and Environment; BS, UNC-Chapel Hill; MA, PhD, Harvard University. (ESP)
E-mail: billy.pizer@duke.edu

*Amilcare Porporato,* Professor of Civil and Environmental Engineering; MS Polytechnic of Turin, Italy; PhD Polytechnic of Milan, Italy
E-mail: amilcare@duke.edu
Dr. Porporato studies the links between the terrestrial water cycles and ecosystems. His work combines theoretical modeling, using methods from nonlinear dynamic systems and stochastic processes, to field investigations, especially at the Duke forest FACE experiment. Dr Porporato’s other interests include nonlinear analysis of hydrologic time series and turbulence. (ESP)

*John Poulsen,* Assistant Professor of Tropical Ecology (ESP); BS, Political Science, Willamette University; MS Biology, San Francisco State University; PhD Biology, University of Florida. (ESP)
E-mail: john.poulsen@duke.edu

*Lincoln F. Pratson,* Professor of Energy and Environment; BS, Geology, Trinity University; MS, Oceanography, University of Rhode Island; MPH, PhD, Geology, Columbia University
E-mail: lincoln.pratson@duke.edu
Dr. Pratson studies how sedimentary processes shape continental margins. Specific research interests include the dynamics of both current- and gravity-driven sediment transport, submarine canyon formation, and seafloor evolution, the causes and consequences of submarine slope failure and the interplay between marine sedimentation and tectonics. He conducts this research using a variety of methods ranging from seafloor mapping using multibeam bathymetry, side-scan sonar imagery and shallow cores, to sequence stratigraphy based on seismic reflection profiles and borehole data constrained in some instances by gravity measurements. Dr. Pratson also uses numerical and experimental models of sedimentary processes for testing ideas about their dynamics and predicting their contribution to and imprint on the morphology and stratigraphy of continental margins. (EOS)

*Andrew J. Read,* Stephen Toth Professor of Marine Biology; BSc, MSc, PhD, Zoology, University of Guelph
E-mail: aread@duke.edu
Dr. Read’s research interests are in the ecology and conservation biology of marine mammals. His work focuses on how dolphins and porpoises obtain prey in a three-dimensional environment and on the life history consequences of energy allocation. Much of his current research documents the direct and indirect effects of human activities on populations of marine mammals and attempts to find solutions to such conflicts, especially between marine mammals and commercial fisheries. This research involves field work, experimentation and modeling. He is particularly interested in the development and application of new conservation tools to resolve such conflicts. (MSC)

*Chantal Reid,* Assistant Professor of the Practice and Biology; BS McGill University; MS, San Diego State University; PhD, Duke University
E-mail: chantal@duke.edu
Dr. Reid studies how plants grow in changing environments, with emphasis on effect of rising CO₂ and other air pollutants. She combines her research and teaching interests, engaging students in research through ecology courses and independent study. (ESP)

*Curtis J. Richardson,* Professor of Resource Ecology; BS, Biology, State University of New York at Cortland; PhD, Ecology, University of Tennessee
E-mail: curtr@duke.edu
Dr. Richardson's research interests in applied ecology are centered on long-term ecosystem response to large-scale perturbations such as acid rain, toxic materials, trace metals, flooding, and nutrient additions. His main interests are in phosphorus nutrient dynamics in wetlands, the effects of environmental stress on plant metabolism and growth response, and wetland restoration. As director of the Duke University Wetland Center since its inception in 1989, Dr. Richardson has directed research efforts to understand the ecological basis for a phosphorus threshold in the Everglades and sustaining ecosystem structure and function. (ESP, MSC)

Daniel D. Richter Jr., Professor of Soils and Forest Ecology; BA, Philosophy, Lehigh University; PhD, Forest Soils, Duke University
E-mail: drichter@duke.edu
Dr. Richter's research centers on applying principles of soil and ecosystem sciences to the management of forests, soils, and watersheds. Recent research has focused on Ultisols and Inceptisols in the southeastern United States, boreal forest Gelisols in interior Alaska, and a wide range of soils in the humid tropics of Indonesia and Costa Rica. Dr. Richter's research centers on biogeochemical change in soil over three time scales: decades, in which contemporary ecosystems and their management affect ongoing dynamics of soil; centuries, in which past land-use practices affect soil properties and processes; and millennia, in which ecosystem processes form soils. Dr. Richter studies three main issues: carbon sequestration, soil-nutrient regeneration, and soil-ecosystem acidification. (ESP)

Dan Rittschof, Professor of Ecology; BS, PhD, Zoology, University of Michigan
E-mail: ritt@duke.edu
Dr. Rittschof's research focuses on ecology with emphasis on the chemical, behavioral, and spatial aspects of the discipline. Presently, he has two areas of focus: the ecology of local macroinvertebrates and the prevention of fouling of marine vessels. Dr. Rittschof is funded in both areas with grants to work on the spatial ecology of blue crabs in the basin drained by the Beaufort Inlet and to develop new antifouling technology. The most extensive of these is a three-year antifouling program in Singapore that started in early January 2002. This program has the goal of using medical drugs as environmentally benign antifoulants. (MSC)

James Salzman, Samuel F. Mordecia Professor of Law and Nicholas Institute Professor of Environmental Policy and Law; BA, History, Yale College; MS, Engineering Sciences, Harvard University; JD, Law, Harvard University
E-mail: salzman@law.duke.edu
Professor Salzman’s major research focus is on the institutions and laws related to the provision of ecosystem services and the creation of markets for ecosystem services. His research also involves challenges in managing the global commons and the management of resources with strong public goods components, such as drinking water. Analytical methods that he employs include legal, public policy, and economic analysis. (ESP)

Thomas Schultz, Lecturer and Director of Undergraduate Studies (MSC); BA and PhD, University of California, San Diego.
Email: tom.schultz@duke.edu
Dr. Schultz's area of expertise is in marine biodiversity and conservation. He is the director of the Marine Conservation Molecular Facility. (MSC)

Elizabeth Shapiro, Assistant Professor of the Practice in Environmental Policy and Management; BA, Biology and Environmental Studies, Oberlin College; MESc, Human Ecology, Yale; PhD, Society and Environment, UC Berkeley (ESP)
E-mail: elizabeth.shapiro@duke.edu
Dr. Shapiro’s experience lies in human and environmental geography; political ecology; qualitative research design and methods; social impact assessment; community-based ecosystem management; market-based environmental policy; Latin America. (ESP)

Drew Shindell, Professor of Climate Sciences; BA, Physics, UC Berkeley; PhD, Physics, State University of New York at Stony Brook
Dr. Shindell's research focuses on the interactions between atmospheric composition and climate change, climate and air quality linkages, and public policy. (EOS)

Brian Silliman, the Rachel Carson Associate Professor of Marine Conservation Biology; BA, University of Virginia, MS, University of Virginia; PhD, Brown University
E-mail: brian.silliman@duke.edu
Dr. Silliman’s research is focused on community ecology of salt marshes and rocky shores, conservation of coastal wetlands and reef fish populations, physical-forcing and disease-mediated control of food web dynamics, plant-animal interactions, and evolution of fungal farming behavior. (MSC)

**Martin D. Smith**, Professor of Environmental Economics; BA, Public Policy, Stanford University; PhD, Agricultural and Resource Economics, University of California, Davis
E-mail: marsmith@duke.edu
Dr. Smith’s research focuses on spatial issues in natural resource use and management. He specializes in applied econometrics and bioeconomic modeling. His current research projects include evaluating marine reserves as a commercial fishery management tool, studying the spatial and intertemporal behavior of renewable resource harvesters, modeling the impacts of commercial fishing on endangered species through predator-prey interactions, analyzing private agricultural land use decisions in federally managed wetlands and identifying transition dynamics in the organic farming industry. (ESP, MSC)

**Heather Stapleton**, Dan and Bunny Gabel Associate Professor of Environmental Ethics and Sustainable Environmental Management; BS, Marine Biology and Marine Chemistry, Southampton College; MS, PhD, Environmental Chemistry, University of Maryland
E-mail: heather.stapleton@duke.edu
Dr. Stapleton’s investigates the fate, transport, and metabolism of halogenated organic contaminants in the environment. Her specific interests focus on species-specific differences in the metabolism of brominated flame retardants in aquatic organisms. Analytical methods employed in Dr. Stapleton’s laboratory include gas chromatography, liquid chromatography, and mass spectrometry. (ESP)

**Jennifer Swenson**, Associate Professor of the Practice of Geospatial Analysis, and Director of Professional Studies; BA, Geography and International Relations, UC Santa Barbara; MA, Geography, San Diego State University; PhD, Forest Ecology, Oregon State University
E-mail: jennifer.swenson@duke.edu
Dr. Swenson is interested in modeling spatial patterns of species and ecosystems, species diversity, and their relationship with functional ecological factors. She has worked in the South American tropics using GIS and remote sensing technology to create information for conservation applications. (ESP)

**John W. Terborgh**, Research Professor; AB, Biology, Harvard College; AM, Biology, PhD, Plant Physiology, Harvard University
E-mail: manu@duke.edu
Dr. Terborgh is codirector of the Center for Tropical Conservation at Duke University. He is a member of the National Academy of Sciences, and for the past thirty-five years he has been actively involved in tropical ecology and conservation issues. An authority on avian and mammalian ecology in neotropical forests, Dr. Terborgh has published numerous articles and books on conservation themes. Since 1973 he has operated a field station in Peru’s Manu National Park where he has overseen the research of more than one hundred investigators. In April 1996, he was awarded the National Academy of Sciences’s Daniel Giraud Elliot medal for his research and for his book *Diversity and the Tropical Rainforest*. (ESP)

**Chris Timmins**, Professor of Economics; BSFS, International Economics, Georgetown University; PhD, Economics, Stanford University
E-mail: timmins@econ.duke.edu
Dr. Timmins focuses on environmental and development economics, with recent projects supported by Resources for the Future, the World Bank, the National Science Foundation, and the Inter-American Development Bank. His current research examines the role of equilibrium models of sorting behavior in describing preferences for non-marketed environmental commodities, identifying agglomeration and congestion effects in urban economies, and describing the spatial variation in multidimensional measures of poverty in Brazil. (ESP)

**Dean L. Urban**, Professor of Landscape Ecology and Chair, Division of Environmental Sciences and Policy; BA, Botany and Zoology, MA, Wildlife Ecology, Southern Illinois University at Carbondale; PhD, Ecology, University of Tennessee
E-mail: deanu@duke.edu
Dr. Urban’s interest in landscape ecology focuses on the agents and implications of pattern in forested landscapes. Increasingly, his research is centered on what has been termed theoretical applied ecology, developing new analytic approaches to applications of immediate practical concern, such as conservation planning. A hallmark of Dr. Urban’s lab is the integration of field studies, spatial analysis, and simulation modeling in environmental problem solving. (ESP)

Cindy Lee Van Dover, Harvey Smith Professor of Biological Oceanography, Director, Marine Laboratory, and Chair, Division of Marine Science and Conservation; BSc, Environmental Science, Rutgers University; MA, Ecology, University of California, Los Angeles; PhD, Biological Oceanography, Massachusetts Institute of Technology and Woods Hole Oceanographic Institute Joint Program
E-mail: cindy.vandover@duke.edu

Dr. Van Dover is a deep-sea biologist and explorer with a primary focus on the ecology of chemosynthetic communities at hydrothermal vents and methane hydrate seeps. Her interests include biogeography, biodiversity, community structure, and the processes that control these attributes within deep-sea ecosystems, and studies of biological adaptations to extreme environments. (MSC)

Avner Vengosh, Professor of Geochemistry; BS, Geology, Hebrew University of Jerusalem; MS, Geology, Hebrew University of Jerusalem; PhD, Environmental Geochemistry, Australian National University, Canberra, Australia
E-mail: vengosh@duke.edu

Dr. Vengosh’s major focus is on the quality of water resources, understanding flow paths, ground- and surface-water interactions, mechanisms of water salinization and contamination, and their societal impact. Current research includes natural contaminants and radioactivity in water resources and their effects on human health, salinization and sustainability of water resources in the Middle East, and anthropogenic modifications of the chemical and isotopic compositions of water resources. His work involves field and laboratory studies. Analytical methods that he employs include aquatic geochemistry, major and trace elements, and stable (boron, sulfur, nitrogen, oxygen, hydrogen) and radiogenic (lead, strontium, uranium, radium, radon) isotopic geochemistry. (EOS)

Rebecca Vidra, Lecturer and Director of Undergraduate Studies (ENV); PhD, North Carolina State University
E-mail: rebecca.vidra@duke.edu

Vidra’s experience lies in environmental ethics, particularly in the ethical challenges of ecological restoration. Active practice in environmental communications. (ESP)

Jeffrey Robert Vincent, Clarence F. Korstian Professor of Forest Economics and Management; AB, Social Anthropology, Harvard University; MS, Forestry, Michigan State University; PhD, Forestry and Environmental Studies, Yale University
E-mail: jeff.vincent@duke.edu

Dr. Vincent is an authority on natural resource and environmental policy issues in developing countries, especially those in the Asia-Pacific region. He has particular expertise on issues related to tropical forests, air and water pollution, and green accounting (the incorporation of environmental quality into GNP and other measures of macroeconomic performance). He has some expertise on the economic impacts of AIDS and other infectious diseases in developing countries. (ESP)

Jesko von Windheim, Professor of the Practice of Environmental Innovation and Entrepreneurship; BSc McMaster University; MS, PhD University of Guelph; MBA, UNC-Chapel Hill
E-mail: jesko@duke.edu

Dr. von Windheim has played an integral role in a number of start-up companies based on early-stage technologies. A current project is Zenalux (www.zenalux.com) which is commercializing technology developed at Duke that can detect biomarkers and diagnose disease such as cancer by shining light onto biological tissue. (ESP)

Erika Weinthal, Lee Hill Snowden Professor of Environmental Policy, and Associate Dean for International Programs; BA, Government and Environmental Studies, Oberlin College; MA, MPhil, PhD, Political Science, Columbia University
E-mail: weinthal@duke.edu

Dr. Weinthal’s research focuses on global environmental politics, the political economy of the resource curse, regional cooperation, and state-society relations. She has carried out field work in Central Asia, the Caucasus, the Russian Federation, and the Middle East. She is the author of State Making and Environmental Cooperation: Linking Domestic and International Politics in Central Asia (Cambridge, Mass.: MIT Press, 2002). (ESP)
Jennifer Wernegreen, Associate Professor of Environmental And Evolutionary Genomics; BA, Earlham College; PhD, Yale University
E-mail: j.wernegreen@duke.edu
Dr. Wernegreen studies the environmental and evolutionary genomics of bacteria. She also studies evolutionary ecology of symbiotic interactions, especially those involving beneficial microbes (ESP).

*Jonathan B. Wiener, Professor of Law and of Environmental Policy; AB, Economics, Harvard College; JD, Harvard Law School
E-mail: jonathan.wiener@duke.edu
Mr. Wiener studies the interplay of science, economics, and law in addressing environmental and human health risks. His policy work and writing have addressed topics including climate change, forest conservation, risk and risk-risk tradeoffs, biotechnology, mass torts and incentives in regulation and litigation. Before coming to Duke in 1994, Mr. Wiener worked on US and international environmental policy at the White House Council of Economic Advisers and Office of Science and Technology Policy, and at the United States Department of Justice, in both the first Bush and Clinton administrations. (ESP)

*Mark Wiesner, James L. Meriam Professor of Civil and Environmental Engineering; PhD, Johns Hopkins University
E-mail: wiesner@duke.edu
Dr. Wiesner's research addresses challenges at the interface between water, energy, and materials. (EOS)

*Norman Wirzba, Professor of Theology, Ecology and Rural Life, Duke Divinity School; BA, University of Lethbridge, Alberta; MA, Yale University; MA and PhD, Loyola University Chicago
E-mail: nwirzba@div.duke.edu
Dr. Wirzba pursues research and teaching interests at the intersections of theology, philosophy, ecology, and agrarian and environmental studies. (ESP)

*Robert L. Wolpert, Professor of Statistics and Decision Sciences and of the Environment; AB, Mathematics, Cornell University; PhD, Mathematics, Princeton University
E-mail: wolpert@stat.duke.edu
Dr. Wolpert works in collaboration with ecologists and other environmental scientists in developing and using statistical, mathematical, and computational models to help improve our understanding and management of complex environmental systems. His specific areas of interest include spatial statistics, stochastic processes, nonparametric Bayesian analysis and meta-analysis (the synthesis of evidence from multiple diverse sources). He works with epidemiologists in England in developing hierarchical Bayesian models for synthesizing evidence about the health effects of environmental pollutants. A new research area involves remote sensing of biomass and assessment of biodiversity. (ESP)

*Justin Wright, Assistant Professor; BA, Williams College; PhD, Cornell University.
Email: justin.wright@duke.edu
Dr. Wright’s interests are in the areas of community, landscape and ecosystem ecology, focusing on understanding the causes and consequences of patterns of biological diversity across the planet. (ESP)

Jim Zhang, Professor of Global Environmental Health; BS and MS, Peking University; PhD, Environmental Sciences, Rutgers University.
Dr. Zhang’s interests lie in the area of global environmental health, focusing on assessing human exposures to various environmental contaminants and resulting health effects. Specifically, he is interested in developing novel methods for measuring trace-level chemical agents in environmental media (air, water, soil, food) and in biological specimens (e.g., blood, breath, urine and hair). (ESP)
Extended Faculty

Abbreviations Key

ESP – Division of Environmental Sciences and Policy
EOS – Division of Earth and Ocean Sciences
MSC – Division of Marine Science and Conservation

Frank Asche, Adjunct Professor, Department of Industrial Economics, University of Stavanger, Norway. (ESP)

Lars Bejder, Adjunct Assistant Professor. Cetacean Research Unit, Centre for Fish and Fisheries Research, Murdoch University, Australia. (MSC)

Nora Bynum, Adjunct Associate Professor and Director for Global Strategy in the Office of Global Strategy and Programs at Duke University; PhD, Yale University. (ESP)

Jens Carlsson, Adjunct Assistant Professor; PhD, Swedish University of Agricultural Sciences. Dr. Carlsson’s experience lies in aquatic organisms, conservation and population genetics, kin selection and behavior, fish and shellfish fisheries. (MSC)

Connie Clark, Research Scientist; PhD, San Francisco State University. Dr. Clark is broadly interested in tropical ecology and conservation. More specifically, she seeks to uncover the ecological processes that maintain biodiversity in tropical forests and to understand how various land use strategies/management regimes might differentially impact these processes. (ESP)

Tom Darrah, Adjunct Assistant Professor; PhD, University of Rochester.
Dr. Darrah’s research is focused in the areas of geochemistry, noble gases and energy. (EOS)

Humberto Díaz, Adjunct Professor; PhD, Duke University. Retiring from a thirty-year career at the Instituto Venezolano de Investigaciones Científicas (IVIC) in Venezuela, Dr. Díaz continues to investigate coastal benthic communities. He works at the interface of developmental biology, sensory biology, behavioral biology and ecology, using adult, juvenile and larval stages of dominant crustaceans as model systems. (MSC)

Luke Dollar, Adjunct Associate Professor; PhD, Duke University. (ESP)

Jean-Christophe Domec, Visiting Professor; PhD, Oregon State University. His current research interests include plant physiology and the relationship of wood structure and anatomy to plant physiology. (ESP)

Gary S. Dwyer, Research Scientist; PhD, Duke University. Dr. Dwyer is a geologist focused on paleoclimatology and paleoceanography using proxy indicators from the sedimentary record. His primary research interest is documenting the history of climate and ocean variability of the past 20,000 years. (EOS)

Edeburn, Judson, Adjunct Professor of the Practice of Forestry, and former Resource Manager of the Duke Forest (ESP)

Ehrlich, Paula, Adjunct Professor of the Practice of Biodiversity Conservation, and President and CEO of the E.O. Wilson Biodiversity Foundation. (ESP)

David J. Erickson III, Adjunct Professor; PhD, University of Rhode Island. Based at Oak Ridge National Laboratory, Dr. Erickson’s expertise lies in the development and application of numerical biogeochemistry models that employ satellite data, high performance computing, experimental results and extensive theoretical constructs to simulate and predict climate change potentialities. (MSC)

John Fay, Instructor, Geospatial Analysis Program; MS, University of Michigan. Fay’s experience lies in spatial analysis of species ranges under changing environmental conditions, habitat connectivity analysis, and geospatial tool development for use in mapping, inventorying, and managing ecosystem services. (ESP)

Mark Feingloss, Divisional Associate; MD, McGill University. Dr. Feinglos is a professor of medicine at the Duke Medical Center, where he specializes in endocrinology. His secondary expertise lies in the area of mineralogy, especially descriptive mineralogy and mineral curation. He has described six new mineral species, including dukeite. The mineral feinglosite was named in his honor. (EOS)
Ari Friedlaender, Adjunct Associate Professor. Dr. Friedlaender's experience lies in marine mammals, foraging ecology, tagging, and the effects of climate change. (MSC)

Barbara Garrity-Blake, Adjunct Scientist; PhD, University of Virginia. (MSC)

Pamela George, Adjunct Professor; PhD, The University of North Carolina at Chapel Hill. Dr. George works on building the research skills and competencies of graduate students to execute meaningful and manageable research projects. She has done this work as a professor of social science and education research for three decades both in North Carolina and at universities abroad in Asia, Southeast Asia, Europe, and Africa (ESP).

Caroline Good, Adjunct Assistant Professor; PhD, Duke University. Dr. Good's studies focus on spatial ecology including the North Atlantic Right Whale (*Eubalaena glacialis*). (MSC)

Peter Harrell, Instructor/Research Associate, Geospatial Analysis Program; MS, Duke University. Harrell's experience lies in GIS and remote sensing. (ESP)

Craig Harms, Associate Professor; PhD, North Carolina State University. Craig specializes in zoological medicine with an aquatics emphasis. (MSC)

Elliott Hazen, Adjunct Assistant Professor; PhD, Duke University. Dr. Hazen's research focus is on linking prey to predator, specifically scale dependence and oceanographic food webs. (MSC)

Gabriele Hegerl, Adjunct Associate Professor. Dr. Hegerl's research is in the natural variability of climate and changes in climate due to natural and anthropogenic changes in radiative forcing (such as greenhouse warming, climate effects of volcanic eruptions and changes in solar radiation). (EOS)

Eric Holm, Adjunct Assistant Professor; PhD, Duke University. Dr. Holm is an ecologist with the Carderock Division of the Naval Surface Warfare Center in Maryland. His work focuses on the settlement and adhesion of marine fouling organisms, and the transport of aquatic exotic species in ballast water and as a component of ship hull fouling. (MSC)

Thomas P. Holmes, Adjunct Professor; PhD, Ohio Wesleyan University. Dr. Holmes is a research forester with the USDA Forest Service's Economics of Forest Protection and Management work unit at Research Triangle Park, NC. His research focuses on the application of nonmarket valuation methods to problems of forest ecosystem protection and conservation in the United States and Brazil. (ESP)

Mark Huntley, Adjunct Scientist; PhD. (MSC)

K. David Hyrenbach, Assistant Research Scientist; PhD, Scripps Institution of Oceanography. Dr. Hyrenbach's research focus is on characterizing the oceanic habitats of pelagic vertebrates (seabirds, turtles, cetaceans and tunas), and the physical mechanisms (upwelling and convergence) that define predictable areas of enhanced biological activity in pelagic systems. (MSC)

Gary Isaksen, Adjunct Professor, PhD, University of Bergen, Norway. Dr. Isaksen is the manager of external technology at ExxonMobil. Isaksen's experience lies in science and technology around fossil fuel exploration, production and processing; petroleum quality and value assessment; leadership and management practices, and philanthropy. (EOS)

Krithi Karanth, Adjunct Assistant Professor; PhD, Duke University. Karanth’s experience lies in species extinction and distribution, risk assessment of human-wildlife conflicts, nature-based tourism, people-park relationships, land-use change, and resettlement of people. (ESP)

Leah Bunce Karrer, Adjunct Scientist; PhD, Duke University. Dr. Karrer's research focuses on marine managed areas including global analysis of climate change impacts. (MSC)

James Kraska, Adjunct Professor. SJD, University of Virginia. Dr. Kraska's work focuses on international law and governance in the global commons, and particularly in the oceans. (MSC)

Rebecca Lewison, Adjunct Assistant Professor. PhD, University of California, Davis. Dr. Lewis' research focuses on the impact of resource and land use on vulnerable wildlife populations. (MSC)
Elizabeth Losos, Adjunct Professor; PhD, Princeton University. Dr. Losos is the president and CEO of the Organization for Tropical Studies (OTS), a consortium of sixty-five universities and research institutions whose mission is to provide leadership in research, education, and the responsible use of natural resources in the tropics. OTS promotes research at its three biological research stations in Costa Rica. The organization also offers field-based courses for undergraduates, graduate students, and environmental professionals in Costa Rica, Peru, Brazil, Mexico, and South Africa. OTS is headquartered at Duke University. (ESP)

Peter Malin, Adjunct Professor; PhD, Princeton University. Dr. Malin is the director of the Institute of Earth Science and Engineering (IESE), a joint venture between the University of Auckland and Auckland UniServices Ltd. His experience lies in Seismic propagation in planetary crusts, borehole investigation of seismic sources and signals, and environmental geology. (EOS)

Grit Martinez, Adjunct Associate Professor; PhD, Ecological Institute Berlin. (MSC)

Suzanne McMaster, Adjunct Associate Professor; PhD, University of Oklahoma Health Sciences Center. Dr. McMaster, who is employed by the Environmental Protection Agency in Research Triangle Park, is broadly interested in problems of environmental risk assessment and specifically in children's health issues. Her research interests include neurodevelopmental effects of pre- and post-natal environmental exposures to pesticides and other chemicals. (ESP)

D. Evan Mercer, Adjunct Professor; PhD, Duke University. Dr. Mercer is a research economist with the USDA Forest Service’s Southern Research Station at Research Triangle Park, North Carolina. His current research examines the economics of agroforestry, nonmarket valuation, rural development, and the effects of government policies, market factors, and societal values on the management and protection of tropical forest resources and properties of lake sediments. (ESP)

Marie Lynn Miranda, Adjunct Professor, and Dean, SNRE, University of Michigan. Dr. Miranda’s research is directed at improving the health status of disadvantaged populations, particularly children. She is the founding director of the Children’s Environmental Health Initiative, a research, education, and outreach program that fosters environments where all children can prosper. (ESP)

Jonas Monast, Adjunct Assistant Professor; Director of Climate and Energy Programs, Nicholas Institute for Environmental Policy Solutions. (ESP)

Michelle Nowlin, Senior Lecturing Fellow, Supervising Attorney for the Environmental Law and Policy Clinic. (ESP)

Lydia Olander, Adjunct Assistant Professor; Director of Ecosystem Services Program, Nicholas Institute for Environmental Policy Solutions. (ESP)

James Oliver, Adjunct Professor. Dr. Oliver’s experience lies in biology of bacteria in the genus Vibrio, especially the human pathogen Vibrio vulnificus. (MSC)

Erik Palkovacs, Adjunct Assistant Professor; Department of Ecology and Evolutionary Biology, University of California – Santa Cruz. (ESP)

Linwood Pendleton, Adjunct Associate Professor, Director of Ocean and Coastal Policy, Nicholas Institute for Environmental Policy Solutions. Dr. Pendleton’s areas of expertise are oceans and coasts, environmental economics, climate adaptation, marine spatial planning, estuaries, coral reefs, Atlantic Intracoastal Waterway. (MSC)

Stephen E. Roady, Adjunct Professor; JD, Duke University School of Law. Roady is a public interest environmental lawyer who specializes in ocean conservation and is closely involved in efforts to improve this country’s management and protection of its oceans and coasts. His interests extend to teaching ocean and coastal law and policy. (MSC)

Bill Ross, Visiting Professor of Environmental Sciences and Policy and Duke Cancer Institute; JD, University of Virginia. (ESP)
Kathryn Saterson, Adjunct Associate Professor; PhD, University of North Carolina at Chapel Hill. A staff member at the Environmental Protection Agency, Dr. Saterson has more than twenty years of experience analyzing, designing, and managing programs and policies to mitigate human impacts on the environment. She uses lessons from field projects and local conservation efforts to improve environmental policy and practice. (ESP)

Sally Shauman, Adjunct Professor; MS, University of Michigan. Dr. Shaumann is professor emerita of landscape architecture at the University of Washington, Seattle. Her interests are in environmental management of landscapes and restoration ecology—most recently, studies of how residential landowners treat the river corridors that adjoin their property. (ESP)

Sonia Silvestri, Research Scientist; PhD, University of Padova. Silvestri’s experience lies in remote sensing of shallow waters (water quality and submerged vegetation), salt marshes and coastal vegetation, and of illegal landfills and contaminated areas. (EOS)

Brandon Southall, Adjunct Assistant Professor; PhD, University of California-Santa Cruz; Southall Environmental Associates. (MSC)

Joseph Stanislaw, Adjunct Professor; PhD, University of Edinburgh. Dr. Stanislaw is founder of the advisory firm the JAStanislaw Group, LLC, specializing in strategic thinking and investment in energy and technology. Previously, Stanislaw was one of three founders of Cambridge Energy Research Associates, where he served as president and chief executive officer. (EOS)

William G. Sunda, Adjunct Assistant Professor; PhD, Massachusetts Institute of Technology/Woods Hole Oceanographic Institution Joint Program. Dr. Sunda conducts research on the interactions between trace metal chemistry in marine systems and phytoplankton dynamics. (MSC)

John J. Vandenberg, Adjunct Professor; PhD, Duke University. Dr. Vandenberg is director of EPA’s research program on airborne particulate matter. His interests include the health effects of air pollutants, atmospheric sciences, and the interface of science and air quality management. (ESP)

Kyle Van Houtan, Adjunct Assistant Professor; PhD, Duke University; Leader, Marine Turtle Assessment Program, NOAA. Dr. Van Houtan’s research interests are biodiversity extinction, conservation ecology, geospatial modeling, and theological ethics (ESP).

Daniel Vermeer, Adjunct Associate Professor; PhD, Duke University; Director of Duke University’s Center for Energy, Development, and the Global Environment. (ESP)

Bryan Wallace, Adjunct Assistant Professor; PhD, Drexel University. Dr. Wallace’s research involves the application of insights from animal ecophysiology to pertinent conservation issues, specifically focusing on sea turtles. (MSC)

Danielle Way, Adjunct Assistant Professor; PhD, University of Toronto. (ESP)

Christopher Wedding, Adjunct Assistant Professor; PhD, The University of North Carolina at Chapel Hill. Dr. Wedding’s experience lies in applied research with a quantitative focus and covers the following areas: green building and development, clean energy and energy efficiency, eco-labels and green informatics, and green business development. (ESP)

Randall Wells, Adjunct Professor; PhD, University of California, Santa Cruz. Dr. Wells’ research interests include, among other things, conservation of marine mammals, behavioral ecology of cetaceans, cetacean social structure and behavior, ecology and feeding biology of small cetaceans. (MSC)

E.O. Wilson, Professor of the Practice of Biodiversity Conservation; the Pellegrino University Research Professor, Emeritus in Entomology for the Department of Organismic and Evolutionary Biology at Harvard University; and Founder of the E.O. Wilson Biodiversity Foundation. (ESP)
Faculty Emeriti

Richard T. Barber, PhD, Harvey W. Smith Professor of Biological Oceanography, Emeritus
Celia Bonaventura, Professor Emeritus of Cell Biology
Joseph Bonaventura, Professor Emeritus of Cell Biology
Norman L. Christensen Jr., Professor Emeritus of Ecology
Bruce H. Corliss, PhD, Professor Emeritus of Earth and Ocean Sciences
John D. Costlow, PhD, Professor Emeritus
George F. Dutrow, PhD, Professor Emeritus
John W. Gutknecht, PhD, Professor Emeritus
Robert G. Healy, Professor Emeritus of Environmental Policy
S. Duncan Heron, PhD, Professor Emeritus of Geology
William Kirby-Smith, PhD, Professor of the Practice Emeritus of Marine Ecology
Daniel A. Livingstone, James B. Duke Professor Emeritus of Biology
Michael K. Orbach, Professor of the Practice Emeritus of Marine Affairs and Policy
Ronald D. Perkins, PhD, Professor Emeritus of Earth Science
Orrin Pilkey, PhD, James B. Duke Professor Emeritus of Geology
Joseph S. Ramus, PhD, Professor Emeritus of Biological Oceanography
Kenneth Reckhow, PhD, Professor Emeritus of Water Resources
James F. Reynolds, Professor Emeritus of Environmental Science and Policy and of Biology
William Schlesinger, PhD, James B. Duke Professor Emeritus of Biogeochemistry
William J. Stambaugh, PhD, Professor Emeritus
Course offerings are subject to change. The student should consult the current university course schedule at http://www.siss.duke.edu/schedule for listings of courses to be offered each term.

Courses Taught in Durham

Environment (ENVIRO)

89S. First-Year Seminar. Topics vary each semester offered. Instructor: Staff. 1 unit.

102. Introduction to Environmental Sciences and Policy. An introduction to the study of environmental sciences and policy through exploration of basic environmental principles in the life, physical, and social sciences. Emphasis on understanding how the atmosphere, hydrosphere, lithosphere, cryosphere, and biosphere function, and how these spheres interact with human consumption, production, and technological patterns and processes. Field trips to a local site as well as the Duke University Marine Laboratory. Instructors: Meyer or Vidra. 1 unit.

153. Ecosystem Health and Human Well-Being. Explores interactions between ecosystem health and human well-being in context of global change and human population growth. Effects of climate change on food supply, water availability, land degradation and human well-being; impact of species distribution, disease spread, and human health; ecosystem services and human well-being. Case studies used to illustrate the scientific process and to evaluate supporting evidence. For nonmajors. Instructor: Reid. 1 unit. C-L: see Biology 153
190FS. Topics in Environment. Topics vary semester to semester. Only open to students in the Focus Program. Consent of Instructor required. Instructor: Staff. 1 unit.

190S. Special Topics in Environmental Science and Policy. Content to be determined each semester. Instructor: Staff. 1 unit.

201. Integrating Environmental Sciences and Policy. Interaction between the natural and the social systems as they relate to the environment. Focus on ecological and earth system cycles, processes, and fundamental relationships. The environmental impact of human-induced change at the local, regional, and global levels. The role of technology and the policy process in determining how environmental problems evolve and are addressed. Use of ethical analysis to evaluate environmental tradeoffs. Use of case studies to integrate multiple disciplinary perspectives on environmental problems and to address issues of environmental justice. Not open to first year students. Prerequisite: Environment 102 or consent of instructor. Instructor: Bennear. 1 unit.

205. Marine Megafauna. Ecology, systematics, and behavior of large marine animals including giant squid, bony fishes, sharks, sea turtles, seabirds, and marine mammals. Relations between ocean dynamics, large marine animals, and their role in ocean food webs. Impact of human activities and technological advancement on populations. Economic, social, and policy considerations in the protection of threatened species. Prerequisite: AP Biology, Introductory Biology, or consent of the instructor. Instructor: Johnston. 1 unit. C-L: see Biology 205

209. Food, Farming, and Feminism. Viewing "agriculture," "nature," and "consumption" as pressing feminist themes and exploration of various dimensions of the cultural and political ecology/economy of producing, processing, circulating, preparing, and consuming sustenance. Particular focus on the ethical impact of US policy on rural farm communities and developing nations. Instructor: Staff. 1 unit. C-L: see Women's Studies 275; also C-L: Global Health 225

209S. Food, Farming, and Feminism. Viewing "agriculture," "nature," and "consumption" as pressing feminist themes and exploration of various dimensions of the cultural and political ecology/economy of producing, processing, circulating, preparing, and consuming sustenance. Particular focus on the ethical impact of US policy on rural farm communities and developing nations. Instructor: Staff. 1 unit. C-L: see Women's Studies 275S; also C-L: Global Health 225S

210D. Conserving the Variety of Life on Earth. An overview of biological diversity, its patterns, and the current extinction crisis. Historical and theoretical foundations of conservation, from human values and law to criteria and frameworks for setting conservation priorities; island biogeography theory, landscape ecology, and socioeconomic considerations in reserve design; management of endangered species in the wild and in captivity; managing protected areas for long term viability of populations; the role of the landscape matrix around protected areas; and techniques for conserving biological diversity in semi-wild productive ecosystems such as forests. Instructor: Pimm. 1 unit.

212. United States Environmental Policy. An overview of the major environmental legislation in the United States. Topics include: air and water pollution, hazardous waste, agriculture, wildlife, and institutions. Political, economic, ethical, and scientific analysis. Open to juniors or seniors or by consent of instructor. Instructor: Bennear or Mullins. 1 unit. C-L: Public Policy Studies 275

214S. Ethical Challenges in Environmental Conservation. Examination of current ethical challenges in environmental conservation. Topics include the philosophical basis and challenges of mankind’s responsibility to the natural world; prioritization of often conflicting conservation efforts; balancing the needs of humans and the environment; the disputed role of scientists as advocates; and the philosophical and political obstacles to conservation efforts. Analysis of the evolving environmental movement, in relation to current issues. Instructor: Vidra. 1 unit.

216S. Environment and Conflict: The Role of the Environment in Conflict and Peacebuilding. Environmental and natural resources as a source of conflict and/or peacemaking between and within nations and states. Analysis of the role of the environment in the conflict cycle and international security. Topics include refugees, climate change, water, and infectious disease. Particular focus on post-conflict and rebuilding in war-torn societies. Examination of the role of international organizations, non-governmental organizations, and emerging standards for environmental management. Examples drawn from conflicts such as Rwanda, Israel/Palestine, Nepal, Sierra Leone and others. Instructor: Weinthal. 1 unit. C-L: Public Policy Studies 279S, Political Science 367S, International Comparative Studies 229S

Courses of Instruction 98
217. **Restoration Ecology: Theory and Applications.** Addresses fundamental principles of ecological restoration. Includes an overview of the discipline, scientific, ethical and philosophical underpinnings, and the legislative framework that guides much of the restoration work in the United States. Principles of ecosystem ecology introduced to provide an understanding of ecosystem processes across landscapes and within specific restoration sites. Students will conduct a comparative study of a restoration site with a reference site and work in small groups to create a monitoring report for this site. Prerequisite: introductory biology or environmental science, or consent of instructor. Instructor: Vidra. 1 unit.

218. **Food and Energy: Applying research and theory to local dining practice.** Examination of link between food and energy, both in science and culture. Includes food production, processing, transportation, consumption, and food security. Project groups will design and complete on-campus research and/or evaluation projects around dining at Duke. Application of basic qualitative research methods, including participant observation, personal interview, and content analysis. Instructor: Clark. 1 unit. C-L: Sociology 372

221. **Environment as Community.** Examination of linkages in both directions between community (family, neighborhood) and responsible environmental behavior. Includes on-site collaboration with a local neighborhood having explicit environmental goals. Application of basic qualitative research methods, including participant observation, personal interview, and content analysis. Instructor: Clark. 1 unit. C-L: see Sociology 215

222S. **Environmental Conservation and Documentary Photography.** Technical and aesthetic training in creating documentaries to communicate critical environmental issues so as to affect societal change. History of the essential role of documentary photography in land conservation, social justice, and protection of biodiversity from the early 1800’s to today leads into individual documentary projects. Studio, seminar, study of photography in university archives and field trips. Consent of Instructor required. Instructor: Satterwhite. 1 unit. C-L: Documentary Studies 248S

226S. **Field Methods in Earth and Environmental Sciences.** Introduction to basic field methods used in the earth and environmental sciences. Field investigations focus on topics such as groundwater and surface water movements, soil chemistry and identification, topographic and geologic mapping, the atmosphere/soil interface, and plant identification and distributions. Design of a field investigation, collection of data to address a specific goal, and interpretation and reporting of the results. Emphasis on learning to report field results in the format of scientific publications. Visits to five local field sites. Open only to juniors and seniors. Instructor: Klein or Dwyer. 1 unit. C-L: see Earth and Ocean Sciences 226S

228. **Food and Fuel for a Growing Population: Nuts and Bolts of Plant Growth and Production.** Covers primary physiological processes from subcellular to whole plant that affect plant growth in a changing environment. Processes include photosynthesis, respiration, water relations, nutrient and carbohydrate allocation, signaling, and stress responses to various biotic and abiotic factors for a range of plant species adapted to different environments. Applications include plant improvement for food and biofuel production, management of plant growth in response to global change. Local field trip planned. Prerequisites: Biology 201L or 202L. Instructors: Reid and Siedow. 1 unit. C-L: see Biology 228

239. **Our Changing Atmosphere: From Air Pollution to Climate Change.** Integrated scientific background for the impact of humans on the natural environment. Topics covered include greenhouse gases and climate, local and regional ozone pollution, long-range pollution transport, acid rain, atmospheric particulate matter pollution, and stratospheric ozone depletion. Pre-requisites: Chemistry 101DL. 1 unit. C-L: see Energy 239

240S. **Biodiversity Issues and Field Methods.** Biodiversity is affected by many factors, both local and global, including climate and climate change, fire regimes, habitat fragmentation, and urbanization. These issues and others will be covered through readings, discussions, and field research. Explores and assesses local biodiversity through field exercises and field trips with emphasis on local flora and fauna identification. Applies field techniques to monitor, compare, and evaluate local communities for biodiversity in both urban and rural settings and their interface. Complements ENVIRON 226, 210, and 217. Instructor: Pippen. 1 unit.

253S. **Urban Environmental Design.** Overview of urban environmental designs, drawing upon natural and social science based evidence to guide solutions. Focus on innovative approaches that protect and restore ecological value, create sustainable spaces, and address ethical dilemmas arising from conflicting public perceptions of sustainability. Review of survey methods used to gather public opinion and participatory planning models that involve the public in solutions. Examination of national and international design examples. Emphasis will be on professional communication including visual and verbal formats. Instructor: Schauman. 1 unit.
260. Global Disasters: Science and Policy. In this interdisciplinary course, students will examine the multifaceted aspects of "global" disasters. Invited experts will first examine the science behind the disasters, discuss the range of meteorologic, hydrologic and geologic factors that cause disasters; explore how societies plan for and/or respond to the immediate and long-term physical, social, emotional and spiritual issues associated with survival; and present case studies of response, recovery and reconstruction efforts. In the second phase of the course, economic experts will address some of the most pressing and rapidly evolving economic calamities. In the third segment of the course, the focus will shift to political "disasters" and how natural and/or economic events can destabilize a political system. Students will attend the lecture and labs components of the course and complete on-line quizzes to demonstrate understanding of the material presented. Additionally, they will prepare one research paper on a relevant topic, the results of which will be presented to the class. Instructor: Schaad. 1 unit. C-L: see Engineering 260; also C-L: Public Policy Studies 276

261S. Ecosystem Ecology for a Crowded Planet. Concepts of ecosystem ecology within the ethical, social and political context context of current environmental policy issues. Lectures, discussions and class activities examine environmental policy issues, linkage between ecosystem science and political issues. Prerequisites: Biology 209 or Environment 89S or consent. Instructor: Bernhardt. 1 unit. C-L: see Biology 261S

262. Global Disasters: Reasons, Response and Recovery. In this interdisciplinary, service learning course, students will conduct a life cycle analysis of a natural disaster. Invited experts will discuss the range of meteorologic, hydrologic and geologic factors that cause disasters; explore how societies plan for and /or will respond to the immediate and long-term physical, social, emotional and spiritual issues associated with survival; and present case studies of response, recovery and reconstruction efforts. Students will participate in a service-learning exercise in an area ravaged by a natural disaster. Students will attend the lecture component of the course and complete on-line quizzes to demonstrate understanding of the material presented. For the service learning experience, students will form interdisciplinary teams to plan and carry out response activities over Spring Break in an area ravaged by a natural disaster (e.g. New Orleans, Outer Banks, and Florida). They will keep a journal (audio or written) of their activities, write a brief synopsis (4-5 pages), and make a group oral presentation of their findings following their return. They will also submit a hypothetical research proposal for project which might stem from the course and their experiences. Instructor: Schaad. 1 unit. C-L: see Engineering 261; also C-L: Public Policy Studies 277

265. Environmental Law and Policy. Legal principles governing environmental problems in the United States, including endangered species, hazardous waste, air pollution. Introduction to the overarching topics in law and in regulatory design that shape the contributions and roles law plays in solutions to environmental problems. Instructor: Staff. 1 unit.

274. People, Plants and Pollution: Introduction to Urban Environments. Cities turn natural lands into impervious surfaces, like roofs and parking lots, while trees, forests, and grass decrease. Course covers urban environmental issues, including energy and carbon, air, heat, and water pollution, the health and welfare of people, and changes in other species and regional/global climatic patterns. Examines costs/benefits of urban nature on solving urban environmental problems, including enhancing the social welfare of people's lives. Instructor: Wilson. 1 unit. C-L: see Biology 262

281A. Conservation and Management of Protected Areas in South Africa. Management of wildlife and natural resources within the ecological, political, social, historical, and economic context of South Africa. (Taught in South Africa.) Instructor: McClearn. 1 unit.

282A. Environmental Science and Policy of the Tropics. Investigates major environmental issues facing tropical nations using concepts from the natural and physical sciences, the social sciences, and resource management. Topics include: climatic and biogeographical patterns, trends in human population size and demography, historical and contemporary issues in resource use and conservation, and sociological and ethical concerns regarding the source and distribution of economic wealth. (Given in Costa Rica.) Prerequisite: Biology 25 or equivalent. Instructor: Shelly. 1 unit.

284A. South African Ecosystems and Diversity. Conceptual themes in ecology emphasizing savannas; also consideration of fynbos, highveld, podocarp forests, coastal and intertidal zones. Topics include climate and geology of South Africa; roles of fire, drought, human presence, invasive species, and herbivores in shaping ecosystems; top-down and bottom-up control of mammalian herbivores; plant pollination and seed dispersal; role of rivers in defining
savanna characteristics; origin and maintenance of biodiversity; vertebrate social systems; major research programs in Kruger National Park (taught in Kruger National Park, South Africa). Prerequisite: Biology 20 or introductory ecology. Instructor: McClearn. 1 unit. C-L: see Biology 284A

285LA. Field Research in Savanna Ecology. Field-based course stressing student design and implementation of research projects in savanna ecosystems. Introduces basic concepts in experimental design and hypothesis testing, long-term monitoring, sampling techniques, parametric and nonparametric analysis. Each student will participate in several faculty-led research projects. In addition, students in small groups will design independent projects, consult with faculty, collect and analyze data, and make oral and written presentations of their results. Each student will work on two of these independent projects. (Taught in Kruger National Park, South Africa) Prerequisite: Biology 20 or introductory ecology or equivalent. Instructor: Staff. 1 unit. C-L: see Biology 285LA

290. Special Topics in Environmental Sciences and Policy. Content to be determined each semester. Consent of instructor required. Instructor: Staff. 1 unit.

290A. Duke-Administered Study Abroad: Advanced Special Topics in Environmental Science and Policy. Topics differ by section. Instructor: Staff. 1 unit.

330. Energy and the Environment. Overview of the challenges confronting humanity as a consequence of our reliance on energy. Challenges include dwindling supplies, rising demand and environmental degradation. Realistic responses require an understanding of the complexity of the energy system, including energy resources, uses, and impacts, in the context of social, political and economic imperatives. Lectures will be augmented by presentations from guest speakers from industry, government and non-profit organizations. Instructor: Pratson. 1 unit. C-L: see Energy 330; also C-L: Earth and Ocean Sciences 330


345. Environmental Politics in the United States. Examine the role environmental issues play in the U.S. political system. Study the way ordinary citizens think about the environment: importance of environmental concerns and how environmental issues influence voting behavior. Assess the role played by each of the major institutions in American politics - Congress, the president, the bureaucracy, the judiciary, state and local governments, political parties, and the media. Pre-requisite: any one field introduction taken at the 100 level. Instructor: Staff. 1 unit. C-L: see Political Science 344; also C-L: Public Policy Studies 281

350S. Marine Science and Conservation Leadership. Exploration of the complex interactions among science, policy and economics in the use of marine resources. Topics explored include the role individuals play in promoting marine conservation and environmental sustainability. Students will evaluate trade-offs systematically and learn to assess how different policy options affect the incentives of resource users and polluters. Serves as the capstone for the Marine Science and Conservation Leadership Certificate. Prerequisite: introductory economics or consent of instructor. Instructor: Staff. 1 unit. C-L: Public Policy Studies 280S

358. Introduction to Satellite Remote Sensing. Introduction to the field of remote sensing and approaches used in image processing and analysis of remote sensing data. Students will acquire an operational knowledge of various remote-sensing tools and data types, with emphasis on their application in environmental and earth science problems. Content will include theory, in-class laboratory exercises, and projects with environmental applications. Prerequisite: introductory or AP physics preferred. Instructor: Silvestri. 1 unit. C-L: see Earth and Ocean Sciences 358


360. Environmental Chemistry and Toxicology. An overview of the fate and effects of chemicals in the environment. Topics include chemical characterization of pollutants, chemistry of natural waters, soil sediment chemistry, atmospheric chemistry, transfers between and transformations within environmental compartments, toxicokinetics, cellular metabolism, biological levels of organization, and approaches for assessing chemical hazards. Incorporates case studies focused on human health and ecosystem protection. Prerequisite: Biology 101L; Chemistry 101DL and 210DL; Mathematics 21. Instructor: Stapleton. 1 unit.
362S. Changing Oceans. Our oceans are under severe stress. This seminar will explore human disturbances of marine environments, including ocean warming, sea level rise, melting of ice caps and sea ice, ocean acidification, coastal eutrophication, changes in primary production and food web dynamics and invasive species, overfishing, increased subsurface hypoxia, changes in circulation, stratification, and physical, chemical (e.g. oil spills) and noise pollution. Instructor: Cassar. 1 unit. C-L: Earth and Ocean Sciences 364S

363. Economics of the Environment. The role of the environment in the theory and practice of economics. Topics include ways in which markets fail to efficiently allocate resources in the presence of pollution, along with the array of policies regulators used to correct those failures; the empirical techniques used by economists to put values on environmental commodities; and an examination of questions related to everyday environmental issues, particularly those confronting the developing world. Prerequisites: Economics 201D and one Statistics course; Economics 208D recommended. One course. C-L: Earth and Ocean Sciences 363, Marine Science and Conservation, Energy and the Environment. Instructor: Timmins. 1 unit. C-L: Economics 439

365. Engineering Sustainable Design and the Global Community. Design and testing of solutions to complex interdisciplinary design products in a service learning context. Technical design principles; sustainable and engineering best practices; prototype formation, testing and evaluation; and establishment of research and analysis methodologies in a community based research experience. Working in partnership with a community agency (local, national, or international) and participation in an experimental learning process by engineering a design solution for an identified community need. Evaluation focused on design deliverables, fabricated prototypes and a critical reflection of the experimental learning process. One credit. Prerequisites: Engineering 201L or Electrical and Computer Engineering 110L or consent of instructor. Instructor: Schaad. 1 unit. C-L: Civil and Environmental Engineering 315; also C-L: Public Policy Studies 211

365-20. Engineering Sustainable Design and the Global Community: Structural Focus. Design and testing of solutions to complex interdisciplinary design products in a service learning context with a focus on structural products. Technical design principles; sustainable and engineering best practices; prototype formation, testing and evaluation; and establishment of research and analysis methodologies in a community based research experience. Working in partnership with a community agency (local, national, or international) and participation in an experimental learning process by engineering a design solution for an identified community need. Evaluation focused on design deliverables, fabricated prototypes and a critical reflection of the experimental learning process. Instructor: Schaad. 1 unit. C-L: Civil and Environmental Engineering 315-20; also C-L: Public Policy Studies 211-20

365-60. Engineering Sustainable Design and the Global Community: Environmental Focus. Design and testing of solutions to complex interdisciplinary design products in a service learning context with a focus on structural products. Technical design principles; sustainable and engineering best practices; prototype formation, testing and evaluation; and establishment of research and analysis methodologies in a community based research experience. Working in partnership with a community agency (local, national, or international) and participation in an experimental learning process by engineering a design solution for an identified community need. Evaluation focused on design deliverables, fabricated prototypes and a critical reflection of the experimental learning process. Prerequisite: Engineering 201L or Electrical and Computer Engineering 110L or consent of instructor. Instructor: Schaad. 1 unit. C-L: Civil and Environmental Engineering 315-60; also C-L: Public Policy Studies 211-60

366. Green Germany: World Leader in Environmental Policy. Exploration of Germany's leading global role in developing and implementing "green" technologies and environmental policies. Analyzes Germany's current and past policies on energy, agriculture, and pollution control. Examines polices in context by studying German ideas about nature, history of German environmentalism, and by looking at Green Germany in European and global perspective. Discusses extent ethics can or ought to influence debates about global climate change and its ramifications. Readings include scholarly studies, exemplary policies, and groundbreaking ecological texts. Instructor: Milder. 1 unit. C-L: German 364; also C-L: History 250, Energy 364

382LA. Marine Molecular Ecology. Marine ecology from a molecular view focusing on microbes as the dominant organisms in ocean ecosystems. Lecture and laboratory integrate the theory and application of modern molecular techniques to quantify abundance, to assess diversity and to determine the interaction of microbes with each other and the marine environment. Prerequisite: AP Biology, introductory biology, or permission of instructor. (Given at Beaufort.) Instructor: Johnson. 1 unit. C-L: Biology 374LA
390. Special Topics in Environmental Sciences and Policy. Content to be determined each semester. Consent of instructor required. Instructor: Staff. 1 unit.

390-1. Special Topics in Environmental Sciences and Policy. Content to be determined each semester. Consent of instructor required. Half credit course. Instructor: Staff. 0.5 units.

390A. Duke-Administered Study Abroad: Advanced Special Topics in Environmental Sciences and Policy. Topics differ by section. Instructor: Staff. 1 unit.

390S-1. Special Topics in Environmental Sciences and Policy. Content to be determined each semester. Consent of instructor required. Half credit course. Instructor: Staff. 0.5 units.

391. Independent Study. Individual readings course or other non-research-based independent course under the supervision of a faculty member, resulting in an academic product. Open to qualified juniors and seniors with consent of instructor and director of undergraduate studies. Instructor: Staff. 1 unit.

391-1. Independent Study. See Environment 391. Open to qualified juniors and seniors with consent of instructor. Half credit. Instructor: Staff. 0.5 units.

393. Research Independent Study. Individual research in a field of special interest, under the supervision of a faculty member, the central goal of which is a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. Open to qualified juniors and seniors with consent of instructor and director of undergraduate studies. Instructor: Staff. 1 unit.

393-1. Research Independent Study. See Environment 393. Open to qualified juniors and seniors with consent of instructor and director of undergraduate studies. Half course. Instructor: Staff. 0.5 units.

452L. Energy and Environment Design. An integrative design course addressing both creative and practical aspects of the design of systems related to energy and the environment. Development of the creative design process, including problem formulation and needs analysis, feasibility, legal, economic and human factors, environmental impacts, energy efficiency, aesthetics, safety, and design optimization. Application of design methods through a collaborative design project involving students from the Pratt School of Engineering and Trinity College. Open only to students pursuing the undergraduate certificate in Energy and Environment. Instructor consent required. Instructor: Klein. 1 unit. C-L: Energy 452L

490. Senior Capstone Course. Interdisciplinary and in-depth study of contemporary environmental issues. Content to be determined each semester. Consent of Instructor required. Instructor: Staff. 1 unit.

501. Environmental Toxicology. Study of environmental contaminants from a broad perspective encompassing biochemical, ecological, and toxicological principles and methodologies. Discussion of sources, environmental transport and transformation phenomena, accumulation in biota and ecosystems. Impacts at various levels of organization, particularly biochemical and physiological effects. Prerequisites: organic chemistry and vertebrate physiology or consent of instructor. Instructor: Di Giulio/Meyer. 3 units.

503. Forest Ecosystems. Emphasis on the processes by which forests circulate, transform, and accumulate energy and materials through interactions of biologic organisms and the forest environment. Ecosystem productivity and cycling of carbon, water, and nutrients provide the basis for lecture and laboratory. Instructor: Oren. 3 units.

505. Tree Structure and Function. Designed primarily for graduate students and advanced undergraduates in areas of ecology, forestry or related disciplines who desire basic understanding of how plants (special focus on woody plants) function at various scales from molecules to canopies. Course will facilitate application of plant physiological principles in the students' specific areas of interest. Focus is on responses of water loss and carbon gain of plants to variation in their environment. Background in biology preferred. Instructor: Palmroth. 3 units.


517. Tropical Ecology. Ecosystem, community, and population ecology of tropical plants and animals with application to conservation and sustainable development. Prerequisite: a course in general ecology. Instructor: Poulsen. 3 units. C-L: Biology 561
520. Resource & Environmental Economics I. Part 1 of a survey course in environmental and natural resource economics. Part 1 focuses on basic theory and methods of economic analysis of environmental problems including benefit-cost analysis, non-market valuation, and instrument choice. Prerequisite: Introductory course in microeconomics and one semester of calculus. Instructor: Bennear or Smith. 1.5 units. C-L: see Energy 520; also C-L: Economics 530, Public Policy Studies 576


521. Resource & Environmental Economics II. Part 2 of a survey course in environmental and natural resource economics. Part 2 focuses on basic theory and methods of economic analysis of natural resource problems including extraction of non-renewable resources over time, fisheries economics and forest economics. Prerequisite: ENVIRON 520. Instructor: Bennear, Smith, or Vincent. Variable credit. C-L: Economics 531, Public Policy Studies 584

524. Water Quality Health. Explore basic concepts of water quality and human health with focus on the global water cycle, global water demand and availability, chemical properties of water, contaminants in water, health implications, and environmental isotope hydrology. Highlights relationships between human activities, water scarcity, water quality degradation, and ecological and health consequences. Addresses some policy implications related to conflicts over water resources and impact of energy production on water resources. Prerequisites: prior knowledge of introductory calculus and chemistry or consent of instructor. Instructor: Vengosh. 3 units. C-L: see Earth and Ocean Sciences 524; also C-L: Global Health 534, Energy 524

530. Remote Sensing in Coastal Environments. Introduction to the field of remote sensing and image processing with focus on applications to coastal monitoring and currently open research questions. Students will acquire an operational knowledge of various remote-sensing tools and data types, with emphasis on their application in coastal areas. Content will include theory, in-class laboratory exercises, and projects with environmental applications. Prerequisite: introductory or AP physics preferred or permission of instructor. Instructor: Silvestri. 3 units. C-L: see Earth and Ocean Sciences 530; also C-L: Civil and Environmental Engineering 574

531. Economic Valuation of the Environment. Quantitative course with focus on economic valuation of changes in environmental quality. Covers theoretical foundations of major nonmarket valuation methods and, through a series of problem sets, provides opportunities to develop skills applying those methods. Also covers a range of regression methods commonly employed in valuation studies. Prerequisite: ENVIRON 520 or equivalent and ENVIRON 710 or equivalent. Instructor: Vincent. 3 units.

532. Evaluation of Public Expenditures. Basic development of cost benefit analysis from alternative points of view, for example, equity, debt, and economy as a whole. Techniques include: construction of cash flows, alternative investment rules, inflation adjustments, optimal timing and duration of projects, private and social pricing. Adjustments for economic distortions, foreign exchange adjustments, risk and income distribution examined in the context of present value rules. Examples and cases from both developed and developing countries. Instructor: Conrad. 3 units. C-L: see Public Policy Studies 596; also C-L: Economics 521


537. Environmental Health. Introduction to environmental effects on human health. Focus on chronic effects of exposure to pollution and other stressors, the interaction between anthropogenic environmental changes and infectious diseases, and the relationship between human health and ecosystem health. Includes lectures from a variety of experts in this field from throughout the Triangle region. Course is designed to facilitate maximum student participation through discussion. For graduate and advanced undergraduate students. Instructor: DiGiulio/Meyer. 3 units.

538. Global Environmental Health: Economics and Policy. Social science perspective on global environmental health. Students will learn to identify primary environmental causes of high burden diseases such as malaria,
diarrhea, and respiratory infections; describe how to measure socio-economic impacts of global environmental health diseases; discuss key policies to control global environmental health problems based on private prevention and therapeutic behaviors; and propose frameworks to empirically monitor and evaluate global environmental health policies. A sub-module will focus on climate change and water-borne diseases. Prerequisites: Introductory course in statistics. Instructor: Pattanayak. 3 units. C-L: Global Health 538, Public Policy Studies 582

539. Human Health and Ecological Risk Assessment. Topics central to both health and ecological risk assessment are explored. Basic concepts of hazard identification, dose-response relationships, exposure assessment, and risk characterization and communication are discussed in the context of both human health and environmental assessment. The basis and rationale for using specific, as well as extrapolated, scientific information and expert judgment, and the strengths and weaknesses of alternative approaches, are evaluated. Applications emphasizing real cases are used to illustrate the interdisciplinary process and products of risk assessment, as well as the regulatory use of the information. Group projects emphasized. Instructors: Mihaich/McMasters. 3 units.

540. Chemical Fate of Organic Compounds. Equilibrium, kinetic, and analytical approaches applied to quantitative description of processes affecting the distribution and fate of anthropogenic and natural organic compounds in surface and groundwaters, including chemical transfers between air, water, soils/sediments, and biota; and thermo-chemical and photochemical transformations. The relationships between organic compound structure and environmental behavior will be emphasized. Sampling, detection, identification, and quantification of organic compounds in the environment. Prerequisites: university-level general chemistry and organic chemistry within last four years. Instructor: Stapleton. 3 units. C-L: Civil and Environmental Engineering 563

542L. Environmental Aquatic Chemistry. Principles of chemical equilibria and kinetics applied to quantitative chemical description of natural and engineered aquatic systems. Topics include acid/base equilibrium, the carbonate system, metal complexation, oxidation/reduction reactions, precipitation/dissolution of minerals, and surface absorption. Instructor: Hsu-Kim. 3 units. C-L: see Civil and Environmental Engineering 561L

543S. Water Cooperation and Conflict. Focuses on potential for transboundary water resources-related conflict and cooperation. Discusses water scarcity concepts, natural resource conflict theory, hydro politics, hydro hegemony, water security, water markets and institutions, game theory, and international water law. Other topics include the economics of water and health. Case studies complement the broader course outlook. Instructor: Jeuland. 3 units. C-L: see Public Policy Studies 580S; also C-L: Global Health 533S, International Comparative Studies 580S

544S. Collective Action, Property Rights, and the Environment. The rational choice tradition (public goods, collective action, game theory, property rights, new institutionalism) as applied to environmental problems, resource exploitation, environmental justice, and the design of an environmentally sound society. Instructor: McKean. 3 units. C-L: see Political Science 549S


548. Solid Waste Engineering. Engineering design of material and energy recovery systems including traditional and advanced technologies. Sanitary landfills and incineration of solid wastes. Application of systems analysis to collection of municipal refuse. Major design project in solid waste management. Prerequisite: Civil and Environmental Engineering 462L, or consent of instructor. Instructor: Staff. 3 units. C-L: see Civil and Environmental Engineering 672

549. California Water Crises: A Case Study Approach. Reviews history of California's water dependent economy, leading to a capture, storage system with conveyances extending thousands of miles to deliver water for agriculture, industry and homes. Examines recent political change coupled with chronic issues of a water-rich north, an expanding urban population and a water-poor but politically strong south. Emphasis includes climate change, seismic vulnerability, redirection of river flows, and large scale water reuse. Course will cover specific water crises in other states and nations, providing in depth coverage of aspects of the international crisis in quantity and quality of freshwater. Instructor: Hinton. 3 units.

555. Applied Regression Analysis. Linear regression using both graphical and numerical methods. Model construction, critique, and correction using graphical residual analysis. One-way and two-way analysis of variance; introduction to design of experiments. Use of a standard statistical software package. Applications and examples drawn from various sources, emphasizing the biological and environmental sciences. Prerequisite: Statistical Science 210B or equivalent. Instructor: Staff. 3 units.

556. Environmental Conflict Resolution. Practical techniques and scholarly underpinnings of environmental conflict resolution, including interest-based negotiation, mediation, public disputes, science-intensive disputes, and negotiation analysis. In-class time will be spent conducting negotiation role plays of increasing complexity and then debriefing them. Outside of class, students will prepare for the role plays and read background material to aid in debriefing. Students will keep a journal of their experiences. Consent of instructor required. Instructor: Albright. 2 units.

557. Social Science Surveys for Environmental Management. Social science research methods for collecting data for environmental management and policy analysis. Sampling, survey design, focus groups, pretesting, survey implementation, coding, and data analysis. Team projects emphasize development and practice of survey skills. Prerequisite: introductory applied statistics or equivalent. Instructor: Kramer. 3 units.

559. Fundamentals of Geographic Information Systems and Geospatial Analysis. Fundamental aspects of geographic information systems and satellite remote sensing for environmental applications. Covers concepts of geographic data development, cartography, image processing, and spatial analysis. Gateway into more advanced training in geospatial analysis curriculum. Consent of instructor required. Instructor: Halpin/ Harrell. 4 units.

563. Applying Economic Analysis for Environmental and Public Health Project Evaluation. Course considers the importance of economic analysis, or cost-benefit analysis (CBA), for public policy assessments. Specific focus is on health and environmental policy, and the steps in identification / cataloguing, quantification, and monetization of impacts of potential policies and projects. Covers: Economic rationale for CBA; Basic principles for assessing the economic effects of projects; Techniques for valuing health and environmental impacts; Intergenerational/philosophical concerns related to CBA; Social discounting; Risk and uncertainty; Comparisons of CBA with other approaches (i.e. cost effectiveness analysis, multi-objective analysis). Instructor: Jeuland. 3 units. C-L: see Global Health 531; also C-L: Public Policy Studies 607

564. Biogeochemistry. Processes controlling the circulation of carbon and biochemical elements in natural ecosystems and at the global level, with emphasis on soil and surficial processes. Topics include human impact on and social consequences of greenhouse gases, ozone, and heavy metals in the environment. Prerequisite: Chemistry 101DL or equivalent; Recommended: Chemistry 210DL. Instructor: Bernhardt. 3 units. C-L: see Biology 564

565S. Stormwater Science: Pollution, Pavement, and Precipitation. Examines pollution emissions/deposition, impervious surfaces, evapotranspiration, groundwater, stormwater runoff, nutrients, thermal pollution, and freshwater effects. Uses primary literature, as well as a couple of books. Also examines "stormwater control measures" that mitigate problems. Student-driven course: Reading, presenting, and discussing primary literature, asking/answering questions in class, and seeking answers. Course designed for graduate and advanced undergraduate students. Prerequisites: one course in Ecology or Environmental Science or instructor consent. Instructor: Wilson. 3 units. C-L: see Biology 563S

566. Environmental Analytical Chemistry. This course covers the fundamentals and applications of analytical chemistry as applied to detection, identification, and quantification of anthropogenic contaminants in environmental samples including air, water, soil, sediment, and biota. The topics include both sample preparation methods (i.e. wet chemistry) and instrumental analysis (e.g. mass spectrometry, chromatography, and optical spectroscopy). Particular emphasis is placed on current advancements in measurement science as applied to environmental chemistry. The material includes both theoretical and practical aspects of environmental analysis. Prerequisite: CHEM 131 or CHEM 151L or consent of instructor. Instructor: Ferguson. 3 units. C-L: see Civil and Environmental Engineering 565

572. Economic Evaluation of Sustainable Development. Examines how one could rationally defend a choice of 'sustainable development' policy. Applies cost-benefit thinking in environment-natural-resources and development contexts. Presents microeconomic concepts emphasizing logic and principles more than mechanics. Intertemporal equity is a focus and equity-efficiency tradeoffs are a theme. Microeconomics prerequisite not required. Instructor: Pfaff. 3 units. C-L: see Public Policy Studies 574
577. Environmental Politics. Environmental policy formation and implementation in comparative perspective. Topics include interest groups, environmental movements and parties, public opinion, political systems and institutions. Case studies selected from the United States and other advanced industrialized countries and the developing world. Spring. Instructor: Albright or Mullin. 3 units. C-L: Public Policy Studies 577, International Comparative Studies 577

579S. Collective Action, Environment, and Development. Examines the conditions under which collective or participatory decisions may raise welfare in defined ways. Presents the growing empirical evidence for an environment and development setting including common property issues (tragedy of the commons and competing models). Identifies what evidence exists for sharing norms on a background of self-interested strategies. Definitions of and reactions to equity and/or its absence are a focus. Providing scientific information for policy is another. Experimental and behavioral economics are frequently applied. Instructor: Pfaff. 3 units. C-L: see Public Policy Studies 579S

590. Special Topics. Content to be determined each semester. May be repeated. Instructor: Staff. Variable credit.

593. Independent Studies and Projects. Directed readings or research at the graduate level to meet the needs of individual students. Consent of instructor required. Units to be arranged. Instructor: Staff. Variable credit.

615S. Environmental Issues & the Documentary Arts. Survey how filmmakers, authors, photographers, and other artists have brought environmental issues to the public's attention in the last century, and in some cases instigated profound societal and political change. Examine the nebulous distinctions between persuasion and propaganda, agenda and allegory, point of view and content. Evolve as a viewer of the environment and a maker of documentary art. Initiate your own projects to address and/or depict environmental issues in one form of a broad range of media. Instructor: Espelie. 3 units. C-L: see Documentary Studies 615S; also C-L: Arts of the Moving Image 643S

621. Water Resources, Finance and Planning. Introductory course to water in the built environment, with basic treatment of hydrology, treatment, regulation, and planning of water resources. Course will serve as a survey course for non-water specialists, and a bridge course from hydrology to policy, management, planning, and finance, or vice versa for policy students interested in bridging to hydrology. Emphasis will be on applications of basic techniques common in management contexts. Instructor: Doyle. 3 units.

624. Agriculture and Sustainability: Feeding the Growing Human Population Today for the Future. Introduces agroecology through basic scientific knowledge of plant physiology and growth for crop production, crop diversity and breeding, and comparison of agricultural practices (industrial, subsistence, organic, sustainable). Covers resources needed for whole-plant growth, biomass output for human use including bioenergy, and impacts on ecosystems. Examines environmental sustainability through assessment of drawbacks and benefits of agricultural practices for human food and biofuel production. Applications include management plan for sustainable agroecosystems and forecast of crop agricultural practices in need of a future altered environment. Prerequisites: Intro Biology or Ecology. Instructor: Reid. 3 units.

626. River Processes. Course focuses on river processes and how rivers change and how to analyze rivers. Course is a mixture of hydrology, geomorphology, and ecology. Focus is on quantitative analysis of processes using simple modeling approaches. Problems will be drawn from policy and river management applications such as river restoration, channel design, dam management, and floodplain regulation. Instructor: Doyle. 3 units.

627. Molecular Ecology. Explore use of molecular tools to investigate ecological processes within natural populations and communities from terrestrial to marine. Emphasis on fundamental principles and predictions from ecological and evolutionary theory, as well as historical approaches and precedents. In addition to exploring very basic ecological questions, course discusses interpretation of molecular datasets to evaluate applied ecological problems with societal implications (e.g., conservation, antibiotic resistance, genetically modified crops, adaptation to climate change). Open to graduate students, and upper-level undergraduates with backgrounds in ecology and/or molecular biology. Instructor: Wernegreen. 3 units. C-L: Genome Sciences and Policy 627, Biology 627

630. Transportation and Energy. Examination of transportation-related energy use and its impact on the environment. Learn how technology, infrastructure, and policy, as well as personal and cultural preferences, interact to meet demands for personal mobility and freight movement. Cutting across these themes will be consideration of strategies to reduce transportation energy use and its environmental impacts, with an introduction to information resources and tools for evaluating both. Provides opportunities to hone problem solving and analytical skills, and challenges students to think critically and creatively about the trade-offs among complex transportation options. Instructor: Johnson. 3 units. C-L: see Energy 630
631. Energy Technology and Impact on the Environment. Efficiencies and environmental impacts of both new and established energy sources and conversion methods. Consideration of alternative energy technologies, including electricity generation by fossil fuels, nuclear, solar, wind and water; space heating and cooling by traditional methods and by solar; and transportation energy in automobiles, mass transit and freight. Environmental consequences of energy choices on local, national and global scales, including toxic emissions, greenhouse gases and resource depletion. Instructor: Johnson. 3 units.

635. Energy Economics and Policy. Economics of markets and policies for various energy supply sources, energy demand and efficiency, their interactions with each other, and with the economy and environment. Will explore rationales for why markets for energy and related technologies have been subject to extensive government intervention. Course will analyze effects of policy responses, including energy price regulation, the interface of energy, environmental, and technology policy, and policy motivated by energy security concerns. Prerequisites: Introductory Microeconomics (ECON 101 or equivalent) and college calculus. Instructor: Newell. 1.5 units. C-L: see Energy 635

636. Methods in Spatial Epidemiology and Demography. Use of analytical tools to understand spatial patterns in health and demographic events. Students acquire skills in spatial data analysis and interpreting spatial patterns. Students will understand fundamental concepts in spatial epidemiology and demography, including spatial autocorrelation, heterogeneity and bias, spatial interaction, and small area estimation; identify spatial and space-time clusters of events and judiciously evaluate hypothesis tests; and develop spatial regression models that appropriately account for spatial heterogeneity or explicitly model spatial autocorrelation. Success in this course requires prior knowledge of Geographic Information System and Statistics. Instructor: Pan. 3 units. C-L: see Global Health 636

637S. Population and Environmental Dynamics Influencing Health. Course examines population, health and environment (PHE) dynamics with focus on interactions in developing or transition economies. Theoretical and empirical approaches governing PHE dynamics from multidisciplinary perspectives, including geography, public health /epidemiology, demography, and economics. Students will obtain experience in design and analysis of PHE studies, and epidemiology of vector-born, chronic and enteric infections. Instructor: Pan. 3 units. C-L: see Global Health 637S

638L. Environmental Life Cycle Analysis & Decision. Provides theoretical foundations of environmental life cycle assessment tools and methods used for products and global supply chains. Introduces various life cycle inventory and life cycle assessment tools used by the community of scientists and industry. Instructor consent required. Instructor: Golden. 3 units. C-L: see Energy 638L

640. Climate Change Economics. This course explores the economic characteristics of the climate change problem, assesses national and international policy design and implementation issues, and surveys the economic tools necessary to evaluate climate change policies. Discussion-oriented requiring high degree of student participation. Course objectives are increased comprehension of economic aspects of climate change and ability to apply tools of economic analysis to climate policy and the responses of firms and households to it. Course designed for graduate and advanced undergraduate students. Instructor: Pizer. 3 units. C-L: Public Policy Studies 585

642. Air Pollution: From Sources to Health Effects. Both urban outdoor air pollution and household indoor air pollution contribute significantly to global burden of disease. Course covers fundamentals about how major air pollutants are generated and transported in the atmosphere and how these pollutants affect human health. Relevant exposure assessment, toxicology and epidemiology case studies are discussed. Prerequisites: general chemistry; introductory-level statistics. Instructor: Zhang. 3 units.

646. Urban Ecology. Addresses how to understand urban areas as ecological and socio-ecological systems and the distinction between the study of ecology in and of cities. Examines both through theoretical lens of socio-ecological systems, in which humans and their actions are a component of, rather than disturbance imposed on, ecological systems. Applies theoretical and methodological tools to global, regional, and local urban issues. Prerequisites: One ecology course and one environmental social sciences course. Instructor: Heffernan. 3 units.

650S. Advanced Topics in the Conservation of Biodiversity. Current topics in conservation and biodiversity. Intended for graduate students; advanced undergraduate students admitted with permission of instructor. Prerequisites: introductory conservation biology or permission of instructor. Instructor: Pimm. 2 units.

658. Applied Qualitative Research Methods. Broadly covers qualitative and mixed methods research design, analysis, and interpretation. Students gather a limited amount of their own data and produce a pilot research project throughout the semester. Students learn to use NVivo10, a qualitative research software program. Instructor: C. Clark. 3 units.
665. **Bayesian Inference for Environmental Models.** Formulation of environmental models and applications to data using R. Distribution theory, algorithms, and implementation. Topics include physiology, population growth, species interactions, disturbance, and ecosystem dynamics. Discussions focus on classical and current primary literature. Instructor: J. Clark. 3 units. C-L: see Biology 665

666. **Aquatic Geochemistry.** Geochemistry of the water-solid interface of soils, minerals, and particles in earth systems. Topics will cover the chemical composition of soils, geochemical speciation, mineral weathering and stability, sorption and ion exchange, soil redox processes, and chemical kinetics at environmental surfaces. Prerequisites: CE/ENVRON 561L or CEE 461L or EOS 525 or ENVRON 360 or permission of instructor. Instructor: Hsu-Kim. 3 units. C-L: see Civil and Environmental Engineering 666

678. **Population Ecology for a Changing Planet.** Overview of the expanding field of population ecology, including the use of new bioinformatic tools to study topics such as the impacts of climate change on population dynamics, population growth and regulation, adaptive evolution, and emerging diseases. Lecture and discussion of case studies will evaluate current knowledge and productive research directions, highlighting analysis of observational and experimental data sets. Prerequisites: introductory statistics and calculus. Instructor: J. Clark. 3 units. C-L: Biology 678

680. **Economics of Forest Resources.** Core economic theory of forest management and application of theory to selected forestry policy issues. Course focuses on management of forests for timber production as well as for non-timber values. Concepts explored include policy challenges such as biodiversity conservation, deforestation, community forest management, and payments for ecosystem services. Two groups of economic tools will be used: non-market valuation methods and program evaluation techniques. Prerequisites: college-level calculus, microeconomics and statistics, as well as Excel proficiency. Instructor: Vincent. 3 units.

700. **Integrated Case Studies.** A group of two to four students may plan and conduct integrated research projects on a special topic, not normally covered by courses or seminars. A request to establish such a project should be addressed to the case studies director with an outline of the objectives and methods of study and a plan for presentation of the results to the school. Each participant's adviser will designate the units to be earned (up to six units) and evaluate and grade the work. Instructor: Staff. Variable credit.

701. **Forest Measurements.** Course is designed to provide field and analytical measurement skills expected of professionals working in forest ecosystem management. Additional emphasis on habitat assessment and forest vegetation and wildlife identification. Extensive field work required. Instructor: Richter. 4 units.

703. **Conservation Biology: Theory and Practice.** An overview of biological diversity, its patterns, and the current extinction crisis. Historical and theoretical foundations of conservation, from human values and law to criteria and frameworks for setting conservation priorities; island biogeography theory, landscape ecology, and socioeconomic considerations in reserve design; management of endangered species in the wild and in captivity; managing protected areas for long term viability of populations; the role of the landscape matrix around protected areas; and techniques for conserving biological diversity in semiwild productive ecosystems like forests. Three field trips. Prerequisite: one ecology course or consent of instructor. Instructor: Pimm. 3 units.

705L. **Ecological Management of Forest Systems (Silviculture).** The aim of the course is to equip future resource managers and environmental consultants with knowledge allowing them to propose lower impact practices to individuals and organizations who need to balance wood production with maintenance of environmental quality. Underlying principles of growth, from seed to mature trees, and stand dynamics are explored. Various alternative methods of manipulating growth, stand structure and development, ranging from little to large perturbations of forest systems, are presented and assessed in terms of their effect on resource quality. Includes laboratory. Instructor: Palmroth. 3 units.

706. **Wildlife Surveys.** With a focus on birds, reptiles, amphibians, and mammals, this course introduces students to a wide variety of wildlife survey methods and skills through both classroom lectures and hands-on experience in the field. Design, practical application, and post-survey data analyses for conducting wildlife surveys for research as well as for management. Limitations and advantages of various field monitoring techniques; learn to identify many common birds, herps, and mammals of season for this area. Significant time spent in the field. Instructor: Swenson or Staff. 2 units.

708. **Silviculture Prescription.** Professional foresters meet management objectives through stand manipulation by using appropriate methods. Silviculture prescription is an operational plan that describes the goals, the silvicultural
manipulations needed to achieve these goals, and the development of the stands over the projected period. Facing
diverse management objectives and stand conditions, success in this planning process depends on understanding the
underlying principles of tree growth and stand dynamics, but also relies on the intuitive knowledge that aids in
assessing stand conditions and future development. Class is designed to provide the practical experience needed for
developing the intuitive knowledge. Instructor: Palmroth. 2 units.

710. Applied Data Analysis for Environmental Sciences. Graphical and exploratory data analysis; modeling,
estimation, and hypothesis testing; analysis of variance; random effect models; regression and scatterplot smoothing;
generalized linear models; resampling and randomization methods. Concepts and tools involved in data analysis.
Special emphasis on examples drawn from the social and environmental sciences. Students to be involved in applied
work through statistical computing using software, STATA or R. Instructor: Albright or Poulsen. 3 units.

711. Energy and Environment. Overview of the challenges confronting humanity as a consequence of our reliance
on energy. Challenges include dwindling supplies, rising demand and environmental degradation. Realistic responses
require an understanding of the complexity of the energy system, including energy resources, uses, and impacts, in
the context of social, political and economic imperatives. Lectures will be augmented by presentations from guest
speakers from industry, government and non-profit organizations. Instructor: Pratson. 3 units. C-L: see Energy 711

712A. Hydrocarbons: Production to Policy Seminar. Field study of hydrocarbons production in and around
Houston, Texas, with first-hand perspective of oil and gas from industry experts. Includes a field trip with a required
fee for the trip. Instructor: Pratson. 1 unit.

713A. Clean Energy Field Trip. Field study of the clean energy industry around the San Francisco Bay area,
California, with first-hand perspective from renewable energy experts. Includes a field trip with a required fee for the
trip. Instructor: Pratson. 1 unit.

714. Landscape Ecology. Landscape ecology embraces spatial heterogeneity in ecosystems: how spatial pattern
arises, how it changes through time, and its implications for populations, communities, and ecosystem processes.
Course adopts task-oriented perspective, emphasizing concepts and tools for habitat classification, inventory and
monitoring, modeling and interpreting landscape change, and site prioritization for conservation or restoration.
Prerequisites: an intermediate course in ecology; introductory statistics helpful but not required. Instructor: Urban.
3 units.

715L. Understanding Energy Models and Modeling. Course aims to nurture basic modeling literacy by focusing
on widely-used class of "bottom-up," optimization-based, energy models commonly used for economic, environ-
mental, and technology assessments. Students will gain practical experience searching for relevant modeling data,
constructing scenarios, and running an energy model. Will gain a working knowledge of model mechanics and
experience asking the type of questions needed to evaluate quality of modeling results. Instructor: T. Johnson. 3
units.

716L. Modeling for Energy Systems. Introduction to computer programming and operations research in energy
systems analysis with emphasis on formulation of optimization problems and simulation models. Applications and
case studies dealing with energy systems problems, their externalities, and government policies that affect them.Data
analysis, spreadsheet modeling, VBA programming in Excel; linear programming (lp), post-optimality and sensi-
tivity analysis, multi-period lp, stochastic lp, network models for minimum path, maximum flow and optimal
planning problems; probabilistic analysis Monte Carlo simulation, including generation of independent and corre-
lated random variables, and goodness of fit tests. Instructor: Patino-Echeverri. 3 units. C-L: see Energy 716L

717. Markets for Electric Power. Examines basic concepts and tools in economics and engineering necessary to
understand the operation of power markets. Includes physical systems; industry structure and economic models to
understand the supply side; operational reliability; long-term reliability; and, integration of renewables. Instructor:
Patino-Echeverri. 3 units.

720. Land Conservation in Practice. Overview of applied conservation practices of land trusts including:
completing real estate transactions, working with private landowners, fundraising, land monitoring and stewardship,
evaluating conservation success, overview of emerging trends. Course will entail guest speaker presentations from a
wide range of private conservation entities from NC and the Triangle region. Attendance is required on a 1-day field
trip. Course assignments: group projects, papers and class presentations. Instructor: Urban/Swenson. 2 units.

720S. Land Conservation in Practice. Seeks to provide a high-quality overview of the applied skills and techniques
needed by students for success as leaders of the modern land conservation movement. Course covers a variety of topics
arranged in a roughly logical order, beginning with setting real-world priorities for conservation, moving on to completing real estate transactions, working with private landowners, fundraising, land monitoring and stewardship, evaluating conservation success, and finishing with an overview of emerging trends. Goal is to increase effectiveness at running the practical business of conservation. Instructor: Swenson. 1 unit.

721L. Soil Resources. Emphasis on soil resources as central components of terrestrial ecosystems, as rooting environments for plants, and as porous media for water. Soil physics and chemistry provide the basis for the special problems examined through the course. Laboratory emphasizes field and lab skills, interpretive and analytical. Instructor: Richter. 3 units.

722. Hydrologic and Environmental Data Analysis. Course will focus on acquisition of skills necessary to extract information from observations of hydrological and environmental processes, connect the extracted information with the physical processes generating the data, and estimate physical quantities at ungauged location/times. Emphasis on process understanding via data analysis techniques. Applications used as a way to understand the general concepts, with examples drawn from water science. Prerequisites: Basic computer skills, Algebra, Calculus are required. Experience with computational software (e.g. Matlab or R) is helpful but not required. Instructor: Marani. 3 units. C-L: see Earth and Ocean Sciences 722; also C-L: Civil and Environmental Engineering 761

724. Landscape Analysis & Management. This course is a task-oriented perspective on landscape ecology and management. The tasks include habitat classification, sampling designs for inventory and monitoring, site selection and prioritization, modeling landscape change, and integrated assessment. These practical tasks are couched in the logical framework of adaptive management. Course consists of lectures and hands-on exercises in the computer lab. Prerequisite: ENVIRON 714 or consent of instructor. Instructor: Urban. 4 units.

725S. Protected Areas, Tourism, and Development. Investigates issues of establishing and managing national parks, biosphere reserves, and other protected areas in situations where local populations compete for the same resources. Tourism is considered as a possible source of negative impacts on the protected area and as a source of local economic development. Includes consideration of tourism policy, resource protection strategies, microenterprise development, sustainable agriculture, and forestry. Instructor: Staff. Variable credit.

727. Forests in the Public Interest Seminar. Discussion of current readings pertaining to forestry issues written about in national newspapers such as the New York Times, Washington Post, and Wall Street Journal, news magazines such as The Economist, and Slate, investigative reports in magazines such as the Atlantic Monthly, New Yorker, Independent, and classic essays; the sort of articles that are read by the educated public - including leaders in public, private and nonprofit sectors - and shape public opinion about forestry and forestry policy issues. Provides an opportunity for students with interests in forests to gain experience evaluating arguments related to forest issues and how they are portrayed in the nonscientific press. Instructor: Richter/Vincent. 1 unit.

728. Fire Ecology and Management Seminar. A wide range of wildland and forest fire seminars are organized for students to interact with leaders in the wide variety of environmental fields that work with fire issues: ecological science of fires, prescribed, fire, fire behavior, fire on federal and state public lands, fire economics, fire and restoration, and fire in history and in the future. Instructor: Richter. 1 unit.

734L. Watershed Hydrology. Introduction to the hydrologic cycle with emphasis on the influence of land use, vegetation, soil types, climate, and land forms on water quantity and quality and methods for control. Development of water balance models. Analysis of precipitation patterns, rainfall and runoff, and nonpoint source impacts. Statistical handling and preparation of hydrologic data, simulation and prediction models, introduction to groundwater flow, laboratory and field sampling methods. Instructor: Katul. 4 units.

739. Our Changing Atmosphere: From Air Pollution to Climate Change. A broad overview of the science of oxidant chemistry in the atmosphere. Basic physical and chemical concepts relevant to the understanding of atmospheric chemistry; several contemporary topics discussed from a process-level perspective. Topics include atmospheric structure and chemical composition; atomic structure and chemical bonds; chemical thermodynamics and kinetics; atmospheric radiation and photochemistry, tropospheric and stratospheric ozone chemistry; aqueous-phase atmospheric chemistry; atmospheric aerosols; and air quality modeling. Prerequisites: one college-level course each in chemistry and calculus. Instructor: Kasibhatla. 3 units. C-L: Civil and Environmental Engineering 665

744. Ecology and Conservation of Streams and Rivers. Overview of ecological processes in flowing waters and application to conservation and management of these ecosystems. Lecture and discussion formats to integrate basic principles governing physical, chemical, and biological structure of streams and rivers with anthropogenic drivers of
change and policy and management tools. Laboratories will provide hands-on experience in collection and analysis of physical, chemical, and biological data. Field and literature projects will enable students to focus on either basic or applied analysis techniques. Prerequisite: general ecology recommended. Instructor: Heffernan. 3 units.

752. Sustainability and Renewable Resource Economics. Economic theories of sustainability, contrasted with other scientific views. Focus on renewable resource economics, modeling, and management. Prerequisite: Environment 520. Instructor: Smith. 3 units. C-L: Economics 752

755. Community-based Environmental Management. Goal of the course is to provide students with fundamental theory and methods that will allow them to identify some of the potential problems and pitfalls associated with community-based environmental management (CBEM) initiatives, both domestically and internationally, along with tools necessary to create and manage their own projects. To accomplish this, course will combine readings and discussion of academic literature with presentations of specific CBEM case studies, guest speakers, and interactions with local CBEM projects. Instructor: Shapiro. 3 units.

756. Spatio-Temporal Environmental Models. Spatio-temporal models are now being widely used for inference on environmental data. This course will consist of weekly topics with readings of new literature and application of models and software to data sets. We will specifically focus on spBayes in R. Students will each volunteer to lead one week, track down and distribute a data set, set up a model and provide a short demo on computation. Instructor: J. Clark. 2 units.

757. Current Issues in Protected Area Management. Principles of management of protected areas. Topics vary and include wilderness, national park, or international protected areas. Focus on legal and historical frameworks, ecological and social issues, and development and practical application of terrestrial protected area management techniques. Lecture and class discussion of topics. Required 1-day field trip to NC wilderness area. Undergraduates may enroll by permission of instructor. Prerequisite: introductory ecology. Instructor: Swenson. 3 units.

760A. Western Field Trip. One-week trip to observe land management and utilization practices in the western United States. Exposure to ecological, economic, and policy issues, as well as watershed, wildlife, and land use questions. May be repeated for credit. Consent of instructor required. Instructor: Staff. 1 unit.


762. Environmental Mega-Trends. Course investigates major, over-arching trends in environmental science, policy, thought, and practice and likely trajectories for the coming 25 years. Goal is to understand these trends and assess how changes in the environment might impact - and be impacted by - society, from the scale of individual decisions to global economies. Individual topics driven by emerging issues that are of most pressing interest but also that may not have immediately obvious connections to contemporary environmental discussions. Instructor: Doyle. 1.5 units.

763. Forest Management Traveling Seminar. Covers current topics in the broad field of forest management. Taught as a set of coordinated field trips with expert contacts in sites in the Carolina piedmont, coastal plain, and mountains. Topics of past seminars include fiber utilization, best management practices, forest regeneration, the chip mill issue, forest-pest management, and forest preservation management. May be repeated for credit. Instructor: Richter. 1 unit.

764. Applied Differential Equations in Environmental Sciences. General calculus and analytic geometry review; numerical differentiation and integration; analytic and exact methods for first and second order ordinary differential equations (ODE); introduction to higher order linear ODE, numerical integration of ODEs and systems of ODEs; extension of Euler's method to partial differential equations (PDE) with special emphasis on parabolic PDE. Example applications include population forecasting, soil-plant-atmosphere water flow models, ground water and heat flow in soils, and diffusion of gases from leaves into the atmosphere. Prerequisite: Mathematics 21 or equivalent or consent of instructor. Instructor: Katul. 3 units.

765. Geospatial Analysis for Coastal and Marine Management. Application course focusing on spatial analysis and image processing applications to support coastal and marine management. Covers benthic habitat mapping, spatial analysis of marine animal movements, habitat modeling, optimization of marine protected areas. Requires
fundamental knowledge of geospatial analysis theory and analysis tools. Consent of instructor required. Prerequisite: Environment 559. Instructor: Halpin. 4 units.

766A. Ecology of Southern Appalachian Forests. Field trips to various forest ecosystems in the southern Appalachian Mountains. Species identification, major forest types, field sampling, and history of effects of human activities. Consent of instructor required. Instructor: Richter. 1 unit.

768. GIS for Water Quantity and Quality Assessment. Spatial analysis and image processing applications to support water resources management: water quality, flooding, and water supply primarily at watershed scale. Topics include water resources data modeling, terrain modeling and processing, river and watershed network analysis, and geospatial modeling of hydrologic processes. Knowledge of geospatial analysis theory and analysis tools. Kumar. 3 units.

769. Hydrologic Modeling for Water Quantity and Quality Assessment. Hydrologic modeling concerns itself with understanding and prediction of different components of the hydrologic cycle by solving abstract representations of respective hydrologic processes. Students acquire an in-depth understanding of how and where hydrologic models can be used, and will be prepared to address water quantity and quality problems using computer models. Course will discuss in detail the assumptions, limitations and uncertainty associated with different modeling strategies. Course addresses both surface and ground water processes. Models discussed in course include TopModel, Stanford Watershed Model, HEC-HMS, SWAT, HSPF, RUSLE, SPARROW, PIHM, etc. Instructor: Kumar. 3 units.

771L. GIS Field Skills. Covers integration of GPS and GIS technology for field data collection. Data is set up in ArcGIS in lab, exported to GPS units, field data to be collected, and imported back to GIS system. ArcGIS Personal Geodatabase is the fundamental data structure. Course covers data accuracy and precision and how to use base stations to correct data differentially for highest possible accuracy. Will discuss how to determine what GPS unit is necessary for project accuracy needs. Prerequisite: Environment 559. Instructor: Harrell. 2 units.

775. Ocean and Coastal Law and Policy. Explores law, policies and attitudes that affect US ocean and coastal resources. Using case studies and other materials, examines use, management and protection of coasts and oceans. Government and private sector approaches to ocean and coastal resources such as, wetlands, estuaries, beaches, reefs, fisheries, endangered species and special areas. Instructor: Roady. 3 units.

782. Foundations of Environmental Entrepreneurship. Focus of course is foundations of entrepreneurial activity within the context of environmental science and policy. Course concentrates on new enterprises based on substantial technology innovations with potential for high growth and funding by venture capitalists. Format is readings, lectures and case discussion with practical exposure to all basic operational tools required to start up and operate a company. Instructor: von Windheim. 3 units.

790. Special Topics. Content to be determined each semester. May be repeated. Instructor: Staff. Variable credit.

790SA. Duke-administered Study Away; Special Topics. Content to be determined each session. Instructor: Staff. Variable credit.

795. Community-Based Environmental Management Practicum. Course is designed for students who wish to learn theory, skills and tools necessary for working with communities to manage their own environment. Course includes in-class lectures, discussions of readings, guest speakers and an in-depth client project with a local community-based environmental organization. Topics will include: community organizing; assessing and capturing resources; participatory planning and evaluation; participatory monitoring; outreach and social marketing; and political action for environmental change. Second of two required courses for the Community-Based Environmental Management certificate (NSOE only). Prerequisite: Environment 755. Instructor: Shapiro. 3 units.

798. Communicating Outside the Box: Effective Science Communications and Research Translation Skills. Course primarily aimed at late-stage doctoral students who wish to translate their own research to audiences outside of the academy. Students will develop skills to effectively communicate science and research to non-academic audiences using a variety of methods and will develop and implement a research translation/communication strategy for their own research. Specific topics include underlying theories and frameworks, science and advocacy, environmental justice/community-based research, science and K-12 education, expert testimony, communicating with media, and communicating with policy makers. Prerequisite: consent of instructor. Instructor: C. Clark. 2 units.
799S. Topics in Ecological Genomics. This graduate seminar explores how genomic approaches are impacting research in ecology and environmental biology. The course is targeted to PhD or research-active masters students interested in genomics, genetics, ecology, ecotoxicology, conservation genetics, environmental sciences, and/or computational biology. Discussions will focus on case studies from primary literature, and computer labs will allow hands-on use of current programs. May be repeated. Wernegreen. 1 unit. C-L: Genome Sciences and Policy 799S

800. Professional Communications for MEM and MF Students. Skills-building in professional communication, emphasizing visual communication and speaking. Oral presentations, written document design, graphic display of information, presentation software, and giving and receiving constructive feedback on projects in these areas. Open only to MEM and MF students. Instructor: Vidra. 1 unit.

801. Topics in Experiential Learning for Environmental Management. Field trips, short courses, guest lectures series and other learning experiences that bring students into practice of environmental management and bring environmental managers to students. Example of topics include sustainable energy and sustainable forest practices. Main mode of instruction: face-to-face participation by students in learning experiences designed by environmental managers; some sections will also include background reading and student project work. Grading: pass/fail, with attendance at all class sessions and completion of any projects required to pass. MEM/MF students may count up to a total of 3 credits toward 48 credits required for the degree. Registration limited to Nicholas School MEM/MF students; undergraduates and PhD students may participate on a non-credit basis if space is available. Fall and Spring. Instructor: Staff. Variable credit.

802. Program Management for Environmental Professionals. Overview of principles of program management, with application to diverse environmental professions. Lectures, case studies and discussion focus on topics including leadership, organizational structures, managing complex systems, adaptive management, risk and uncertainty, and advocacy within an organization. MEM and MF students only. Instructors: Staff. 3 units.

803. Principles of Environmental Modeling. Design, implementation, and interpretation of mathematical and computer models in environmental science and management. Combination of lectures, discussion sessions, and computer lab exercises. Goals of course are to develop skills: (1) to conceptualize environmental problems and (2) to design, program, implement and interpret mathematical and computer models to help solve environmental problems. Instructor: Reynolds. 3 units.

809. Wetland Restoration Ecology. Restoration of wetlands requires understanding of wetland hydrology, biogeochemical processes, decomposition, community habitat requirements and soil processes. Factors are discussed in an ecosystem context along with current restoration techniques. Course utilizes newly constructed wetlands in Duke Forest to explore wetland restoration principles. Students teamed together to develop restoration plan for a restored wetland. Final report and oral presentation required. Instructor: Richardson. 3 units. C-L: see Biology 803

810. Topics in Environmental and Ecological Statistics. Project-based course on environmental and ecological statistics for PhD/MS students. Students work on specific data analysis projects associated with current research. Class consists of modules based on specific topics. Students required to complete introduction module and one additional module. Presentation and discussion of projects after introduction module required. Objective of class to provide statistical guidance in students' thesis research work. Instructor: Staff. 3 units.

811. Sustainable Systems Theory and Drivers. Theoretical grounding on Sustainable Systems (SS) thinking and overview of national and international frameworks that have led to development and use of sustainable systems modeling, life cycle analysis and policy decision models. Topics include socio-metabolic consumption, sustainability as a field of inquiry, systems thinking, industrial ecology, earth systems engineering, complexity and resiliency. Explore current drivers and implications of sustainable systems with specific focus on nexus of industry and environmental systems including examining cumulative impacts and benefits resulting from shifting supply chains, green engineering, technological designs and consumer behavior. Instructor: Golden. 3 units. C-L: see Energy 811

812. Wetlands Ecology and Management. The study of bogs, fens, marshes, and swamps. Emphasis on processes within the ecosystem: biogeochemical cycling, decomposition, hydrology, and primary productivity. Ecosystem structure, the response of these systems to perturbations, and management strategies are discussed. A research project is required. Prerequisites: one course in ecology and chemistry. Instructor: Richardson. 3 units.

813. Advanced Environmental Toxicology. Discussion of current issues. Topics vary but may include chemical carcinogenesis in aquatic animals; biomarkers for exposure and sublethal stress in plants and animals; Discussion of current issues. Topics vary but may include chemical carcinogenesis in aquatic animals; biomarkers for exposure and
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sublethal stress in plants and animals; techniques for ecological hazard assessments; and means of determining population, community, and ecosystem level effects. Lectures and discussions led by instructor, guest speakers, and students. Prerequisite: Environment 501. Instructor: Di Giulio. 3 units.

814. Integrated Case Studies in Toxicology. Students are assigned topics relative to their chosen research discipline in toxicology and are asked to develop case studies to present at a roundtable workshop. Emphasis on review and analysis of toxicological problems from a holistic (multidisciplinary) viewpoint. Offered on demand. Instructor: Abou-Donia. 1 unit. C-L: see Pharmacology and Cancer Biology 814

815. Focused Topics in Toxicology. A contemporary advanced toxicology research area covered with readings from the current primary literature. An integrative review of the topic prepared as a collaborative effort. Consent of instructor required. Prerequisites: Pharmacology 533 and 847S. Instructor: Levin. 1 unit. C-L: Pharmacology and Cancer Biology 815

816. International Climate Change Negotiations Practicum. Climate change promises to impact almost every aspect of life on earth across the globe. It is an issue that, because of the diffuse nature of its causes and solutions, will require a global solution. Since the Rio Earth Summit in 1992, the United Nations Framework Convention on Climate Change (UNFCCC) has been the primary forum for the negotiation of international agreements concerning climate change. Students will learn about primary issues involved in negotiation of international climate change agreements under UNFCCC and train them to take part as a stakeholder with the intention of developing students' analytical thinking through experiential learning at international level. Instructor: Shapiro. 3 units.

819. Mechanisms in Environmental Toxicology. Provides an in-depth examination of key molecular and biochemical mechanisms by which organisms defend themselves against environmental pollutants. Cellular mechanisms by which chemicals produce toxicity when the defense systems are overwhelmed will be addressed. Includes examinations of "state of the art" approaches for experimentally elucidating these phenomena. Course format will be that of a graduate seminar, with lectures given and discussions led by the instructors, guest speakers, and course participants. Prerequisites: one course in biochemistry and one course in toxicology. Instructors: DiGiulio. 3 units.

820S. Conservation Ethics. Students will delve into the tension between science and advocacy through the lens of environmental ethics. Students will gain a strong foundation in principles of environmental ethics, drawing from the rich literature on this topic from the fields of philosophy and ethics, environmental communications and education, and conservation ecology. Seminar-style course requires students to actively lead and participate in weekly discussions, write a series of essays and collaboratively design and initiate a semester project. Ultimately, the course is about reflecting on not just the academic literature and individual scenarios but seriously considering the role our own values play in our work. Instructor: Vidra. 3 units.

821. Advanced Readings in Soil Science. An advanced discussion course based on readings that concern current critical topics in the soil sciences. Readings are selected from both basic and applied aspects of the field. Instructor: Richter. 1 unit.

823. Ecological Resilience and Ecosystem Management. Course provides an introduction to concepts of ecological resilience and its application to the management of ecological systems, and is intended for both PhD and MEM students. The course does not require formal mathematical training, but students are expected to engage the models used in this field. Course consists of lectures, discussion, and a group research project. Lectures will address fundamental theory, case studies, and empirical approaches used to understand the resilience of basic ideas, observations, and approaches to understanding the ecology of flowing water systems. Instructor: Heffernan. 3 units.

826. Global Environmental Politics. Course examines how states and non-states actors cooperate to resolved global environmental problems. Central focus is on the creation of international environmental regimes, their implementation, and effectiveness. Case studies include climate change, ozone depletion, water sharing and dams, fisheries, biodiversity, forestries, oil pollution, sustainable development, environmental security, and trade and the environment. Instructor: Weinthal. 3 units.

827. Principles of Management. Provides introduction to business terminology and practices for environmental professionals. Introduce students to foundational concepts and language associated with the different functional areas of the firm and to some of the processes and tools available to organizational managers to enhance organizational effectiveness. Areas covered include finance and accounting, management and leadership, and organizations and strategy. Permission of instructor required. Instructor: Emery. 3 units.
831. **Sustainable Business Strategy.** Businesses are increasingly applying strategic management tools to incorporate consideration of sustainability into decision-making and operations. While some businesses incorporate sustainable practices because of ethical convictions, most businesses are motivated to do so to address pressures from stakeholders such as regulators, shareholders, customers and neighbors and to exploit knowledge and experience for long term competitive advantage. Students will learn how businesses develop and implement strategies to promote sustainability by examining roles and responsibilities of sustainable strategic managers and applying tools of strategic business management to problems of sustainability. Permission of instructor required. Instructor: Gallagher. 3 units.

832. **Environmental Decision Analysis.** Quantitative methods for analyzing environmental problems involving uncertainty and multiple, conflicting objectives. Topics include subjective probability, utility, value of information, multi-attribute methods. Students will apply these tools to an environmental policy decision in a group project. Prerequisite: introductory applied statistics or equivalent. Instructor: Maguire. 3 units.

834S. **Environmental Social Science Research Workshop.** Seminar format designed to give graduate students in environmental social sciences a venue to present research proposals and preliminary work. Emphasis is on application of social science research methods. Includes presentations by faculty and students. Intended for doctoral students in environmental social sciences. Students wishing to earn more than one credit will prepare an additional separate paper on topic with approval of instructor. Permission of instructor required. Instructor: Kramer or Smith. Variable credit.

835. **Environmental Law.** Examination of rapidly growing body of law concerned with interrelationships between human activities and the larger environment. Focus on rationales for environmental protection; risk assessment and priorities. Instructor: Salzman. 3 units. C-L: see Energy 835

838. **Environmental Modeling: A Bayesian Perspective.** Introduction to Bayesian hierarchical and Bayesian networks models and their applications in water quality modeling and assessment. Offered in Spring. Instructor: Reckhow. 2 units.

841. **Ecological perspectives: Individuals to communities.** Enrollment: Ph.D. students only. 4 units. C-L: see University Program in Ecology 701; also C-L: Biology 841

842. **Ecological perspectives: Ecophys to Ecosystems.** A comprehensive course on the processes and factors that determine the capture and flow of energy and materials through individual organisms, populations, and entire ecosystems, both natural and disturbed. Interactions between ecosystem processes and the determinants of species number, and home range link this course to material covered in University Program in Ecology 701. Focus on human impacts that affect the movements of energy and materials in ecosystems. Studies of paleoecology provide a historical context for current patterns of global change. Instructor: Staff. 4 units. C-L: see University Program in Ecology 702; also C-L: Biology 842

848S. **Seminar in Toxicology.** A weekly research seminar throughout the year is required of participants in the Toxicology Program. Students, faculty, and invited speakers present their findings. Instructor: Levin. 1 unit. C-L: see Pharmacology and Cancer Biology 848S

851S. **Environment and Development Economics.** Readings course surveys range of important natural resource and environmental issues in developing countries. Emphasizes use of economic principles to understand these issues and to formulate effective policy responses to them. Course has theoretical content, but deals with theory more qualitatively than mathematically. Provides an opportunity for learning how economic theory taught in other courses can be applied to natural resource and environmental issues in developing countries. Course objective: familiarize students with key portions of literature on environment and development economics and foster students’ abilities to read this literature critically and after graduation. Instructors: Vincent or Pattanayak. 1.5 units. C-L: Public Policy Studies 827S

852. **Spatial Analysis for Ecologists.** Descriptive and inferential statistics for spatial data as encountered in community and landscape ecology. Course covers spatial point patterns (e.g., clustering in plant communities), geostatistical samples (e.g., species-environment relationships inferred from spatially distributed samples), and lattices (e.g., maps, networks). Emphasis on hands-on applications with ecological data sets. Students may analyze their own datasets as a term project. Prerequisites: Introductory statistics, basic ecology, or consent of instructor. Taught in alternate, odd-numbered years, spring semester. Instructor: Urban. 3 units.
853. Advanced Topics in Landscape Ecology. Small groups of students working together to complete a project in landscape analysis integrating remote sensing, geographic information systems, spatial analysis, and simulation modeling. Expectation is that each student will have experience in at least one of these areas. Consent of instructor required. Offered on demand. Instructors: Halpin and Urban. Variable credit.

854. GIS Analysis for Conservation Management. This course explores applications of geographic and spatial analysis to conservation management issues such as habitat analysis, biodiversity protection assessments, and nature reserve design. The primary goals of the course are: (1) to critically assess the theoretical underpinnings of conservation analysis techniques; and (2) to develop a high level of proficiency in the application of geographic and spatial analysis techniques for conservation management problems. Prior experience with GIS systems and consent of instructor required. Instructors: Halpin and Urban. 3 units.

856. Environmental Fluid Mechanics. Introduction to turbulent fluid flow and Navier Stokes equations; basic concepts in statistical fluid mechanics; development of prognostic equations for turbulent fluxes, variances, and turbulent kinetic energy; Monin and Obukhov similarity theory for stratified turbulent boundary layer flows; applications to CO2, water vapor, and heat fluxes from uniform and nonuniform surfaces; the local structure of turbulence and Kolmogorov's theory; turbulent energy transfer and energy cascade between scales; turbulence measurements in the natural environment. Prerequisite: Civil Engineering 301L, Mathematics 230, or equivalent. Instructor: Katul. 3 units.

857L. Satellite Remote Sensing for Environmental Analysis. Environmental analysis using satellite remote sensing. Theoretical and technical underpinnings of remote sensing (corrections/pre-processing, image enhancement, analysis) with practical applications (land cover mapping, change detection e.g. deforestation mapping, forest health monitoring). Strong emphasis on hands-on processing and analysis. Will include variety of image types: multi-spectral, hyper-spectral, radar and others. Prerequisite: familiarity with GIS. Instructor: Swenson. 4 units.

858. Multivariate Analysis for Ecologists. All of nature is multivariate, and this course embraces this richness. Two general approaches include classification (creating discrete groups) and ordination (emphasizing continuous trends in data). Ecological applications include habitat classification and species distribution modeling, clustering (i.e., community classification), and ordination-based approaches to integrated assessment. Prerequisites: Introductory statistics, basic ecology, or consent of instructor. Taught alternate (even-numbered) years, spring semester. Instructor: Urban. 3 units.

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868. Natural Resources Law. Focus on constitutional, statutory, and common law governing the legal status and management of federal lands and natural resources. Instructor: Salzman. 2 units. C-L: see Law 368

869. Environmental Law Clinic. Under supervision of Law clinical faculty, students work on current case and policy advocacy priorities as determined by Clinic's Intake Board. Cases and issues undertaken by the Clinic will vary by semester. Skills training emphasizes skills needed to counsel clients, examine witnesses and to advocate effectively in rulemaking and litigation settings. One semester enrollment; 2 semesters with instructor consent. Minimum 100 hours of clinic work per semester plus weekly group training meetings. Must be in second or third semester in Nicholas School to enroll. Suggested for students to also enroll in Environment 835, Environmental Law. Instructor: Longest and Nowlin. 4 units.

870. Fire Ecology and Management. Principles underlying field of fire ecology and skillful application of fire to meet land management objectives are explored through guest lectures, training sessions, readings and assignments. Specific topics range from history of fire in America, to role of fire in landscape change, to relationship of fire to climate change. Prescribed burning and use of fire in the contemporary landscape are important topics in the class. Instructor: Richter. 1 unit.

871. Fish As Models For Disease Research. Fish serve as models for disease research in genetic regulation of development, aging, cancer and high throughput screening of drugs and toxins. Due to their importance in human nutrition, fish are a central part of resource assessment following oil spills. To better appreciate fish as models and sentinels, this course will include coverage at all levels of biological organization and will acquaint the student with current methods, approaches and analyses. Instructor: Hinton. 4 units.

891. Topics in Environmental Regulation. In-depth analysis of current issues in environmental regulation. Topics vary. Course may be repeated. Instructor: Bennear. 1.5 units. C-L: see Energy 891
898. Program Area Seminar. Required symposium in each program area. Students present master’s project research. Pass/fail grading only. Instructor: Staff. 1 unit.

899. Master’s Project. An applied study of a forestry or environmental management problem or a theoretical research effort. A seminar presentation of the objectives, methodology, and preliminary findings is required. A written (or other medium) report at the conclusion of the project is also required. Undertaken with the guidance of the student’s adviser. Consent of instructor required. Pass/fail grading only. Instructor: Staff. Variable credit.

Duke Environmental Leadership (DEL) Courses (ENVIRON)

The following courses are offered to students enrolled in the Duke Environmental Leadership program. Other MEM/MF students can take these courses numbered 900-939 only with permission of the instructor and if space is available. Courses are held primarily online, using webconferencing technology.

905. DEL: Environmental Communication for Behavior Change. Course provides environmental professionals with a practical introduction to the strategies, methods, and tools of environmental communication that effectively lead to changes in behavior. Emphasis on practical, field-based tools. Intensive online course. Consent of instructor required. Instructor: Day. 1 unit.

906. DEL: Social Media for Environmental Communication. This six-week distance learning course is offered by Duke Environmental Leadership. Students will become competent in the basic features and functions of popular social media tools. Students will understand the advantages and limitations of these tools and be able to choose the most appropriate ones for their programs. Students will become comfortable communicating through various social media tools and be able to incorporate these tools into a larger communication plan. Instructor: Thaler, Besch, Nevius. 1 unit.

907. DEL: Writing for Environmental Professionals. Writing in environmental fields encompasses many genres, from policy memos to manuals, blog posts to interpretive signs. This course will allow you to refine and reflect on your writing process. For some, the course may serve as a tune-up; for others, a significant remodeling. Through six modules, online discussion, and a series of writing assignments, we will examine the more important aspects of any piece of professional writing: organization, use of evidence, clarity and cohesion, and incorporating feedback during the revision process. The goal is for your writing to become more powerful as a result of this work. Instructor: Cagle and Besch. 1 unit.

924. DEL: Agriculture and Sustainability. Introduces agroecology through basic scientific knowledge of plant physiology and growth for crop production, crop diversity and breeding, and comparison of agricultural practices (industrial, subsistence, organic, sustainable). Covers resources needed for whole-plant growth, biomass output for human use including bioenergy, and impacts on ecosystems. Examines environmental sustainability through assessment of drawbacks and benefits of agricultural practices for human food and biofuel production. Applications include management plan for sustainable agroecosystems and forecast of crop agricultural practices in need of a future altered environment. Prerequisites: Intro Biology or Ecology. Instructor consent required. Instructor: Reid. 3 units.

935. DEL: Social Science Research Methods & Design. Provides students with introduction to theory and practice of social science research methods and design. Intended for students who wish to learn both qualitative and quantitative research methods or who wish to combine natural and social science questions and methods into their research. Through lecture, discussion of readings and case studies, and review of research proposals of their peers, students will become proficient at not only social science theory, but at producing a sound and well-designed research proposal. Instructor consent required. Instructor: Shapiro. 3 units.

955. DEL: Community-Based Environmental Management. Course combines analysis of potential problems and pitfalls involved in community-based environmental management with discussion of the tools necessary to create and manage these projects. Focus is on discussion of academic literature with presentations of specific case studies and analysis of a community program in students’ proximity. 3 units.

958. DEL: Applied Qualitative Research Methods. Broadly covers qualitative and mixed methods research design, analysis, and interpretation. Students gather a limited amount of their own data and produce a pilot research project throughout the semester. Students learn to use NVivo10, a qualitative research software program. Instructor consent required. Instructor: Clark, Charlotte. 3 units.


962. Duke Environmental Leadership: Economics of Environmental Management. An economic perspective on the management of env. resources. Conceptual topics emphasized include env. externalities, market failure, public goods, sustainability, and benefit-cost analysis. Applications illustrate the role of price signals in energy choices, managing renewable resource use over time, use of marketable pollution permits to encourage voluntary reductions in air and water pollution, and the political economy of env. policy formulation. Case studies examine carbon trading and taxes to address climate change, and economic incentives and values for biodiversity conservation. DEL-MEM students only. Online course. Instructor: Murray. 3 units.

963. DEL: Program Management for Environmental Professionals. In the private and public sectors, as well as not-for-profit organizations, managerial effectiveness is central to environmental leadership. This course will focus on the development of management skills including decision-making, motivation, working in teams, organizational cultures, organizational design, learning organizations and change management. Open to Duke Environmental Leadership Master of Environmental Management students only. Instructor: Shapiro. 3 units.

964. Duke Environmental Leadership: Environmental Law and Policy. Environmental policies have evolved from strict reliance on command and control systems to experimentation with alternative approaches. In this course students study this evolution by first examining the history and context of U.S. policy development processes and institutions. Command approaches to air and water pollution and waste management are considered along with alternative approaches, such as market-based programs, public-private partnerships and voluntarism. Policies for managing land, natural resources, species protection and addressing transnational and global environmental problems are examined. Policy implementation and devolution of responsibilities to state and local governments and the private sector is stressed. Open to Duke Environmental Leadership Master of Environmental Management students only. Online course. Instructor: Gallagher. 3 units.

965. DEL: Environmental Leadership Module. One of the driving themes of the DEL-MEM Program is leadership. We believe that leadership is cultivated by each individual and requires time and effort; it is a process. Participation in the DEL-MEM program will put students one step closer in their leadership pursuit by providing opportunities to assess and enhance leadership skills, building confidence in critical and creative thinking, communication, collaboration and conflict resolution. This course is designed to orient students towards these goals. More specifically, to provide a framework and point of reference for students’ leadership development. During the three-day session, we will explore leadership in a variety ways, including individual meetings with prominent leaders in the field, discussions, and case study project. Students will also experience Washington, D.C. through a tour of the Capitol, meetings with Congressional members and staff, and time on the Mall. Open to Duke Environmental Leadership Master of Environmental Management students only. Instructor: Gallagher. 3 units.

966. DEL: Professional Writing Course. This course teaches skills and strategies to make the writing process less intimidating and written work more clear and powerful. Comprised of online writing modules that provide examples of excellent nonfiction writing with the goal of identifying what makes the writing successful. Students develop and sharpen their own writing skills through incorporating feedback from a series of drafts. Student writing is reviewed in various forums-including writing workshops, peer reviews, and teacher conferences-to provide detailed feedback, allowing students to rethink and revise their writing. Open to Duke Environmental Leadership Master of Environmental Management students only. Online course. Instructor: Cagle. 1 unit.
967. DEL: Environmental Communications Planning. Acquire necessary tools for environmental professionals to write successful and comprehensive communications plans. Students engage in developing a full communications plan, including identifying stakeholders and appropriate media, crafting messages, and evaluating success of delivery. Complements DEL: Environmental Communications for Behavior Change. Online course. Instructor: Vidra. 1 unit.

972. DEL: Making Environmental Decisions. In environmental management, things don't always turn out as expected. You must address multiple goals, even when those goals themselves conflict. You must respond to diverse stakeholders, with varying worldviews. The tools of decision analysis help you to - going beyond unaided intuition - organize and analyze difficult environmental management decisions. This course covers quantitative methods for analyzing environmental problems involving uncertainty and multiple, conflicting objectives. Topics include subjective probability, utility, value of information, and multiattribute methods. Students will apply these tools to an environmental policy decision in a group or individual project. Open to Duke Environmental Leadership Master of Environmental Management students only. Online course. Instructor: Kasibhatla. 1 unit.

973. DEL: Business Strategy for Environmental Sustainability. Businesses are increasingly applying strategic management tools to incorporate considerations of sustainability into decision-making and operations. Course focuses on the development and implementation of strategies to promote environmental sustainability. Students examine roles and responsibilities of sustainable strategic managers and learn how to apply the tools of strategic management: external analysis, forecasting and stakeholder management to problems of sustainability. Business case studies are used. Instructor consent required. Online course. Instructor: Maguire. 3 units.

974. DEL: Seeing the Big Picture: Lessons from Watershed Management in California. This course is an exploration of the interdisciplinary and often controversial nature of watershed management in California using examples from arguably the most manipulated and well-studied watershed in the US. These problems and their solutions are relevant to all watersheds. Topics include: host factors governing fish and wildlife responses and effects; fate, transport, and biogeochemistry of agricultural chemicals; exotic species introduction; economics considerations governing water allocations storage; transport, and conservation; and conflict resolution efforts between competing interest groups. Instructor consent required. Online course. Instructor: Hinton. 3 units.

975. DEL: Community Based Environmental Management in Mexico. Class offers students a focused introduction to the general history of rural common property governance and resource politics and management in Mexico and to the specific history and current context of community environmental management in Oaxaca. Requires participation in week long field trip (spring break) to Oaxaca (additional costs involved). Prerequisite: ENVIRON 755 or ENVIRON 955. Instructor consent required. Instructor: Shapiro, Elizabeth. 2 units.

976. DEL: Restoration Ecology: Practice and Principles. Class explores the fundamental principles of ecological restoration, environmental history, and social context. Faculty and students will use the restoration process as a framework and will focus on how the science informs the practice and vice versa. Requires participation in week long field trip over spring break to Hawaii. Instructor consent required. Instructor: Vidra. 2 units.

977. DEL: Classic Environmental Literature. Classic environmental literature shapes contemporary discourse about environmental issues. These texts also reveal our relationships with nature and offer new approaches to living with our environment. In this class, we will consider six classic works: Walden, A Sand County Almanac, Silent Spring, Limits to Growth, Small is Beautiful, and Our Common Future. Using close reading, discussion, and written reflection, we will analyze both the social and environmental context, as well as the enduring impact, of each work. Instructor consent required. Online course. Instructor: Cagle. 2 units.

978. DEL: Energy and Environment Today. This course will provide students with a broad overview of why and how we use energy, the complex system that has evolved for furnishing energy, the challenges that our energy use has spawned, specifically with respect to the environment, and possible paths to a sustainable energy future. The course is designed to give students a framework for thinking about why energy-related events are happening, what that means for future energy uses and societal well-being, and how we might change the system moving forward. For DEL-MEM students only. Instructor consent required. Online course. Instructor: Pratson. 1 unit.

979. DEL: Contemporary Scientific Understanding of Climate Change. This course will provide students with a broad, policy-relevant overview of contemporary scientific understanding of climate change. The recently released IPCC Fourth Assessment Report (IPCC AR4) titled ‘Climate Change 2007’ will provide the framework for discussion of various aspects of climate change, including the fundamental physical science basis, potential impacts and vulnerability, and mitigation of climate change. Instructor consent required. Instructor: Kasibhatla. 1 unit.
980. DEL: California Water Management Field Trip. California has long been the poster child for conflict over water management and appropriation. Much of that conflict has focused on the diversion of water from the Sierra Nevada and the Great Central Valley. In this 5-day field course we will provide an overview of the hydrology and history of water development of the Central Valley, and focus on three case studies: Hetch Hetchy, the Californian Aquaduct, and the re-watering of the San Joaquin River. Instructor consent required. Instructor: Christensen and Hinton. 1 unit.

982. DEL: Sustainable Development in Chile. In this 5-day field course we will provide an overview of international sustainable development in Chile, while focusing on environmental management at the government level, sustainable forestry, fisheries, and wineries, and eco-tourism. Instructor consent required. Instructor: Gallagher. 2 units.

983. DEL: Green Development. Students will explore the varying definitions of green development; how it is applied at the community, site, and building level; what it can cost; how it can create economic, social and environmental values; how it can be measured; who is practicing and implementing it; how it is financed; and what third-party standards exist to verify it. Explore new opportunities and new models for green development along with its various challenges and limitations. Examine these topics through structured discussion boards, readings, lectures, conference calls, memorandum writing, analytical exercises and group presentations. Instructor consent required. Online course. Instructor: Wedding. 3 units.

985. DEL: Energy, Environment and the Law. Examines legal framework governing energy production and consumption in US, environmental issues associated with the nation’s energy sectors, and policy approaches for balancing energy needs with environmental protection. Three main sections: state utility regulation; energy resources for electricity generation; petroleum. Instructor consent required. Online course. Instructor: Monast. 3 units.

986. DEL: Environmental Ethics and Advocacy. Are you an environmentalist? Do we have a moral obligation to protect the planet? Can we imagine solutions to the environmental crises that are powerfully possible? In this course, we will step back from the details of ecology and conservation, energy and economics to consider the big picture of the environmental movement and our role within it. To inspire our thinking, we will draw on a collected set of essays that address climate change, specifically, and other readings to broaden our thinking about what it means to be an environmentalist. We will also examine the recent history of the environmental movement and the criticisms that have come from within and outside that movement. By examining the ethical frameworks of the contemporary environmental movement, students will gain a more nuanced perspective of the role and challenges of advocacy. Instructor consent required. Online course. Instructor: Vidra. 2 units.

987. DEL: Contemporary Environmental Issues. This course examines a broad range of contemporary environmental issues, including climate change impacts, endangered species conservation, and environmental health. This examination draws from the most-cited and recent peer-reviewed literature, current academic texts, and essays from popular literature. During the course, you will practice weighing evidence, synthesizing research, and articulating your perspective through written reflection and discussion. Discussions will also give you the opportunity to moderate conversations on hot-button issues. Instructor consent required. Online course. Instructor: Cagle. 2 units.

990. DEL: Special Topics. Content to be determined each semester. May be repeated. Instructor: Staff. Variable credit.

997. Duke Environmental Leadership: Independent Studies and Projects. Directed readings or research at the graduate level to meet the needs of individual students. Open to Duke Environmental Leadership-Master of Environmental Management students only. Instructor consent required. Instructor: Staff. Variable credit.

999. Duke Environmental Leadership: Master's Project. An applied study of a forestry or environmental management problem or an original research effort. A seminar presentation of the objectives, methodology, and preliminary findings is required. A written (or other medium) report at the conclusion of the project is also required. Undertaken with the guidance of the student's advisor. Open to Duke Environmental Leadership Master of Environmental Management students only. Consent of instructor required. Instructor: Staff. 4 units.
Biology (BIOLOGY)

205. Marine Megafauna. Ecology, systematics, and behavior of large marine animals including giant squid, bony fishes, sharks, sea turtles, seabirds, and marine mammals. Relations between ocean dynamics, large marine animals, and their role in ocean food webs. Impact of human activities and technological advancement on populations. Economic, social, and policy considerations in the protection of threatened species. Prerequisite: AP Biology, Introductory Biology, or consent of the instructor. Instructor: Johnston. 1 unit. C-L: Environment 205

Earth and Ocean Sciences (EOS)

89S. First-Year Seminar. Topics vary each semester offered. Instructor: Staff. 1 unit.

101. The Dynamic Earth. Introduction to the dynamic processes that shape the Earth and the environment and their impact upon society. Volcanoes, earthquakes, seafloor spreading, floods, landslides, groundwater, seashores and geohazards. Emphasis on examining the lines of inductive and deductive reasoning, quantitative methods, modes of inquiry, and technological developments that lead to understanding the Earth's dynamic systems. Instructors: Klein or Glass. 1 unit.

102. The Dynamic Oceans. The oceans and their impact on the Earth's surface, climate, and society. Topics include seafloor evolution, marine hazards, ocean currents and climate, waves and beach erosion, tides, hurricanes/cyclones, marine life and ecosystems, and marine resources. Emphasis on the historical, society and economic roots of oceanography, the formulation and testing of hypotheses, quantitative assessment of data, and technological developments that lead to understanding of current and future societal issues involving the oceans. Includes a field trip at the Duke University Marine Laboratory. Instructors: Glass. 1 unit. C-L: Biology 157


202. Atmosphere and Ocean Dynamics. Introduction to the dynamics of ocean and atmospheric circulations, with particular emphasis on the global climate cycle. Prerequisites: Mathematics 21 and 122, Physics 141L or consent of instructor. Instructor: Lozier. 1 unit.


226S. Field Methods in Earth and Environmental Sciences. Introduction to basic field methods used in the earth and environmental sciences. Field investigations focus on topics such as groundwater and surface water movements, soil chemistry and identification, topographic and geologic mapping, the atmosphere/soil interface, and plant identification and distributions. Design of a field investigation, collection of data to address a specific goal, and interpretation and reporting of the results. Emphasis on learning to report field results in the format of scientific publications. Visits to five local field sites. Open only to juniors and seniors. Instructor: Klein or Dwyer. 1 unit. C-L: Environment 226S


315. Waves, Beaches, and Coastline Dynamics. Oceanographic and geologic processes responsible for the evolution of nearshore features; fluid motions of many time scales in the nearshore environment, including waves and currents. Conceptual basis for models of how fluid motions interact with the shape of the beach and bed in the surf zone, giving rise to features such as beach cusps, bars, channels, and barrier islands. Various attempted engineering and coastal management solutions to the global retreat of shorelines. Instructor: Murray. 1 unit.

316A. Beach and Island Geological Processes. Field seminar on the evolution of beaches and barrier islands with emphasis on the interactions between nearshore processes and human development. Prerequisite: Earth and Ocean Sciences 315/515 or consent of instructor. Also taught as Earth and Ocean Sciences 716A. Instructor: Murray. 0.5 units.
323. **Landscape Hydrology.** An introduction to hydrology by examining how rainfall and snowmelt become streamflow, evapotranspiration, and groundwater with emphasis on hydrological processes inside watersheds. Topic areas include: hydrologic cycle and water balances, evapotranspiration and snow energy balances, vadose zone hydrology, hydrogeology, hyporheic zones, riparian zones, streamflow generation mechanisms, biogeochemical budgets, and field measurement techniques. Linkages between physical hydrology and broader ecological and environmental sciences will be highlighted. Includes local field trips. Instructor consent required. Instructor: McGlynn. 1 unit.

325. **The Anthropocene: The Next Epoch of Geologic History.** Introduction to the next epoch of geologic history. The evolution of the technosphere, the global human-technological system that increasingly dominates biology, hydrology, and other major natural earth systems. The future of the earth and humanity. Instructor consent required. Prerequisite: Earth and Ocean Sciences 101 or 203. Instructor: Haff. 1 unit.

330. **Energy and the Environment.** Overview of the challenges confronting humanity as a consequence of our reliance on energy. Challenges include dwindling supplies, rising demand and environmental degradation. Realistic responses require an understanding of the complexity of the energy system, including energy resources, uses, and impacts, in the context of social, political and economic imperatives. Lectures will be augmented by presentations from guest speakers from industry, government and non-profit organizations. Instructor: Pratson. 1 unit. C-L: see Energy 330

341. **Dinosaurs with Feathers and Whales with Legs: Major Evolutionary Transitions in the Fossil Record.** Focus on the fossil record of the differentiation of the major vertebrate groups. Study and critical evaluation of the paleontological and neontological evidence for four major macroevolutionary transitions in the history of life: fish to tetrapods, the reptile/mammal differentiation, the evolution of birds from dinosaurs, and the origin of whales. Stresses the importance of the fossil record in the reconstruction of transitions but also covers genetic, physiological, and developmental evidence gathered from living representatives. Prerequisite: Prior course work in Earth and Ocean Sciences or Biology or consent of instructor. Instructor: Glass. 1 unit. C-L: Biology 345

355. **Global Warming.** Broad, interdisciplinary course on the science of global warming, the evidence for climate change and anthropogenic forcings. Includes coverage of weather and climate, greenhouse gases, paleoclimate studies, climate models, and future projections. Course also includes thorough analysis of climate change denial and the politics of global warming in the United States. Instructor: Glass. 1 unit.

358. **Introduction to Satellite Remote Sensing.** Introduction to the field of remote sensing and approaches used in image processing and analysis of remote sensing data. Students will acquire an operational knowledge of various remote-sensing tools and data types, with emphasis on their application in environmental and earth science problems. Content will include theory, in-class laboratory exercises, and projects with environmental applications. Prerequisite: introductory or AP physics preferred. Instructor: Silvestri. 1 unit. C-L: Environment 358

359. **Fundamentals of GIS and Geospatial Analysis.** Fundamental aspects of geographic information systems and satellite remote sensing for environmental applications. Concepts of geographic data development, cartography, image processing, and spatial analysis. Instructor: Cleary. 1 unit. C-L: see Environment 359

364S. **Changing Oceans.** Our oceans are under severe stress. This seminar will explore human disturbances of marine environments, including ocean warming, sea level rise, melting of ice caps and sea ice, ocean acidification, coastal eutrophication, changes in primary production and food web dynamics, invasive species, overfishing, increased subsurface hypoxia, changes in circulation, stratification, and physical, chemical (e.g. oil spills) and noise pollution. Instructor: Cassar. 1 unit. C-L: Environment 362S

365. **Introduction to Weather and Climate.** Introduction to weather and climate. Topics include atmospheric structure, composition, circulation and energy properties; severe weather events such as cyclones, hurricanes, and tornados; ozone depletion; natural climate variability; climate change and global warming. Instructor: Li. 1 unit.

385K. **Water Resources.** Fundamental concepts of aquatic geochemistry and biogeochemistry applied to water pollution and resources. Marine and freshwater case studies will be presented. Taught at Duke Kunshan University. Instructors: Cassar and Vengosh. 1 unit.

390. **Special Topics in Earth and Ocean Sciences.** Content to be determined each semester. Consent of instructor required. Instructor: Staff. 1 unit.
391. Independent Study. Directed reading or individual projects. Term paper required. Open only to qualified juniors and seniors by consent of director of undergraduate studies and supervising instructor. Instructor: Staff. 1 unit.

392. Independent Study. See Earth and Ocean Sciences 391. Term paper required. Open only to qualified juniors and seniors by consent of director of undergraduate studies and supervising instructor. Instructor: Staff. 1 unit.

393. Research Independent Study. Individual research in a field of special interest under the supervision of a faculty member, the central goal of which is a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. Open only to qualified juniors and seniors by consent of director of undergraduate studies and supervising instructor. Instructor: Staff. 1 unit.

394. Research Independent Study. See Earth and Ocean Sciences 393. Open only to qualified juniors and seniors by consent of director of undergraduate studies and supervising instructor. Instructor: Staff. 1 unit.

402S. Volcanology: Geology of Hawaii. Geology of volcanic processes and the benefits and hazards they present to society. Lectures, discussion and student presentations of independent research reports. Required field trip to Hawaii during spring break. Prerequisite: Earth and Ocean Sciences 101 recommended. Consent of instructor required. Instructor: Boudreau. 1 unit.


404S. Geology of Tropical Marine Environments. Spatial and temporal analysis of the geology of tropical shallow marine environments. Includes class discussions, required spring-break field trip to South Florida, Belize, Turks and Caicos Islands, or similar setting, in-class and field trip presentations, post-trip research paper. Examination of tropical shallow marine sedimentary environments including reefs, mudbanks, and mangrove forests and islands, and their ancient counterparts in rock outcrops and sediment cores. Includes a field trip with a required fee for the trip. Prerequisite: Earth and Ocean Sciences 101 or 102, or consent of instructor. Instructor: Dwyer. 1 unit.

405S. The American Southwest. Geomorphic and geologic features of arid terrain, including volcanism, tectonics, soils and weathering, paleo-lakes, wind-blown sand and dust, landslides, and alluvial fans. Reconstruction of paleo-landscape processes based on observations of present landforms. Interpretation of landform development and process from geomorphic field evidence. Focus on the Mojave Desert region of California and Nevada. Includes week-long field trip with fees required for the trip. Prerequisite: Earth and Ocean Sciences 101, and consent of instructor. Instructor: Haff. 1 unit.

410S. Senior Capstone Experience. Senior capstone field trip course. Field location varies. Topics in geology, hydrology, biology, climate, and other environmental subjects as appropriate for field area, especially human impact on the earth and the role of earth scientists as observers and teachers of earth-system change. Course content partially determined by students. Prerequisites: Open only to senior Earth and Ocean Sciences majors. Department consent required. Instructor: Staff. 1 unit.

507S. The Amazon: Geology, Climate, Ecology, and Future Change. This course will study the natural history of the Amazon including its biodiversity, geological evolution, and modern climate and hydrology. The present development of the Amazon and best strategies for its future conservation will be discussed. Instructor: Baker. 3 units.


509S. Paleoclimate. Nature and mechanisms of climate variability throughout Earth history. Topics include general theory of climate, paleoclimate modeling and comparisons with observations, methodologies of reconstructing past climate variations, the observational record of paleoclimate extending from the Precambrian through the Ice Ages and Holocene to present, and the impact paleoclimate on biotic evolution/paleogeography and human cultural history. Consent of instructor required. Instructor: Baker. 3 units.
510S. **Paleoenvironmental Analysis.** Methods of paleoenvironmental and paleoclimatic analysis. Includes radiometric and other methods of dating, stable isotopes, trace elements, paleobiotic and other methods of reconstructing climate, hydrology and environment of the past. Also includes approaches to modeling paleoenvironmental data. Instructor: Baker. 3 units.

511. **The Climate System.** Components of the climate system: observed climate change, concept of energy balance, basic circulation of the atmosphere and ocean, introduction to climate models, sample applications of climate models, interactions between the atmosphere/ocean and biosphere, land surface, cryosphere (snow and ice), and chemistry of the atmosphere. Prerequisite: consent of instructor. Instructor: Staff. 3 units.

512. **Climate Change and Climate Modeling.** Course aims to provide knowledge and understanding of physics of climate system and Earth system modeling for scientists, engineers and policy students with physics and mathematics background. Fundamental principles controlling physical and dynamic structure of climate system; discussion of relative roles of natural climate variability and external forces and anthropogenic influences. Explore numerical methods, develop computing skills, and deal with data handling as a means to an end of quantifying climate system behavior. Pre-requisite: Earth and Ocean Sciences 511. Instructor: Li. 3 units.

514. **Energy and Ecology.** Develop understanding of interactions between energy and ecology. Examine ecological effects of energy use, production and waste products. Examine ecological consequences of energy use broadly, and discuss potential consequences of science and policy decisions. Prerequisite: introductory college course in ecology or equivalent. Instructor: Jackson. 3 units.

515. **Mountain Ecohydrology Field Course -Montana.** Study of watershed ecohydrology and the interactions and feedback among hydrological and ecological processes in the western United States. Includes required pre-semester week-long field trip to Montana (with required fee), where participants visit active research watersheds, some of the most intensively instrumented ecohydrological research sites in the country. Students learn techniques to collect hydrologic and ecological field data and work with instructors to collect a comprehensive suite of ecohydrological data, to be interpreted and presented during series of follow-up class meetings. Prerequisite: General background in Earth and Environmental Sciences. Instructor: McGlynn. 3 units.

520. **Introduction to Fluid Dynamics.** Conservation equations for mass, momentum and heat, with an emphasis on large temporal and spatial scales; application to the earth, ocean, and environmental sciences. Some background in differential equations highly recommended. Instructor: Lozier. 3 units.

524. **Water Quality Health.** Explore basic concepts of water quality and human health with focus on the global water cycle, global water demand and availability, chemical properties of water, contaminants in water, health implications, and environmental isotope hydrology. Highlights relationships between human activities, water scarcity, water quality degradation, and ecological and health consequences. Addresses some policy implications related to conflicts over water resources and impact of energy production on water resources. Prerequisites: prior knowledge of introductory calculus and chemistry or consent of instructor. Instructor: Vengosh. 3 units. C-L: Environment 524, Global Health 534, Energy 524

525. **Fundamentals of Water Biogeochemistry and Pollution.** Course is designed to present students with a comprehensive introduction to the sources and impacts of pollution in marine and freshwater environments. Fundamental concepts and principles of aquatic biogeochemistry will first be introduced: marine and freshwater chemistry, primary production and food webs. Topics to be covered include biological (e.g. pathogens, invasive species), physical (e.g. thermal, plastics), and chemical (e.g. nutrient loading, oil, pesticides, metals) pollutants. Instructor: Cassar. 3 units.

526S. **Water Forum Speaker Series.** Seminar including visiting scholars covering a broad array of issues on water including water quality, hydrogeology, biogeochemistry, water management, water treatment, ecology, water economy, and water policy and law at both the national and international levels. Instructor: Vengosh. 3 units.

527. **International Water Resources.** Overview of the hydrology, hydrogeology, water quality, and management of major international water resources. Focus on cross-boundary international rivers and aquifers, up-stream versus down-stream water users, the politics of water sharing and disputes, the role of science in water management, and prospects and implications for future utilization of contaminated rivers and stressed aquifers. Examples from international rivers such as the Tigris, Euphrates, Nile, Jordan, Colorado, Indus, Ganges, and Mekong and international aquifer systems such as the Mountain aquifer, Gaza Strip, Disi, and Nubian basins in northern Africa. Instructor: Vengosh. 3 units.
528S. Biological-Physical Couplings in Coastal Environments; Responses to Changing Forcing. Focus on select examples of biological-physical couplings that shape coastal environments (i.e. coastal "ecomorphodynamics") and help determine how those environments respond to changing climate and land use. Environments include: barrier islands, tidal wetlands. Grading based on in-class presentations, and a final project (in the form of a research proposal). Instructor consent required. Instructor: Murray. 3 units.


542S. New Perspectives and Methods in Surface Process Studies. Nonlinear dynamics and related approaches to understanding, modeling, and analyzing physical systems, with emphasis on applications in geomorphology. Consent of instructor required. Instructor: Murray. 3 units.

543S. Landscape Dynamics. How landscape changes with time. The dynamics and mechanisms of earth surface processes underlying landscape change. Hillslope, fluvial, marine, glacial, volcanic, tectonic and aeolian processes. Reading and discussion of primary literature; several field trips to Duke Forest. Prerequisite: Earth and Ocean Sciences 101 or consent of instructor. Instructor: Haff and Pratson. 3 units.

544S. Geotechnics. Discussion of proposals for large-scale intentional modification and/or control of climate. Physical mechanisms, intended benefits, risks, costs, scenarios for deployment, historical analogs, possible unintended physical and social consequences, ethical dilemmas, oath for earth and environmental scientists. Prerequisite: one course in Earth and Ocean Sciences or consent of instructor. Instructor: Haff. 3 units.

551S. Global Environmental Change. Topics in the seminar will include climate change, earth surface alteration, prediction, water and carbon cycling, sea-level rise and coastal erosion, biodiversity, fossil fuels and energy resources, water resources, soil fertility, human impact on coastal zone ecosystems. Prerequisite: consent of instructor. Instructor: Baker. 3 units.

567. Analyzing Time and Space Series. Ways to extract information from data; methods for probing time or spatial series including spectral and wavelet analyses, correlation techniques, and nonlinear-dynamics approaches for determining how deterministic and linear the processes producing the data are, and for reconstructing and quantitatively comparing state-space plots. Instructor: Murray. 3 units.

569. Thermodynamics of Geological Systems. Introductory thermodynamics applied to geologic problems through understanding of phase equilibrium. Prerequisites: Earth and Ocean Sciences 201; and Mathematics 122 or consent of instructor. Instructor: Boudreau. 3 units.

571. Stable and Radioactive Isotopes in Environmental Sciences. Theory and applications of stable and radioactive isotope distributions in nature (including oceanographic, geologic, hydrologic, and biological processes). Prerequisites: Chemistry 210DL and Mathematics 122. Instructor: Baker or Vengosh. 3 units.

573S. Analytic Techniques. An introduction to advanced analytic procedures used in the earth sciences: such as electron microbeam techniques (scanning electron microscopy, electron microprobe analysis) and plasma emission/absorption spectroscopy. Consent of instructor required. Instructor: Boudreau. 3 units.


590. Special Topics in Earth and Ocean Sciences. Content to be determined each semester. Consent of instructor required. Instructor: Staff. Variable credit.

590S. Special Topics in Earth and Ocean Sciences. Content to be determined each semester. Consent of instructor required. Instructor: Staff. Variable credit.

710S. Bio-geomorphology: The Biophysical Processes Shaping the Earth's Surface. Course examines recent literature contributions shedding light on the two-way interactions among the biosphere, the atmosphere, the hydrosphere, and the lithosphere. Emphasis will be placed on the general emergent properties of coupled bio-physical systems, such as multistability, critical behavior, optimality, etc. Topics will include tidal bio-geomorphology, fluvial eco-hydrology, eco-hydrology of arid ecosystems, coastline dynamics, global biogeochemical cycles. Instructor: Marani. 1 unit.
715. Introduction to Coastal Environmental Change Processes. Nearshore physical processes responsible for the evolution of beaches and barrier islands. Various problems and possible solutions arising from human development of retreating shorelines. Involves a field trip and research paper. Instructor: Murray. 3 units.

722. Hydrologic and Environmental Data Analysis. Course will focus on acquisition of skills necessary to extract information from observations of hydrological and environmental processes, connect the extracted information with the physical processes generating the data, and estimate physical quantities at ungauged location/times. Emphasis on process understanding via data analysis techniques. Applications used as a way to understand the general concepts, with examples drawn from water science. Prerequisites: Basic computer skills, Algebra, Calculus are required. Experience with computational software (e.g. Matlab or R) is helpful but not required. Instructor: Marani. 3 units. C-L: Environment 722, Civil and Environmental Engineering 761

790. Special Topics in Earth and Ocean Sciences. Content to be determined each semester. Consent of instructor required. Instructor: Staff. 3 units.

790S. Advanced Topics in Geology. Topics, instructors, and credits to be arranged each semester. Instructor: Staff. Variable credit.


890A. Advanced Topics in Earth and Ocean Sciences. To meet the individual needs of graduate students for independent study. Instructor: Staff. Variable credit.

990A. Advanced Topics in Earth and Ocean Sciences. To meet the individual needs of graduate students for independent study. Instructor: Staff. Variable credit.

Energy (ENERGY)

239. Our Changing Atmosphere: From Air Pollution to Climate Change. Integrated scientific background for the impact of humans on the natural environment. Topics covered include greenhouse gases and climate, local and regional ozone pollution, long-range pollution transport, acid rain, atmospheric particulate matter pollution, and stratospheric ozone depletion. Pre-requisites: Chemistry 101DL. 1 unit. C-L: see Environment 239

310. Introduction to Energy Generation, Delivery, Conversion and Efficiency. An overall introduction to energy issues as they related to generation, delivery, conversion and efficiency. Topics include efficiencies of both new and established energy generation and conversion methods, electricity generation by fossil fuels, nuclear, solar, wind and hydropower and alternative energy technologies. Other topics include space heating and cooling by traditional methods and by solar, transportation energy in automobiles, mass transit and freight. Topics are evaluated quantitatively by modeling and using principles of fluid mechanics, thermodynamics and heat transfer. The environmental consequences of energy choices on local, national and global scales, including toxic emissions, greenhouse gases and resource depletion are also discussed in integrated throughout the course. Prerequisite: Mechanical Engineering 331L, or Mechanical Engineering 512, or Physics 311, or similar thermodynamics, or consent of instructor. One course. C-L: Energy 310. Course is not open to students who have taken Mechanical Engineering 461. Instructors: Cocks and Knight. 1 unit. C-L: see Energy Engineering 310

330. Energy and the Environment. Overview of the challenges confronting humanity as a consequence of our reliance on energy. Challenges include dwindling supplies, rising demand and environmental degradation. Realistic responses require an understanding of the complexity of the energy system, including energy resources, uses, and impacts, in the context of social, political and economic imperatives. Lectures will be augmented by presentations from guest speakers from industry, government and non-profit organizations. Instructor: Pratson. 1 unit. C-L: see Environment 330; also C-L: Earth and Ocean Sciences 330

395. Connections in Energy: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing energy issues. Teams may also include postdoctoral fellows, visiting energy fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires substantive paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 1 unit.
Courses of Instruction

395-1. Connections in Energy: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing energy issues. Teams may also include postdoctoral fellows, visiting energy fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires substantive paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 0.5 units.

396. Connections in Energy: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing energy issues. Teams may also include postdoctoral fellows, visiting energy fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires substantive paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 1 unit.

396-1. Connections in Energy: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing energy issues. Teams may also include postdoctoral fellows, visiting energy fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires substantive paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 0.5 units.

452L. Energy and Environment Design. An integrative design course addressing both creative and practical aspects of the design of systems related to energy and the environment. Development of the creative design process, including problem formulation and needs analysis, feasibility, legal, economic and human factors, environmental impacts, energy efficiency, aesthetics, safety, and design optimization. Application of design methods through a collaborative design project involving students from the Pratt School of Engineering and Trinity College. Open only to students pursuing the undergraduate certificate in Energy and Environment. Instructor consent required. Instructor: Klein. 1 unit. C-L: see Environment 452L

520. Resource & Environmental Economics I. Part 1 of a survey course in environmental and natural resource economics. Part 1 focuses on basic theory and methods of economic analysis of environmental problems including benefit-cost analysis, non-market valuation, and instrument choice. Prerequisite: Introductory course in microeconomics and one semester of calculus. Instructor: Bennear or Smith. 1.5 units. C-L: see Environment 520; also C-L: Economics 530, Public Policy Studies 576

524. Water Quality Health. Explore basic concepts of water quality and human health with focus on the global water cycle, global water demand and availability, chemical properties of water, contaminants in water, health implications, and environmental isotope hydrology. Highlights relationships between human activities, water scarcity, water quality degradation, and ecological and health consequences. Addresses some policy implications related to conflicts over water resources and impact of energy production on water resources. Prerequisites: prior knowledge of introductory calculus and chemistry or consent of instructor. Instructor: Vengosh. 3 units. C-L: see Earth and Ocean Sciences 524; also C-L: Environment 524, Global Health 534

590S. Advanced Topics in Energy. Selected topics vary by semester. Instructor: Staff. 3 units.

630. Transportation and Energy. Examination of transportation-related energy use and its impact on the environment. Learn how technology, infrastructure, and policy, as well as personal and cultural preferences, interact to meet demands for personal mobility and freight movement. Cutting across these themes will be consideration of strategies to reduce transportation energy use and its environmental impacts, with an introduction to information resources and tools for evaluating both. Provides opportunities to hone problem solving and analytical skills, and challenges students to think critically and creatively about the trade-offs among complex transportation options. Instructor: Johnson. 3 units. C-L: see Environment 630

635. Energy Economics and Policy. Economics of markets and policies for various energy supply sources, energy demand and efficiency, their interactions with each other, and with the economy and environment. Will explore
rationales for why markets for energy and related technologies have been subject to extensive government intervention. Course will analyze effects of policy responses, including energy price regulation, the interface of energy, environmental, and technology policy, and policy motivated by energy security concerns. Prerequisites: Introductory Microeconomics (Economics 101 or equivalent) and college calculus. Instructor: Newell. 1.5 units. C-L: see Environment 635

638L. Environmental Life Cycle Analysis & Decision. Provides theoretical foundations of environmental life cycle assessment tools and methods used for products and global supply chains. Introduces various life cycle inventory and life cycle assessment tools used by the community of scientists and industry. Instructor consent required. Instructor: Golden. 3 units. C-L: see Environment 638L

711. Energy and Environment. Overview of the challenges confronting humanity as a consequence of our reliance on energy. Challenges include dwindling supplies, rising demand and environmental degradation. Realistic responses require an understanding of the complexity of the energy system, including energy resources, uses, and impacts, in the context of social, political and economic imperatives. Lectures will be augmented by presentations from guest speakers from industry, government and non-profit organizations. Instructor: Pratson. 3 units. C-L: see Environment 711

716L. Modeling for Energy Systems. Introduction to computer programming and operations research in energy systems analysis with emphasis on formulation of optimization problems and simulation models. Applications and case studies dealing with energy systems problems, their externalities, and government policies that affect them. Data analysis, spreadsheet modeling, VBA programming in Excel; linear programming (lp), post-optimality and sensitivity analysis, multi-period lp, stochastic lp, network models for minimum path, maximum flow and optimal planning problems; probabilistic analysis Monte Carlo simulation, including generation of independent and correlated random variables, and goodness of fit tests. Instructor: Patino-Echeverri. 3 units. C-L: see Environment 716L

727. Energy Law. The course will examine the legal framework governing energy production and consumption in the United States, and policy approaches for balancing energy needs with other societal goals. Instructor: Monast. 3 units. C-L: see Law 327

795. Connections in Energy: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing energy issues. Teams may also include postdoctoral fellows, visiting energy fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires substantive paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 3 units.

795-1. Connections in Energy: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing energy issues. Teams may also include postdoctoral fellows, visiting energy fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 1.5 units.

796. Connections in Energy: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing energy issues. Teams may also include postdoctoral fellows, visiting energy fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires substantive paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 3 units.

796-1. Connections in Energy: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing energy issues. Teams may also include postdoctoral fellows, visiting energy fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will partic-
ipate in seminars, lectures, field work and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 1.5 units.

811. Sustainable Systems Theory and Drivers. Theoretical grounding on Sustainable Systems (SS) thinking and overview of national and international frameworks that have led to development and use of sustainable systems modeling, life cycle analysis and policy decision models. Topics include socio-metabolic consumption, sustainability as a field of inquiry, systems thinking, industrial ecology, earth systems engineering, complexity and resiliency. Explore current drivers and implications of sustainable systems with specific focus on nexus of industry and environmental systems including examining cumulative impacts and benefits resulting from shifting supply chains, green engineering, technological designs and consumer behavior. Instructor: Golden. 3 units. C-L: see Environment 811

835. Environmental Law. Examination of rapidly growing body of law concerned with interrelationships between human activities and the larger environment. Focus on rationales for environmental protection; risk assessment and priorities. Instructor: Salzman. 3 units. C-L: see Environment 835

891. Topics in Environmental Regulation. In-depth analysis of current issues in environmental regulation. Topics vary. Course may be repeated. Instructor: Bennear. 1.5 units. C-L: see Environment 891

Public Policy Studies (PUBPOL)

280S. Marine Science and Conservation Leadership. Exploration of the complex interactions among science, policy and economics in the use of marine resources. Topics explored include the role individuals play in promoting marine conservation and environmental sustainability. Students will evaluate trade-offs systematically and learn to assess how different policy options affect the incentives of resource users and polluters. Serves as the capstone for the Marine Science and Conservation Leadership Certificate. Prerequisite: introductory economics or consent of instructor. Instructor: Staff. 1 unit. C-L: see Environment 350S

579S. Collective Action, Environment, and Development. Examines the conditions under which collective or participatory decisions may raise welfare in defined ways. Presents the growing empirical evidence for an environment and development setting including common property issues (tragedy of the commons and competing models). Identifies what evidence exists for sharing norms on a background of self-interested strategies. Definitions of and reactions to equity and/or its absence are a focus. Providing scientific information for policy is another. Experimental and behavioral economics are frequently applied. Instructor: Pfaff. 3 units. C-L: Environment 579S

Courses Taught at the Marine Laboratory

Environment (ENVIRON)

219A. Science and Nature Writing: Naturalist Narratives, Classic to Contemporary. Introspective and expository prose is effective in transferring concepts and information from scientists to other segments of society. Students will explore nonfiction writing about marine ecosystems as the basis for discussion and analysis. They will experiment with essays that convey information about the natural world and that target specific audiences (e.g., children, general public, business executives, the blogosphere, etc.) and specific goals. Exercises will stress practice in crafting essays that convey scientific information with a nature writer’s eloquence. Particular emphasis will be placed on editing and revision toward publication-quality manuscripts. (Given at Beaufort). Instructor: Van Dover. 1 unit. C-L: English 219A

270A. Conservation Biology and Policy. Introduction to the key concepts of ecology and policy relevant to conservation issues at the population to ecosystems level. Focus on the origin and maintenance of biodiversity and conservation applications from both the biology and policy perspectives (for example, endangered species, captive breeding, reserve design, habitat fragmentation, ecosystem restoration/rehabilitation). (Given at Beaufort.) Prerequisites: introductory biology; suggested: a policy and/or introductory ecology course. Instructors: Staff. 1 unit. C-L: see Biology 270A

271A. Biology for Engineers: Informing Engineering Decisions. Biology from an engineering perspective. Emphasis on biological processes that inform engineering decisions. Topics include: environmental chemicals, biological command and control, nanostructures, e-waste, biology and engineered materials, organotoxins, metal-toxins, nanotoxins, biofouling, biomembrics, biological glue, biocorrosion, biodegradation, bioremediation,
biological resistance, and biological virulence. Environmental and human health policy. (Given at Beaufort.) Prerequisite: introductory chemistry. Instructor: Rittschof. 1 unit. C-L: see Biology 275A

272A. Analysis of Ocean Ecosystems. The history, utility, and heuristic value of the ecosystem; ocean systems in the context of Odum's ecosystem concept; structure and function of the earth's major ecosystems. (Given at Beaufort.) Prerequisite: one year of biology, one year of chemistry, or consent of instructor. Instructor: Johnson. 1 unit. C-L: see Biology 272A; also C-L: Earth and Ocean Sciences 272A

273LA. Marine Ecology. Factors that influence the distribution, abundance, and diversity of marine organisms. Course structure integrates lectures and field excursions. Topics include characteristics of marine habitats, adaptation to environment, species interactions, biogeography, larval recruitment, and communities found in rocky shores, tidal flats, beaches, mangrove, coral reefs, and subtidal areas. Not open to students who have taken Biology 773LA. (Given at Beaufort fall and summer.) Prerequisite: introductory biology. Instructors: Silliman or staff. 1 unit. C-L: see Biology 273LA; also C-L: Earth and Ocean Sciences 374LA

275SA. Global Fisheries Conflicts: Exploring Local and Global Economic, Ecological, and Social Impacts. Interdisciplinary investigation of fisheries management. Theoretical and practical policy questions regarding resource allocation measures (e.g., quota systems, marine protected areas, seasonal closures, and gear restrictions) and place-specific conflicts (e.g., over space, regulatory measures, cultural meanings, and livelihoods). Evaluation of fisheries science and examination of economic, ecological, and social ramifications of different management scenarios. Broad overview of the state of fisheries and fishing practices around the globe; in-depth analysis of local science and policy conflicts. (Given at Beaufort.) Instructor: Staff. 1 unit.

278LA. Physiology of Marine Animals. Comparative physiology of estuarine and marine animals. Physics and chemistry of estuarine and marine environments and physiological adaptations of animal residents. Focus on theory, behavioral, and physiological responses of animals to the major environmental drivers of temperature, salinity, oxygen, and light. Lectures and laboratories illustrating the approaches and methodology, analysis techniques, and written reporting of classical environmental physiology research. One course (fall); one and one-half courses (summer). (Given at Beaufort.) Prerequisites: AP biology, introductory biology, or consent of the instructor; and Chemistry 101DL. Instructor: Wise or Staff. Variable credit. C-L: see Biology 278LA

279LA. Marine CSI: Conservation Forensics in the Marine Environment. Application of forensic genetic techniques to the study of marine crime. Reveal marketing frauds, mislabeling of seafood, and fishing violations using modern molecular forensic tools. Field trips to acquire samples for forensic analysis from local fishermen, retailers and restaurants; hands-on forensic genetics lab work and group assignments. Techniques include microsatellites and restriction fragment length polymorphism. Statistical approaches to forensics and species/population identity and assignment tests. (Given at Beaufort). Prerequisites: Introductory Biology. Instructor: Schultz. 1 unit.

280LA. Sound in the Sea: Introduction to Marine Bioacoustics. Fundamentals of marine bioacoustics with a focus on current literature and conservation issues. Topics include: introduction to acoustics; acoustic analysis methods and quantitative tools; production and recording of sound; ocean noise; propagation theory; active and passive acoustics; hearing, sound production and communication in marine organisms, potential impacts of anthropogenic noise; and regulation of marine sound. Labs will focus on methodologies used for generating, recording and analyzing marine sounds. (Given at Beaufort). Course prerequisites: AP Biology, introductory biology, or consent of instructor; Physics 141L or 161L (or equivalent Physics courses) or consent of instructor. Instructor: Nowacek. 1 unit. C-L: Electrical and Computer Engineering 384LA, Earth and Ocean Sciences 280LA, Biology 279LA

283A. Hollywood and the Environment: Exploring the Human Connection with Nature Through Film. Critical assessment of the relationship between people and nature, using film as the springboard for discussion. Assess the human perception of nature, and our place in it, using films representing four major themes: 1) wilderness and the frontier; 2) man vs. nature; 3) international perspectives on nature; and 4) destruction of the environment. Films will be drawn from various genres, including animated film, drama, western, and science fiction. Full-length feature films will be paired with in-class screenings of independent documentary films that are provided to our class by internationally recognized film-makers. (Given at Beaufort). Instructor: Staff. 1 unit.

286A. Marine Policy. Policy and policy-making concerning the coastal marine environment. History of marine-related organizations, legislation, and issues and their effects on local, regional, national, and international arenas.
Use of theoretical and methodological perspectives, including political science, sociology, and economics. (Given at Beaufort.) Instructor: Staff. 1 unit. C-L: Public Policy Studies 281A

**287A. Marine Conservation Service Learning Course: Challenges at Sea.** Introduction to marine conservation biology emphasizing community outreach at local middle schools. Material focuses on issues in marine conservation and how they are addressed. Lectures cover principles of conservation, biodiversity, extinction risks, genetic tools, fishery by-catch, over-exploitation, habitat degradation, invasive species, climate change, and marine protected areas. Based on class discussions, students will develop and teach activities that address local conservation topics for middle school students. (Given at Beaufort.) Prerequisite: introductory biology. Instructor: Johnston and Schultz. 1 unit. C-L: Public Policy Studies 287A

**289A Views of Environmental Change: Documentary Research in Natural Resources Management.** Hands-on introduction to the practical skills, theoretical grounding, and ethical sensitivities needed to conduct documentary research on controversial environmental issues. Emphasis on responsibly eliciting and representing diverse stakeholder views. Students will conduct fieldwork on land use change in coastal communities as part of an ongoing Duke Marine Lab research project. Methods introduced will include interviewing, video/audio recording, documentary photography, interview data analysis, and basic video editing. Student teams will produce edited video segments for presentation to a community audience. (Given at Beaufort.) Instructor: Cumming. 1 unit. C-L: Documentary Studies 353A

**346A. Marine Conservation Policy - a Practicum.** Immersion in marine conservation policy basics for 21st Century society including two week-long, current issue modules. Hands-on, team-based, experiential learning with meaningful faculty-student engagement. Phenomena affecting maintenance and loss of biodiversity; key concepts of social science and law for instituting policy; capstone-position papers and stakeholder negotiation highlighting ecological, economic, cultural, and institutional complexity associated with negotiating stakeholders' priorities for public trust resources. (Given at Beaufort.) Prerequisites: Biology 202L, Public Policy 155D suggested, or instructor consent. Concurrent enrollment required in Environ 384A/Biology 384A. Instructor: Nowacek. 1 unit. C-L: Public Policy Studies 246A

**370A. Introduction to Physical Oceanography.** Fundamental physical principles of ocean circulation. Physical properties of seawater; forces acting on the ocean such as heat, pressure gradients, wind stress, rotation, and friction; and conservation equations for heat, mass and momentum. Applications include geostrophic balances, thermal wind, coastally trapped waves, El Nino/ENSO, and tidal circulation. (Given at Beaufort.) Prerequisites: one year of calculus and one year of physics, or permission of instructor. Instructor: Hench. 1 unit. C-L: Earth and Ocean Sciences 370A

**372LA. Biochemistry of Marine Animals.** The molecular basis of behavioral and physiological responses of organisms. Evolution of molecular endocrinology and signal transduction pathways. Focus on the theory and research methodology used to study the evolution of molecular signaling and control systems. Research projects using local invertebrates to study behavioral and physiological responses to environmental signals. Field trips include night walks in local environments and marine fossil expeditions to local strip mines involved with production of fertilizer, food additives, cement, and gravel. One course (fall); one and one-half courses (summer). (Given at Beaufort.) Prerequisites: AP Biology, introductory biology, or consent of instructor; and Chemistry 101DL. Instructor: Rittschof. Variable credit. C-L: see Biology 372LA

**374SA. Community-Based Marine Conservation in the Gulf of California.** Experiential education course on community-based conservation. Students learn first-hand about the challenges (accomplishments, failures, and promises) involved in its design and practice in developing countries of high biological diversity. Learn about the unique natural and political history, and social characteristics of the places where conservation takes place. Students link local context to broader perspectives through key readings and class discussions. (Given at Beaufort). Travel to biodiversity hotspots in the Gulf of California Required. Consent of instructor required. Instructor: Basurto. 1 unit.

**375A. Biology and Conservation of Sea Turtles.** Essential biology of sea turtles (evolution, anatomy, physiology, behavior, life history, population dynamics) and their conservation needs; emphasis on their role in marine ecosystem structure and function. Basic ecological concepts integrated with related topics including the conservation and management of endangered species, the contributions of technology to the management of migratory marine species, the role of research in national and international law and policy, and the veterinary aspects of conservation. (Given at Beaufort.) Field trip to Puerto Rico required. Prerequisite: Introductory Biology. Consent of instructor required. Instructor: Godfrey or staff. 1 unit. C-L: see Biology 375A
375LA. Biology and Conservation of Sea Turtles. Laboratory version of Biology 375A. Includes laboratory and field experience with animals and with their habitat requirements. (Given at Beaufort.) Prerequisite: Introductory Biology. Instructor: Godfrey or staff. 1 unit. C-L: see Biology 375LA

376A. Marine Mammals. The biology of cetaceans, pinnipeds, sirenians, and sea otters. Topics covered include the diversity, evolution, ecology, and behavior of marine mammals and their interactions with humans. Detailed consideration given to the adaptations that allow these mammals to live in the sea. Evaluation of the scientific, ethical, and aesthetic factors influencing societal attitudes toward these animals and of their conservation management in light of domestic legislation and international treaties. (Given at Beaufort.) Prerequisite: introductory biology. Instructor: Read. 1 unit. C-L: see Biology 376A

376LA. Marine Mammals. Laboratory version of Biology 376A. Laboratory and field exercises consider social organization, behavior, ecology, communication, and anatomy of local bottlenose dolphins. (Given at Beaufort.) Prerequisite: introductory biology. Instructor: Read or staff. 1 unit. C-L: see Biology 376LA

377LA. Marine Invertebrate Zoology. Structure, function, and development of invertebrates collected from estuarine and marine habitats. Not open to students who have taken Biology 777LA. One course (fall, spring, and Summer Term II); one and one-half courses (Summer Term I). (Given at Beaufort fall, spring, and summer.) Prerequisite: AP Biology or introductory biology or consent of instructor. Instructor: Van Dover or staff. Variable credit. C-L: see Biology 377LA; also C-L: Earth and Ocean Sciences 377LA

378LA. Marine Ichthyology. Overview of the bony and cartilaginous fishes, including their taxonomy, anatomy, functional morphology, and physiology. Aspects of their relationship with humans, specifically how fish biology and life history affect this relationship. Lectures and discussion of current scientific literature, and field/lab experiences to explore and collect data on local fish populations. Quantitative genetic techniques to explore fish population and community structure. (Given at Beaufort.) Prerequisite: AP Biology or introductory biology or consent of instructor. Instructor: Nowacek. 1 unit. C-L: see Biology 378LA

379LA. Research Methods in Marine Science. Introduction to research methods in the marine sciences through lectures and customized individual independent research. Lectures on all aspects of research including ethics, intellectual property, budgeting, laboratory and reporting practices, data analysis techniques, reporting and presenting. Draft manuscript and proposal for future research and travel to meeting required. (Given at Beaufort, summer) Prerequisite: AP Biology or Introductory biology and permission of instructor. Instructor: Rittschof or staff. 1 unit. C-L: see Biology 379LA

382LA. Marine Molecular Ecology. Marine ecology from a molecular view focusing on microbes as the dominant organisms in ocean ecosystems. Lecture and laboratory integrate the theory and application of modern molecular techniques to quantify abundance, to assess diversity and to determine the interaction of microbes with each other and the marine environment. Prerequisite: AP Biology, introductory biology, or permission of instructor. (Given at Beaufort.) Instructor: Johnson. 1 unit. C-L: Biology 374LA

383LA. Marine Molecular Microbiology. Introduction to microbiology from a marine perspective. Topics include microbial phylogeny, evolution, symbiosis, biotechnology, genomics, and ecology. Laboratory will employ modern molecular techniques to investigate the ecology and evolution of prokaryotic and eukaryotic microbes. Prerequisite: AP Biology, introductory biology, or permission of instructor. (Given at Beaufort.) Instructor: Hunt. 1 unit. C-L: Biology 380LA

384A. Marine Conservation Biology - a Practicum. Immersion in marine conservation biology basics for 21st Century society and anthropocene epoch including two week-long current issue modules. Phenomena affecting maintenance and loss of biodiversity (climate change, habitat destruction); strategies for combating threats to biodiversity; exploration of this field's interdisciplinary nature; introduction to key concepts of ecology relevant to conservation issues at the level of populations and ecosystems; unique capstone-position papers and stakeholder negotiation. (Given at Beaufort.) Prerequisites: AP Biology, Biology 202L, Introductory Ecology suggested, or instructor consent. Concurrent enrollment required in Environ 346A/Pubpol 246A. Instructor: Nowacek. 1 unit. C-L: Biology 384A

390SA. Special Topics in Environmental Science and Policy. Marine Lab version of ENVIRON 390S. Student must be enrolled at Duke Marine Lab in Beaufort. Instructor: Staff. 1 unit.
391. **Independent Study.** Individual readings course or other non-research-based independent course under the supervision of a faculty member, resulting in an academic product. Open to qualified juniors and seniors with consent of instructor and director of undergraduate studies. Instructor: Staff. 1 unit.

391A. **Independent Study.** Marine Lab version of Environment 391. (Offered at Beaufort). Instructor: Staff. 1 unit.

393. **Research Independent Study.** Individual research in a field of special interest, under the supervision of a faculty member, the central goal of which is a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. Open to qualified juniors and seniors with consent of instructor and director of undergraduate studies. Instructor: Staff. 1 unit.

393-1. **Research Independent Study.** See Environment 393. Open to qualified juniors and seniors with consent of instructor and director of undergraduate studies. Half course. Instructor: Staff. 0.5 units.

393A. **Research Independent Study.** Marine Lab version of Environment 393. Offered at Beaufort. Instructor: Staff. 1 unit.

394A. **Research Independent Study.** Marine Lab version of Environment 394. Offered at Beaufort. Instructor: Staff. 1 unit.

445A. **Climate Change in the Marine Environment.** Exploration of climate change science focusing on marine ecosystems and inhabitants - specifically ocean acidification, warming and sea level rise. Factors causing climate change, and how those vary spatially, focusing on sensitive polar ecosystems and marine mammal populations. Critical examination of climate change modeling using EdGCM (research-grade Global Climate Model), focusing on how scientists use models, observations/theory to predict climate, and assumptions/uncertainty implicit in modeling. Discussion of potential human impacts including consequences of sea level rise and potential increases in disease due to climate change. (Taught at Beaufort.) Instructor: Hunt. 1 unit. C-L: Biology 445A, Public Policy Studies 445A

533A. **Marine Fisheries Policy.** Principles, structure, and process of public policy-making for marine fisheries. Topics include local, regional, national, and international approaches to the management of marine fisheries. A social systems approach is used to analyze the biological, ecological, social, and economic aspects of the policy and management process. (Given at Beaufort.) Instructor: Staff. 3 units.

543A. **Respiratory Proteins and the Environment.** Molecular diversity in structure, function and evolution of respiratory proteins. Field trips to biodiverse areas of Costa Rica and coastal NC complement text and lectures. Covers molecular adaptations that underlie macroscopic biodiversity, blood functions and blood pathogens, oxidative and nitrosative stress. Lectures and readings on the balance between pathways for metabolic oxygen utilization and alternative disease-causing pathways. (Given at Beaufort.) Field trip to Costa Rica required. Prerequisite: one semester of organic chemistry or consent of instructor. Instructor: C. Bonaventura. 3 units.

551DA. **International Conservation and Development.** Interrelated issues of conservation and development. Topics include the evolution of the two concepts and of theories regarding the relationship between them, the role of science, values, ethics, politics and other issues in informing beliefs about them, and strategies for resolving conflicts between them. While attention will be given to all scales of interaction (i.e. local, regional, national, international), the focus will be on international issues and the 'north-south' dimensions of the conservation and development dilemma. Examples from marine and coastal environments will be highlighted. Consent of instructor required. (Given at Beaufort.) Instructor: Campbell. 3 units.


573A. **Coastal Ecotoxicology and Pollution.** Principles of transport, fates, food-web dynamics, and biological effects of pollutants in the marine environment. No laboratories. Short local field trips possible. (Given at Beaufort.) Prerequisites: AP Biology, introductory biology, or consent of instructor; introductory chemistry or consent of instructor. Instructor: C. Bonaventura. 3 units.

579LA. **Biological Oceanography.** Physical, chemical, and biological processes of the oceans, emphasizing special adaptations for life in the sea and factors controlling distribution and abundance of organisms. Four units (spring);
six units (summer). (Given at Beaufort.) Prerequisite: introductory biology. Instructor: Johnson. Variable credit. C-L: Biology 579LA, Earth and Ocean Sciences 579LA

580A. Green Futures: Exploring Environmental, Economic, and Social Sustainability. Theory and application of environmentally and socially sustainable practices in settings including businesses, academic institutions, and personal lives. Ethical concerns that accompany modern local and global environmental problems. Challenges, trade-offs between costs and benefits, and potential solutions to different greening options. Topics include alternative energy production and consumption, sustainable agriculture practices, resource conservation, environmental assessments, economic questions and social responsibility. (Given at Beaufort.) Prerequisites: None for graduate students. Undergrads: Introductory Biology and Environmental Science and Policy or consent of instructor. Instructor: Rittschof. 3 units.

585A. Fisheries Ecology. Current topics in fish and fisheries ecology, explored through lecture and discussion of primary literature. Participation in collaborative research and synthesis projects. Intended for master and doctoral students; undergraduates by permission of instructor. Prerequisites: basic knowledge of ecology and oceanography. Instructor: Staff. 3 units.

590A. Duke-Administered Study Away: Special Topics. Content to be determined each semester. May be repeated. Offered only in Beaufort. Instructor: Staff. Variable credit.

590LA. Duke-administered Study Away; Special Topics. Content to be determined each semester. May be repeated. Offered only in Beaufort. Instructor: Staff. 4 units.

590SA. Seminar in Ocean Sciences. Biological, chemical, physical, and geological aspects of the ocean and their relation to environmental issues. Consent of instructor required. (Given at Beaufort.) Instructor: Staff. Variable credit.

709A. Conservation Biology and Policy. Introduction to the key concepts of ecology and policy relevant to conservation issues at the population to ecosystems level. Focus on the origin and maintenance of biodiversity and conservation applications from both the biology and policy perspectives (for example, endangered species, captive breeding, reserve design, habitat fragmentation, ecosystem restoration/rehabilitation). Open to undergraduates only under Biology 270A. (Given at Beaufort.) Prerequisite: introductory biology; suggested: a policy and/or introductory ecology course. Instructors: Nowacek (Beaufort). 3 units.

745A. Climate Change in the Marine Environment. Exploration of climate change science focusing on marine ecosystems and inhabitants - specifically ocean acidification, warming and sea level rise. Factors causing climate change, and how those vary spatially, focusing on sensitive polar ecosys and mar mammal populations. Critical examination of climate change modeling using EdGCM (research-grade Global Climate Model), focusing on how scientists use models, observations/theory to predict climate, and assumptions/uncertainty implicit in modeling. Discussion of potential human impacts incl consequences of sea level rise and potential increases in disease due to climate change. (Taught at Beaufort.) Grad students responsible for research paper. Instructor: Hunt. 3 units.

746A. Marine Conservation Summer Institute. Immersion in marine conservation biology and policy. Basic tools of marine conserv bio and policy for 21st Century society and 'anthropocene' epoch intertwined w/two week-long modules. Hands-on, team-based, experiential learning w/meaningful faculty-student engagement. Phenomena affecting maintenance and loss of biodiversity (climate change, habitat destruction); strategies for combatting threats to biodiversity; key concepts of social science and law for instituting conserv policy; unique capstone-position papers and stakeholder negotiation; grad student s will critique position papers.(Given at Beaufort.) Prerequisites: AP Bio, Bio 202L, suggested policy and/or intro ecol, or instructor consent. Instructor: Nowacek. 7 units. C-L: Public Policy Studies 946A

753LA. Sensory Physiology and Behavior of Marine Animals. Sensory physiological principles with emphasis on visual and chemical cues. Laboratories will use behavior to measure physiological processes. Only open to undergraduates under Biology 373LA. (Given at Beaufort.) Prerequisites: introductory biology and chemistry. Instructor: Rittschof. 4 units.

754A. Qualitative Research Design in Marine Studies. Examination of the concept of research (philosophy, epistemology, practice) along with methods used widely in the social sciences. Focus is on qualitative methods, and related research ethics, objectives, design, data collection, analysis, and presentation. Consideration of utility of
qualitative methods for understanding activities and policy in the marine and coastal environment. (Given at Beaufort.) Instructor: Campbell. 3 units.

770A. Introduction to Physical Oceanography. Fundamental physical principles of ocean circulation. Physical properties of seawater; forces acting on the ocean such as heat, pressure gradients, wind stress, rotation, and friction; and conservation equations for heat, mass and momentum. Applications include geostrophic balances, thermal wind, coastally trapped waves, El Nino/ENSO, and tidal circulation. (Given at Beaufort.) Prior course work in calculus and physics is required or permission of instructor. Instructor: Hench. 3 units.

772LA. Biochemistry of Marine Animals. Functional, structural, and evolutionary relationships of biochemical processes of importance to marine organisms. Open to undergraduates only under Biology 372LA. (Given at Beaufort.) Prerequisites: AP Biology, introductory biology, or consent of instructor; and Chemistry 101DL or introductory chemistry equivalent. Instructor: Rittschof. Variable credit. C-L: Biology 772LA

773LA. Marine Ecology. Ecology from a basic science perspective. Laboratories target a science-oriented graduate audience. Lecture topics include factors that influence the distribution, abundance, and diversity of marine organisms, characteristics of marine habitats, adaptation to environment, species interactions, biogeography, larval recruitment, and communities found in rocky shores, tidal flats, beaches, mangrove, coral reefs, and subtidal areas. Laboratories and field trips cover ecological principles from a basic science perspective. Not open to students who have taken Biology 273LA and not open to undergraduates. (Given at Beaufort.) Prerequisite: Introductory Biology. Instructors: Silliman or staff. 4 units. C-L: see Biology 773LA

776A. Marine Mammals. Ecology, social organization, behavior, acoustic communication, and management issues. Focused on marine mammals in the southeastern United States (for example, bottlenose dolphin, right whale, West Indian manatee). Only open to undergraduates under Biology 376A. (Given at Beaufort.) Prerequisite: introductory biology. Instructor: Read. 3 units.

776LA. Marine Mammals. Laboratory version of Environment 776LA. Laboratory exercises consider social organization and acoustic communication in the local bottlenose dolphin population. (Given at Beaufort.) Prerequisite: introductory biology. Instructor: Read. 4 units.

777A. Biology and Conservation of Sea Turtles. Essential biology of sea turtles (evolution, anatomy, physiology, behavior, life history, population dynamics) and their conservation needs, emphasizing their role in marine ecosystem structure and function. Will integrate basic ecological concepts with related topics including conservation and management of endangered species, contributions of technology to management of migratory marine species, role of research in national and international law and policy, and veterinary aspects of conservation. Given at Beaufort. Field trip to Puerto Rico is required. Instructor permission is required. Prerequisite: Introductory Biology. Instructor: Godfrey or Staff. 3 units.

777LA. Biology and Conservation of Sea Turtles. Biology including the anatomy, physiology, behavior, life histories, and population dynamics of sea turtles linked to conservation issues and management. Focus on threatened and endangered sea turtle species, with special attention to science and policy issues in United States waters. Includes field experience with the animals and with their habitat requirements. Sea turtle assessment and recovery efforts, fishery-turtle interactions, population modeling and state/national/international management efforts. Only open to undergraduates under Biology 375AL. (Given at Beaufort.) Prerequisite: introductory biology. Instructor: Godfrey or Staff. 4 units.

778LA. Comparative Physiology of Marine Animals. Environmental factors, biological rhythms, and behavioral adaptations in the comparative physiology of marine animals. Open to undergraduates only under Biology 278LA. Four units (fall); six units (summer). (Given at Beaufort.) Prerequisites: introductory biology and chemistry. Instructor: Wise or Staff. Variable credit. C-L: see Biology 778LA

779LA. Marine Ichthyology. Overview of the bony and cartilaginous fishes, including their taxonomy, anatomy, functional morphology, and physiology. Aspects of their relationship with humans, specifically how fish biology and life history affect this relationship. Lectures and discussion of current scientific literature, and field/lab experiences to explore and collect data on local fish populations. Quantitative genetic techniques to explore fish population and community structure. (Given at Beaufort.) Prior course work in biology is required or permission of instructor. Instructor: Nowacek. 4 units.

784LA. Sound in the Sea: Introduction to Marine Bioacoustics. Fundamentals marine bioacoustics with focus on current lit and conserv issues. Topics include: intro acoustics; acoustic analysis methods and quant tools; production/
recording of sound; ocean noise; propagation theory; active/passive acoustics; hearing, sound production and communication in marine organisms, potential impacts of anthropogenic noise; and regulation of marine sound. Lab focus on methodologies for generating, recording and analyzing marine sounds. Grad students responsible for additional acoustic analyses and results prep for student projects plus preparation additional lit review/critique. (Given at Beaufort). Prerequisites: AP or Intro Biology or consent; Physics 41L or 161L (or equivalent) or consent. Instructor: Nowacek. 4 units. C-L: Biology 784LA, Electrical and Computer Engineering 784LA

786A. Marine Policy (A). Formal study of policy and policy-making concerning the coastal marine environment. History of specific marine-related organizations, legislation, and issues and their effects on local, regional, national, and international arenas. Topics explored through use of theoretical and methodological perspectives, including political science, sociology, and economics. Consent of instructor required. (Given at Beaufort.) Instructor: Staff. 3 units. C-L: Public Policy Studies 749A, Political Science 707A

787A. Analysis of Ocean Ecosystems. The history, utility, and heuristic value of the ecosystem; ocean systems in the context of Odum's ecosystem concept; structure and function of the earth's major ecosystems. Open to undergraduates only under Biology 272A. (Given at Beaufort.) Prerequisite: one year of biology, one year of chemistry, or consent of instructor. Instructor: Johnson. 3 units.

788LA. Marine Invertebrate Zoology. Structure, function, and development of invertebrates collected from estuarine and marine habitats. Not open to students who have taken Biology 377LA or Biology 777LA. Open to undergraduates only under Biology 377LA. Four credits (fall, spring, and Summer Term II); six credits (Summer Term I). (Given at Beaufort.) Prerequisite: AP Biology, introductory biology, or consent of instructor. Instructor: Van Dover or Staff. Variable credit. C-L: Biology 777LA

822A. Coastal Watershed and Policy. Examine hydrology of coastal watersheds and how watersheds modifications impact estuaries and near shore coastal ecosystems. Hydrologic functioning of natural unaltered watersheds is contrasted with changes caused by man's modification of those systems. Include discussion of efforts to remedy impacts through installation of Best Management Practices and wetlands restoration. Emphasis on gaining understanding of what the impacts of hydrologic change are on biology of coastal waters as watershed development alters the physics, chemistry, and geology of coastal waters. Includes field trips to watersheds in coastal North Carolina. Instructor: Kirby-Smith. 3 units.

824A. Marine Conservation Biology. Introduction to marine conservation in a small island context with an exploration of how traditional and modern methods play out in practice. Most of the course will be taught in Palau, where students will meet traditional chiefs, fishers, state governors, NGO practitioners, scientists and politicians to hear their perspectives on marine conservation. The course will focus on the theory and practice of marine conservation, as exemplified by case studies in traditional management, marine protected areas, conservation of protected species and ecotourism. (Given at Beaufort). Trip to Palau required. Permission required. Instructor: Staff. 3 units.

825LA. Marine Molecular Microbiology. Covers a broad overview of the ecological and biogeochemical role that microbes play in marine environments. Lab exercises focus on applying molecular techniques to the study of microbial ecology. (Offered at Beaufort). Instructor: Hunt. 4 units.

828A. Community-Based Marine Conservation in the Gulf of California. This is an experiential education course designed to allow students to learn first-hand about the accomplishments, challenges, and promises of community-based conservation in biodiversity hotspots in developing countries. Students have the opportunity to interact directly with individuals practicing marine conservation, and travel to unique, remote, and beautiful places of rich biological diversity that have made the Gulf of California a world-renown biodiversity hotspot. Instructor: Staff. 3 units.

849A. Doctoral Student Seminar and Professional Development. Addresses topics of relevance to the professional development of PhD students in the Marine Science Conservation program. Topics addressed include: the nature of inter-disciplinary research, critical reading, grant writing, communicating results to the public, mentoring students, and preparing manuscripts for academic journals. (Offered at Beaufort). Instructor: Campbell. 1 unit.

860SA. Political Ecology. Seminar to examine concept of political ecology as means of conceptualizing conservation and development conflicts and solutions. Intended to engage students with political ecology to strengthen usefulness, enrich possibilities, and improve participants ongoing research, collaborations and critical inquiries. Enrollment limited to graduate students. (Given at Beaufort). Instructor: Campbell. 3 units.
866A. Professional Writing and Self-Editing. Shows students how to become more effective writers and editors. Focus on reading excellent factual writing. Through various writing assignments learn how to write for the job, publications and popular general media. Course includes on-on-one work with professional editor. (Offered at Beaufort.) Instructor: Ramus. 3 units.

875A. Conservation Genetics. Application of evolutionary principles and molecular genetic tools for addressing conservation problems. Topics include genetic management of endangered species, wildlife forensics, contemporary evolution, anthropogenic selection, evolutionary impact assessments, genetic diversity and ecosystem function, and genetic-based biodiversity metrics. For graduate students with an interest in evolutionary biology, ecology, and conservation biology. Taught spring or fall. (Offered at Beaufort.) Instructor: Palkovacs. 2 units.

876A. Data and Time Series Analysis in Marine Sciences. Analysis of environmental time-series and other data sets. Topics include discrete sampling issues, data rejection and interpolation, coordinate rotations and principal axes, curve fits, regression, error and propagation of uncertainty, bootstrapping, filtering, spectral analysis, harmonic analysis, EOFs, wavelets. Lectures, workshops and homework assignments will apply these methods to environmental data sets. Each student will complete a final project, applying methods covered in class to data sets they choose, as part of or related to their research. Consent of instructor required. Instructor: Hench. 4 units.

878A. Current Topics in Marine Biology. PhD-level reading seminar to review current literature in marine biology focusing on basic ecological principles. Course will satisfy the "Current Topics" requirement in the Marine Biology track of the Marine Science and Conservation Ph.D. degree. Students will rotate presenting primary literature on current week's topic. Although based on current primary literature, relevant classic articles will be included. Discussion will place articles in the broader context of evolution, ecology and biogeochemistry. Instructor: Staff. 2 units.

886A. Current Topics in Marine Conservation. Discussion of a topic of interest chosen by students with guidance from instructors. Topic is discussed from a social and natural science perspective. Open only to PhD students. Offered at Beaufort. Instructor: Staff. 2 units.

887A. Theory and Methods for Policy Analysis of the Commons. Survey course of main theories and methods used by scholars to understand how collective action problems and different institutional arrangements affect how common-pool resources and public goods are governed. Students are asked to design a project that incorporates some of the concepts and methodological approaches learned in class. Offered at Beaufort. Instructor: Basurto. 3 units.

Biology (BIOLOGY)

175LA. Marine Biology. Physical and chemical aspects of estuarine and marine ecosystems and environments. Functional adaptations of marine organisms and the role of man and society on the ecosystems. Includes field trips to local environments with an emphasis on impacted environments and their relation to societal activity and policy. For students not majoring in natural sciences. (Given at Beaufort.) Instructor: Staff. 1 unit.

201LA. Gateway to Biology: Molecular Biology. Introduces major concepts in biology through the lens of molecular biology. Molecular mechanisms that comprise the Central Dogma and variants. DNA structure and function, replication, transcription, and translation. Protein synthesis, folding, structure and function. Supporting topics related to the structure of cells, metabolism and energetics. Integration of physical and quantitative principles to molecular biology. Relevance to human diseases and the biotechnology industry. Laboratory includes an introduction to recombinant DNA technology. Prerequisite: Chemistry 101DL. Taught only in the Beaufort Marine Lab program. Instructor: Schultz.

270A. Conservation Biology and Policy. Introduction to the key concepts of ecology and policy relevant to conservation issues at the population to ecosystems level. Focus on the origin and maintenance of biodiversity and conservation applications from both the biology and policy perspectives (for example, endangered species, captive breeding, reserve design, habitat fragmentation, ecosystem restoration/rehabilitation). (Given at Beaufort.) Prerequisites: introductory biology; suggested: a policy and/or introductory ecology course. Instructors: Staff. 1 unit. C-L: Environment 270A

272A. Analysis of Ocean Ecosystems. The history, utility, and heuristic value of the ecosystem; ocean systems in the context of Odum's ecosystem concept; structure and function of the earth's major ecosystems. (Given at Beaufort.) Prerequisite: one year of biology, one year of chemistry, or consent of instructor. Instructor: Johnson. 1 unit. C-L: Environment 272A, Earth and Ocean Sciences 272A
273LA. Marine Ecology. Factors that influence the distribution, abundance, and diversity of marine organisms. Course structure integrates lectures and field excursions. Topics include characteristics of marine habitats, adaptation to environment, species interactions, biogeography, larval recruitment, and communities found in rocky shores, tidal flats, beaches, mangrove, coral reefs, and subtidal areas. Not open to students who have taken Biology 773LA. (Given at Beaufort fall and summer.) Prerequisite: introductory biology. Instructors: Silliman or staff. 1 unit. C-L: Environment 273LA, Earth and Ocean Sciences 374LA

275A. Biology for Engineers: Informing Engineering Decisions. Biology from an engineering perspective. Emphasis on biological processes that inform engineering decisions. Topics include: environmental chemicals, biological command and control, nanostructures, e-waste, biology and engineered materials, organotoxins, metal-toxins, nanotoxins, biofouling, biomembranes, biological glues, biocorrosion, biodegradation, bioremediation, biological resistance, and biological virulence. Environmental and human health policy. (Given at Beaufort.) Prerequisite: introductory chemistry. Instructor: Rittschof.

278LA. Comparative Physiology of Marine Animals. Comparative physiology of estuarine and marine animals. Physics and chemistry of estuarine and marine environments and physiological adaptations of animal residents. Focus on theory, behavioral, and physiological responses of animals to the major environmental drivers of temperature, salinity, oxygen, and light. Lectures and laboratories illustrating the approaches and methodology, analysis techniques, and written reporting of classical environmental physiology research. One course (fall); one and one-half courses (summer). (Given at Beaufort). Prerequisites: AP biology, introductory biology, or consent of the instructor, and Chemistry 101DL. Instructor: Forward. Variable credit. C-L: Environment 278LA

279LA. Sound in the Sea: Introduction to Marine Bioacoustics. Fundamentals of marine bioacoustics with a focus on current literature and conservation issues. Topics include: introduction to acoustics; acoustic analysis methods and quantitative tools; production and recording of sound; ocean noise; propagation theory; active and passive acoustics; hearing, sound production and communication in marine organisms, potential impacts of anthropogenic noise; and regulation of marine sound. Labs will focus on methodologies used for generating, recording and analyzing marine sounds. Taught in Beaufort. Course prerequisites: AP Biology, introductory biology, or consent of instructor; Physics 141L or 161L (or equivalent Physics courses) or consent of instructor. Instructor: Nowacek. 1 unit. C-L: Electrical and Computer Engineering 384LA, Earth and Ocean Sciences 280LA, Environment 280LA

293. Research Independent Study. Individual research in a field of special interest, under the supervision of a faculty member, the major product of which is a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. Open to all qualified students with consent of supervising instructor and director of undergraduate studies. May be repeated. Continued in Biology 493. Instructor: Staff. 1 unit.

293-1. Research Independent Study. Individual research and reading in a field of special interest, under the supervision of a faculty member, resulting in a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. Open to all qualified students with consent of supervising instructor and director of undergraduate studies. Instructor: Staff. 0.5 units.

293A. Research Independent Study. Individual research in a field of special interest, under the supervision of a faculty member the major product of which is a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. May be repeated. Continued in Biology 493A. Taught only in the Beaufort Marine Lab program. Instructor: Staff. 1 unit.

293A-1. Research Independent Study. Individual research and reading in a field of special interest, under the supervision of a faculty member, resulting in a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. Open to all qualified students with consent of supervising instructor and director of undergraduate studies. (Given at Beaufort only). Half course. Instructor: Staff. 0.5 units.

372LA. Biochemistry of Marine Animals. The molecular basis of behavioral and physiological responses of organisms. Evolution of molecular endocrinology and signal transduction pathways. Focus on the theory and research methodology used to study the evolution of molecular signaling and control systems. Research projects using local invertebrates to study behavioral and physiological responses to environmental signals. Field trips include night walks in local environments and marine fossil expeditions to local strip mines involved with production of fertilizer, food additives, cement, and gravel. One course (fall); one and one-half courses (summer). (Given at Beaufort.) Prereq-
uisites: AP Biology, introductory biology, or consent of instructor; and Chemistry 101DL. Instructor: Rittschof. Variable credit. C-L: Environment 372LA

373LA. Sensory Physiology and Behavior of Marine Animals. Sensory physiological principles with emphasis on visual and chemical cues. Laboratories will use behavior to measure physiological processes. (Given at Beaufort.) Prerequisites: AP Biology or introductory biology or consent of instructor and Chemistry 101DL. Instructor: Rittschof. 1 unit. C-L: Neuroscience 381LA

374LA. Marine Molecular Ecology. Marine ecology from a molecular view focusing on microbes as the dominant organisms in ocean ecosystems. Lecture and laboratory integrate the theory and application of modern molecular techniques to quantify abundance, to assess diversity and to determine the interaction of microbes with each other and the marine environment. Prerequisite: AP Biology, introductory biology, or permission of instructor. (Given at Beaufort.) Instructor: Johnson. 1 unit. C-L: Environment 382LA

375A. Biology and Conservation of Sea Turtles. Essential biology of sea turtles (evolution, anatomy, physiology, behavior, life history, population dynamics) and their conservation needs; emphasis on their role in marine ecosystem structure and function. Basic ecological concepts integrated with related topics including the conservation and management of endangered species, the contributions of technology to the management of migratory marine species, the role of research in national and international law and policy, and the veterinary aspects of conservation. (Given at Beaufort.) Field trip to Puerto Rico required. Prerequisite: Introductory Biology. Consent of instructor required. Instructor: Godfrey or staff. 1 unit. C-L: Environment 375A

375LA. Biology and Conservation of Sea Turtles. Laboratory version of Biology 375A. Includes laboratory and field experience with animals and with their habitat requirements. (Given at Beaufort.) Prerequisite: Introductory Biology. Instructor: Godfrey or staff. 1 unit. C-L: Environment 375LA

376A. Marine Mammals. The biology of cetaceans, pinnipeds, sirenians, and sea otters. Topics covered include the diversity, evolution, ecology, and behavior of marine mammals and their interactions with humans. Detailed consideration given to the adaptations that allow these mammals to live in the sea. Evaluation of the scientific, ethical, and aesthetic factors influencing societal attitudes toward these animals and of their conservation management in light of domestic legislation and international treaties. (Given at Beaufort.) Prerequisite: introductory biology. Instructor: Read. 1 unit. C-L: Environment 376A

376LA. Marine Mammals. Laboratory version of Biology 376A. Laboratory and field exercises consider social organization, behavior, ecology, communication, and anatomy of local bottlenose dolphins. (Given at Beaufort.) Prerequisite: introductory biology. Instructor: Read. 1 unit. C-L: Environment 376LA

377LA. Marine Invertebrate Zoology. Structure, function, and development of invertebrates collected from estuarine and marine habitats. Not open to students who have taken Biology 777LA. One course (fall, spring, and Summer Term II); one and one-half courses (Summer Term I). (Given at Beaufort fall, spring, and summer.) Prerequisite: AP Biology or introductory biology or consent of instructor. Instructor: Van Dover or staff. Variable credit. C-L: Environment 377LA, Earth and Ocean Sciences 377LA

378A. Marine Ichthyology. Overview of the bony and cartilaginous fishes, including their taxonomy, anatomy, functional morphology, and physiology. Aspects of their relationship with humans, specifically how fish biology and life history affect this relationship. Lectures and discussion of current scientific literature, and field/lab experiences to explore and collect data on local fish populations. Quantitative genetic techniques to explore fish population and community structure. (Given at Beaufort.) Prerequisite: AP Biology or introductory biology or consent of instructor. Instructor: Nowacek. 1 unit. C-L: Environment 378LA

379A. Research Methods in Marine Science. Introduction to research methods in the marine sciences through lectures and customized individual independent research. Lectures on all aspects of research including ethics, intellectual property, budgeting, laboratory and reporting practices, data analysis techniques, reporting and presenting. Draft manuscript and proposal for future research and travel to meeting required. (Given at Beaufort, summer) Prerequisite: AP Biology or Introductory biology and permission of instructor. Instructor: Rittschof or staff. 1 unit. C-L: see Biology 379LA

380LA. Marine Molecular Microbiology. Introduction to microbiology from a marine perspective. Topics include microbial phylogeny, evolution, symbiosis, biotechnology, genomics, and ecology. Laboratory will employ modern molecular techniques to investigate the ecology and evolution of prokaryotic and eukaryotic microbes. Prerequisite:
AP Biology, introductory biology, or permission of instructor. (Given at Beaufort.) Instructor: Hunt. 1 unit. C-L: Environment 383LA

384A. Marine Conservation Biology – a Practicum. Immersion in marine conservation biology basics for 21st Century society and ‘anthropocene epoch including two week-long current issues modules. Phenomena affecting maintenance and loss of biodiversity (climate change, habitat destruction); strategies for combating threats to biodiversity; exploration of this field’s interdisciplinary nature; introduction to key concepts of ecology relevant to conservation issues at the level of populations and ecosystems; unique capstone-position papers and stakeholder negotiation. (Given at Beaufort.) Prerequisites: AP Biology, Biology 202L, Introductory Ecology suggested, or instructor consent. Concurrent enrollment required in Environ 346A/Pubpol 246A. Instructor: Nowacek. 1 unit. C-L: Environment 384A


490S. Special Topics Seminar. Seminar on a selected topic. Offerings vary each semester. Instructor: Staff. 1 unit.

490T. Tutorial. For junior and senior majors with consent of director of undergraduate studies and supervising instructor. Instructor: Staff. 1 unit.

490T-1. Tutorial. For junior and seniors with consent of director of undergraduate studies and supervising instructor. Instructor: Staff. 0.5 units.

490TA. Tutorial (topics). For junior and senior majors with consent of Director of Undergraduate Studies and supervising instructor. Taught only in the Beaufort Marine Lab program. Instructor: Staff. 1 unit.

493A. Research Independent Study. Continuation of Biology 293A. Individual research and reading of the primary literature in a field of special interest, under the supervision of a faculty member, the major product of which is a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. Open to juniors and seniors only with consent of supervising instructor. (Given at Beaufort only). Pre-requisites: Biology 293A or Biology 379LA. May be repeated. Instructor: Staff. 1 unit.

493A. Research Independent Study. Continuation of Biology 293A. Individual research and reading of the primary literature in a field of special interest, under the supervision of a faculty member, the major product of which is a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. Open to juniors and seniors only with consent of supervising instructor. (Given at Beaufort only). Pre-requisites: Biology 293A or Biology 379LA. May be repeated. Instructor: Staff. 1 unit.

570LA-1. Experimental Tropical Marine Ecology. Distribution and density of marine and semi-terrestrial tropical invertebrate populations; behavioral and mechanical adaptations to physical stress, competition, and predation using rapid empirical approaches and hypothesis testing. Offered only at Beaufort, with preparation for fieldwork before and analysis and presentation of projects after required one week intensive field experience on the coast of Panama. Consent of instructor required. Instructor: Diaz. 2 units.

570LA-2. Marine Ecology of the Pacific Coast of California. Ecology of the rocky intertidal, kelp forest, and mud flat habitats. Introduction to marine mammals, fish and other large West Coast vertebrates. Offered only at Beaufort, with preparation for fieldwork before and analysis and presentation of projects after required one week intensive field experience on the coast of Northern California. Prerequisite: Concurrent registration in Biology 273LA and consent of instructor. Instructor: Staff. 2 units.

570LA-3. Harmony in Brittany: French Use of Marine Environments. Intensive field experience on the coast of Brittany, including French maritime cultural heritage, regional and national coastal reserves (Le Parc naturel régional d’Armorique; Presqu’île de Crozon), shellfish aquaculture (La Tremblade), seaweed harvest (Lanildut), and tidal energy (La Rance). Offered only in Beaufort, with preparation for fieldwork before and analysis and presentation of
projects after required one week intensive field experience on the coast of France over Fall Break. Prerequisites: AP Biology or introductory biology and consent of instructor. Instructor: Van Dover. 2 units.


579LA. Biological Oceanography. Physical, chemical, and biological processes of the oceans, emphasizing special adaptations for life in the sea and factors controlling distribution and abundance of organisms. Four units (spring); six units (summer). (Given at Beaufort.) Prerequisite: introductory biology. Instructor: Johnson. Variable credit. C-L: Environment 579LA, Earth and Ocean Sciences 579LA

772LA. Biochemistry of Marine Animals. Functional, structural, and evolutionary relationships of biochemical processes of importance to marine organisms. Open to undergraduates only under Biology 372LA. (Given at Beaufort.) Prerequisites: AP Biology, introductory biology, or consent of instructor; and Chemistry 101DL or introductory chemistry equivalent. Instructor: Rittschof. Variable credit. C-L: see Environment 772LA

773LA. Marine Ecology. Ecology from a basic science perspective. Laboratories target a science-oriented graduate audience. Lecture topics include factors that influence the distribution, abundance, and diversity of marine organisms, characteristics of marine habitats, adaptation to environment, species interactions, biogeography, larval recruitment, and communities found in rocky shores, tidal flats, beaches, mangrove, coral reefs, and subtidal areas. Laboratories and field trips cover ecological principles from a basic science perspective. Not open to students who have taken Biology 273LA and not open to undergraduates. (Given at Beaufort.) Prerequisite: Introductory Biology. Instructors: Silliman or staff. 4 units. C-L: Environment 773LA

777LA. Marine Invertebrate Zoology. Structure, function, and development of invertebrates collected from estuarine and marine habitats. Not open to students who have taken Biology 377LA or Biology 777LA. Open to undergraduates only under Biology 377LA. Four credits (fall, spring, and Summer Term II); six credits (Summer Term I). (Given at Beaufort.) Prerequisites: introductory biology or consent of instructor. Instructor: Van Dover or Staff. Variable credit. C-L: see Environment 778LA

778LA. Comparative Physiology of Marine Animals. Environmental factors, biological rhythms, and behavioral adaptations in the comparative physiology of marine animals. Open to undergraduates only under Biology 278LA. Four units (fall); six units (summer). (Given at Beaufort.) Prerequisites: introductory biology and chemistry. Instructor: Wise or Staff. Variable credit. C-L: Environment 778LA

784LA. Sound in the Sea: Introduction to Marine Bioacoustics. Fundamentals marine bioacoustics w/ focus on current lit and conserv issues. Topics incl: intro acoustics; acoustic analysis methods and quant tools; production/recording of sound; ocean noise; propagation theory; active/passive acoustics; hearing, sound production and communication in marine organisms, potential impacts of anthropogenic noise; and regulation of marine sound. Lab focus on methodologies for generating, recording and analyzing marine sounds. Grad students responsible for addit acoustic analyses and results prep for student projects plus preparation addtl lit review/critique. Taught in Beaufort. Prereqs: AP or Intro Bio or consent; Phy 41L or 161L (or equiv) or consent. Instructor: Nowacek. 4 units. C-L: Environment 784LA, Electrical and Computer Engineering 784LA

791T. Tutorial. Carried out under the direction of the appropriate staff members. Consent of instructor required. Hours and credit to be arranged. Instructor: Staff. Variable credit.

792. Research. To be carried on under the direction of the appropriate staff members. Consent of instructor required. Hours and credit to be arranged. Instructor: Staff. Variable credit.

Cell Biology (CELLBIO)

493. Research Independent Study. Individual Research in a field of special interest under the supervision of a faculty member, the central goal of which is a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. Consent of instructor required. Instructor: Staff. 1 unit.
Documentary Studies (DOCST)

353A. Views of Environmental Change: Documentary Research in Nature. Hands-on introduction to the practical skills, theoretical grounding, and ethical sensitivities needed to conduct documentary research on controversial environmental issues. Emphasis on responsibly eliciting and representing diverse stakeholder views. Students will conduct fieldwork on land use change in coastal communities as part of an ongoing Duke Marine Lab research project. Methods introduced will include interviewing, video/audio recording, documentary photography, interview data analysis, and basic video editing. Student teams will produce edited video segments for presentation to a community audience. (Given at Beaufort.) Instructor: Cumming. 1 unit. C-L: Environment 289A

Earth and Ocean Sciences (EOS)

272A. Analysis of Ocean Ecosystems. The history, utility, and heuristic value of the ecosystem; ocean systems in the context of Odum's ecosystem concept; structure and function of the earth's major ecosystems. (Given at Beaufort.) Prerequisite: one year of biology, one year of chemistry, or consent of instructor. Instructor: Johnson. 1 unit. C-L: see Biology 272A; also C-L: Environment 272A

280LA. Sound in the Sea: Introduction to Marine Bioacoustics. Fundamentals of marine bioacoustics with a focus on current literature and conservation issues. Topics include: introduction to acoustics; acoustic analysis methods and quantitative tools; production and recording of sound; ocean noise; propagation theory; active and passive acoustics; hearing, sound production and communication in marine organisms, potential impacts of anthropogenic noise; and regulation of marine sound. Labs will focus on methodologies used for generating, recording and analyzing marine sounds. Taught in Beaufort. Course prerequisites: AP Biology, introductory biology, or consent of instructor; Physics 141L or 161L (or equivalent Physics courses) or consent of instructor. Instructor: Nowacek. 1 unit. C-L: Electrical and Computer Engineering 384LA, Environment 280LA, Biology 279LA

370A. Introduction to Physical Oceanography. Fundamental physical principles of ocean circulation. Physical properties of seawater; forces acting on the ocean such as heat, pressure gradients, wind stress, rotation, and friction; and conservation equations for heat, mass and momentum. Applications include geostrophic balances, thermal wind, coastally trapped waves, El Nino/ENSO, and tidal circulation. (Given at Beaufort.) Prerequisites: one year of calculus and one year of physics, or permission of instructor. Instructor: Hench. 1 unit. C-L: see Environment 370A

374LA. Marine Ecology. Factors that influence the distribution, abundance, and diversity of marine organisms. Course structure integrates lectures, field excursions, lab exercises and an independent project. Lecture topics include physical characteristics of marine systems, adaptation to environment, species interactions, biogeography, larval recruitment, and biodiversity and conservation of communities found in rocky shores, tidal flats, beaches, marshes, mangrove, coral reefs, and subtidal areas. Not open to students who have taken Biology 773LA. (Given at Beaufort fall, spring, summer. Spring enrollment requires travel to Caribbean). Prerequisite: introductory biology. Instructor: Silliman. 1 unit. C-L: Environment 273LA, Biology 273LA

377LA. Marine Invertebrate Zoology. Structure, function, and development of invertebrates collected from estuarine and marine habitats. Not open to students who have taken Biology 777LA. One course (fall, spring, and Summer Term II); one and one-half courses (Summer Term I). (Given at Beaufort fall, spring, and summer.) Prerequisite: AP Biology or introductory biology or consent of instructor. Instructor: Van Dover or staff. Variable credit. C-L: see Biology 377LA; also C-L: Environment 377LA

391. Independent Study. Directed reading or individual projects. Term paper required. Open only to qualified juniors and seniors by consent of director of undergraduate studies and supervising instructor. Instructor: Staff. 1 unit.

392. Independent Study. See Earth and Ocean Sciences 391. Term paper required. Open only to qualified juniors and seniors by consent of director of undergraduate studies and supervising instructor. Instructor: Staff. 1 unit.

393. Research Independent Study. Individual research in a field of special interest under the supervision of a faculty member, the central goal of which is a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. Open only to qualified juniors and seniors by consent of director of undergraduate studies and supervising instructor. Instructor: Staff. 1 unit.

393A. Research Independent Study. Marine Lab version of Earth and Ocean Sciences 393. (Offered at Beaufort). Instructor: Staff. 1 unit.

394. Research Independent Study. See Earth and Ocean Sciences 393. Open only to qualified juniors and seniors by consent of director of undergraduate studies and supervising instructor. Instructor: Staff. 1 unit.

579LA. Biological Oceanography. Physical, chemical, and biological processes of the oceans, emphasizing special adaptations for life in the sea and factors controlling distribution and abundance of organisms. Four units (spring); six units (summer). (Given at Beaufort.) Prerequisite: introductory biology. Instructor: Johnson. Variable credit. C-L: Biology 579LA, Environment 579LA

716A. Beach and Island Geological Processes. Field seminar on the evolution of beaches and barrier islands with emphasis on the interactions between nearshore processes and human development. Prerequisite: Earth and Ocean Sciences 315/515 or consent of instructor. Also taught as Earth and Ocean Sciences 316A. Instructor: Murray. 2 units.

890A. Advanced Topics in Earth and Ocean Sciences. To meet the individual needs of graduate students for independent study. Instructor: Staff. Variable credit.

990A. Advanced Topics in Earth and Ocean Sciences. To meet the individual needs of graduate students for independent study. Instructor: Staff. Variable credit.

Electrical and Computer Engineering (ECE)

384LA. Sound in the Sea: Introduction to Marine Bioacoustics. Fundamentals of marine bioacoustics with a focus on current literature and conservation issues. Topics include: introduction to acoustics; acoustic analysis methods and quantitative tools; production and recording of sound; ocean noise; propagation theory; active and passive acoustics; hearing, sound production and communication in marine organisms, potential impacts of anthropogenic noise; and regulation of marine sound. Taught in Beaufort. Course prerequisites: AP Biology, introductory biology, or consent of instructor; Physics 141L or 161L (or equivalent Physics courses) or consent of instructor. Instructor: Nowacek. 1 unit. C-L: Environment 280LA, Earth and Ocean Sciences 280LA, Biology 279LA

784LA. Sound in the Sea: Introduction to Marine Bioacoustics. Fundamentals marine bioacoustics w/focus on current lit and conserv issues. Topics incl: intro acoustics; acoustic analysis methods and quant tools; production/recording of sound; ocean noise; propagation theory; active/passive acoustics; hearing, sound production and communication in marine organisms, potential impacts of anthropogenic noise; and regulation of marine sound. Lab focus on methodologies for generating, recording and analyzing marine sounds. Grad students responsible for addtl acoustic analyses and results prep for student projects plus preparation addtl lit review/critique. Taught in Beaufort. Prereqs: AP or Intro Bio or consent; Phy 41L or 161L (or equiv) or consent. Instructor: Nowacek. 4 units. C-L: Biology 784LA, Environment 784LA

English (ENGLISH)

219A. Science and Nature Writing: Naturalist Narratives, Classic to Contemporary. Introspective and expository prose is effective in transferring concepts and information from scientists to other segments of society. Students will explore nonfiction writing about marine ecosystems as the basis for discussion and analysis. They will experiment with essays that convey information about the natural world and that target specific audiences (e.g., children, general public, business executives, the blogosphere, etc.) and specific goals. Exercises will stress practice in crafting essays that convey scientific information with a nature writer's eloquence. Particular emphasis will be placed on editing and revision toward publication-quality manuscripts. (Given at Beaufort.). Instructor: Van Dover. 1 unit. C-L: Environment 219A

Neuroscience (NEUROSCI)

381LA. Sensory Physiology and Behavior of Marine Animals. Sensory physiological principles with emphasis on visual and chemical cues. Laboratories will use behavior to measure physiological processes. (Given at Beaufort.) Prerequisites: AP Biology or introductory biology or consent of instructor and Chemistry 101DL. Instructor: Rittschof. 1 unit. C-L: Biology 373LA

Physics (PHYSICS)

141LA. General Physics I. First part of a two-semester, calculus-based, physics survey course for students planning study in medicine or the life sciences. Topics: kinematics, dynamics, systems of particles, conservation laws, statics, gravitation, fluids, oscillations, mechanical waves, sound, thermal physics, laws of thermodynamics. For credit,
enrollment in Physics 141L and a lab/recitation (Physics 141L9, 141D) section required. Students planning to major in physics should enroll in Physics 161L, 162L in their freshman year. Closed to students having credit for Physics 151L, 153L, or 161L. Prerequisites: one year of college calculus (or equivalent) such as Math 105L, 106L, or 21. Math 122 recommended. Instructor: Brown or Tyndall. 1 unit.

142LA. General Physics II. Second part of a two-semester calculus based course surveying principles of physics for students planning to study medicine or life sciences. Topics include: electrostatic fields and potential, capacitors, DC circuits, magnetic fields, electromagnetic induction, Maxwell’s equations, electromagnetic waves, properties of light (including reflection, refraction, polarization), geometric optics, wave optics, atomic and nuclear physics. Students must enroll in both a lecture and a lab/recitation section to receive credit. Open only to students in the Duke Marine Lab. Closed to students having credit for Physics 152L, 153L or 162L. Prerequisites: Physics 141L, 151L, or 161L. Instructor: Brown. 1 unit.

Political Science (POLSCI)

707A. Marine Policy (A). Formal study of policy and policy-making concerning the coastal marine environment. History of specific marine-related organizations, legislation, and issues and their effects on local, regional, national, and international arenas. Topics explored through use of theoretical and methodological perspectives, including political science, sociology, and economics. Consent of instructor required. (Given at Beaufort.) Instructor: Staff. 3 units. C-L: see Environment 786A; also C-L: Public Policy Studies 749A

Public Policy Studies (PUBPOL)

246A. Marine Conservation Policy Practicum. Immersion in marine conservation policy basics for 21st Century society including two week-long, current issue modules. Hands-on, team-based, experiential learning with meaningful faculty-student engagement. Phenomena affecting maintenance and loss of biodiversity; key concepts of social science and law for instituting policy; capstone-position papers and stakeholder negotiation highlighting ecological, economic, cultural, and institutional complexity associated with negotiating stakeholders' priorities for public trust resources. (Given at Beaufort.) Prerequisites: Biology 202L, Public Policy 155D suggested, or instructor consent. Concurrent enrollment required in Environ 384A/Biology 384A. Instructor: Nowacek. 1 unit. C-L: Environment 346A

281A. Marine Policy. Policy and policy-making concerning the coastal marine environment. History of marine-related organizations, legislation, and issues and their effects on local, regional, national, and international arenas. Use of theoretical and methodological perspectives, including political science, sociology, and economics. (Given at Beaufort.) Instructor: Staff. 1 unit. C-L: Environment 286A

445A. Climate Change in the Marine Environment. Exploration of climate change science focusing on marine ecosystems and inhabitants - specifically ocean acidification, warming and sea level rise. Factors causing climate change, and how those vary spatially, focusing on sensitive polar ecosystems and marine mammal populations. Critical examination of climate change modeling using EdGCM (research-grade Global Climate Model), focusing on how scientists use models, observations/theory to predict climate, and assumptions/uncertainty implicit in modeling. Discussion of potential human impacts including consequences of sea level rise and potential increases in disease due to climate change. (Taught at Beaufort.) Instructor: Hunt. 1 unit. C-L: Biology 445A, Environment 445A

749A. Marine Policy (A). Formal study of policy and policy-making concerning the coastal marine environment. History of specific marine-related organizations, legislation, and issues and their effects on local, regional, national, and international arenas. Topics explored through use of theoretical and methodological perspectives, including political science, sociology, and economics. Consent of instructor required. (Given at Beaufort.) Instructor: Orbach. 3 units. C-L: see Environment 786A; also C-L: Political Science 707A

946A Marine Conservation Institute. Immersion in marine conservation biology and policy. Basic tools of marine conserv bio and policy for 21st Century society and 'anthropocene' epoch intertwined with two week-long modules. Hands-on, team-based, experiential learning w/meaningful faculty-student engagement. Phenomena affecting maintenance and loss of biodiversity (climate change, habitat destruction); strategies for combatting threats to biodiversity; key concepts of social science and law for instituting conserv policy; unique capstone-position papers and stakeholder negotiation; grad students will critique position papers. (Given at Beaufort). Prerequisites: AP Bio, Bio
202L, suggested policy and/or intro ecol, or instructor consent. Instructor: Nowacek. 7 units. C-L: Environment 746A
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