
bulletin of
Duke University
2010–2011

Nicholas School of the Environment



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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Nicholas School of the Environment

The information in this bulletin applies to the academic year 2010-2011 and is accurate and current, to the extent possible, as of June, 2010. 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 prohibits discrimination, and provides equal employment opportunity without regard to race, color, religion, national origin, disability, veteran status, sexual orientation, gender identity, sex or age. The university also makes good faith efforts to recruit, employ, and promote qualified minorities, women, individuals with disabilities, and veterans. It admits qualified students to all the rights, privileges, programs, and activities generally accorded or made available to students. The university prohibits harassment of any kind.

Questions, comments or complaints of discrimination or harassment should be directed to the Office for Institutional Equity, (919) 684-8222. Further information, as well as the complete text of the harassment policy, may be found at <http://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 Student Right to Know and Campus Security Acts may be obtained from the Office of University Relations at (919) 684-2823 or in writing to 615 Chapel Drive, Box 90563, Duke University, Durham, North Carolina 27708.

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, Georgia 30033-4097 or call 404-679-4500 for questions about the accreditation of Duke University.

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Academic Calendar

2010-2011

FALL 2010

August 23	Monday. Nicholas School orientation begins.
August 24	Tuesday. New graduate student orientation.
August 25	Wednesday. 4:00 p.m. Convocation for graduate and professional school students
August 30	Monday. 8:30 a.m. Fall Semester classes begin; Drop/add continues
September 6	Monday. Labor Day. Classes in session
September 10	Friday. Drop/add ends
October 3	Sunday. Founders' Day
October 8	Friday. 7:00 p.m. Fall break begins
October 13	Wednesday. 8:30 a.m. Classes resume
November 3	Wednesday. Registration begins for spring semester, 2011
November 17	Wednesday. Registration ends for spring semester, 2011
November 18	Thursday. Drop/Add begins for spring 2011
November 23	Tuesday. 10:30 p.m. Thanksgiving recess begins
November 29	Monday. 8:30 a.m. Classes resume
December 3	Friday. Graduate classes end
December 4-13	Saturday-Monday. Graduate reading period; length of the 200-level course reading period is determined by the instructor
December 14	Tuesday. Final examinations begin (9:00 a.m.)
December 19	Sunday. 10:00 p.m. Final examinations end

SPRING 2011

January 12	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 13; classes meeting in a Wednesday/Friday meeting pattern begin January 14; drop/add continues
January 13	Thursday. Regular class meeting schedule begins
January 17	Monday. Martin Luther King, Jr. Day holiday: classes are rescheduled on Wednesday, January 12
January 26	Wednesday. Drop/add ends
February 21	Monday. Registration begins for summer 2011
March 4	Friday. 7:00 p.m. Spring recess begins
March 14	Monday. 8:30 a.m. Classes resume
April 6	Wednesday. Registration begins for fall semester 2011; summer 2011 registration continues
April 15	Friday. Registration ends for fall semester 2011; summer 2011 registration continues
April 16	Saturday. Drop/add begins
April 20	Wednesday. Graduate classes end
April 21 - May 1	Thursday-Sunday. Graduate reading period; length of the 200-level course reading period is determined by the instructor

May 2	Monday. Final examinations begin
May 7	Saturday. 10:00 p.m. Final examinations end
May 13	Friday. Commencement begins
May 15	Sunday. Graduation exercises; conferring of degrees

SUMMER 2011

February 21	Monday. Registration begins for all Summer sessions
May 18	Wednesday. Term I classes begin. The Monday class schedule is in effect on this day. Regular class meeting schedule begins on Thursday, May 19; Drop/Add continues
May 19	Thursday. Regular class meeting schedule begins
May 20	Friday. Drop/Add for Term I ends
May 30	Monday. Memorial Day holiday. No classes are held
June 16	Wednesday. Last day to withdraw W from Term I classes
June 27	Monday. Term I classes end
June 28	Tuesday. Reading period
June 29	Wednesday. Term I final examinations begin
June 30	Thursday. Term I final examinations end
July 4	Monday. Independence Day holiday observed. No classes are held.
July 5	Tuesday. Term II classes begin
July 7	Thursday. Drop/Add for Term II ends
August 1	Monday. Last day to withdraw W from Term II classes
August 11	Thursday. Term II classes end
August 12	Friday. Reading period (Until 7:00 p.m.)
August 12	Friday. Term II final examinations begin, 7:00 p.m.
August 14	Sunday. Term II final examinations end

General Information

Introduction

Headquartered in the heart of the Duke campus, the Nicholas School of the Environment functions as an environmental forum and an intellectual hub, drawing input from all disciplines at Duke—including law, business, medicine, science and engineering. The goal is to develop critical and creative thinkers and doers who will forge a sustainable future.

No other university—and no other environmental school—takes such a broad approach to environmental science and policy.

The mission of the Nicholas School is education and research to understand basic earth and environmental processes, to understand human behavior related to the environment and to inform society about the conservation and enhancement of the environment and its natural resources for future generations. Intrinsic to this mission are (1) a commitment to interdisciplinary approaches; (2) a commitment to objective and, where possible, quantitative approaches; (3) a commitment to principles of ecological integrity; (4) a commitment to the sustainable use of natural resources; and (5) a commitment to environmental education at all levels. The overall objective is to assist in the definition and resolution of environmental problems confronting society, through excellence in natural resource and environmental education and research.

Both basic and applied research are integral to the Nicholas School's mission. The faculty is engaged in a dynamic program of research, much of which is focused on contemporary natural resource and environmental issues, both terrestrial and marine, that are regional, national and global in scope. Students also are encouraged to apply basic research to help solve real-world environmental problems. Alumni of the Nicholas School hold leadership positions in government, private industry, academia and not-for-profit organizations throughout the nation and the world.

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. 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 Duke's Fuqua School of Business (MBA), the School of Law (JD), the Sanford School of Public Policy (MPP), the Pratt School of Engineering (MEMP), and the Master of Arts in Teaching (MAT) through the Duke Graduate School.

Doctoral Degrees

The traditional PhD, which is offered to Nicholas School students through the Duke 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 Trinity College of Arts and 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 60 Duke professors in 20 cooperating departments and schools. The Biology Department 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 is the newest school to be formed at Duke University, but it 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 new Division of Earth and Ocean Sciences was created when the former Department of Geology, previously a part of Trinity College of Arts and 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 2003, Peter and Ginny Nicholas pledged \$70 million to establish the Nicholas Institute for Environmental Policy Solutions and other activities for the Nicholas School to assume environmental leadership and achieve worldwide impact.

Divisions

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

Earth and Ocean Sciences (EOS)

With focal areas in climate change, energy, solid earth processes and surficial processes, this division is headquartered in the Old Chemistry building at Duke. 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 (ESP)

With focal areas in ecosystem science and management, environmental health, wetlands and environmental economics and policy, ESP is headquartered in the Levine Science Research Center. 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 (MSC)

With focal areas in marine ecology, estuarine processes and coastal geology, this division is headquartered at the Duke University Marine Laboratory at Beaufort, NC. Faculty research interests include studies of marine conservation biology and fisheries practice, the post-hurricane health of the Neuse River and Pamlico Sound, applications of social science to environmental policy and management of marine ecosystems.

Location

Duke University is situated in Durham, a city of more than 220,000 inhabitants in the central piedmont region of North Carolina. The Appalachian escarpment lies approximately 100 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 east 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.

Facilities

The Nicholas School of the Environment is headquartered in the Levine Science Research Center (LSRC), an interdisciplinary research facility situated on Research Drive on Duke University's West Campus. The building includes state-of-the-art classrooms, computer labs specializing in the analysis of geospatial data and research laboratories and instrumentation supporting both teaching and research. The Division of Environmental Sciences and Policy is located in the LSRC.

The Division of Earth and Ocean Sciences occupies renovated laboratories in the Old Chemistry building on the West Campus. The Division maintains state-of-the-art facilities for geochemical analysis and climate modeling studies.

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 over 7,000 acres of land in Durham, Orange and Alamance counties and has been managed for research and teaching purposes since 1931. The mission of the Forest is to facilitate research that addresses fundamental and applied questions concerning forested and aquatic ecosystems and to aid in the instruction of students so that they will be informed citizens and effective stewards of our natural resources. The Duke Forest, because of its size, diversity, proximity to campus and over 75 years of accumulated research data, is a natural resource unequalled at any other university.

The Forest lies primarily near the eastern edge of the piedmont plateau and supports a cross-section of the woodlands found in the upper coastal plain and lower piedmont of the Southeast. A variety of timber types, plant species, soils, topography, and past land use conditions are represented. Elevations range from 260 to 760 feet above sea level. Soils of the region are derived from such diverse parent materials as metamorphic rock of the Carolina Slate formation, granite, Triassic sedimentary rock and basic intrusives.

Academic use of the Duke Forest ranges from class instruction to long-term research projects, including studies on such diverse topics as vegetation composition, landscape ecology, remote sensing, invertebrate zoology, atmospheric science and global climate change. Background information useful to research covers such features as soils,

topography, forest inventory, plantation and cultural records, as well as a bibliography of past and current studies. Much of this data is available electronically in Geographic Information System (GIS) format.

In addition to leading educational tours and field laboratory exercises, Duke Forest staff are available to assist researchers in site establishment and management. Researchers can request forest stand manipulations, such as thinning and prescribed burning. Staff can also assist in preparing field areas through mowing, disking or planting with in-house equipment. Location of study areas can be mapped using our Global Positioning System (GPS) unit.

All students who wish to initiate research or lead class activities in the Duke Forest should contact the Office of the Duke Forest to discuss the project. Through a simple registration process, students can gain access to all of the Forest's services, including maps and gate keys (for a \$10 deposit). More information can also be found on the Internet 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 and research in basic ocean and coastal ecosystem processes, marine conservation biology, and ocean and coastal environmental management and policy.

The Marine Lab operates year-round to provide training, educational and research opportunities to about 10,000 people annually, including undergraduate, graduate degree and doctoral students enrolled in the university's academic programs; students from other colleges enrolling for one or more semesters; visiting student groups who use the laboratory's facilities; and scientists who come from North America and abroad to conduct research. A seminar/lecture series features many 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 30 and 40 miles offshore, with reefs on the wide continental shelf. 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.

Seven other laboratories 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, the Center for Marine Science and Technology, the North Carolina State University Seafood Laboratory, the North Carolina Aquarium at Bogue Banks, the North Carolina Divisions of Marine Fisheries and Coastal Management, the North Carolina Maritime Museum, and the National Oceanic and Atmospheric Administration's (NOAA) Beaufort Laboratory. This concentration of marine scientists provides a critical mass for the pursuit of science, conservation and education.

Teaching and Research Facilities

The Marine Lab consists of 24 buildings: dormitories, a dining hall, a student commons, classrooms, laboratories and six research buildings, including the new Marguerite Kent Repass Ocean Conservation Center, the Marine Lab's first LEED-Certified green building. 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 televideo facilities, linked to the outside world through a DS3 line. 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. In addition, the Marine Lab now features a new, fully equipped and state-of-the-art molecular genetics facility that can host eight scientists. The molecular facility is capable of a range of genetic studies ranging 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, and is the home port for the R/V Cape Hatteras, a 135-foot oceanographic research vessel operated by the Duke/University of North Carolina Oceanographic Consortium (DUNCOC).

Duke/University of North Carolina Oceanographic Consortium (DUNCOC)

The Duke/UNC Oceanographic Consortium operates the *R/V Cape Hatteras*, one of the ships in the fleet of oceanographic vessels supported by the National Science Foundation, for the purpose of providing research opportunities for scientists from across the nation. The ship is based at the Marine Lab and operates both on the continental shelf and in the deep sea in the western North Atlantic, concentrating on the region between Nova Scotia and the Caribbean. The *Hatteras* is used for training at sea by members of the Consortium (Duke, the University of North Carolina at Chapel Hill, North Carolina State University, University of North Carolina Coastal Studies Institute, the University of North Carolina at Wilmington, the University of North Carolina at Greensboro, and East Carolina University). Inquiries regarding the use of the research vessel should be directed to the Marine Superintendent at the Duke University Marine Lab.

Computer Resources

The Nicholas School of the Environment maintains its own Information Technology department in addition to participating in Duke's centralized computing initiatives. The Nicholas School IT department supports students, faculty and staff in all divisions and locations. Resources at each location vary, but all provide computing labs, specialized software packages, data storage, printers, scanners and network/Internet access.

Hardware offerings include Nicholas School-only computing labs; instructional computing classrooms; loaner laptops, tablets and iPods; high-speed printers; a large-format plotter for printing posters and maps; and several digital projector/PC carts available for checkout.

The Nicholas School provides access to ArcGIS software and is the main source of training and support. Duke site-licensed software as well as typical office packages and presentation software are also installed on Nicholas School computers. Operating systems supported include Linux, Mac OSX and Windows XP Professional.

Network services include centralized data storage and archiving, videoconferencing and access to Duke's broadband and wireless networks.

Because the Nicholas School is spread across several locations, videoconferencing is a frequently employed tool enabling faculty, staff and students to communicate and visualize information regardless of distance. Certain courses are co-located in both Durham and Beaufort.

Several Nicholas School faculty participate in Duke's high-performance computing initiative. E-mail, Blackboard, AFS Course Folders, WebFiles, Duke Wiki, Lectopia, and web conferencing are examples of other Duke centralized initiatives that are being used in the Nicholas School.

Since computing resources change frequently 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, 10 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 co-publishes 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 co-sponsors 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 Internet 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 Business School at the University of North Carolina at Chapel Hill, the Center for Sustainable Enterprise offers educational programs, research and outreach to help companies and nonprofit organizations grow and profit in non-traditional and emerging markets with economically, environmentally and socially 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/cse>.

Organization for Tropical Studies at Duke

The Organization for Tropical Studies (OTS) is a non-profit consortium that has grown to include 63 universities and research institutions from the United States, Latin America and Australia. In the early 1960's, scientists from U.S. 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 U.S. 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 10 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, and the Music Library - and the libraries affiliated with the Divinity School, the Fuqua School of Business, the 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 15 million volumes. Library patrons can search our more than 6 million volume collection, search over 168,000 electronic resources, and print articles on demand or download them to their computer or smart phone. Through a single interface, they can search the catalogs of our Triangle Research Libraries Network partners (UNC-CH, NCSU, and NCCU) and have a book from our combined collection of more than 15 million volumes delivered within 24 hours. They can ask a Duke librarian a question from anywhere in the world by email, phone, or IM. Last year, Duke University librarians made 563 presentations to more than 7,000 students and answered more than 137,000 questions in person, by phone, live chat, or IM.

The Pearse Memorial Library on the Beaufort campus is a branch library 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 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. While limited housing for graduate students is available on campus, most graduate students in the Nicholas School of the Environment have no trouble finding a place to live off campus. 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 Web site at <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 Karen Kirchof, Assistant Dean, Career Services, Nicholas School of the Environment at Box 90332, Duke University, Durham, NC 27708 or at 919-613-8016.

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. Internet: http://healthydevil.studentaffairs.duke.edu/medical_services.

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 24 hours a day during the 12-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 660-1000 or visiting CAPS, 214 Page Building.

Career Services

The Nicholas School of the Environment operates its own Career Services office for MEM/MF students and alumni. The mission of Career Services is to offer high quality services, training programs and career opportunities that are academically relevant and positively contribute to a student's professional development and eventual career success. Helping students and alumni make the most of their Nicholas education, resources, and connections to develop career interests and values. Professional staff members are available to assist Nicholas School students in Durham and Beaufort with individual career planning, internship and employment searches and professional development needs. The career services Web site (<http://www.nicholas.duke.edu/career>) provides current students and alumni career advice, access to an active alumni network, employment/internship opportunities and information about scholarships, research grants and fellowship opportunities.

The University Career Center at Duke (<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 University 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, post office and bank 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.

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

Nicholas School students can participate in a wide variety of environmental education, service learning and outreach activities through the DEL Program. Opportunities include working with students and teachers in local partner schools, participating in community outreach workdays, and planning and implementing Duke University's Earth Day and Earth Month activities.

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 non-hierarchical, consensus basis. Learn more at <http://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. Arranges the silent auction at Spring Banquet, Veggies Sales, Nicholas School sweatshirts, etc.

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 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 30 (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. Tentatively planning to attend the Coastal Cities Conference in November.

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 students, giving providing a glimpse into professional life after the Nicholas School. Council members also communicate with Nicholas administrators on the state of the MEM program, 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).

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 Degree Programs

Undergraduate Degrees

The Nicholas School of the Environment collaborates with Trinity College of Arts and Sciences in awarding four undergraduate degrees: (1) the Bachelor of Arts in Environmental Sciences and Policy, (2) the Bachelor of Science in Environmental Sciences, (3) the Bachelor of Arts in Earth and Ocean Sciences, and (4) 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 107 Old Chemistry Building; undergrad@nicholas.duke.edu, or through the program Web site at nicholasundergrad.net.

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 and Sciences or the Pratt School of Engineering. All applicants should contact the Office of Undergraduate Admissions or visit their Web site, <http://www.admissions.duke.edu>.

Environmental Sciences and Policy (ENVIRON)

Professor Emily Klein, *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 environmental 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. Upper-level 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 25 Introduction to Environmental Sciences and Policy
- Biology 101L or 102L. Gateway to Biology. A biodiversity course: Biology 26A(L) or 26B(L) Diversity of Life, or 140 Plant Diversity, or 176 Marine Invertebrate Zoology, or Environment 103 Conserving the Variety of Life
- Chemistry 31L Core Concepts in Chemistry or equivalent
- Economics 51D Economic Principles or Economics 55D Intermediate Microeconomics I, or equivalent
- Earth and Ocean Sciences 11 The Dynamic Earth, or Earth and Ocean Sciences 12 The Dynamic Oceans (C-L: Biology 53)
- Mathematics 31L and 32L Laboratory Calculus I and II, or equivalent



Major Requirements

1. Intermediate Core Course: Environment 101
2. Environmental Policy. One course from an approved list of environmental policy courses. Approved courses include:
 - Environment 149/Public Policy Studies 149 United States Environmental Policy
 - Environment 152S/Public Policy Studies 167S/Political Science 152S Environment and Conflict
 - Environment 175 Marine Policy
 - Public Policy 147/Political Science 147 Environmental Politics and Policies in the Developing World
 - Political Science 102 Introduction to Political Inquiry
 - Political Science 148/Public Policy Studies 143 Environmental Policies Beyond Borders
 - Public Policy Studies 297/Environment 276 Marine Policy
 - Environment 273 Marine Fisheries Policy
3. Probability and Statistics. (Statistics 101, 102, 103, or equivalent).
4. Focused Study. Five upper-level courses proposed by the student in consultation with his or her advisor to fit a particular theme or career objective. At least two of these courses must be selected from approved lists in each of the social sciences/humanities and sciences/engineering areas. These lists are available from the undergraduate web page at <http://www.nicholas.duke.edu/people/students/undergrad/masterlist.pdf>. One course must be an upper-level seminar, a senior capstone course or a 200-level course.

Independent Study/Internship/Field Experience. Students complete an approved independent study, internship, or field experience which may or may not include course credit toward upper-level requirements.

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 pre-medical 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.

For the BS Degree

Corequisites

The following courses or their equivalents (for example, Advanced Placement credit) are required. Approval to substitute course 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 101L or 102L. Gateway to Biology. Chemistry 31L Core Concepts in Chemistry and 32L Modern Applications of Chemical Principles, or 151L Organic Chemistry
- Physics 41L and 42L, or Physics 51L and 52L, or Physics 53L and 54L. Chemistry 151L may be substituted for the second semester of Physics
- Mathematics 31L Laboratory Calculus I and 32L Laboratory Calculus II, or Mathematics 41L Introductory Calculus II with Applications
- Environment 25 Introduction to Environmental Science and Policy, or Earth and Ocean Sciences 11 The Dynamic Earth; or Earth and Ocean Sciences 12 The Dynamic Oceans (C-L: Biology 53)

Major Requirements

1. Five Core Courses selected from the following six courses or course lists:
 - A. Earth and Ocean Sciences 102 The Fluid Earth
 - B. Environment 160 Environmental Chemistry and Toxicology
 - C. Earth and Ocean Sciences 107L The Evolving Earth and Life
 - D. Earth and Ocean Sciences 123 Hydrogeology
 - E. One course from an approved list of ecology courses. Approved course list includes:
 - Environment 110 Ecology (C-L Biology 110)
 - Biology 116 Ecology and Evolution
 - Biology 129L/Environment 139L Marine Ecology
 - Biology 114L/Environment 114L Biological Oceanography
 - Biology 123/Environment 123 Analysis of Ocean Ecosystems

- F. One course from an approved list of courses that focus on the interface between humans and the environment. Approved course list includes:
- Environment 101 Introduction to Environmental Sciences and Policy
 - Environment 103 Conserving the Variety of Life on Earth
 - Environment 129 Environmental Science and Policy of Tropics
 - Environment 149/Public Policy Studies 149 United States Environmental Policy
 - Biology 109 Conservation Biology and Policy (Beaufort)
 - Economics 163 Economics of the Environment.
 - Philosophy 115 Applied & Environmental Ethics
2. Probability and Statistics (Statistics 101, 102, 103, 112, Economics 139, Political Science 138, Psychology 117, or equivalent)
 3. 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 web page at <http://www.nicholas.duke.edu/people/students/undergrad/masterlist.pdf>. The student will submit to his or her advisor, usually at the beginning of their junior year, a written rationale for the courses selected.

Independent Study, Internship, or Field Experience. Students pursuing the BS degree complete an independent study, internship, or a field experience related to their proposed course of study. The director's office, in collaboration with Duke's Career Development and Counseling Office, maintains information on available internships. Field experiences may include a semester or summer session at the Duke University Marine Laboratory, participation in field-oriented study abroad programs, or studies at approved field laboratories.

THE MINOR

Environmental Sciences and Policy

Requirements: Five courses: two core courses (Environment 25 and Environment 101); the remaining three courses selected from 100-level or above Environment courses, which may include one substitution of a course in another department.

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 faculty advisor who has agreed to supervise the research. Participants write a substantial paper describing their completed research, which is evaluated by the faculty committee. Graduation with Distinction candidates normally enroll in an Independent Study course (Environment 191/192) supervised by the research advisor; this course cannot be used to satisfy the major requirements. For additional information and an application form, contact the director of undergraduate programs or visit <http://www.nicholas.duke.edu/people/students/undergrad/distinction.html>.

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 Business School, the Divinity School, the Law School, the Medical School, the Pratt School of Engineering, and any Environment courses at or above the 200-level in the Nicholas School of the Environment.

Earth and Ocean Sciences (EOS)

Professor Professor Bruce Corliss, *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 Trinity College of Arts and Sciences. A minor in Earth and Ocean Sciences also is offered.

The majors are administered by the Nicholas School of the Environment. Courses for the major include introductory and advanced courses in coastal geology, climate change, environmental geology, hydrology, energy resources, geochemistry, geomorphology, oceanography, paleontology, petrology, sedimentology, and marine geology. 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 environmental earth sciences. A Bachelor of Arts degree is offered for those students who do not intend to pursue the earth sciences professionally, but wish to understand more fully local and global earth and environmental issues. For additional information, consult the program Web site, at nicholasundergrad.net.

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 11, or 12, followed by six Earth and Ocean Sciences courses of which five must be 100-level or higher, and three additional 100-level or higher courses in either Earth and Ocean Sciences or related fields (physics, mathematics, biology, biological anthropology and anatomy, environment), as approved by the director of undergraduate studies.

For the BS Degree

The BS degree provides a background suitable for subsequent graduate or professional work in the earth and ocean sciences.

Prerequisites. Earth and Ocean Sciences 11 and 12; Chemistry 31L and 32L or 151L; Mathematics 31L and 32L or 41L; Physics 53L (or Physics 51L); Biology 102L.

Major requirements. Earth and Ocean Sciences 101, 102, 103S, and 107L, followed by five additional Earth and Ocean Sciences courses at the 100-level, including one field-oriented class. Up to two courses from a related field (biology, chemistry, physics, environment, or mathematics) 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 11 or 12, and four additional earth and ocean sciences courses, three of which must be 100-level or higher.

Graduation with Distinction

The Earth and Ocean Science 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 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 faculty advisor who has agreed to supervise the research. Participants write a substantial paper describing their completed research, which is evaluated by the faculty committee. Graduation with Distinction candidates normally enroll in an Independent Study course (Earth and Ocean Sciences 191/192) supervised by the research advisor; this course cannot be used to satisfy the major requirements. For additional information and an application form, contact the director of undergraduate programs or visit <http://www.nicholas.duke.edu/people/students/undergrad/distinction.html>.

Leadership in Marine Science and Conservation (Undergraduate Certificate)

Professor Van Dover, Director

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

The Marine Science and Conservation Leadership program is rooted in marine science and conservation and 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 Certificate will provide undergraduate students with leadership skills and an understanding of both natural and social science concepts and practices.

The Certificate program requires a residential component at the Duke Marine Lab in Beaufort, NC, for one full academic semester (fall or spring) or two five-week summer terms. Marine Lab residence features opportunities that bring Duke undergraduates together with local, regional, national, and international leaders in formal and informal settings.

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 Leadership in Marine Science and Conservation may also satisfy the requirements of any major, minor, or other certificate program.

The certificate requires one introductory course (ENV 25 or ENV 101 with permission, for students who place out of ENV 25) on environmental sciences and policy that introduces students to the integration of natural and social sciences and a means of evaluating an environmental issue and developing an effective solution. The certificate also requires 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. The approved course list is at <http://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.

UNDERGRADUATE CERTIFICATE REQUIREMENTS

The certificate requirements are: (1) a total of six courses, as described above; (2) no more than three courses may originate in a single department; and (3) no more than two courses that are counted toward the Leadership in Marine Science and Conservation Certificate may also satisfy the requirements of any major, minor, or other certificate program.

Energy and the Environment (Undergraduate Certificate)

Tod A. Laursen 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, non-profit, 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://www.nicholas.duke.edu/programs/undergrad/energycert.html>.

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.

Energy use is a multi-faceted 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 certificate requires three integrative courses.

Two introductory courses:

Civil and Environmental Engineering 24L

Environment 130

One Capstone Project Course

In this course, teams of students explore the feasibility of a new or modified energy resources or technology. Three elective courses are also required, with one from each area (Markets and Policy, Environment, and Energy Technology) taken from the below list. The most up-to-date version of this list can be found on the program's Web site: <http://www.nicholas.duke.edu/programs/undergrad/undergraduate-certificate-in-energy-and-environment>.

Core Courses (required)

Civil and Environmental Engineering 24L. Introduction to Environmental Engineering and Science

Earth and Ocean Sciences/Environment 130. Energy and the Environment

Electives (one from each area)

Markets & Policy

Economics 163/ Environment 163 Economics of the Environment

Environment 149 /Public Policy 149 U.S. Environmental Policy

Environment 298.80 Energy Economics & Policy

Environment

Civil Engineering 120L Chemical Processes in Environmental Engineering

Civil Engineering 124L Environmental Engineering

Chemistry 83 Chemistry/Technology/Society

Environment 25 Intro to Environmental Science and Policy

Environment 131 World Trade in Energy
Environment 160 Environmental Chemistry & Toxicology
Environment 179 Introduction to Atmospheric Chemistry
Earth and Ocean Sciences 155 Global Warming

Energy Technology

Environment 298.23 Energy Technology & the Environmental Impact (Trinity College)
Mechanical Engineering 121 Energy Engineering and the Environment (Pratt School)

CERTIFICATE REQUIREMENTS

The certificate requirements are: (1) a total of six courses, as described above; (2) no more than three courses may originate in a single department; and (3) 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.

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, N.C. Academic programs include a fall semester, a spring semester and two five-week summer terms. The fall and spring semesters include Beaufort Signature Courses with extended field trips to Singapore, Puerto Rico, Mexico, Costa Rica, Panama, and California. The academic programs integrate classroom lectures and laboratories with direct field and shipboard experiences. For more information, visit the Duke Marine Lab Web site at <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/conc/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 Web site with up-to-date information about major requirements at nicholasundergrad.net.

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.

Lawrence E. Blanchard Society of Scholars and Fellows. This fund, established by Mr. and Mrs. Lawrence E. Blanchard and Mr. and Mrs. Charles F. Blanchard and later enhanced by Charles and Bernard Blanchard, provides scholarships to undergraduates and fellowships to graduate students studying at the Duke University Marine Laboratory.

Bookhout Research Scholarship. Each summer the Marine Laboratory offers a scholarship for a student interested in course work and research related to the invertebrate zoology of marine animals. The scholarship provides for room and board at the Marine Laboratory during the two summer terms, a stipend for living expenses, full tuition for the first summer term, and funds for research supplies. The student takes one to three courses during the first summer term and undertakes a research internship on some aspect of the biology of invertebrate animals during the second term. The scholarship is restricted to a rising junior or senior student from an accredited college or university or a student who will be a matriculating graduate student in the following fall. For additional information about the scholarship and application requirements and deadlines, students are encouraged to contact Dr. William Kirby-Smith (wwks@duke.edu; phone 252-504-7577).

August A. Busch Jr. Memorial Wholesalers Scholarship Endowment. Established by friends and colleagues of Mr. Busch, this fund provides scholarships to undergraduates studying at the Marine Lab.

Laura J. Grierson Memorial Scholarship. Established by David and Lynn Perry and Palmer L. Whisenant, this fund provides scholarships to undergraduates engaged in independent studies at the Marine Lab.

Lawrence I'Anson Jr. Scholarship. Established by Captain Lawrence I'Anson Jr., this scholarship is for summer students with financial need studying at the Marine Lab.

Richard C. and Linda G. Seale Scholarship. Established by Dick and Linda Seale, this scholarship is for students studying at the Marine Lab, with preference given to Denison University students.

Harvey W. Smith Undergraduate Scholarship. Established by the estate of Evelyn Chadwick Smith, this scholarship provides financial aid to undergraduates studying at the Marine Lab.

Deborah Susan Steer Scholarship. Established by Mr. and Mrs. John W. Steer, this scholarship is for undergraduates studying at the Marine Lab, with priority given to summer students.

Wade Family Scholarship. Established by Charles B. Wade Jr., this scholarship provides financial aid to undergraduates studying at the Marine Lab.

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>.

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 Masters 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 (M.E.M) 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 units of credit is earned, students will receive 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 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.

Professional Graduate Degree Programs

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, nonprofit organizations and international organizations.

The Distinction between Professional and Doctoral Degrees

Professional graduate programs such as the Master of Environmental Management (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 urged to pursue the doctoral (Ph.D) 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/bulletins/Graduate>). For more detailed information, visit the Graduate School Web site at <http://www.gradschool.duke.edu>.

Professional Masters 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 and Air Resources

An eighth program of study, Forest Resource Management, is available to students seeking the Master of Forestry (MF) degree. The MF is accredited by the Society of American Foresters.



Program Requirements

Each of the Nicholas School's professional programs requires the completion of 48 units of graduate credit. 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 credits of course work at the 100-level with a grade of at least B toward their degree requirements.

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.

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, ENVIRON 302, Program Management, during their first fall term. A one-half credit professional communications course also must be taken by all students during their first fall term.

Quantitative and Analytical Courses

All programs require six to 12 units of courses 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 four to six units of credit 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 for one unit of credit. These seminars prepare students for the Master's Project.

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, and in the National Environmental Policy Act (offered via participation in intensive courses).

In addition, Nicholas School students sometimes complete certificate programs in other schools or departments, such as the International Development Policy or Health Policy certificates offered by the Sanford School of Public Policy.

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 Education program.

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 Laboratory 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 policy makers in the application of science to policy. Potential opportunities for participation in the policy-making process are emphasized throughout the program.

Prerequisites: calculus, statistics, introductory economics including microeconomics.

Core Courses: Environment 276, Marine Policy; Environment 270, Resource and Environmental Economics; one additional policy course; one ecology course, and one ocean science course. and one science and policy synthesis course..

For more detailed information about this program, including specific prerequisites and degree requirements, see: <http://nicholas.duke.edu/people.students/advising/curriculum-course-planning-sheets/cem.pdf/view>.

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.

For more detailed information about this program, including specific prerequisites and degree requirements, see: <http://nicholas.duke.edu/people/students/advising/curriculum-course-planning-sheets/esc.pdf/view>.

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 U.S. 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.

Core courses: Environment 240 Chemical Fate of Organic Compounds; Environment 212 Environmental Toxicology; Environment 239 Human Health and Environmental Risk Assessment; Environment 298.02, Environmental Epidemiology; one additional course in ecology; three courses in specialization/focus.

For more detailed information about this program, including specific prerequisites and degree requirements, see: <http://nicholas.duke.edu/people/students/advising/curriculum-course-planning-sheets/eeh.pdf/view>.

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).

Core course: Environment 211 Energy and the Environment.

For more detailed information about this program, including specific prerequisites and degree requirements, see: <http://nicholas.duke.edu/people/students/advising/curriculum-course-planning-sheets/ee.pdf/view>.

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, introductory economics including microeconomics.

Core Courses. Environment 270 Resource and Environmental Economics; Environment 274 Environmental Politics, and Law 235 Environmental Law.

For more detailed information about this program, including specific prerequisites and degree requirements, see: <http://nicholas.duke.edu/people/students/advising/curriculum-course-planning-sheets/eep.pdf/view>.

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.

Core courses: EOS 211 The Climate System; EOS 251S Global Environmental Change, four other courses in basic global change science, three courses in the area of analytic methods and tools, and four courses in policy and management.

For more detailed information about this program, including specific prerequisites and degree requirements, see: <http://nicholas.duke.edu/people/students/advising/curriculum-course-planning-sheets/gec.pdf/view>.

WATER AND AIR RESOURCES

The program in Water and Air Resources (WAR) enables students to understand the basic physical, chemical and biological processes affecting these aquatic and atmospheric 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 researchers and environmental managers.

Coursework and other training in the program cover basic physical and chemical processes relevant to hydrologic and atmospheric sciences, methods of quantitative and statistical analysis and methods of management and decision making. The basic processes emphasized are watershed hydrology; stream and lake water quality; aquatic and atmospheric chemistry; general meteorology and climatology; and the origins, transport and fate of aquatic and atmospheric pollutants. Quantitative analysis techniques include statistical and numerical methods, probabilistic and deterministic models and optimization and simulation methods. These courses are integrated with classes in economic and policy analysis.

Graduates of the program have the skills to become analysts or consultants for employers concerned with understanding the management and protection of water and air resources. These employers include government agencies, public utilities, consulting firms, and hydrologic, atmospheric or environmental research centers.

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

Core Courses: At least one course from among those approved in each of four areas: physical sciences, chemical sciences, biological or ecological sciences and social sciences; three additional courses in an area of concentration (e.g., water, air) and three courses in quantitative and analytical methods related to resource management.

For more detailed information about this program, including specific prerequisites and degree requirements, see: <http://nicholas.duke.edu/people/students/advising/curriculum-course-planning-sheets/war.pdf/view>.

FOREST RESOURCE MANAGEMENT

The Forest Resource Management (FRM) program integrates forest ecology and management within an educational program that emphasizes related environmental fields. This program leads to the receipt of the Master of Forestry degree (MF). 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 and 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 Forest Resource Management program 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 Postsecondary Accreditation and the Department of Education as the 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.

Students who have an undergraduate degree in forestry may earn a Master of Forestry degree with only 30 units of credit. To be admitted with the one-year degree option, the student must have received a Bachelor of Science in Forestry degree from an accredited forestry school. The student must spend a minimum of two semesters in residence at Duke.

Prerequisites: statistics, calculus, principles of ecology, introductory economics including microeconomics.

Core Courses. Environment 201 Forest Resources Field Skills; Environment 206 Forest Vegetation Sampling; Environment 213 Forest Ecosystems; Environment 205L Silviculture; Environment 320 Ecosystem Management (or equivalent); forest policy and administration and professional ethics.

For more detailed information about this program, including specific prerequisites and degree requirements, see: <http://nicholas.duke.edu/people/students/advising/curriculum-course-planning-sheets/frm.pdf/view>.

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 tracks available to all traditional MEM and MF students.

The **Duke Environmental Leadership Master of Environmental Management (DEL-MEM)** is for mid-career professionals with leadership potential. The DEL-MEM program has a major online component and thus requires minimal time on campus, 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.

These professional degree candidates must spend at least one semester at Duke enrolled in regular graduate-level courses. Up to 15 credit hours are taken during this semester. The remaining credit hours required for the MEM or MF degree (usually 15 additional credits) may be earned through another semester in residence or through continuing education intensive courses, independent study and the Master's Project. Candidates have five years from the date of acceptance to complete the credit 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 credit hours are required.

DUKE ENVIRONMENTAL LEADERSHIP—MASTER OF ENVIRONMENTAL MANAGEMENT

The Duke Environmental Leadership Master of Environmental Management (DEL-MEM) degree is a two-year, 30-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 allows professionals to pursue a master's degree while maintaining a commitment to job and family.

Program Format

The DEL-MEM combines distance-learning courses and short intensive on-campus sessions. The 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 D.C. Leadership Module in which students convene in Washington, D.C., 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, conference calls, Skype, e-mail, and other advanced interactive technologies.

Prerequisites: Five years of relevant work experiences 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, 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 3-6 days); and a Master's Project.

Elective Courses: Elective courses, developed around more specialized themes, are available to give the student flexibility in pursuing an area of interest. Independent studies and projects and one-credit intensive short courses may also be taken.

Master's Project: A Master's Project constituting four units of credit 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/del-mem/courses-and-curriculum>.

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, Web site <http://www.nicholas.duke.edu/del/del-mem>.

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 chapter 2, Undergraduate Degree Programs, for more details about the program. Application procedures are described in Chapter 4, Academic Information for Professional Degree Students.*

Concurrent Degrees

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 units of credit under the requirements set forth in the previous section.
2. For the second degree, the student must complete an additional 24 units 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 Duke's 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 units of credit within the Nicholas School are required to receive the MEM or MF degree; these include 4 to 6 units 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. Students electing to pursue the MEM concurrently with the MBA must complete requirements for both degrees before either degree will be awarded.

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 that is reviewed by each school. Notification of admission status will be transmitted separately by each school. 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 the Fuqua Web site at <http://www.fuqua.duke.edu>.

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 policy-making. 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 units of credit 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 complete both a Master's Project for the policy degree and a separate Master's Project for the MEM or MF degree. 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 Web site 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 School of Law have developed a cooperative arrangement to allow pursuit of concurrent Master of Environmental Management and Juris Doctor degrees.

For students in the concurrent MEM/JD program, the Nicholas School requires 36 units of credit, including a Master's Project. The School of Law requires 84 units of law credit, 12 units of which may be satisfied through courses taken in the Nicholas School.

Typically, a student will complete the first year of study in the School of Law and the second in the Nicholas School of the Environment. 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 School of Law. For information on the law degree, prospective students should write to the 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 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 Law School at <http://law.duke.edu/admis>. The application is also reviewed by faculty in the Nicholas School, and admission is offered by the 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 units of credit in the Graduate School, of which 24 must be graded, and 72 units in the School of Law. 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 last 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 units of credit in the Nicholas School, including a Master's Project. For the MAT degree, students will complete 30 units of credit, 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; telephone (919) 684-4353, <http://www.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 (MEM) 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 MEM should plan on two to three years of study.

Students must complete 36 units of credit in the Nicholas School, including a master's project. An additional 24 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 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. Questions concerning the MEM 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/.

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 units of credit 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.

Academic Information for Professional Degree Students

Admissions

REQUIREMENTS AND PREREQUISITES

The Nicholas School of the Environment welcomes applications from men and women 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 special or non-degree student may also be granted under appropriate circumstances.

Prerequisites

All students admitted to the school are expected to have had the following:

1. Some previous training in the natural sciences or the social sciences related to their area of interest in natural resources and environment.
2. At least one college semester of calculus.
3. 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
- Energy 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 and Air Resources: economics; undergraduate training in chemistry recommended

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 units of credit 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. Appointments should be made at least two weeks in advance. 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. During the middle of the fall semester and the beginning of the spring semester, formal visitation programs are hosted by the Office of Academic and Enrollment Services of the Nicholas School of the Environment.

Each year representatives of the Nicholas School travel throughout the country to visit undergraduate schools and participate in graduate school fairs. Applicants interested in meeting with a representative of the school should write or call the Office of Academic and Enrollment Services, or check the Web site, 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 write to the Office of Academic and Enrollment Services, send an e-mail to admissions@nicholas.duke.edu, or call (919) 613-8070.

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.

APPLICATION PROCEDURES

Application for admission to the 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.

Normally, students are admitted at the beginning of the fall term. The application deadline is February 1 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 February 1 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.

When space is available, a few students are admitted for matriculation in January. Students seeking spring semester admission should submit their applications no later than October 1 prior to their matriculation.

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 Web site, <http://www.nicholas.duke.edu/programs/professional/apply>. The Admissions 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.
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 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 February 1 priority deadline. Scores should be reported to Duke University code number 5156. Registration forms may be obtained by writing to GRE, Educational Testing Service, Princeton, NJ 08540, or 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.)

ADDITIONAL PROCEDURES FOR INTERNATIONAL STUDENTS

Each year the Nicholas School of the Environment welcomes a number of international students among its professional degree candidates. 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, Box 6151, Princeton, NJ 08540-6151; telephone 609-771-7100. 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.

Proficiency exams in written and spoken English will be given to non-native 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 towards their degree; otherwise, English language instruction does not count toward credit hours required for the MEM or MF degree.

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.

ADMISSION THROUGH THE COOPERATIVE COLLEGES (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). More details can be found in Chapters 2 and 3 of this Bulletin.

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 February 1 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 February 1 for the fall term and by October 1 for the spring term. Normally, degree candidates in the Senior Professional Program take the required semester in residence during the term following admission.

ADMISSION WITH NON-DEGREE STATUS

Persons wishing to enter the Nicholas School of the Environment as non-degree students must submit a special application form requesting non-degree 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 course work. 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 non-degree 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 non-degree student does not guarantee future admission to the MEM or MF degree. Non-degree students who complete an application for the professional degree and are offered admission may transfer a limited number of appropriate credits from their non-degree status at Duke into the MEM degree. The student's program chair will determine which if any credits may be counted towards the degree. Applying credits taken as a non-degree student does not reduce the number of semesters required for the degree or the tuition required.

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 beginning in March. 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. 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. However, on occasion a deferral of admission may be granted so that the applicant can gain experience or strengthen academic qualifications for graduate study, or for other valid reasons. Financial preparedness is rarely an acceptable reason for a deferral. A deferral of admission cannot be granted for more than one year. Deferral is granted on an individual basis, and the size of each class frequently precludes open-ended guarantees of future admission.

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 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 2008-2009, 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.

Tuition (\$14,500 per semester)	\$29,000
Student health fee (\$290 per semester)	\$580
Graduate student activity fee (\$16 per semester)	\$32
Recreation fee (\$34 per semester)	\$68
Transcript fee (first semester only)	\$40

Housing	\$7,056
Food	\$4,738
Books and supplies	\$1,236
Transportation	\$2,318
Motor Vehicle Registration and Parking Automobile	\$82-\$1,158

In addition to these fixed expenses, the student may incur other expenses, which will depend to a large extent upon individual tastes and habits. The average Duke student, however, can plan on a budget in the range of \$45,000 to \$51,000 for the academic year. Students with spouses and children naturally will have higher expenses.

Flat-rate Tuition

Professional degree students in the Nicholas School pay a flat rate of tuition per semester (excluding the summer session). Students in the two-year MEM and MF programs will pay the flat-rate tuition for four semesters. Students in concurrent degree programs at Duke pay a flat rate to the university that is split proportionately between the two programs regardless of where the student is taking courses in a particular semester. Students in the concurrent MEM/MF program pay the flat-rate tuition for a minimum of five semesters. Students in the one-year MF degree option will pay the flat rate for two semesters.

The flat-rate tuition allows Master of Environmental Management and Master of Forestry degree candidates to register for 9 or more units of credit for a *fixed tuition payment* per semester. The normal full-time enrollment is expected to be 12 units per semester, although units 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 units in a semester.

If the student is permitted to be enrolled part time (fewer than 9 units), he or she will be charged per unit of credit (\$1,300 per unit for the 2010-2011 academic year). Students who are approved for part-time enrollment status are not eligible for school or federal financial aid.

Students who wish to earn additional credits during the summer will be charged at the part-time rate per units of 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 2010–2011) 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.

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; telephone 800-722-4867, <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:

Withdrawal	Refund
Before classes begin	full amount
During first or second week	80 percent
During third, fourth or fifth week	60 percent
During sixth week	20 percent
After sixth week	none

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 \$1,300 per course.

Transcripts

Transcripts are available on request from the Duke University Office of the 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 Services Office. Parking fees vary according to location and type of vehicle. Duke University provides a ZipCar service for students, faculty and staff to use as needed.

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 unless they can provide proof of health insurance that is comparable in coverage to the Duke policy. International students are required to carry health insurance for a spouse or children living in Durham.

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 Marine Lab courses in the second summer session during the summer prior to their first fall semester at no additional tuition charges. Students may enroll in Conservation Biology and one other course under this arrangement. Students choosing to study at the Marine Lab during the summer are still required to pay four (4) full semesters of tuition and be in residence for at least three (3) semesters in the pursuit of their degree. Information on fees, housing, policies and procedures related to the Duke University summer session is available from the Duke University Web site, at <http://www.learnmore.duke.edu/summersession>.

Summer semester 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.

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.

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 federally subsidized loan programs provide a large portion of the funds necessary to cover the cost of attendance.

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.

No student will receive financial aid while on probation unless an appeal is approved by the Admissions and Awards Committee.

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 units of course work with at least 6 units 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 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.

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 to 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.

Gray Family Fellowship Fund. Established by Lyons Gray and Connie Gray, this fund provides fellowships for Nicholas School students.

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.

Tim and Karen Hixon Wildlife Conservation Fellowship. Established by George C. and Karen Hixon, this fellowship is for Nicholas School students with interests in careers related to wildlife management and conservation.

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. Keese Jr. Fellowship. Established by Thomas Keese Jr., this fellowship is for 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.

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.

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.

Nancy A. and Simon B. Rich Fellowship. Established by Simon and Nancy Rich, this fellowship provides financial support to Nicholas School students.

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.

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 to 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.

John and Sue Wall Fellowship. Established by John and Sue Wall, this fellowship is offered to Nicholas School students pursuing the Master of Forestry degree.

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.

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. During the second year of study, professional students may fulfill the assistantship requirement by working independently on their Master's Project.

Students who receive assistantships are paid by the Nicholas School on the monthly payroll. For the 2009–2010 academic year, the award for eight hours per week of assistance is \$2,900. Normally, assistantships are available only for the academic year and require full-time enrollment in the school. A few awards may be available during the summer, however, for faculty research, staff and Duke Forest assistance. Summer assistantships are paid on a biweekly or monthly basis.

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.

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 February 1 prior to fall term enrollment. Completed applications received after the February 1 deadline 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 May 1 without prejudice. However, offers accepted and left in effect after May 1 are binding for both the student and the school.

LOANS

Federally insured student loans are often necessary and useful in helping a needy student to 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 (\$8,500 subsidized and \$12,000 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. If a student is eligible for a subsidized federal Stafford loan, interest is paid by the federal government while the student is enrolled in school. Interest on unsubsidized loans must be paid by the student during enrollment or capitalized to the principal at the borrower's request.

Students may be eligible for a combination of subsidized and unsubsidized loans. Eligibility for the subsidized loan is determined by subtracting all financial aid awards and the student's expected contribution from the Nicholas School's student budget. The student's contribution is computed from the income and asset information submitted on the FAFSA. Eligibility for the unsubsidized loan takes into consideration the other financial aid being received by the student, but the expected student contribution is not considered. Students may borrow from the unsubsidized loan program the difference between the student budget and their other aid (including any subsidized Stafford loan), up to a maximum of \$20,500 for an academic year.

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 Subsidized and Unsubsidized 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 60 days after the final disbursement of each loan. The maximum repayment period is 10 years, and the minimum monthly payment is \$50.00. Students may be eligible to defer payments as long as they maintain at least half-time enrollment. A loan fee of 3 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 8.5 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.

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, 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.

LANGUAGE TESTING

Proficiency exams in written and spoken English will be given to non-native 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 towards their degree; otherwise, English language instruction does not count toward credit hours required for the MEM or MF degree.

REGISTRATION

Entering students who enroll in the Master of Environmental Management or Master of Forestry 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.

Credit Hours

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 units per semester, although a variation from 9 to 15 units is common. Students must have the permission of their advisor to register for more than 15 units in a semester, and all students who wish to enroll for fewer than 9 units must make a formal request to the Education Committee to study part-time.

Late Registration

All students should register at the times specified by the university. The charge for late registration is \$25.

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 six hours of credit (two course maximum) per semester at the University of North Carolina at Chapel Hill, North Carolina State University, or North Carolina Central University or any other university participating in the Interinstitutional Agreement provided that they are also registered for at least six hours of credit at Duke during the same semester. Similarly, graduate students at these universities may take up to six hours 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.

IMMUNIZATION REQUIREMENT

North Carolina law requires students entering a college or university in the state to be immunized against measles, rubella, tetanus, 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.

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. Students register to take independent study credit under ENVIRON 299. Several students can work together under the supervision of a faculty member by registering for ENVIRON 200.

Master's Project

All students must complete a Master's Project of four to six 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. 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. 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, and 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/>.

Auditing

Students registered for a full course load may audit courses free of charge. Otherwise, the audit fee is \$1,300 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.

Intensive Courses

Short-term intensive courses are offered through the Nicholas School's Duke Environmental Leadership Program. For the special intensive 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 instructor. Students may not register for more than two intensives in a

semester without permission of their advisor and the intensive course coordinator. Students who wish to drop an intensive must do so prior to the first day of the course.

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.

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.

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 towards 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 three situations will result in probationary status for the following semester:

1. failing one or more courses
2. two or more *C* (*C-*, *C*, *C+*) grades in a semester,
3. failing to maintain a cumulative average of at least *B-*.

A student on probation must meet jointly with his/her advisor and one additional 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 units of credit 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.

HONOR CODE

The Nicholas School 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 non-academic 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>.

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.

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, the normal time for completing a professional master's degree is four semesters. Exceptions may be made for students who have an undergraduate degree in forestry and for students enrolled in the Senior Professional Program. No student is allowed more than five years to complete the requirements for the master's degree.

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 dean 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 Services

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 Services Office to provide a wide variety of services, programs and resources to enhance a student's professional preparation and career opportunities.

The Career Services Web site (<http://www.nicholas.duke.edu/career>) 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 Services staff assists students with exploring career options, developing individualized strategies for finding internships and permanent employment and making contacts with alumni and employers. Career Services 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.

Career Services 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 900 potential employers and is made available to employers online at <http://www.nicholas.duke.edu/career/resumes>.

The Alumni Career Network is an excellent online resource for networking with practicing professionals that can be searched by geographic region, employment sector, specific employer or type of environmental expertise. Alumni listed in the Career Network 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.

Career Services 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 Career Services 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 Services 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 and 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 Services 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.

Doris Duke Conservation Fellowships. The Nicholas School of the Environment is one of a select group of schools to partner with the Doris Duke Charitable Foundation to identify students with professional promise for future leadership in U.S.-based conservation. Up to seven Fellows are competitively selected during the first semester of study and are awarded a summer internship stipend and tuition support for second year of study.

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.

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 50 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.

Student International Discussion Group (SIDG) Internship Fund. SIDG is a nonprofit student discussion group for international and national environmental issues. SIDG manages an annual grant program that provides seed grants to Nicholas School students with international internship projects.

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.

Employment statistics are collected, annually, six months following our annual graduation in May. The Nicholas School averages an 81 percent graduate response rate and of the respondents 95 percent are employed in positions directly or closely related to their program of study. The data below illustrates the diversity of career paths and employment locations of recent Nicholas School graduates:

Geographic Distribution for 2009 Graduates

Mid-Atlantic US/Washington DC	42%
Midwest US	3%
Western US	13%

Southeast US	31%
Northeast US	9%
International	2%
Employer Distribution for 2009 Graduates	
Federal Government	37%
Consulting	26%
Nonprofit Organizations/NGO	20%
State/Local Government	8%
Research/Think Tank	6%
Industry	3%

The following is a list of selected employers of recent Nicholas School graduates:

Annual employment statistics and salary offers for recent Nicholas School graduates are updated on the Career Services Web site at <http://www.nicholas.duke.edu/career>.

Consulting Firms

- ABT Associates
- ARCADIS
- Booz, Allen and Hamilton
- CDM
- Chemrisk
- The Clark Group, Inc.
- ERG, Inc.
- Ecology and Environment Inc.
- ECORYS Research & Consulting
- EDAW, Inc.
- Emerging Energy Research
- ENTRIX, Inc.
- ENVIRON
- ERM
- ESA
- Geo-Marine, Inc.
- ICF International
- Kinetix
- Louis Berger Group
- Pace Global Energy Services
- PRIZM
- Project Performance Corporation
- SAIC
- Stratus Consulting
- TechniData America LLC
- TetraTech Inc.
- Trinity Consultants
- URS Corporation
- WSP Environment and Energy

Not-for-Profit/NGO/PVO

- Alliance to Save energy
- Cape Cod Hook Fisherman's Association
- Cascade Land Conservancy
- Chemonics
- Conservation International
- Consortium for Energy Efficiency
- Ducks Unlimited
- Environmental Defense Fund
- Environmental Law Institute

Global Environment & Technology Foundation
Great Lakes Commission
IUCN - The World Conservation Union
Las Vegas Springs Preserve
MacArthur Foundation
Marine Conservation Biology Institute
Mesa Landtrust
Nature Conservancy
NatureServe
Monterey Bay Marine Sanctuary Foundation
NC Solar Center
NC Sustainable Energy Association
Northeast Midwest Institute
NRDC
Oceana
Panthera
Resources for the Future
Rocky Mountain Institute
Royal Society for the Conservation of Nature
St. Simons Land Trust
Sustainable Forestry Board
The Climate Registry
The Conservation Fund
The Ocean Conservancy
The Trust for Public Land
Winrock International
World Bank
World Resources Institute
Worldwatch Institute
World Wildlife Fund

Federal Government

Bonneville Power Administration
Bureau of Indian Affairs
Bureau of Land Management
Department of Homeland Security
Energy Information Administration
Federal Emergency Management Agency
Federal Energy Regulatory Commission
Mineral Management Services/DOI
Marine Conservation Biology Institute
National Estuarine Research Reserves
National Marine Fisheries Service
National Park Service
NOAA
Office of Budget and Management
US AID
USDA Economic Research Service
US Department of Energy
US EPA
US Fish and Wildlife Service
US Forest Service
US General Accounting Office
US Geological Survey
US Housing and Urban Development
US Marine Mammal Commission

US Nuclear Regulatory Commission
US Senate

Post-Masters Fellowships

Coastal Services
Fulbright Commission
Knauss Marine Policy Fellowship
Luce Scholars
Presidential Management Fellowship
US EPA STAR

Industry/Business

American Electric Power
Bank of America
BP
Chevron Technology Ventures
Coca-Cola Company
EcoAsset Solutions
Element Markets
Eli Lilly & Company
Energetix
GE Power Systems
Georgia Power
Green Crow
Horizon Wind Energy
Lowe's
IBM
International Paper Company
Morgan Stanley
Pfizer, Inc.
PG&E
Skanska USA Building, Inc.
Southern Company
Wal-Mart
Winafrique Technologies, LTD

State/Local Government

Atlantic States Marine Fisheries Commission
American Samoa Coastal Zone Management
British Consulate in Houston
California Public Utilities Commission
City of Atlanta Sustainability Office
County of Albemarle Virginia
Florida Fish and Wildlife Conservation Commission
Georgia Department of Natural Resources
Idaho Department of Water Resources
King County (WA) Conservation District
Massachusetts Department of Conservation and Recreation
Massachusetts Water Resources Authority
Missouri Department of Conservation
New England Fisheries Management Council
New England Interstate Water Pollution Control Commission
New York State Department of Health
North Carolina Department of Emergency Management
North Carolina Department of Environment & Natural Resources
NC Wildlife Resources Commission
Piedmont Triad Council of Governments

Santa Ana Regional Water Quality Control Board
State of Utah, Division of Wildlife Resources
Texas Natural Resources Conservation Commission
UNEP
UNDP
UN Institute for Training and Research (UNITAR)
Virgin Island Coastal Zone Management
Washington Department of Natural Resources

Nicholas Institute for Environmental Policy Solutions

The Nicholas Institute for Environmental Policy Solutions at Duke University is a nonpartisan institute founded in 2005 to engage with decision makers in government, the private sector, and the nonprofit community to develop innovative proposals that address critical environmental challenges.

The Institute staff work in conjunction with Duke faculty and students, as well as partners outside Duke's walls, to produce the research and policy design that best informs decisions by the government, private sector, and nonprofit community on environmental matters.

The Institute is housed on Campus Drive on the Duke campus, and also maintains an office in Washington, D.C. and has staff in Beaufort, NC.

FOCUS

Since its inception, the Institute has strategically sought partnerships in its core focus areas and invested its intellectual resources in projects and products that address society's most pressing environmental concerns. Building upon the existing areas of excellence at Duke, and in consideration of the policy concerns that the world will face in the coming decades, the Nicholas Institute has developed four initial areas of core policy expertise: climate and energy, coasts and oceans, water, and ecosystem services. The Institute's work also encompasses aspects of conservation, environmental health, and nanotechnology. In all of these areas, the Institute will work at multiple jurisdictional levels—international, national, regional, state—developing environmental solutions where they can be most effective.

THE CLIMATE CHANGE POLICY PARTNERSHIP

The Climate Change Policy Partnership was established at Duke University in October 2005 through a gift from founding partner Duke Energy. The CCPP's focus is to address questions on climate change science and policy and initiate research to fill data gaps. The project leverages the resources of Duke to determine practical strategies to respond to the pressing challenges of global climate change. The three primary participants from Duke University are the Nicholas Institute for Environmental Solutions, the Center on Global Change (CGC), and the Nicholas School. Currently, Duke Energy, ConocoPhillips, and MeadWestvaco are corporate partners. Building from the foundational research in low carbon technology and infrastructure developed by the partnership new research initiatives are under development.

CORPORATE SUSTAINABILITY INITIATIVE (CSI)

CSI is an initiative of the Nicholas Institute, and draws on faculty and students from the Nicholas School, Fuqua School, and other affiliated institutions to explore novel public policies and business strategies that have the potential to create sustainable businesses, i.e., viable business enterprises that do not consume resources or impact the natural environment in such a way to harm future economic and societal development.

Working with Students

The Institute provides a number of opportunities for Nicholas School doctoral and professional graduate students, as well as students from other Duke units and other universities to engage in projects.

Students may also have the opportunity to work with the institute in the Nicholas School assistantship program such as the Climate Change Policy Partnership fellows and through various other special assignments.

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

PUBLICATIONS, EVENTS, AND PROJECT DETAILS

For more information about the Institute, including publications, events, and project details, see the Web site for the Institute, at www.nicholasinstitute.duke.edu.



Doctoral Programs

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. Except for the Division of Earth and Ocean Sciences, 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.

All faculty in the Nicholas School are members of the faculty of the Graduate School of Duke University and are actively involved in the training of doctoral (PhD) students in the fields of earth and ocean, marine, and environmental sciences. Because of the intensive research nature of the degree, it is recommended that students contact individual faculty mentors prior to applying to the doctoral program to ensure mutual interests in research topics. *Doctoral students should note that policies and procedures for admission and registration, academic regulations and requirements for degrees 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 at Duke University; 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

Doctoral students planning to work at the Marine Lab typically spend one to three 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

UNIVERSITY PROGRAM IN INTEGRATED TOXICOLOGY (UIT)

Some faculty of the Nicholas School are members of the Duke University Program in Integrated Toxicology (UIT). This program operates under a specific charter to develop holistic and innovative approaches to studies of toxicology and to training students and postdoctoral fellows in this field.

Research in environmental toxicology within the Nicholas School focuses on molecular and biochemical aspects of pollutant metabolism, adaptations of organisms in polluted environments, and modes of toxic action. This work employs freshwater, marine, and terrestrial organisms as toxicological models. Toxicological research in the School strives to achieve a fundamental understanding of the fates and effects of contaminants in the environment and to elucidate linkages between human and ecosystem health. To achieve this goal, the curriculum and research activities of the program are designed to teach students the principles and methodologies of environmental chemistry, biochemistry, molecular biology, pathology, toxicology, ecology and quantitative analysis. Upon completion of doctoral studies, these students are experienced in the design, execution and interpretation of current research in

environmental toxicology. Completion of this training at the doctoral level provides career opportunities in academia, industry and research laboratories.

Students seeking admission to this PhD program should file an application with the Graduate School, seeking admission to one of the departments participating in the UIT Program, including the Nicholas School. Direct inquiries to Dr. Richard T. Di Giulio, Director, Integrated Toxicology Program, Box 90328, Nicholas School of the Environment, Duke University, Durham, NC 27708; Internet: <http://www.duke.edu/web/toxicology>.

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 in one of two ways: 1) direct admission to the program through the Graduate School; or 2) admission to the doctoral program of one of the departments participating in the program. Departments participating in the Ecology Program guarantee that any student admitted via the first track is automatically admitted for PhD study in the home department of the student’s major professor. Students in the latter track earn their degrees in the department sponsoring their admission and receive a Certificate of Graduate Study in Ecology from the University Program in Ecology.

The University Program in Ecology admits students with the promise of two years of financial support from the program, following which support is garnered 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, which include those in the Nicholas School. Direct inquiries to ecology@duke.edu or to Graduate Studies, University Program in Ecology, Box 90328, Duke University, Durham, NC 27708. Further information on the University Program in Ecology can be found on the Internet at: <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 the Sanford School who are interested in environmental policy. It draws on the intellectual resources of not only the two schools but also related disciplinary departments (Economics, Political Science) and other professional schools (Law School, Fuqua School, 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 U.S. 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 on the Internet at: <http://www.nicholas.duke.edu/programs/doctoral/upep.html>.

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>. 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 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). Registration for courses and continuation is completed through the online registration system. Registration requirements and procedures are described in the Bulletin of the Graduate School.

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 that covers 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. They are usually supported on research assistantships during the other years of their programs. Students supported on teaching or research assistantships may also receive support for up to three summer months from research funding.

The hours of assistance may limit the number of credit hours for which a student may register. Normally, PhD students who receive assistantships for ten hours per week are limited to 12 units of credit per semester. Exceptions require the permission of the student's advisor.

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 30 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, NC, 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 Duke University 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 Web sites 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 tuition is a scholarship from School funds and is tax exempt. The monthly stipend (\$2,161 per month in 2009-2010) requires up to 15 hours of work per week during the nine-month academic year and is taxable. 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 20 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

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 upon 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 for Comparative Biology of Vulnerable Populations

Director: Richard T. Di Giulio, Professor of Environmental Toxicology, Nicholas School of the Environment

The Center for Comparative Biology of Vulnerable Populations (CCBVP) supports research aimed at understanding how biological, physiological, and social aspects of vulnerability alter the effect of the environment on human health. Despite the tremendous inter-individual variability in the response to environmental toxins, we simply do not understand why certain people develop disease when challenged with environmental agents, and others remain healthy. Although an emerging consensus suggests that many of the complex and prevalent diseases that humans develop

occur as a result of multiple biologically unique gene-gene and gene-environment interactions, this conceptual framework is limited. In fact, the development of disease in humans, environmental and otherwise, is far more complex.

Environmental exposures affect those that are vulnerable temporally (age), spatially (geographically), and by unique circumstance (co-morbid disease, nutritional status, economic status, race, and genetics). Even this paradigm fails to address the complex interaction of endogenous and exogenous risks that ultimately interact to cause disease. While the recent advances in human and molecular genetics provide an unparalleled opportunity to understand how genes and genetic changes interact with environmental stimuli to either preserve health or cause disease, without accounting for the temporal, spatial, and other unique components of an individual's microenvironment, our understanding of environmental health will remain incomplete. The CCBVP builds on established strengths in environmental health, toxicology, genetics/genomics, bioinformatics, spatial analysis, and environmental policy and ethics, and places particular emphasis on the use of complementary biological systems. Primary funding source: National Institute of Environmental Health Sciences. Internet: <http://www.env.duke.edu/ccbvp/>.

Center for Geospatial Medicine

Director: Marie Lynn Miranda, Associate Professor, Division of Environmental Sciences and Policy, Nicholas School of the Environment

The Center for Geospatial Medicine (CGM) is an interdisciplinary center that provides cutting edge geospatial tools to researchers, clinicians, and health services administrators across the university and health system. The mission of the CGM is to develop systematic, spatially-based methods for analyzing the pathways through which the environment, host factor, and psychosocial domains jointly shape health and well-being. The CGM combines advanced geographic information systems (GIS) with world class statistical analysis, working with statistician and biostatistician faculty from across the university. The CGM promotes interdisciplinary research interactions among programs in biomedicine, environmental health, statistics, and social sciences by using advanced spatial statistical approaches in



combination with techniques from genetics and genomics. The CGM also serves as the geospatial medicine analytical core within the Duke Translational Medicine Institute. Internet: <http://www.nicholas.duke.edu/cgm/>.

The CGM promotes interdisciplinary research interactions among programs in biomedicine, environmental health, statistics, and social sciences to link social, environmental, and host factor vulnerability using advanced spatial statistical approaches in combination with techniques from genetics and genomics. Using pregnancy outcomes as a prototype health endpoint, the CGM is developing a generalized framework for applying these methods to a wide variety of health endpoints, including autism, asthma, ADHD, and obesity. Internet: <http://www.env.duke.edu/cehi>.

Center on Global Change

Faculty Director: Robert B. Jackson, Nicholas Professor of Global Environmental Change and Biology

Administrative Coordinator : Klugh Jordan

Duke University created the Center on Global Change (CGC) in 2001 as a university-wide initiative to facilitate innovative, interdisciplinary research and graduate education in the area of global change science. The goals of the Center are to advance scientific understanding, provide new educational opportunities, attract additional funding from public and private entities and enhance Duke's reputation as a leader in global change research and education.

The scope of the Center is intentionally broad to encourage creativity and to leverage Duke's strengths across a range of disciplines, including ecology, biology, earth sciences, ocean sciences, statistics, engineering, computer sciences and math. The center's main emphasis is the intersection of climate change, energy, and the global carbon and water cycles. In addition, the Center also supports multiple efforts by faculty and students to create new collaborations, both internal and external to the University, across traditional disciplines and on a range of topics relevant to global change.

In 2005 the CGC, Nicholas School of the Environment, and the Nicholas Institute for Environmental Policy Solutions initiated the Climate Change Policy Partnership. This initiative conducts climate change and energy policy research in partnership with industrial sponsors. 2005 also saw the CGC established as the SE Regional Center of the Department of Energy's National Institute for Climate Change Research program. Under this program, the CGC administers a 5-year, \$10 million climate change research program for Universities in the southeastern United States.

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. Internet: <http://www.nicholas.duke.edu/cgc>.

Center for Marine Conservation

Director: Larry B Crowder, Stephen Toth Professor of Marine Biology, Duke University Marine Lab, Nicholas School of the Environment

The Duke Center for Marine Conservation (CMC) is an interdisciplinary consortium focusing on research, education, and outreach in marine conservation. Recognizing the interdisciplinary and often global nature of marine conservation, the center seeks to integrate across the natural and social sciences and to engage international partners. It focuses on problem solving and incorporating science into regional, national and international policy-making.

Key elements of the center's approach include: developing geospatial analysis tools to integrate, display and analyze spatially explicit data for dynamic oceans; collecting, cleaning and archiving spatially-explicit data on the physical, biological, social economic and governance features of coastal and ocean ecosystems; and developing new biophysical and social scientific analyses in support of policy development for integrated place-based management of coastal and marine ecosystems.

Center projects include the following: 1) The Global Fellows in Marine Conservation program, which provides support for international students to participate in the Integrated Marine Conservation Program at Duke University Marine Laboratory; 2) The Global Fellows Enhancement Projects (Mini-grants) Program, which provides support for former Global Fellows to implement marine conservation projects in their home countries; and 3) The Multi-disciplinary Marine Science and Conservation PhD program, which uses start-up funds from the Provost's office to support selected PhD students to work collaboratively with two Center faculty on issues in marine conservation that integrate the natural and social sciences. The faculty of Duke CMC is uniquely qualified to address the key issues for developing a place-based approach for the management of these systems. They provide an unparalleled range of expertise and experience from natural and social sciences, as well as experience with integrating science into policy in a variety of marine systems. By partnering with the Nicholas Institute for Environmental Policy Solutions, Duke CMC will provide government officials with the tools and approaches that will enhance their ability to implement ecosystem-based management. While we are elaborating the concepts and developing the tools, we will also educate a new generation of researchers and environmental managers to take on the challenges of place-based management in marine ecosystems. Internet: <http://www.marineconservation.duke.edu>.

Center for Tropical Conservation

Director: John Terborgh, Research Professor 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 over 300 publications. Internet: <http://www.duke.edu/web/ctc>.

Children's Environmental Health Initiative

Director: Marie Lynn Miranda, Associate Professor, Division of Environmental Sciences and Policy, Nicholas School of the Environment

The Children's Environmental Health Initiative (CEHI) is a research, education, and outreach program committed to fostering environments where all children can prosper. Housed within the Nicholas School of the Environment at Duke University, CEHI oversees multiple environmental research projects emphasizing the special vulnerabilities of children. CEHI projects focus on incorporating innovative spatial analysis into children's environmental health research. CEHI's long term vision is to use spatial analytical methods to forge a whole new approach to addressing children's environmental health issues. CEHI has developed and maintains and extends an extensive fully spatially referenced data architecture. This makes it possible to jointly consider diverse variables collected by different disciplines, creating the opportunity to explore the complex and dynamic relationships among the components of health. Thus, CEHI works collaboratively across disciplines to develop sound and systematic methodologies for assessing and analyzing the causal interactions and pathways through which the environment, host, and social domains operate in a child's life. CEHI maintains a deep institutional commitment to issues of social and environmental justice and thus focuses much of its work in low income and minority communities. Internet: <http://www.nicholas.duke.edu/cehi>.

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 for the nation and the world. 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, waterfowl, and wading birds and supply a vital link between surface water and groundwater. However, the functions and services of wetlands are often poorly understood by the people expected to comply with wetland regulations.

By bringing together scientists and professionals, the Duke University Wetland Center is able to focus attention on these and other 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 Wetland Center works independently on wetland issues without the political pressures often brought to bear upon public institutions. Internet: <http://www.nicholas.duke.edu/wetland>.

Southern Center for Sustainable Forests

Director: Daniel D. Richter, Jr., Professor of Soils and Forest Ecology, Division of Environmental Sciences and Policy, Nicholas School of the Environment

The Southern Center for Sustainable Forests engages in innovative research and practical applications for enhancing sustainable forest management in the South. Research has examined economic and ecological effects of wood chip facilities, leading industrial and environmental certification systems, and long-term changes in soils and ecosystems as affected by forest land history and current management practices, including for woody biomass energy.

The Center is a cooperative organization with three participant institutions: North Carolina State University, Department of Forestry; Duke University, Nicholas School of the Environment; and the Division of Forest Resources of the North Carolina Department of Environment and Natural Resources. Internet: <http://www.nicholas.duke.edu/scsf>.

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 fate and developmental effects of chemicals found at Superfund sites. The Center is supported by the National Institute of Environmental Health Sciences (NIEHS).

The goal of the Center is to study the mechanisms of exposure and toxicity in humans and ecosystems to specific Superfund chemicals that are 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, and metals that produce an array of developmental effects. In addition to conducting basic research in these areas, the Center's role includes communicating this information to health professionals, community leaders and the public. Internet: <http://www.duke.edu/superfund>.

The Faculty

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

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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)

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

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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)

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 w/minor in Cultural Anthropology, University of Arizona.

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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 Benneer, Assistant Professor of Environmental Science and Policy; AB Economics and Environmental Studies, Occidental College; MA, Economics, Yale University; PhD, Public Policy, Harvard University

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Dr. Benneer'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 S. Bernhardt**, Assistant Professor of Biogeochemistry; BS, Biology, University of North Carolina, Chapel Hill; PhD, Ecology and Evolutionary Biology, Cornell University

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Dr. Bernhardt is broadly interested in the capacity of ecosystems to retain nutrients and energy in the face of human accelerated environmental change. Her research primarily focuses on controls of carbon and nitrogen cycling in streams and soils. The majority of her research to date has taken place in aquatic systems, but she considers biogeochemistry in a watershed context and her lab group currently works in upland, riparian and stream ecosystems. Much of Dr. Bernhardt's recent research takes advantage of large scale river restoration projects to understand how stream and riparian ecosystems function. (ESP)

Celia Bonaventura, Professor of Cell Biology; BA, Zoology, San Diego State University; PhD, Biochemistry, University of Texas at Austin

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Dr. Bonaventura's research is focused on the structure/function relationships of oxygen and electron-transport proteins. She compares human proteins to those of marine organisms in structure/function assays that involve equilibrium measurements and complementary studies of rapid reaction kinetics, using UV/VIS and fluorescence spectroscopy and novel methods of spectroelectrochemistry. This work has led to an increased understanding of molecular adaptations in the respiratory proteins, with a focus on interactions with nitric oxide and reactive oxygen species. Dr. Bonaventura's comparative studies illustrate aspects of environmental adaptations and mechanisms of toxicity associated with exposure to free radicals and metals. (MSC)

Joseph Bonaventura, Research Professor of Cell Biology; BA, Zoology, San Diego State University; PhD, Biochemistry, University of Texas at Austin

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Dr. Bonaventura's research involves marine organisms found in diverse environments. He studies their red blood cells and respiratory proteins in order to understand molecular adaptations and the mechanisms that give rise to functional flexibility. Dr. Bonaventura also examines the kinetics and equilibria of ligand binding to hemoglobins, hemocyanins and cytochrome c oxidase. These studies are complemented by work in which properties of chemically modified, crosslinked and immobilized forms of biologically active molecules are characterized. His recent research concerns the development of a synthetic blood substitute for humans. A new focus concerns the biochemistry of nitric oxide in the human body and the development of a hypothesis of how this molecule might act as a regulator of the biosphere. (MSC)

Alan E. Boudreau, Professor of Geology; BA, Geology, University of California, Berkeley; MS, Geology, University of Oregon; PhD, Geology, University of Washington

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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; 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 socio-economic development, primarily in rural areas of developing countries. She studies the process of policy making, the transition from policy to practice, and the impacts of (and responses to) implementation at the local level. At the policy making 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, Assistant Professor, 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)

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

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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 towards 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)

Norman L. Christensen Jr., Professor of Ecology; AB, MS, Biology, California State University, Fresno; PhD, Biology, University of California, Santa Barbara

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Dr. Christensen's research focuses on the effects of disturbance on the structure and function of populations, communities and ecosystems. Ongoing studies include an analysis of patterns of forest development following cropland abandonment, comparative studies of ecosystem responses to varying fire regimes across temperate North America and research on the utilization of remote sensing systems such as synthetic aperture radar to evaluate long-term changes in forest ecosystems. In addition, Dr. Christensen has written widely on the importance of natural disturbance in the management of forests, shrublands and wetlands. He is interested in the application of basic ecological theory and models to management, and has collaborated with others in the development of the concept of ecosystem management. (ESP)

***James S. Clark**, H. L. Blomquist Professor of Environment, Professor of Biology, Professor of Statistics; BS, Entomology, North Carolina State University; MS, Forestry and Wildlife, University of Massachusetts; PhD, Ecology, University of Minnesota

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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 succession 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 100 scientific articles and edited the book *Sediment Records of Biomass Burning and Global Change* (Springer, 1997). (ESP, EOS)

Bruce H. Corliss, Professor of Earth and Ocean Sciences, and Director of Undergraduate Studies (EOS); Director, Duke/University of North Carolina Oceanographic Consortium; BA, Geology, University of Vermont; MS, PhD, Oceanography, University of Rhode Island

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As a geological oceanographer, Dr. Corliss's research interests include the ecology, functional morphology and geochemistry of deep-sea benthic foraminifera, Cenozoic paleoceanography and deep-sea benthic ecology. His early work dealt with the distribution of Quaternary deep-sea benthic foraminifera in the Southern Ocean and their relationship with present and past deep bottom water circulation patterns. This effort was followed by studies of Eocene-Oligocene paleoceanography based on the analysis of microfossils and sediments from Deep Sea Drilling Project samples. An ancillary aspect of his research has been in deep-sea sedimentation. Dr. Corliss's current research deals with the ecology of living deep-sea benthic foraminifera using data from box core samples taken on a number of oceanographic cruises in the Atlantic, Pacific and Arctic Oceans. (EOS, MSC)

Larry B. Crowder, Stephen Toth Professor of Marine Biology; BA, Biology and Mathematics, California State University, Fresno; MS, PhD, Zoology, Michigan State University

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Dr. Crowder's research centers on predation and food web interactions, mechanisms underlying recruitment variation in fishes, and population and food web modeling in conservation biology. He has studied food web processes in estuaries and lakes and has used observational, experimental and modeling approaches to understand these

interactions in an effort to improve fisheries management. He co-directed the South Atlantic Bight Recruitment Experiment (SABRE) and examines the life histories of estuarine-dependent fishes. Dr. Crowder conducts model and statistical analyses to assist in endangered species management for both aquatic and terrestrial species, notably sea turtles and red-cockaded woodpeckers. Recently he has begun developing more extensive programs in marine conservation, including research on bycatch, spatial analysis, nutrients and low oxygen, marine invasive species and integrated ecosystem management. (MSC, ESP)

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

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Dr. Di Giulio'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 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. Di Giulio serves as Director of Duke University's Integrated Toxicology Program and the Superfund Basic Research Center. (ESP, MSC)

Jean-Christophe Domec, Visiting Assistant Professor

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., Professor of Zoology and Bass Fellow; BS, Biology, Stanford University; PhD, Biology, University of California, Santa Barbara

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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, Assistant Professor of the Practice of Resource and Environmental Policy; BS, Chemical Engineering, Northwestern University; MPP, Harvard University; PhD, Public Policy, University of North Carolina at Chapel Hill.

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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

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Prof. 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)

Peter K. Haff, Professor of Geology and of Civil and Environmental Engineering; BA, Physics, Harvard University; PhD, Physics, University of Virginia

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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

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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 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

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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 is also 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 excursions, 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

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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)

Robert B. Jackson, Nicholas Professor of Global Environmental Change; Professor of Biology; and Sr. Associate Dean for Research; BS, Chemical Engineering, Rice University; MS, Plant Ecology, MS, Statistics, PhD, Plant Ecology, Utah State University

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Dr. Jackson examines feedbacks between global change and the biosphere. Current projects in his lab include studies of the global carbon and water cycles, biosphere/atmosphere interactions and vegetation change. He leads research projects for two core projects of the International Geosphere Biosphere Programme, Global Change and Terrestrial Ecosystems (GCTE) and Biosphere Aspects of the Hydrological Cycle (BAHC). He is the Director of Duke's Center on Global Change and of the Stable Isotope Mass Spectrometry Laboratory. (EOS)

***Sonke Johnsen**, Assistant Professor of Biology; BA, Mathematics, Swarthmore College; PhD, Biology, University of North Carolina at Chapel Hill

E-mail: sjohnsen@duke.edu

Dr. Johnsen's research interests are comparative physiology of marine organisms focusing on optical adaptations to a pelagic existence, including topics such as transparency, cryptic coloration, bioluminescence, ultraviolet protection and vision and orientation and navigation. (MSC)

Zackary Johnson, Assistant Professor of Biological Oceanography and Marine Biotechnology; BS, Civil and Environmental Engineering, Massachusetts Institute of Technology; PhD, Botany, Duke University.

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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, Associate Professor of Environmental Chemistry; BS, Chemical Engineering, University of Bombay; MS, PhD, Chemical Engineering, University of Kentucky

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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

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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, Senior Associate Dean and Director of Undergraduate Studies (NSOE); BA, English, Barnard College; MS, PhD, Geology, Columbia University

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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; BA, Economics, University of North Carolina at Chapel Hill; ME, Economics, North Carolina State University; PhD, Agricultural Economics, University of California, Davis

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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. (ESP)

***Michael Lenox**, Associate Professor of Business and Environmental Policy; BS, Systems Engineering, University of Virginia; MS, Systems Engineering, University of Virginia; PhD, Technology and Policy, Massachusetts Institute of Technology

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Professor Lenox's research is at the interface of business strategy and public policy. His work draws upon emerging scholarship on the institutional, or non-market, strategies of firms and explores the prospects for industry self-regulation of its environmental impacts — both the incentives firms have to self-regulate and the institutions created by firms and policy makers to facilitate self-regulation. (ESP)

***Edward D. Levin**, Professor of Psychiatry and Behavioral Sciences, Duke University Medical Center; BA, Psychology, University of Rochester; MS, Psychology, PhD, Environmental Toxicology, University of Wisconsin–Madison

E-mail: edlevin@duke.edu

Dr. Levin's research interests concern neurobehavioral toxicology and neurobehavioral pharmacology. He is particularly concerned with drug and toxicant effects on cognitive function. He has characterized the cognitive deficits from exposure to lead, PCBs, cocaine, nicotine, the pesticide chlorpyrifos and the marine toxin *Pfiesteria piscicida*. He and his collaborators have been working with rat, mouse and zebrafish models of toxicant-induced neurocognitive deficits to determine the mechanisms of these impairments and therapeutic treatments to reverse them. He also has appointments in the Department of Pharmacology and Cancer Biology, the Comprehensive Cancer Center and the Duke University Integrated Toxicology Program. (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)

***Elwood Linney**, Professor of Microbiology and of Environment; BS, Engineering Physics, University of Illinois; MS, Biophysics, Michigan State University; PhD, Molecular Biology, University of California, San Diego

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Dr. Linney focuses on using zebrafish embryonic models for investigating the effects of environmental toxicants. His laboratory produces and studies transgenic, fluorescent zebrafish as biosensors for environmental insult. In addition, his group is using microarray techniques for identifying genes that are affected by environmental toxicants. (ESP, MSC)

M. Susan Lozier, Professor of Physical Oceanography, Bass Fellow, and Chair, Division of Earth and Ocean Sciences; 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, and Director of Professional Studies; 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)

***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)

***Miguel A. Medina Jr.**, Professor of Civil and Environmental Engineering and of Environment; BS, MS, Civil Engineering, University of Alabama; PhD, Water Resources and Environmental Engineering Sciences, University of Florida

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Dr. Medina's research interests focus on water resources, hydrologic and water quality mathematical modeling and integration of contaminant transportation prediction models within a decision-analysis framework for risk assessment. (ESP)

Joel N. Meyer, Assistant Professor of Environmental Toxicology; BA, Environmental Studies and Peace and Conflict Studies, Juniata College; PhD, Environmental Toxicology, Duke University.

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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)

Marie Lynn Miranda, Associate Professor of Environmental Sciences and Policy; AB, Mathematics and Economics, Duke University; MA, PhD, Economics, Harvard University

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Dr. Miranda's primary research is in resource and environmental economics, environmental health sciences and environmental justice, with an emphasis on interdisciplinary, policy-oriented perspectives. She holds a deep interest in children's special vulnerability to environmental toxicants. She has developed courses and conducted research on issues of environmental health with a particular emphasis on reproductive and developmental toxicants and childhood lead exposure. Her most recent work uses Geographic Information Systems to develop predictive risk exposure models for children's environmental health, including lead-based paint, allergen and asthma triggers and fire risks. Dr. Miranda serves as the Director of the Children's Environmental Health Initiative (CEHI) within the Nicholas School. (ESP)

A. Brad Murray, Associate Professor of Geomorphology and Coastal Processes; BA, Journalism, BIS, General Science, MS, Physics, PhD, Geology, University of Minnesota

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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, MSC)

Brian Murray, Research Professor and Director for Economic Analysis, Nicholas Institute for Environmental Policy Solutions. BS, Economics and Finance, University of Delaware; M.S., Resource Economics and Policy, Duke University; PhD Resource Economics and Policy, Duke University.

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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 Associate Professor of Energy and Environmental Economics (currently on leave of absence serving in the Obama administration as administrator of the federal Energy Information Administration); BS, Materials Engineering, BA, Philosophy, Rutgers University; M.P.A., Public Policy, Princeton University; PhD, Public Policy, Harvard University

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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.

Douglas Nowacek, Repass-Rogers University Associate Professor of Conservation Technology and Associate Professor of Electrical and Computer Engineering. B.A., Ohio Wesleyan University; PhD, Biological Oceanography, Woods Hole Oceanographic Institute of Technology.

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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)

Michael K. Orbach, Professor of the Practice of Marine Affairs and Policy; BA, Economics, University of California, Irvine; MA, PhD, Cultural Anthropology, University of California, San Diego

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Dr. Orbach has performed research on and been involved in coastal and marine policy on all coasts of the United States and in Mexico, Central America, the Caribbean, Alaska and the Pacific, and has published widely on social science and policy in coastal and marine environments. Among his publications are *Hunters, Seamen and Entrepreneurs: The Tuna Seinermen of San Diego* (University of California Press, 1977), *U.S. Marine Policy and the Ocean Ethos* (Marine Technology Society Journal, 1982), *North Carolina and the Sea: An Ocean Policy Analysis* (with D. Moffitt et al., North Carolina Department of Administration, 1985), and "A Fishery in Transition: The Impact of Urbanization on Florida's Spiny Lobster Fishery" (with J. Johnson, *City and Society*, 1991). (MSC, ESP)

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 CO₂ 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, Assistant Research Professor; M.Sc., 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)

Dalia Patino-Echeverri, Gendell Assistant Professor of Energy Systems and Public Policy. BS, University of Andes, Colombia; M.S. 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, Associate Professor of Public Policy and Environmental Economics; B.A., Economics, University of Delhi; M.S., Economics, Purdue University; PhD, Duke University.

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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 non-industrial private forestry, urban land use dynamics, benefits of safe drinking water and benefits transfer methodology. (ESP)

***Jeffrey Peirce**, Associate Professor of Civil and Environmental Engineering; BES, Engineering Mechanics, The Johns Hopkins University; MS, PhD, Civil and Environmental Engineering, University of Wisconsin-Madison

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Dr. Peirce studies the design, construction and use of experimental devices to observe, measure and model the movement of fluids, non-water liquids and gases through porous materials in natural and engineered systems. His current research focuses on the production and transformation of gases in soil and their transport to the lower troposphere. (ESP)

***Alex Pfaff**, Associate Professor of Public Policy Studies, BS, Applied Math/Economics, Yale University, PhD, MIT

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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

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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 hotspots 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*. (ESP, MSC)

***Amilcare Porporato**, Professor of Civil and Environmental Engineering., MS Polytechnic of Turin, Italy; PhD Polytechnic of Milan, Italy.

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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)

Lincoln F. Pratson, Professor of Energy and Environment; BS, Geology, Trinity University; MS, Oceanography, University of Rhode Island; M.Ph., PhD, Geology, Columbia University

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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, MSC)

Song S. Qian, Associate Research Professor; BS, Environmental Engineering, Tsinghua University; MS, Environmental Systems Engineering, Nanjing University; MS, Statistics, Duke University; PhD, Environmental Science, Duke University

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Dr. Qian's major focus is environmental and ecological modeling. His current work includes watershed nutrient loading modeling, integrated watershed – estuary water quality/ecological modeling using Bayesnet, quantification of ecological thresholds, multilevel/hierarchical modeling in ecological studies, and statistical modeling of marine mammal habitat and density. (ESP)

Joseph S. Ramus, Research Professor of Biological Oceanography; BA, PhD, Botany, University of California, Berkeley

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Dr. Ramus's research is centered on the ecological response of a large estuary, the Pamlico Sound system, to watershed-scale natural and anthropogenic perturbations. The information will be used in predictive modeling to guide policy and management actions such as river basin nutrient management plans. A recent collaborative project, FerryMon, is a time- and space-intensive measurement of water quality parameters, designed to monitor status and

trends analysis for the Sound. It utilizes fully automated sonde and grab sampler systems aboard Pamlico Sound ferries. A high priority is the coupling of the FerryMon program to coastal remote sensing.(MSC)

Andrew J. Read, Rachel Carson Associate Professor of Marine Conservation Biology; B.Sc., M.Sc., PhD, Zoology, University of Guelph

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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)

Kenneth H. Reckhow, Professor of Water Resources; BS, Engineering Physics, Cornell University; MS, PhD, Environmental Science and Engineering, Harvard University

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Dr. Reckhow's research activities have concerned the development, evaluation and application of models and other assessment techniques for the management of water quality. Recent work has focused on the assessment of nonpoint source pollution on surface water quality and the development of "Total Maximum Daily Loads" (TMDLs). For example, a current project involves the modeling and assessment of allowable nitrogen loads to the Neuse River Estuary in North Carolina in order to achieve compliance with the chlorophyll standard. Dr. Reckhow was recently chair of the National Academy of Sciences Committee assessing the scientific basis of the EPA TMDL program. (ESP)

Chantal Reid, Assistant Professor of the Practice and Biology; BS McGill University; MS, San Diego State University; PhD, Duke University

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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)

James F. Reynolds, Professor of Environmental Science and Policy and of Biology; BS, Botany, Northern Arizona University; MS, Botany, University of Wyoming; PhD, Biology, New Mexico State University

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Dr. Reynolds participates in various international research efforts on land degradation in arid and semiarid regions of the world. He established ARID (Assessment, Research, and Integration of Desertification), a research initiative on global desertification that emphasizes the interdependencies of natural and human systems in elucidating mechanisms of desertification. In addition, Dr. Reynolds is conducting basic ecological research on desertification, including field and laboratory experiments and applying the Patch Arid Lands Simulator (PALS) ecosystem model to explore the effects of climate variability on carbon, nitrogen, and water dynamics in arid ecosystems. The Duke Phytotron houses Dr. Reynolds' research on the effects of elevated CO₂ and climate change on plants and ecosystems. (ESP)

Curtis J. Richardson, Professor of Resource Ecology; BS, Biology, State University of New York at Cortland; PhD, Ecology, University of Tennessee

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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

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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, Lee Hill Snowdon 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, Nicholas Institute Professor of Environmental Law and Policy; BA, History, Yale College; MS, Engineering Sciences, Harvard University; JD, Law, Harvard University

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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)

Elizabeth Shapiro, Assistant Professor of the Practice in Environmental Policy and Management; BA, Biology and Environmental Studies, Oberlin College; MEd, Human Ecology, Yale; PhD, Society and Environment, UC Berkeley. (ESP)

Martin D. Smith, Associate 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, Assistant Professor of Environmental Chemistry; BS, Marine Biology and Marine Chemistry, Southampton College; MS, PhD, Environmental Chemistry, University of Maryland

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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, Assistant Professor of the Practice of Geospatial Analysis; BA, Geography and International Relations, U.C. Santa Barbara; MA, Geography, San Diego State University; PhD, Forest Ecology, Oregon State University.

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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

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Dr. Terborgh is co-director of the Center for Tropical Conservation at Duke University. He is a member of the National Academy of Sciences, and for the past 35 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 100 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)

***Wayne Thomann**, Assistant Research Professor; BS, MS, Microbiology, Florida Atlantic University; PhD, Biohazard Science, University of North Carolina at Chapel Hill

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Dr. Thomann's interests are indoor air quality, bioaerosols and asthma, safety management and chemical and medical waste management. Thomann is the lead instructor for two courses: Survey of Occupational Health & Safety and Survey of Environmental Health & Safety. He is a research collaborator and co-principal investigator with Children's Environmental Health Initiative (CEHI) and he is director of research for many graduate students, not only for the Nicholas School but throughout Duke. (ESP)

***Chris Timmins**, Associate Professor of Economics; BSFS, International Economics, Georgetown University; PhD, Economics

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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 Science and Policy; BA, Botany and Zoology, MA, Wildlife Ecology, Southern Illinois University at Carbondale; PhD, Ecology, University of Tennessee

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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

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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.

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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)

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

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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)

Erika Weinthal, Associate Professor of Environmental Policy; BA, Government and Environmental Studies, Oberlin College; MA, MPhil, PhD, Political Science, Columbia University

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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)

***Jonathan B. Wiener**, Professor of Law and of Environmental Policy; AB, Economics, Harvard College; JD, Harvard Law School

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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 U.S. 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.

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Dr. Wiesner's research addresses challenges at the interface between water, energy and materials. (EOS)

***Robert L. Wolpert**, Professor of Statistics and Decision Sciences and of the Environment; AB, Mathematics, Cornell University; PhD, Mathematics, Princeton University

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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 P. Wright**, Assistant Research Professor of Biology; BA, Biology, University Williams College; PhD, Ecology and Evolutionary Biology, Cornell University

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Dr. Wright's research focuses on understanding the causes and consequences of patterns of biological diversity across the planet. He is particularly interested in two broad questions: 1) How does the modification of the environment by organisms affect community structure and ecosystem function? and 2) what aspects of biodiversity matter most in the regulation of ecosystem function? While much of his research has focused on wetland plant communities, he has worked in systems ranging from tropical streams to desert shrublands to answer various questions. His research program combines observational and experimental approaches with modeling to develop and test hypotheses and build synthetic ecological theory. (ESP)

Extended Faculty

ABBREVIATIONS

ESP – Division of Environmental Sciences and Policy

EOS – Division of Earth and Ocean Sciences

MSC – Division of Marine Science and Conservation

Richard Anderson, Adjunct Assistant Professor; PhD, Johns Hopkins University. Dr. Anderson's research focus lies in developing rigorous and useful applications of decision and systems analysis to real world watershed management and water resources problems. The main tools he employs are decision analysis, systems modeling, applied statistics, and optimization. (ESP)

Steven Anderson, Adjunct Professor; PhD, North Carolina State University. Dr. Anderson serves as President and CEO of the Forest History Society, based in Durham, NC. He has broad experience in leading programs for extension forestry, wildlife and aquaculture and has provided leadership to numerous educational programs. (ESP)

Marcia Angle, Visiting Professor; MD, Duke University. Dr. Angle studies issues in international health and global epidemiology, with a special focus on reproductive health and family planning in the developing world. She also studies the strength of the epidemiologic evidence linking various environmental exposures to human disease. (ESP)

Fred Kofi Boadu, Divisional Associate; PhD, Georgia Institute of Technology. A faculty member in the Pratt School of Engineering, Dr. Boadu focuses on applications of basic principles and methods of geophysics to solve fundamental problems related to the geosciences, especially hydrology, using theoretical and phenomenological models for laboratory and field studies. (EOS)

Catherine Burns, Adjunct Assistant Professor; PhD, Yale University. Dr. Burns' research aims to understand how human-driven landscape change alters animal populations and communities, and specifically how these effects are shaped by behavior (such as non-random habitat selection and territoriality). Her research is aimed toward contributing directly to the conservation and management of wildlife populations and communities. (MSC)

Nora Bynum, Adjunct Assistant Professor; PhD, Yale University. Dr. Bynum is associated with the Center for Biodiversity and Conservation (CBC) of the American Museum of Natural History (AMNH) in New York. She is director of the Network of Conservation Educators and Practitioners (NCEP), which produces and disseminates teaching resources for university faculty on topics relevant to biodiversity conservation. (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)

Charlotte Clark, Visiting Assistant Professor; PhD., Duke University. 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)

Kevin Craig, Assistant Research Scientist; PhD, Duke University. Dr. Craig's research addresses the effects of human-induced environmental stress on fish populations in nearshore coastal and estuarine systems, including including nutrient loading and associated hypoxia.(MSC)

Humberto Díaz, Adjunct Professor; PhD, Duke University. Retiring from a 30-year career at the Instituto Venezolano de Investigaciones Científicas (IVIC) in Venezuela, Dr. Diaz 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)

Jean-Christophe Domec, Visiting Assistant Professor; PhD. 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 last 20,000 years. (EOS)

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. (EOS)

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 Feinglos, 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)

Jonathan Freedman, Adjunct Professor, PhD, Albert Einstein College of Medicine. Working at NIH's National Institute for Environment Health Sciences, Dr. Freedman examines the regulatory processes controlling the response of organisms to environmental stress, particularly exposure to toxic metals.

Alex Glass, Instructor, Invertebrate Paleontology and Science Education; PhD, University of Illinois. Glass's 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)

Matthew Godfrey, Adjunct Assistant Professor; PhD, University of Toronto. Dr. Godfrey is coordinator of the Sea Turtle Project, a project of the North Carolina Wildlife Resources Commission. He is also involved in research, education, regulatory activities and conservation policy. (MSC)

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

Gary S. Hartshorn, Adjunct Professor of Tropical Ecology; PhD, Washington University. Dr. Hartshorn's expertise lies in tropical forest ecology, conservation and management. He is President and CEO of the World Forestry Center in Portland, Oregon. (ESP)

Nicholas Hayman, Assistant Research Scientist; PhD, University of Washington. Dr. Hayman conducts geological investigations of fault zones in both the oceanic and continental crusts. (EOS)

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)

Gabriel 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)

Richard Henkins, Adjunct Professor; PhD, Yale University. Dr. Henkins examines the effects of various chemical substances, especially nitric oxide, on hemoglobin function in marine environments. (MSC)

Selina Heppell, Adjunct Assistant Professor; PhD, Duke University. Dr. Heppell is an assistant professor in the Department of Fisheries and Wildlife at Oregon State University. Her research involves landscape-level predictors of biodiversity and exotic species interactions, specifically amphibian population models and wetlands restoration in Oregon. (MSC)

Jeffrey Herrick, Adjunct Research Scientist; PhD, Duke University. Dr. Herrick is a soil scientist at the Jornada Experimental Range. He works on management technologies for arid rangelands. (ESP)

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)

K. David Hyrenbach, Assistant Research Scientist; PhD, Scripps Institution of Oceanography. Dr. Hyrenbach's research focuses 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)

Sonke Johnsen, Assistant Professor of Biology; PhD, University of North Carolina at Chapel Hill. Dr. Johnsen's experience lies in aspects of visual ecology, with a focus on fisheries and fish ecology, as well as marine science. (ESP)

Timothy Johnson, Adjunct Assistant Professor, PhD, Carnegie Mellon University. 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)

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

Richard Kwok, Adjunct Assistant Professor; PhD, University of North Carolina. Dr. Kwok is a Research Epidemiologist at RTI International, an independent, non-profit research organization based in Research Triangle Park, NC. His research interests include cardiovascular, reproductive, and cancer health outcomes in relation to occupational and environmental exposures. Dr. Kwok has a special interest in children's health and is currently collaborating with investigators from around the world on a childhood cancer study. He has additional experience working with geographic information systems and spatial statistics, cancer registries, and socioeconomic status issues associated with the U.S. Census. (ESP)

Rebecca Lewison, Adjunct Assistant Professor. PhD, University of California, Davis. Dr. Lewis's 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 65 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)

Carol Mansfield, Adjunct Associate Professor; PhD, University of Maryland. Dr. Mansfield is a senior economist at RTI International. Her research focuses on environment, health and natural resource management, with an emphasis on modeling and measuring the benefits from improved environmental quality. Her work is funded primarily from the Environmental Protection Agency, the Centers for Disease Control and Prevention, and the National Park Service. (ESP)

Patricia McClellan-Green, Adjunct Assistant Professor; PhD, North Carolina State University. Dr. McClellan-Green's research focuses on the study of natural and human toxins in the marine environment and their effects on the metabolic activities of marine organisms. Her current research includes an examination of the molecular and biochemical pathways involved in endocrine disruption, the mechanisms of PAH and PCB mediated gene regulation in fish and other organisms, the isolation and characterization of various cytochrome P450s in marine species, and the effects of marine dinoflagellate toxins on cellular metabolism. (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, NC. 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)

Ellen M. Mihaich, Adjunct Professor; PhD, Duke University. Dr. Mihaich is a senior environmental toxicologist with Rhodia Inc., an international chemical company. Her research focuses on sound, scientific environmental risk assessment, identifying data needs and methods of interpretation of both exposure and effects data. Recently, she has been involved in environmental endocrine issues and the risk assessment of chemicals that can mimic natural hormones. (ESP)

Bruce F. Molnia, Adjunct Professor; PhD; University of South Carolina. As a member of the U.S. Geological Survey, Dr. Molnia has conducted glacial, marine, remote sensing and coastal research in equatorial, temperate, sub-polar and polar regions for more than 35 years. Dr. Molnia's current research interests are in glacial processes, impacts of changing climate, fiord and shallow-water marine geology, remote sensing, and glacial-marine sedimentation. (EOS)

Jeffrey Moore, Adjunct Assistant Professor; PhD, Purdue University. Dr. Moore's research interests include population dynamics of species of conservation concern, effects of human activities on ecological processes in coastal system and interdisciplinary approaches to promote sustainable resource use, especially in marine fisheries. (MSC)

Norman Myers, Adjunct Professor; PhD, University of California. Dr. Myers is an independent scientist working on issues of global environment and development. He is a Fellow of the School of the Environment and Business School at Oxford University. (ESP)

Eva Oberdoester, Associate Research Scientist; PhD, Duke University. Dr. Oberdoester's research focuses on the types of cell-signaling pathways used by invertebrate peptide and steroid hormones, organism fitness after exposure to toxicants, and the mechanism of nanoparticle toxicity in aquatic systems.(MSC)

Eric P. Palkovacs, McCurdy Visiting Scholar and Visiting Assistant Professor; PhD, Yale University. Dr. Palkovacs's research focuses on interactions between ecology and evolution in nature. Specifically, he is interested in how evolution at the population level shapes communities and ecosystems and how these ecological changes feedback to shape the trajectory of evolution. (MSC)

Jeffrey S. Pippen, Instructor, Associate in Research; MS, University of Michigan. Pippen's experience lies in global change ecology, North Carolina natural history, and identification of birds, butterflies, and plants, as well as biodiversity. (ESP)

Stephen E. Roady, Adjunct Professor; J.D., 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)

Erika Sasser, Adjunct Assistant Professor; PhD, Duke University. Dr. Sasser works as a policy advisor in the United States Environmental Protection Agency (EPA). Currently, she is part of the Health and Environmental Impacts Division of the Office of Air Quality Planning and Standards, located in Research Triangle Park, NC, where she works on domestic and international air pollution policy. She has a background in natural resource policy (especially forestry and land use) and a strong research interest in private voluntary regimes, especially as related to forest certification. (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 20 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)

Leala Sayigh, Adjunct Associate Professor; PhD, MIT. Dr. Sayigh's focuses on cetaceans, specifically dolphins. (MSC)

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)

Dongil Seo, Adjunct Professor; PhD, University of Michigan, Ann Arbor. Dr. Seo's research focus is in the areas of water quality modeling and management techniques for surface waters. (ESP)

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)

Jan Vymazal, Adjunct Associate Professor; PhD, Prague Institute of Chemical Technology. Dr. Vymazal, a private consultant on wetlands in the Czech Republic, has studied many aspects of nutrient loading, eutrophication and constructed wetlands, and serves as a collaborator on Nicholas School programs in the Florida Everglades (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)

Jeffrey Warren, Adjunct Assistant Professor; PhD, Geological Sciences. Dr. Warren's work focuses on coastal hazards and management. (MSC)

David N. Wear, Adjunct Professor; PhD, University of Montana. Dr. Wear's current research concerns the economics of ecosystem management, the design of forestry policies, and the regional assessment of forest production and investment. He is project leader for the economics of forest protection and management with the USDA Forest Service, Southeastern Forest Experiment Station, Research Triangle Park, NC. (ESP)

Christopher Wedding, Lecturing Fellow; PhD, University of North Carolina, 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)

Robert Young, Adjunct Professor, PhD Duke University. Dr. Young is a Professor of Geology at Western Carolina University and Director of the Program for the Study of Developed Shorelines, WCU/Duke University. (EOS)

Faculty Emeriti

Richard T. Barber, PhD, Harvey W. Smith Professor of Biological Oceanography, Emeritus

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

Kenneth R. Knoerr, PhD, Professor Emeritus of Environmental Meteorology and Hydrology

***Daniel A. Livingstone**, James B. Duke Professor Emeritus of Biology

Ronald D. Perkins, PhD, Professor Emeritus of Earth Science

Orrin Pilkey, PhD, James B. Duke Professor Emeritus of Geology

William Schlesinger, PhD, James B. Duke Professor Emeritus of Biogeochemistry

William J. Stambaugh, PhD, Professor Emeritus

Courses of Instruction

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 (ENVIRON)

25. 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: Christensen or Meyer. 1 unit.

49S. First-Year Seminar. Topics vary each semester offered. Instructor: Staff. 1 unit.

99FCS. Topics in Environment. Topics vary semester to semester. Only open to students in the Focus Program. Consent of Instructor required. Instructor: Staff. 1 unit.

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

101. 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 25 or consent of instructor. Instructor: Miranda. 1 unit.

103D. 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.

110L. Ecology. Physical, chemical, and biological processes that determine the distribution and abundance of plants and animals, emphasizing physiological responses, population dynamics, species interaction, biogeography, nutrient cycling, and energy flow through food webs. Laboratory includes fieldwork. Prerequisites: Biology 25L and Mathematics 31. Instructor: Reid. 1 unit. C-L: Biology 110L

126S. 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. 1 unit. C-L: see Earth and Ocean Sciences 126S

129. 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. C-L: International Comparative Studies 103C

130. 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: Earth and Ocean Sciences 130

131. World Trade In Energy and Mineral Resources. Exploration of the physical, economic and geopolitical flow of energy and mineral resources around the world. Topics include examination of economically important energy and mineral resources, their uses, geologic/geographic distribution, and influence on the economic and political organization of and interaction between nations. The trade of energy and mineral resources explored in light of current demand, remaining supplies, technical and geopolitical accessibility, refining and distribution systems, and pricing, as well as the environmental impacts and future challenges facing continued use of these resources. Prerequisite: Earth and Ocean Sciences 11 or 12 or Environment 25. Instructor: Pratson. 1 unit. C-L: Earth and Ocean Sciences 131

149. 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. Consent of instructor required. Instructor: Gallagher or staff. 1 unit. C-L: Public Policy Studies 149

159. 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. Prerequisite: an introductory statistics course. Instructor: Halpin. 1 unit. C-L: Earth and Ocean Sciences 159

160. 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 25L; Chemistry 31L and 32L; Chemistry 151L; Mathematics 31. 1 unit.

161. Science and Policy of Natural Catastrophes. In this interdisciplinary course students will conduct a life cycle analysis of a natural disaster. Invited experts will discuss 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. Students will attend the lecture component of the course and complete on-line quizzes to demonstrate understanding of the material presented. Additionally, they will prepare an individual paper (~ 10 pages) on a relevant topic and one group paper, the results of which will be presented to the class. Instructor: Schaad. 1 unit. C-L: see Engineering 60; also C-L: Public Policy Studies 107

162. Natural Catastrophes: Rebuilding from Ruins. Research Service Learning Gateway course where students will conduct a life cycle analysis of natural disasters. Invited experts will discuss meteorologic, hydrologic and geologic factors that cause disasters; explore how societies plan 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. 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 carry out response activities over Spring Break in an area ravaged by a natural disaster. They will keep a journal (audio and 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 a project which might stem from the course and their experiences. Instructor: Schaad. 1 unit. C-L: see Engineering 61; also C-L: Public Policy Studies 109

163. 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. Prerequisite: Economics 105D and Statistics. Instructor: Timmins. 1 unit. C-L: see Economics 163

171. 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 172

172S. 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. Taught at the Center for Documentary Studies using state of the art camera and audio recording equipment and methods for web and gallery exhibition. Seminar, studio, and study of photography in university archives and field trips. Consent of Instructor required. Instructor: Satterwhite. 1 unit. C-L: Documentary Studies 172S

173S. Ecosystem Ecology for a Crowded Planet. Concepts of ecosystem ecology within the ethical, social and political context of current environmental policy issues. Lectures, discussions and class activities examine environmental policy issues, linkage between ecosystem science and political issues. Prerequisites: BIO 110L, 116 or ENV 49S, or by permission. Instructor: Bernhardt. 1 unit. C-L: see Biology 172S

179. Introduction to Atmospheric Chemistry. 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. Prerequisites: Chemistry 31L. 1 unit.

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

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

185. 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.

189. Views of Environmental Change: Documentary Research in Natural Resource 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 119

190L. 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: Pratson. 1 unit.

191. 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.

191A. Research Independent Study. See Environment 191. Open to qualified juniors and seniors with consent of instructor and director of undergraduate studies. Half course. Instructor: Staff. 0.5 units.

192. 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.

197. 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 25L or equivalent. Instructor: McClearn. 1 unit. C-L: see Biology 137

200. 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.

201. Forest Resources Field Skills. Introduction to field techniques commonly used to quantify and sample forest resources: trees, soils, water, and animal resources. Dendrology, vegetation sampling, soil mapping, river flow estimation, field water quality sampling, surveying, and use of compass. Instructor: Richter. 2 units.

203. 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.

205L. 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: Oren. 4 units.

206. Forest Vegetation Sampling. Theory and application of forest vegetation sampling. Direct and indirect estimation methods that range from timber cruising and inventory to sampling for species composition. Laboratory applications in Duke Forest to include over- and understory vegetation. Instructor: Staff. 3 units.

207. Forest Health Management. Non-lab version of Environment 207L. Instructor: Staff. 3 units.

207L. Forest Health Management. Fundamentals of forest fire management, entomology and plant pathology (including air pollution and chemical damage) related to understanding their impacts on forest productivity and forest management. Regional case examples and complexes are evaluated in terms of pest-population, forest-stand dynamics; economic and societal constraints; treatment strategies; monitoring systems; and benefit-cost analysis. Approach seeks to develop predictive capabilities in long range pest management and decision making. Field oriented lab focuses on diagnostics and impact analysis. Instructor: Staff. 4 units.

210. Applied Data Analysis for Environmental Sciences. Graphical and exploratory data analysis; modeling, estimation, and hypothesis testing; analysis of variance; random effect models; nested models; regression and scatterplot smoothing; resampling and randomization methods. Concepts and tools involved in data analysis. Special emphasis on examples drawn from the biological and environmental sciences. Students to be involved in applied work through statistical computing using software, often S-plus, which will highlight the usefulness of exploratory methods of data analysis. Other software, such as SAS, may be introduced. Instructor: Qian. 3 units. C-L: Statistics and Decision Sciences 240

211. 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.

212. 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. 3 units.

213. 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.

214. Landscape Ecology. Emphasis on the role of spatial heterogeneity in terrestrial systems: its detection and description, agents of pattern formation, landscape dynamics and models, and the implications of heterogeneity of populations, communities, and ecosystems. Prerequisites: an intermediate-level ecology course, introductory applied statistics, and Environment 351, or consent of instructor. Instructor: Urban. 3 units.

216. Applied Population Ecology. Population dynamics of managed and unmanaged populations. A quantitative approach to exploitation and conservation of animal and plant populations, including harvesting, population viability analysis, population genetics. Prerequisites: introductory statistics, calculus, and computer programming or consent of instructor. Instructor: Pimm. 3 units.

217. 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: Staff. 3 units. C-L: Biology 215

221L. 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.

231L. Models for Environmental Data. Formulation of environmental models and applications to data. Topics include physiology, population growth, species interactions, disturbance, and ecosystem dynamics. Model development, analysis, and interpretation. Discussions focus on classical and current primary literature. Lab focuses on analysis of data using R, making use of likelihood models, bootstrapping, and Bayesian approaches. Instructor: Clark. 3 units. C-L: see Biology 268L

234L. 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.

235. Air Quality Management. Types, sources, effects of air pollutants. Regulatory framework emphasizing the Clean Air Act Amendments of 1990 and federal, state, local agency implementation. Application of risk assessment, technology, market incentives to air management. Scientific, policy aspects of acid deposition, global climate change, indoor air, mobile sources control. Dispersion modeling, exposure assessment. Instructor: Vandenberg. 3 units.

236. Water Quality Management. Types, sources, and effects of pollutants. Water quality standards and criteria. Engineering approaches to water management. Mathematical models and their application to water quality management. Federal regulations, in particular, the Federal Water Pollution Control Act and the Safe Drinking Water Act. Policy analysis for water quality management planning. Instructor: Reckhow. 3 units.

238. 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 Certificate 238, Public Policy Studies 237

239. 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 and McMasters. 3 units.

240. 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 thermochemical 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 Engineering 240

242. 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. Prerequisite: Civil and Environmental Engineering 120L or Environment 160 or equivalent. Instructor: Hsu-Kim. 3 units. C-L: see Civil Engineering 242

246. Survey of Occupational Health and Safety. Occupational risks associated with biological, chemical, ergonomic, radiation, and toxic hazards. The nature and scope of occupational hazards, health effects, and risk assessment and management strategies. Open to undergraduates by consent. Instructor: Thomann. 3 units.

247. Survey of Environmental Health and Safety. Environmental risks from the perspective of global ecology, biology, chemistry, and radiation. The nature and scope of environmental hazards, environmental impacts and health effects, and risk assessment and management strategies. Open to undergraduates by consent. Instructor: Thomann. 3 units.

248. 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 Engineering 124L or consent of instructor. Instructor: Staff. 3 units. C-L: see Civil Engineering 248

252. Sustainability and Renewable Resource Economics. Economic theories of sustainability, contrasted with other scientific views. Focus on renewable resource economics, modeling, and management. Prerequisite: Environment 270. Instructor: Smith. 3 units.

255. 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: Statistics 210B or equivalent. Instructor: Qian. 3 units. C-L: Statistics and Decision Sciences 242

259. 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. 4 units.

260. 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: Edeburn. 1 unit.

261. Geospatial Analysis for Conservation Management. Application course focusing on spatial analysis and image processing applications to support conservation management. Habitat mapping, spatial analysis of animal movements, habitat modeling, and the optimization of nature reserve selection. Requires a fundamental knowledge of geospatial analysis theory and analysis tools. Consent of instructor required. Prerequisite: Environment 259. Instructor: Swenson. 4 units.

262. 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. Consent of instructor required. Instructor: Richter. 1 unit.

264. 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 31 or equivalent or consent of instructor. Instructor: Katul. 2 units.

265. 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 259. Instructor: Halpin. 4 units.

266. 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.

270. Resource and Environmental Economics. The application of economic concepts to private- and public-sector decision making concerning natural and environmental resources. Intertemporal resource allocation, benefit-cost analysis, valuation of environmental goods and policy concepts. Prerequisite: introductory course in microeconomics. Instructor: Bennear or Smith. 3 units. C-L: Economics 270, Public Policy Studies 272

271. Economic Analysis of Resource and Environmental Policies. Case and applications oriented course examining current environmental and resource policy issues. Benefits and costs of policies related to sustaining resource productivity and maintaining environmental quality will be analyzed using economic and econometric methods. Topics include benefit-cost analysis, intergenerational equity, externalities, public goods, and property rights. Prerequisite: Environment 270 or equivalent; Economics 149 recommended. Instructor: Vincent. 3 units. C-L: Economics 272

272. 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 261; also C-L: Economics 261

274. 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 students selected from the United States and other advanced industrialized countries and the developing world. Spring. Instructor: Weinthal. 3 units. C-L: see Public Policy Studies 274

275S. 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.

277. Professional Ethics for Environmental Practitioners. Give students training and experience in applying moral reasoning to the types of ethical problems likely to be encountered by environmental practitioners. Instructor: Maguire. 1 unit.

278. Lessons from Watershed Management in California: Seeing the Big Picture. Watershed formed by Sacramento and San Joaquin Rivers. History of competing interests and conflicts. Bay Delta Accord and coalition of federal and state agencies (CALFED) management to assure ecological integrity and water supply availability. Geography, stressors, legal claims for water, and attempts to store snowmelt in winter for dispersal throughout year. Instructor: Hinton. 3 units.

279. Introduction to Atmospheric Chemistry. 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 Engineering 279

280. 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.

282. 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 31L or equivalent; Recommended: Chemistry 32L. Instructor: Bernhardt. 3 units. C-L: see Biology 272

285. Land Use Principles and Policy. Consideration of four major roles of land in the United States: as a producer of commodities, financial asset, component of environmental systems, and location of development. Analysis of market allocation of land, market failure, role of public planning and regulation. Instructor: Staff. 3 units. C-L: see Public Policy Studies 285

294. Water Quality Skills. Introduction to field and laboratory techniques for monitoring water quality characteristics including heat properties, BOD, flow, dissolved oxygen, nutrients, benthic invertebrates, and coliform indicators. Emphasis on technical report writing. Prerequisite: Environment 236. Instructor: Stow. 3 units.

296. 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: Maguire. 2 units.

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

299. 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.

301. 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 if 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.

302. 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: Christensen and Gallagher. 3 units. 3 units.

303. 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. C-L: see Biology 303

309. 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.

310. 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: Qian. 3 units.

312. 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.

313. Advanced Topics in 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; 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 212. Instructor: Di Giulio. 3 units.

314. 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: Pharmacology and Cancer Biology 314

315. 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 233 and 347. Instructor: Levin. 1 unit. C-L: Pharmacology and Cancer Biology 315

317. Tropical Forests and Global Change. Tropical ecologists labor to understand how the diversity and dynamics of humid tropical forests are being affected by land use change in the form of ecosystem loss, fragmentation and disturbance regimes. More recently ecologists have begun to realize the complex synergies at various scales that link climate change and land use change in the tropics. Course will consider causes, consequences and possible mitigations of global change for tropical forests in the context of the fundamental ecology of tropical forested ecosystems. Instructor: Bynum. 3 units.

319. 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.

320. Ecosystem Management. Principles of environmental management in the context of arbitrary temporal and spatial boundaries, complexity, dynamic processes, uncertainty and varied and changing human values. Topics to include adaptive management, decision making in the content of uncertainty, conflict resolution, strategic planning, evaluation and accountability. Case studies will cover terrestrial, aquatic and marine ecosystems and an array of social and institutional settings. Instructor: Christensen. 3 units.

321. 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.

326. 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.

331. 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.

338. 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.

346. 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.

348. 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 348

352. Spatial Analysis in Ecology. Techniques of spatial analysis as applied to ecological data, including scaling techniques, pattern analysis, indices of patchiness (adjacency, contagion), and inferential methods (cross-correlation, permutation procedures). Emphasis on hands-on applications in computer lab. Prerequisite: Environment 214 or consent of instructor. Instructor: Urban. 3 units.

353. 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.

354. 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.

356. 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 122L, Mathematics 111 or 135, or equivalent. Instructor: Katul. 3 units.

357L. Satellite Remote Sensing for Environmental Analysis. Environmental analysis using primarily satellite remote sensing. Theoretical and technical underpinnings of remote sensing (georectification, image analysis, classification) coupled with practical applications (land cover mapping, change analysis, ground truth techniques). Strong emphasis on hands-on processing and analysis. Will include variety of image types: multi-spectral, hyper-spectral, radar and others. Prerequisite: Environ 259 or consent of instructor. Instructor: Swenson. 4 units.

358. Multivariate Analysis in Community and Landscape Ecology. Assembly in a lab setting portfolios of strategies for interpreting multivariate ecological datasets such as those relating species abundance to environmental variables, focusing on techniques commonly used by vegetation scientists (for example, ordination, classification, etc.). Emphasis on using and interpreting UNIX and PC-based software. Consent of instructor required. Instructor: Urban. 3 units.

364. Multidisciplinary Approaches to Global Health. Students are introduced to the multidisciplinary theories and techniques for assessing and addressing infectious, chronic, and behavioral health problems in less wealthy areas of the world. The course addresses global health issues from disciplines such as: epidemiology, biology, engineering, environment, business, human rights, nursing, psychology, law, public policy, and economics. For example, obesity can be examined in terms of: differential rates around the world; biological and psychological causes; environmental differences; ethics of subsidizing nutritious foods; policies limiting the availability of wealthy nation fast food; the economics consequences of the disease, and intervention. Instructor: Staff. 3 units. C-L: Public Policy Studies 254

368. Natural Resources Law. Focus on constitutional, statutory, and common law governing the legal status and management of federal lands and natural resources. Instructor: Law Faculty. 2 units. C-L: see Law 368

374. 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.

385. Environmental Decision Analysis. Quantitative methods for analyzing environmental problems involving uncertainty and multiple, conflicting objectives. Topics include subjective probability, utility, value of information,

multiattribute methods. Students will apply these tools to an environmental policy decision in a group project. Prerequisite: introductory applied statistics or equivalent. Instructor: Reckhow. 3 units.

391. 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. Variable credit.

394. Professional and Field Skills. A series of modules offered on a rotating basis over the four semesters of a professional master's program. Modules consist of one to twenty hours of instruction in a skill needed for professional development or competence in field sampling or laboratory techniques. Examples of topics include environmental negotiation; environmental safety; use of computer packages; preparing presentations and written reports; sampling design; field sampling of trees, herbaceous plants, streambottom organisms; toxicological testing using plankton. Instructor: Maguire. Variable credit.

398. Program Area Symposium. Required symposium in each program area. Students present master's project research. Pass/fail grading only. Instructor: Staff. 1 unit.

399. 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 400–459 only with permission of the instructor and if space is available. Courses numbered 460 and above are open only to D.E.M.–MEM students.

405. Environmental Communication for Behavior Change - Online Course. 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.

410. Implementation of the National Environmental Policy Act on Federal Lands and Facilities. Overview of NEPA history, purpose, content, case law, and current issues. Discussion of methods of implementing regulations efficiently, conducting and processing an environmental impact analysis, and determining the proper level of documentation to fully record and disclose to the public the results of environmental analysis. Intensive. Consent of instructor required. Instructor: Clark. 1 unit.

417. Preparing and Documenting Environmental Impact Analyses. Principles of how to acquire, assemble, analyze, and present in document form, information required by the National Environmental Policy Act. Extensive practical exercises designed to make use of realistic case study materials provided by students. Consent of instructor required. Instructor: Staff. 1 unit.

441. Forest Appraisal. Presentation of the principles of real estate appraisal as they apply to valuation problems in forestry. Consideration of appraisal theory, accounting, and tax concepts in forest land management. Application of financial analysis techniques to forest land management through lectures and problem-solving sessions. Staff. Variable credit.

442. New Advances in Ecological Risk Assessment. Overview of ecological risk assessment and discussion of current methods, approaches, and issues. Consideration of both aquatic and terrestrial environments, drawing upon case study illustrations and risk assessment methods with environmental monitoring data. Consent of instructor required. Intensive. Consent of instructor required. Instructor: DiGuilio. 1 unit.

445. GIS-based Analyses for Conservation Management. The goal of this course is to introduce conservation practitioners to the capabilities of GIS-based analyses to serve as an integrating framework for conservation management, providing functionality including data acquisition, management, analysis and decision support, visualization, and documentation via metadata. Instructor: Staff. 1 unit.

460. Duke Environmental Leadership: Orientation Course: Making a Difference in the World. One-week course to introduce the curriculum of the Duke Environmental Leadership (DEL) program. Provides framework for program studies. Focus on real-world environmental challenges and timely case studies. For Duke Environmental

Leadership-Master of Environmental Management students only. Field studies in Durham and at Duke University Marine Lab, Beaufort, NC. Instructor consent required. Instructor: Christensen. 1 unit.

461. Duke Environmental Leadership: Ecosystem Science and Management. Principles of environmental management in the context of arbitrary temporal and spatial boundaries, complexity, dynamic processes, uncertainty, and varied and changing human values. Topics to include adaptive management, decision making in the context of uncertainty, conflict resolution, strategic planning, evaluation, and accountability. Case studies will cover terrestrial aquatic and marine ecosystems and an array of social and institutional settings. For Duke Environmental Leadership-Master of Environmental Management students only. Instructor consent required. Instructor: Christensen. 3 units.

462. Duke Environmental Leadership: Economics of Environmental Management. An economic perspective on the management of environmental resources. Conceptual topics emphasized include environmental 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 environmental policy formulation. Case studies examine carbon trading and taxes to address climate change, and economic incentives and values for biodiversity conservation. Instructor consent required. For Duke Environmental Leadership-Master of Environmental Management students only. Instructor: Kramer. 3 units.

463. Duke Environmental Leadership: 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. For Duke Environmental Leadership-Master of Environmental Management students only. Consent of instructor required. Instructor: Christensen. 3 units.

464. 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. For Duke Environmental Leadership-Master of Environmental Management students only. Consent of instructor required. Instructor: Gallagher. 3 units.

465. 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. For DEL-MEM students only. Permission of instructor required. Instructor: Christensen. 1 unit.

466. 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. For DEL-MEM students only. Consent of instructor required. Instructor: Reynolds. 1 unit.

470. Duke Environmental Leadership: A Landscape Perspective on Environmental Management. Environmental management is pursued at increasingly larger spatial scales. As a direct consequence, we encounter more spatial heterogeneity and logistical constraints on empirical approaches. The field of landscape ecology specifically addresses issues of spatial scale and heterogeneity as these influence our ecological understanding and management of natural and seminatural systems. This course is an applications-driven survey of common tasks in landscape management, including inventory and monitoring programs and prioritizing sites according to various criteria

(e.g., diversity hotspots, environmental impacts). Specific applications emphasize ecosystem processes (productivity, hydrology) and conservation planning at large scales. To address the uncertainty that naturally attends these applications, the course is developed in the framework of adaptive management. For Duke Environmental Leadership-Master of Environmental Management students only. Consent of instructor required. Instructor: Urban. 3 units.

471. Duke Environmental Leadership: U.S. Land Use Policy. This course covers the economic and demographic forces that drive the allocation of land among alternative uses, and the institutional structure that has evolved in the U.S. at local, state and federal levels to deal with land use problems. Topics include food and timber supply, federal lands, sprawl, industrial siting, property rights, and coastal zone management. For Duke Environmental Leadership-Master of Environmental Management students only. Consent of instructor required. Instructor: Healy. 3 units.

472. DEL: Environmental Decision Analysis. 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. For DEL-MEM students only. Instructor: Maguire. 3 units.

473. DEL: Business Strategy for Environmental Sustainability. Businesses are increasingly applying strategic management tools to incorporate considerations of sustainability into decision-making and operations. While some businesses incorporate sustainable practices because of an ethical conviction to do well for the environment, most businesses are motivated to do so to address pressures from stakeholders such as regulators, shareholders, customers and neighbors and to exploit knowledge and expertise for long-term competitive advantage. This 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, such as external analysis, forecasting and stakeholder management to problems of sustainability. Business case studies are critical component to this course. For DEL-MEM students only. Instructor: Gallagher. 3 units.

474. 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. Permission of instructor required. Instructor: Hinton. 3 units.

475. DEL: Ecosystem Change: Science and Management Implications. This course will review classical models and case studies of disturbance and ecosystem succession, patch dynamics, and non-equilibrium models for ecosystem change. Particular attention will be given to the influence invasive species and climate change on patterns succession and to concepts such as multiple stable points and change thresholds. The implications for management of terrestrial, aquatic and marine ecosystems of these concepts will be emphasized. Lectures, readings, and discussion. Term paper required. Permission of instructor required. Instructor: Christensen. 1 unit.

476. DEL: Emerging Perspectives on Landscape Management. This course is developed in response to a few emerging trends in environmental management. First, management is being pursued at increasingly larger spatial scales. Second, the context of management is also rapidly changing, including increasing emphasis on multi-criteria or multi-objective programs, prioritization of sites strictly in relationship to a larger network of units, and adaptive approaches to management. Beyond these trends, it is important to note that the tools of environmental management are also evolving rapidly. This module is designed as a "professional update" in emerging trends, as well as an introduction to new methods being applied to these areas. Permission of instructor required. Instructor: Urban. 1 unit.

477. DEL: Environmental Information and Analysis Systems. Developing, maintaining and sharing high-quality information is one of the fastest growing challenges in the field of environmental management. Environmental researchers and managers are both the developers and consumers of extensive geographic data, imagery and statistical archives. Environmental managers now must meet expectations of real-time data sharing across widely distributed projects within detailed data assurance standards. In order to meet these challenges, managers must understand complex relational databases, internet-based data delivery systems, and international metadata standards. This course focuses on essential issues of database development, delivery and maintenance for environmental managers. The course highlights new developments in digital data archives, internet map servers and collaborative programs, and uses

emerging projects, protocols and current case studies to demonstrate good management choices, strategies and evaluation processes. Instructor: Halpin. 1 unit.

478. DEL: Energy & 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. Instructor: Pratson. 1 unit.

480. 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 Aqueduct, and the re-watering of the San Joaquin River. For DEL-MEM students only. Instructor consent required. Instructor: Christensen and Hinton. 1 unit.

481. DEL: Environmental Entrepreneurship. This course will address the following seven questions: 1) What is entrepreneurship? 2) What is social entrepreneurship? 3) What is environmental entrepreneurship? 4) What differentiates an idea from an opportunity? 5) Is climate/environmental change a source of entrepreneurial opportunity? 6) Is market failure a source of entrepreneurial opportunity? 7) Are others' waste products a source of entrepreneurial opportunity? Students will craft an executive summary for a business model that will pursue a viable opportunity for environmental entrepreneurship. One credit. For DEL-MEM students only. Instructor: Archer. 1 unit.

482. 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. Two credits. For DEL-MEM students only. Instructor: Gallagher and Healy. 2 units.

483. DEL: Green Development. In this course, 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. The class will also explore new opportunities and new models for green development along with its various challenges and limitations. Students will examine these topics through structured discussion boards, readings, lectures, conference calls, memorandum writing, analytical exercises and group presentations. Three credits. For DEL-MEM students only. Instructor: Wedding. 3 units.

484. DEL: Changing Tropical Ecosystems. The tropical regions of the earth contain the majority of the world's biological diversity, as well as the majority of the world's human population and its cultural diversity. This course will identify the primary drivers of change for tropical ecosystems, with a particular focus on land use change and present and future effects of global climate change. Possible solutions and mitigations for the threats that face tropical ecosystems, and by extension, human populations in the tropics and globally will then be considered. Three credits with field component, two credits without. For DEL-MEM students only. Instructor: Bynum. Variable credit.

497. Duke Environmental Leadership: Independent Studies and Projects. Directed readings or research at the graduate level to meet the needs of individual students. For Duke Environmental Leadership-Master of Environmental Management students only. Instructor consent required. Instructor: Staff. Variable credit.

499. 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. For Duke Environmental Leadership-Master of Environmental Management students only. Consent of instructor required. Instructor: Staff. 4 units.

Earth and Ocean Sciences (EOS)

11. 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: Baker, Klein, Murray, Glass. 1 unit.

12. 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. Required fee for trip. Instructors: Corliss, Glass, Murray. 1 unit. C-L: Biology 53

49S. First-Year Seminar. Topics vary each semester offered. Instructor: Staff. 1 unit.

50. Duke-Administered Study Abroad: Special Topics in Earth and Ocean Sciences. Topics differ by section. Instructor: Staff. 1 unit.

100. Duke-Administered Study Abroad: Advanced Special Topics in Earth and Ocean Sciences. Topics differ by section. Instructor: Staff. 1 unit.

101L. The Solid Earth: Minerals, Rocks and Structural Geology. Description and interpretation of minerals, rocks and geologic structures. Lectures on theoretical aspects, lab on practical applications and use of petrographic microscope. Prerequisite: Earth and Ocean Sciences 11. Instructor: Boudreau. 1 unit.

102. Ocean and Atmosphere Dynamics. Introduction to the dynamics of ocean and atmospheric circulations, with particular emphasis on the global climate cycle. Prerequisites: Mathematics 31 and 32, Physics 53L or consent of instructor. Instructor: Lozier. 1 unit.

103S. The Surface of the Earth. Fundamental earth surface processes involving weathering, soils, hillslopes, rivers, wind, glaciers, and tectonic activity. Humans as agents of landscape change. The future of landscape. Prerequisites: Earth and Ocean Sciences 11 or 12. Instructor: Haff or Murray. 1 unit. C-L: Visual Studies 111AS

107L. The Evolving Earth and Life. Evolution of the earth and life through time. Weekend field trip to Appalachian Mountains. Recommended: Earth and Ocean Sciences 11. Instructor: Corliss. 1 unit.

115. 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. Includes a field trip with a required fee for the trip. Instructor: Murray. 1 unit.

116. 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 115/215 or consent of instructor. Also taught as Earth and Ocean Sciences 202. Instructor: Murray. 0.5 units.

120. Environmental Geology. A case history, field and lab exercise, and quantitative model approach to the role of geological materials and processes in environmental assessment studies. The quantitative and qualitative impact of rock type, faulting, folding, volcanism, weathering, erosion, flooding, and underground fluid flow on the human environment. An introduction to quantitative probabilistic hazard analysis and its application to establishing monetary cost/benefit ratios. The basics of engineering geology in environmental studies. Cases taken from current and past geological studies of environmentally sensitive sites. Consent of instructor required. Instructor: Staff. 1 unit. C-L: Earth and Ocean Sciences 224

123. Hydrogeology. An overview of the hydrologic cycle and its impact on global climate and local environmental problems. Examines ethical dilemmas encountered in communicating environmental analysis to the public. Prerequisite: Mathematics 32 and Chemistry 31L or equivalent, or consent of the instructor. Instructor: Vengosh. 1 unit.

125. The Future. Introduction to the future as a continuation of the geological, biological, and technological evolution of the Earth. Topics include developments and trends in computation, the internet, nanotechnology, space exploration, artificial intelligence, robots and biotechnology and their effects in society. Prerequisite: Earth and Ocean Sciences 11 or 12. Instructor: Haff. 1 unit.

126S. 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. 1 unit. C-L: Environment 126S

130. 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 130

131. World Trade In Energy and Mineral Resources. Exploration of the physical, economic and geopolitical flow of energy and mineral resources around the world. Topics include examination of economically important energy and mineral resources, their uses, geologic/geographic distribution, and influence on the economic and political organization of and interaction between nations. The trade of energy and mineral resources explored in light of current demand, remaining supplies, technical and geopolitical accessibility, refining and distribution systems, and pricing, as well as the environmental impacts and future challenges facing continued use of these resources. Prerequisite: Earth and Ocean Sciences 11 or 12 or Environment 25. Instructor: Pratson. 1 unit. C-L: see Environment 131

141. 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. Required fieldtrip to the Museum of Natural History in Raleigh. Prerequisite: Prior course work in Earth and Ocean Sciences or Biology or consent of instructor. Instructor: Glass. 1 unit. C-L: Biology 145

151S. 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, and human impact on coastal zone ecosystems. Instructor consent required. Instructor: Baker. 1 unit.

155. Global Warming. Broad, interdisciplinary course on the science of global warming, its predicted impact, and various policy and technology options that have been proposed to mitigate its effect. Includes a short introduction to climate theory and models, discussions on important greenhouse gas, and model projections for the twenty-first century and beyond. Instructor: Staff. 1 unit.

159. 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. Prerequisite: an introductory statistics course. Instructor: Halpin. 1 unit. C-L: see Environment 159

173. Dinosaurs, Fossil Fish, and Yellowstone. Paleontology, geology, and ecology of Dinosaur National Monument, Fossil Butte National Monument, and Yellowstone National Park. Includes a field trip with a required fee for the trip. Consent of instructor required. Recommended prerequisite: Earth and Ocean Sciences 107L. Instructor: Corliss. 1 unit.

180S. 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 11 recommended. Consent of instructor required. Instructor: Boudreau. 1 unit.

181S. 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 11, and consent of instructor. Instructor: Haff or Murray. 1 unit.

187S. Marine Geology of South Florida. Spatial and temporal analysis of geology of south Florida. Includes class discussions, required spring break field trip to South Florida, trip presentation, post-trip research paper. Examination of 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 11 or 12, or consent of instructor. Instructor: Dwyer. 1 unit.

189S. 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.

191. 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.

192. Research Independent Study. See Earth and Ocean Sciences 191. Open only to qualified juniors and seniors by consent of director of undergraduate studies and supervising instructor. Instructor: Staff. 1 unit.

193. 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.

194. Independent Study. See Earth and Ocean Sciences 193. Term paper required. Open only to qualified juniors and seniors by consent of director of undergraduate studies and supervising instructor. Instructor: Staff. 1 unit.

195. Independent Study for Nonmajors. Individual research and reading in a field of special interest, under the supervision of a faculty member, resulting in a term paper containing significant analysis and interpretation of a previously approved topic at end of semester. Open to qualified juniors and seniors upon approval of the departmental faculty. Instructor: Staff. 1 unit.

209S. 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.

210S. 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.

211. 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.

212. 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: EOS 211. Instructor: Li. 3 units.

214. Advanced Issues in Paleoclimatology. Major issues in paleoclimatology including: decadal-millennial climate variability, ice age climates, the deglaciation, nonglacial climates, Paleozoic climates, ice core studies, Snowball Earth, carbon dioxide, volcanism, abrupt climate change, modeling studies, climate and extinctions. Consent of instructor required. Instructor: Staff. 3 units.

215. Introduction to Physical Coastal 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. 3 units.

220. 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.

225. Water Contamination. Geochemistry of water contamination, focusing on behavior of inorganic constituents dissolved in rainwater. Contaminants produced by human interactions with the environment, such as industry and construction. Salinization and desalinization. Prerequisites: Chemistry 22L. Instructor: Vengosh. 3 units.

226S. 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.

227. 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.

236S. Lithosphere Plate Boundaries. Plate tectonics and the geological and geophysical expression of orogenic belts, spreading centers, transform faults, subduction zones. Prerequisite: Earth and Ocean Sciences 101L or consent of instructor. Instructor: Staff. 3 units.

240. Introduction to Modeling in the Earth Sciences. Elementary methods for quantitatively modeling problems in the earth sciences. Formulation and solution of classical equations that express fundamental behaviors of fluids, sediments, and rocks. Examples from different fields of geology. Simple modeling exercises, including a final project. Instructors: Haff, Murray, and Pratson. 3 units.

242S. 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.

243S. 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 11 or consent of instructor. Instructor: Haff and Pratson. 3 units.

251S. 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.

267. 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.

269. Thermodynamics of Geological Systems. Introductory thermodynamics applied to geologic problems through understanding of phase equilibrium. Prerequisites: Earth and Ocean Sciences 101L; and Mathematics 32 or consent of instructor. Instructor: Boudreau. 3 units.

271. 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 22L and Mathematics 32. Instructor: Baker or Vengosh. 3 units.

273S. 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.

278. Tropical Climate and Paleoclimate. Thermodynamics of tropical climate. Nature and mechanisms of climate variability in the tropics on time scales from daily to multi-millennial. Impact of climatic variability on the tropical biota. Effects of anthropogenic changes of the environment on future climatic change in the tropics and potential extratropical teleconnections. Prerequisite: Earth and Ocean Sciences 11 or 12. Instructor: Baker. 3 units.

291. Independent Study. Consent of instructor required. Instructor: Staff. 3 units.

293S. Frontiers of Geology I. Survey of the history, status, and trajectory of "hard-rock" petrology, structural geology, tectonics, and geophysics. Instructors: Karson and staff. 3 units.

294S. Frontiers of Geology II. Survey of the history, status, and trajectory of "soft-rock" petrology, stratigraphy, sedimentation, geochemistry, hydrology, and paleontology. Instructors: Karson and staff. 3 units.

295S. Advanced Topics in Geology. Topics, instructors, and credits to be arranged each semester. Instructor: Staff. Variable credit.

300. Topics in Earth Processes. A broad overview of earth processes pertaining to human and environmental concerns. Provides the essential background for all environmental fields. Especially relevant to interests in global change, coastal zone processes, energy, and resources. Lectures and panel discussions with faculty from the Nicholas School and invited outside participants. Instructor: Varies. 3 units.

371. Advanced Topics in Geology. To meet the individual needs of graduate students for independent study. Instructor: Staff. Variable credit.

372. Advanced Topics in Geology. To meet the individual needs of graduate students for independent study. Instructor: Staff. Variable credit.

Courses Taught at the Marine Laboratory

Environment (ENVIRON)

109. 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: Crowder (Beaufort) and Rubenstein (visiting summer faculty). 1 unit. C-L: Biology 109

114L. Biological Oceanography. Physical, chemical, and biological processes of the oceans, emphasizing factors controlling distribution and abundances of organisms. The theory, methods, and limitations of biological oceanographic research. The laboratory teaches quantitative methods, experimental design, data acquisition, data processing, and data analysis and culminates in a research cruise where the students organize into a scientific party. One course (spring); one and one-half courses (summer). (Given at Beaufort) Prerequisite: Biology 25L. Instructor: Staff. Variable credit. C-L: see Biology 114L; also C-L: Earth and Ocean Sciences 114L

115. 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 115

123. 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: Staff. 1 unit. C-L: see Biology 123; also C-L: Earth and Ocean Sciences 122

125. 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 or staff. 1 unit. C-L: see Biology 126

125L. Marine Mammals. Laboratory version of Biology 126. 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 126L

132S. Current Topics in Oceanography and Marine Biology. Topics including the Iron Hypothesis, toxic algal blooms, and UV light considered through readings in the primary literature and student presentations. Emphasis on critical analysis of methodology, data analysis, and conclusions in primary peer-reviewed literature. Prerequisite: introductory biology. Instructor: Staff. 0.5 units.

133S. Molecular Approaches to Questions of Physiology, Ecology, and Evolution in the Marine Environment. Techniques of molecular biology as they relate to physiological, ecological, and evolutionary questions. Examples from the subcellular to global scale taken from classic and contemporary readings from the primary scientific literature. Each participant in the course presents a critical analysis of the literature on a chosen subject. Prerequisite: introductory biology. Instructor: Staff. 0.5 units. C-L: see Biology 133S

134S. Hands on Habitats: Life in Coastal Communities. Natural history and community ecology of coastal habitats. Focus on natural communities and artisan/commercial fishing practices in the coastal ocean, barrier islands, sounds and estuaries. Critical habitats; nursery areas, nesting beaches and rookeries. Commercially important, keystone as well as introduced and endangered vertebrate and invertebrate species. Concurrent enrollment in Humans and the Coast. (Given at Beaufort.) Instructor: Rittschof. 1 unit.

135. 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 Trinidad required. Prerequisite: Introductory Biology. Consent of instructor required. Instructor: K. Eckert and S. Eckert. 1 unit. C-L: see Biology 125

135L. Biology and Conservation of Sea Turtles. Laboratory version of Biology 125. Includes laboratory and field experience with animals and with their habitat requirements. (Given at Beaufort.) Prerequisite: Introductory Biology. Instructor: Staff. 1 unit. C-L: see Biology 125L

139L. 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 203L. (Given at Beaufort fall and summer.) Prerequisite: introductory biology. Instructors: Crowder or Kirby-Smith (Beaufort). 1 unit. C-L: see Biology 129L; also C-L: Earth and Ocean Sciences 129L

141S. Humans and Development of North Carolina Coasts. Human behaviors, laws and policies that affect development related to coasts and coastal oceans. Leisure tourism development of barrier islands and sounds. Special interests, social groups, political groups and cross cultural conflicts and their resolution. Concurrent enrollment with Hands on Habitats. (Given at Beaufort.) Instructor: Staff. 1 unit.

150L. 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: Biology 25L and Chemistry 31L. Instructor: Forward. Variable credit. C-L: see Biology 150L

155L. 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: Biology 25L; and Chemistry 31L. Instructor: Rittschof. Variable credit. C-L: see Biology 155L

175. 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: Orbach. 1 unit.

176L. Marine Invertebrate Zoology. Structure, function, and development of invertebrates collected from estuarine and marine habitats. Not open to students who have taken Biology 274L. One course (fall, spring, and Summer Term II); one and one-half courses (Summer Term I). (Given at Beaufort fall, spring, and summer.) Prerequisite: Biology 25L. Instructor: Kirby-Smith or staff. Variable credit. C-L: see Biology 176L; also C-L: Earth and Ocean Sciences 176L

188L. 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: Introductory biology and permission of instructor. Instructor: Staff. 1 unit. C-L: see Biology 188L

191. 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.

191A. Research Independent Study. See Environment 191. Open to qualified juniors and seniors with consent of instructor and director of undergraduate studies. Half course. Instructor: Staff. 0.5 units.

192. 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.

208. Estuarine Ecosystem Processes. A study of the physical, chemical, geological, and biological processes that control the structure of estuarine communities. Includes readings, oral presentations, and discussion of current literature from the journal *Estuaries*. Discussions focus on the management and policy implications of the science. Restricted to graduate students. (Given at Beaufort.) Prerequisite: ecology, systematics, or field biology course or consent of instructor. Instructor: Staff. 3 units.

209. 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 109. (Given at Beaufort.) Prerequisite: introductory biology; suggested: a policy and/or introductory ecology course. Instructors: Crowder/Orbach (Beaufort). 3 units.

219L. 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 BIO 129L and not open to undergraduates. (Given at Beaufort.) Prerequisite: Introductory Biology. Instructors: Crowder or Kirby-Smith. 4 units. C-L: see Biology 203L

224L. Coastal Ecosystem Processes. Physical, chemical, and biological processes in the coastal zone of the Carolinas. A unifying theme will be the coupling of watersheds, river basins, estuaries, and the coastal ocean through the movement of ground and surface waters. Topics include hydrology, nutrient cycles, sediment-water column interactions, primary and secondary production, and food web dynamics. Sustaining coastal ecosystems in the face of land use change. (Given at Beaufort.) Instructor: Staff. 4 units. C-L: Biology 219L

226. 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 126. (Given at Beaufort.) Prerequisite: introductory biology. Instructor: Read or staff. 3 units.

226L. Marine Mammals. Laboratory version of Environment 226. Laboratory exercises consider social organization and acoustic communication in the local bottlenose dolphin population. (Given at Beaufort.) Prerequisite: introductory biology. Instructor: Read, Reynolds, or staff. 4 units.

227. 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 Trinidad is required. Instructor permission is required. Prerequisite: Introductory Biology. Instructors: S. Eckert, K. Eckert. 3 units.

227L. 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 125L. (Given at Beaufort.) Prerequisite: introductory biology. Instructor: K. Eckert or S. Eckert. 4 units.

228L. Physiology of Marine Animals. Environmental factors, biological rhythms, and behavioral adaptations in the comparative physiology of marine animals. Open to undergraduates only under Biology 150L. Four units (fall); six units (summer). (Given at Beaufort.) Prerequisites: introductory biology and chemistry. Instructor: Forward. Variable credit. C-L: Biology 253L

229L. Biochemistry of Marine Animals. Functional, structural, and evolutionary relationships of biochemical processes of importance to marine organisms. Open to undergraduates only under Biology 155L. Four units (fall and

spring); variable credit (summer). (Given at Beaufort.) Prerequisites: Biology 25L and Chemistry 11L, 12L. Instructor: Rittschof (fall and summer). Variable credit. C-L: Biology 255L

243. Respiratory Proteins and the Environment. Structure, function and evolution of copper and iron based respiratory proteins in response to environmental oxygen levels and physiological needs. Lectures and readings on the balance between pathways for metabolic oxygen utilization and alternative disease-causing pathways involving oxidative and nitrosative reactions. Interactive molecular graphics and student presentations supplement text and lectures. Covers molecular adaptations, circulation, allostery, reaction kinetics and thermodynamics, reactive oxygen and nitrogen species, gene expression, blood pathogens, malaria, sickle cell anemia. (Given at Beaufort.) Prerequisites: organic chemistry or consent of instructor. Instructor: C. Bonaventura. 3 units. C-L: see Cell Biology 243

253L. 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 156L. (Given at Beaufort.) Prerequisites: introductory biology and chemistry. Instructor: Rittschof. 4 units.

254. 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.

256S. 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. 2 units.

267S. Conservation Biology of Marine Mammals. Examination of issues affecting the conservation of marine mammal populations, including: habitat loss and degradation, interactions with commercial fisheries, and direct harvests. Consent of instructor required. (Given at Beaufort.) Instructor: Read. 2 units.

273. 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: Orbach. 3 units.

276. 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: Public Policy Studies 297, Political Science 264

292L. 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: Staff. Variable credit.

293. 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 123. (Given at Beaufort.) Prerequisite: one year of biology, one year of chemistry, or consent of instructor. Instructor: Barber. 3 units.

295L. Marine Invertebrate Zoology. Structure, function, and development of invertebrates collected from estuarine and marine habitats. Not open to students who have taken Biology 176L, Biology 274L, or Zoology 274L. Open to undergraduates only under Biology 176L. Four units (fall, spring, and Summer Term II); six units (Summer Term I). (Given at Beaufort fall, spring, and summer or at Bermuda, spring.) Prerequisite: Biology 25L. Instructors: Dimock (Beaufort) or Kirby-Smith (Beaufort); Wood (Bermuda). Variable credit. C-L: Biology 274L

322. Coastal Watershed and Policy. Examine hydrology of coastal watersheds and how watershed 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: Staff. 3 units.

324. Marine Conservation Biology. Focus on the ecological effects of fishing, the major threat to marine biodiversity, by examining selected case studies, discussing conservation strategies, and learning how science and

policy can be integrated to solve real-world problems. We will use the recent report of the Pew Oceans Commission as the starting point of our discussion. Taught at Beaufort. Trip to Hawaii is required. Permission of the instructor is required. Instructor: Read. 3 units.

360S. 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. Taught at Beaufort. Instructor: Campbell. 3 units.

369. Environmental Law Clinic. Under supervision of Law clinical faculty, students work on current case and policy advocacy priorities as determined by Clinic's Advisory Board. Cases and issues undertaken by the Clinic will vary. 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 third semester in Nicholas School to enroll. Pre-requisite: LAW 235 Environmental Law. Instructor: Longest. 4 units.

370. 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. Course credit: 1 unit. Instructor: Richter. 1 unit.

Biology (BIOLOGY)

10L. 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.

109. 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: Crowder (Beaufort) and Rubenstein (visiting summer faculty). 1 unit. C-L: Environment 109

114L. Biological Oceanography. Physical, chemical, and biological processes of the oceans, emphasizing factors controlling distribution and abundances of organisms. The theory, methods, and limitations of biological oceanographic research. The laboratory teaches quantitative methods, experimental design, data acquisition, data processing, and data analysis and culminates in a research cruise where the students organize into a scientific party. One course (spring); one and one-half courses (summer). (Given at Beaufort) Prerequisite: Biology 25L. Instructor: Staff. Variable credit. C-L: Environment 114L, Earth and Ocean Sciences 114L

123. 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: Staff. 1 unit. C-L: Environment 123, Earth and Ocean Sciences 122

125. 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 Trinidad required. Prerequisite: Introductory Biology. Consent of instructor required. Instructor: K. Eckert and S. Eckert. 1 unit. C-L: Environment 135

125L. Biology and Conservation of Sea Turtles. Laboratory version of Biology 125. Includes laboratory and field experience with animals and with their habitat requirements. (Given at Beaufort.) Prerequisite: Introductory Biology. Instructor: Staff. 1 unit. C-L: Environment 135L

126. 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 or staff. 1 unit. C-L: Environment 125

126L. Marine Mammals. Laboratory version of Biology 126. 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: Environment 125L

129L. 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 203L. (Given at Beaufort fall and summer.) Prerequisite: introductory biology. Instructors: Crowder or Kirby-Smith (Beaufort). 1 unit. C-L: Environment 139L, Earth and Ocean Sciences 129L

132S. Marine Biodiversity. Marine biodiversity in the context of theoretical ecology and environmental physiology. Topics include methods for quantifying and evaluating diversity and biological diversity in major marine habitats. Primary literature examples focus on quantifying human impacts and developing conservation measure. Prerequisite: introductory biology. Instructor: Staff. 0.5 units.

133S. Molecular Approaches to Questions of Physiology, Ecology, and Evolution in the Marine Environment. Techniques of molecular biology as they relate to physiological, ecological, and evolutionary questions. Examples from the subcellular to global scale taken from classic and contemporary readings from the primary scientific literature. Each participant in the course presents a critical analysis of the literature on a chosen subject. Prerequisite: introductory biology. Instructor: Staff. 0.5 units. C-L: Environment 133S

145. 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. Required fieldtrip to the Museum of Natural History in Raleigh. Prerequisite: Prior course work in Earth and Ocean Sciences or Biology or consent of instructor. Instructor: Glass. 1 unit. C-L: see Earth and Ocean Sciences 141

150L. 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: Biology 25L and Chemistry 31L. Instructor: Forward. Variable credit. C-L: Environment 150L

155L. 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: Biology 25L; and Chemistry 31L. Instructor: Rittschof. Variable credit. C-L: Environment 155L

156L. 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: Biology 25L and Chemistry 31L. Instructor: Rittschof. 1 unit.

176L. Marine Invertebrate Zoology. Structure, function, and development of invertebrates collected from estuarine and marine habitats. Not open to students who have taken Biology 274L. One course (fall, spring, and Summer Term II); one and one-half courses (Summer Term I). (Given at Beaufort fall, spring, and summer.) Prerequisite: Biology 25L. Instructor: Kirby-Smith or staff. Variable credit. C-L: Environment 176L, Earth and Ocean Sciences 176L

178L. 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.) Pre-requisite: Biology 25L or equivalent, or consent of the instructor. Instructor: Nowacek. 1 unit. C-L: Environment 178L

190. 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. Variable credit.

191. 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 297. Instructor: Staff. 1 unit.

193T. Tutorial. For junior and senior majors with consent of director of undergraduate studies and supervising instructor. Instructor: Staff. 1 unit.

197T. Tutorial. For junior and senior majors with consent of director of undergraduate studies and supervising instructor. Instructor: Staff. 0.5 units.

203L. 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 BIO 129L and not open to undergraduates. (Given at Beaufort.) Prerequisite: Introductory Biology. Instructors: Crowder or Kirby-Smith. 4 units. C-L: Environment 219L

207AL. 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: Rittschof. 2 units.

207BL. 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 129L and consent of instructor. Instructor: Crowder. 2 units.

207CL. Ocean Ecosystems. Interaction of physical, chemical and biological processes, emphasizing processes that determine species composition and quality of plants and animals. Field work with marine organisms, especially plankton, sampling habitats from the continental shelf to the subtropical gyre. Offered only at Beaufort, with preparation for fieldwork before and analysis and presentation of projects after required one week intensive field experience at sea on an oceanographic vessel. Consent of instructor required. Instructor: Staff. 2 units.

207EL. 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: Biology 25L and consent of instructor. Instructor: Van Dover. 2 units.

216. Sojourn in Singapore: Urban Tropical Ecology. The mix of human ecology, tropical diversity, disturbed habitats and invasive species in Singapore. How Singapore maintains and enhances the quality of life of its citizens while radically modifying its environment. Research on politics, management or biology. Travel to Singapore required. Taught in Beaufort. Consent of instructor required. Instructor: Orbach and Rittschof. 3 units.

218L. Barrier Island Ecology. An integration of barrier island plant and animal ecology within the context of geomorphological change and human disturbance. Experimental evidence supporting the theory of barrier island formation and migration; plant and animal adaptations and their evolution, succession ecology, and conservation and restoration ecology. Strong emphasis in labs on independent use of quantitative field observation and research techniques. (Given at Beaufort.) Prerequisite: Biology 25L or equivalent; suggested: course in botany or ecology. Instructor: Staff. 4 units. C-L: see Environment 218L

219L. Coastal Ecosystem Processes. Physical, chemical, and biological processes in the coastal zone of the Carolinas. A unifying theme will be the coupling of watersheds, river basins, estuaries, and the coastal ocean through the movement of ground and surface waters. Topics include hydrology, nutrient cycles, sediment-water column interactions, primary and secondary production, and food web dynamics. Sustaining coastal ecosystems in the face of land use change. (Given at Beaufort.) Instructor: Staff. 4 units. C-L: Environment 224L

252. Marine Conservation Biology. Ecological effects of fishing, the major threat to marine biodiversity, examined through selected case studies. Conservation strategies and ways that science and policy can be integrated to solve real-world problems. Field trip to Hawaii required. (Taught at Beaufort.) Instructor: Read. 3 units.

253L. Physiology of Marine Animals. Environmental factors, biological rhythms, and behavioral adaptations in the comparative physiology of marine animals. Open to undergraduates only under Biology 150L. Four units (fall); six units (summer). (Given at Beaufort.) Prerequisites: introductory biology and chemistry. Instructor: Forward. Variable credit. C-L: see Environment 228L

254. Vertebrate and Invertebrate Endocrinology. Comparative study of the major pathways of hormonal regulation from the organismal to the molecular level in vertebrate and invertebrate models. Applications of endocrinology in pharmaceuticals, cosmetics, and environmental issues. Prerequisites: Biology 25L and Chemistry 152L. A biochemistry course recommended. (Given at Beaufort.) Instructor: Rittschof. 3 units.

255L. Biochemistry of Marine Animals. Functional, structural, and evolutionary relationships of biochemical processes of importance to marine organisms. Open to undergraduates only under Biology 155L. Four units (fall and spring); variable credit (summer). (Given at Beaufort.) Prerequisites: Biology 25L and Chemistry 11L, 12L. Instructor: Rittschof (fall and summer). Variable credit. C-L: see Environment 229L

274L. Marine Invertebrate Zoology. Structure, function, and development of invertebrates collected from estuarine and marine habitats. Not open to students who have taken Biology 176L, Biology 274L, or Zoology 274L. Open to undergraduates only under Biology 176L. Four units (fall, spring, and Summer Term II); six units (Summer Term I). (Given at Beaufort fall, spring, and summer or at Bermuda, spring.) Prerequisite: Biology 25L. Instructors: Dimock (Beaufort) or Kirby-Smith (Beaufort); Wood (Bermuda). Variable credit. C-L: see Environment 295L

295S. Special Topics Seminar. Seminar on a selected topic. Offerings vary each semester. Consent of instructor required. Instructor: Staff. 3 units.

297. Research Independent Study. Continuation of Biology 191. 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. May be repeated. Instructor: Staff. 3 units.

351. 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.

353. 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)

210. 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. Variable credit.

243. Respiratory Proteins and the Environment. Structure, function and evolution of copper and iron based respiratory proteins in response to environmental oxygen levels and physiological needs. Lectures and readings on the balance between pathways for metabolic oxygen utilization and alternative disease-causing pathways involving oxidative and nitrosative reactions. Interactive molecular graphics and student presentations supplement text and lectures. Covers molecular adaptations, circulation, allostery, reaction kinetics and thermodynamics, reactive oxygen and nitrogen species, gene expression, blood pathogens, malaria, sickle cell anemia. (Given at Beaufort.) Prerequisites: organic chemistry or consent of instructor. Instructor: C. Bonaventura. 3 units. C-L: Environment 243

Earth and Ocean Sciences (EOS)

122. 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: Staff. 1 unit. C-L: see Biology 123; also C-L: Environment 123

191. 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.

192. Research Independent Study. See Earth and Ocean Sciences 191. Open only to qualified juniors and seniors by consent of director of undergraduate studies and supervising instructor. Instructor: Staff. 1 unit.

193. 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.

194. Independent Study. See Earth and Ocean Sciences 193. Term paper required. Open only to qualified juniors and seniors by consent of director of undergraduate studies and supervising instructor. Instructor: Staff. 1 unit.

195. Independent Study for Nonmajors. Individual research and reading in a field of special interest, under the supervision of a faculty member, resulting in a term paper containing significant analysis and interpretation of a previously approved topic at end of semester. Open to qualified juniors and seniors upon approval of the departmental faculty. Instructor: Staff. 1 unit.

202. 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 115/215 or consent of instructor. Also taught as EOS 116. Instructor: Murray. 2 units.

371. Advanced Topics in Geology. To meet the individual needs of graduate students for independent study. Instructor: Staff. Variable credit.

372. Advanced Topics in Geology. To meet the individual needs of graduate students for independent study. Instructor: Staff. Variable credit.

Physics (PHYSICS)

53L. 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 53L and a lab/recitation (Physics 53L9,R) section required. Students planning to major in physics should enroll in Physics 41L, 42L in their freshman year. Closed to students having credit for Physics 41L, 61L, or 63L. Prerequisites: one year of college calculus (or equivalent) such as Mathematics 25L, 26L, or 31. Mathematics 32 recommended. Instructor: Mehen or Tornow. 1 unit.

54L. General Physics II. The second part of a two-semester calculus based course providing a survey of the 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 (interference and diffraction), atomic and nuclear physics. Students must enroll in both a lecture (Physics 54L) and a lab/recitation (Physics 54L9,R) section in order to receive credit for the course. Closed to students having credit for Physics 42L, 62L or 63L. Prerequisites: Physics 41L, 61L, or 53L. Instructor: Brown or Thomas. 1 unit.

Political Science (POLSCI)

264. 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 276; also C-L: Public Policy Studies 297

Public Policy Studies (PUBPOL)

297. 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 276; also C-L: Political Science 264

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