The Mission of Duke University

The founding Indenture of Duke University directed the members of the university 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 foster health and well-being through medical research and patient care; and to promote a sincere spirit of tolerance, 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.
The information in this bulletin applies to the academic year 2000-2001 and is accurate and current, to the extent possible, as of August 1999. The university reserves the right to change programs of study, academic requirements, teaching staff, the calendar, and other matters described herein without prior notice, in accordance with established procedures.

Duke University does not discriminate on the basis of race, color, national origin, handicap, sexual orientation or preference, gender, or age in the administration of educational policies, admission policies, financial aid, employment, or any other university program or activity. It admits qualified students to all the rights, privileges, programs, and activities generally accorded or made available to students. For further information, contact the equal opportunity officer (919-684-4736).

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 684-2823 or in writing to 615 Chapel Drive, Box 90563, Duke University, Durham, North Carolina 27708.

Duke University is accredited by the Commission on Colleges of the Southern Association of Colleges and Schools (1866 Southern Lane, Decatur, Georgia 30033-4097; telephone number 404-679-4501) to award baccalaureates, masters, doctorates, and professional degrees.
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University Administration

GENERAL ADMINISTRATION

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Ralph Snyderman, M.D., Chancellor for Health Affairs and Executive Dean, School of Medicine
Tallman Trask III, M.B.A., Ph.D., Executive Vice-President
Eugene J. McDonald, LL.M., Executive Vice President - Asset Management
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Edward W. Holmes, M.D., Vice-Chancellor for Medical Center Academic Affairs and Dean, School of Medicine
Michael Israel, M.P.H., Vice-Chancellor for Health Affairs and Chief Executive Officer, Duke University Hospital
Jean Galliard Spaulding, M.D., Vice-Chancellor for Health Affairs
R.C. "Bucky" Waters, Vice-Chancellor for Special Projects
Gordon D. Williams, B.A., Vice-Chancellor for Medical Center Operations and Vice-Dean for Administration and Finance, School of Medicine
David B. Adcock, J.D., University Counsel
N. Allison Halton, A.B., University Secretary
William H. Willimon, S.T.D., Dean of the Chapel
Joseph L. Allegra, M.B.A., Director of Athletics

Administration of the Nicholas School of the Environment

Norman L. Christensen, Jr., Ph.D., Dean
Bertie S. Belvin, M.A., Associate Dean for Academic Services
Peggy Dean Glenn, B.A., Associate Dean for Development & Alumni Affairs
Bruce H. Corliss, Ph.D., Senior Associate Dean
James C. Haggard, M.B.A., Associate Dean for Finance & Administration
Michael K. Orbach, Ph.D., Director, Nicholas School of the Environment Marine Laboratory
Robin Puckett, Assistant to the Dean
Jim Rattray, B.A., Director of Communications

Professional and Administrative Staff

Cynthia Baldwin Adams, Assistant Director of Alumni Affairs & the Annual Fund; Manager of Auxiliaries & Administrative Services, Marine Laboratory
Heather Bennett, B.A., Assistant Director of Development
Zb Bornemann, PC System Manager
Leslie H. Boyd, Computer Project Manager
Tim Boynton, Data Processing Specialist, Marine Laboratory
Gail Cannon, Coastal Environmental Management Program Coordinator and Recruitment Specialist, Marine Laboratory
Charlotte Clark, M.EM., Director of the Center for Environmental Education
Wendy Dedzins, Student Services Officer
Judson D. Edelburn, M.F., Duke Forest Resource Manager
Dianne G. Gagnon, Business Manager, Marine Laboratory
Bill Hunning, Technical Services Manager, Marine Laboratory
Aaryn Kay, M.EM., K-12 Program Coordinator, Center for Environmental Education
Karen G. Kirchof, M.A., Director of Career Services
Quentin Lewis, Marine Services Manager, Marine Laboratory
Helen E. Nearing, Academic Coordinator, Marine Laboratory
Scott D. Taylor, B.A., Assistant Director of Communications
Howard Weckerle, Physical Plant Manager, Marine Laboratory
Belinda Williford, Administrative Assistant to the Marine and Freshwater Biomedical Center
Board of Visitors, School of the Environment
John O. Blackburn, Maitland, Florida
George E. Brown, Jr., United States House of Representatives, Committee on Science, Space and Technology, Washington, D.C.
Josephine Cooper, Alliance of Automobile Manufacturers, Washington, D.C.
Timothy J. Creem, Bridgeton, Maine
Bruce Cummings, Elben LLC, New York, New York
Robert E. Denton, Baltimore Gas and Electric Co., Lusby, Maryland
Richard J. Diforio, Jr., Champion International Corporation, Stamford, Connecticut
Michael Fatemi, U.S. Environmental Protection Agency, Washington, D.C.
F. Daniel Gabel, Jr., Hagedorn & Company, New York, New York
Harvey Goldman, Vestcom International, Inc., Lyndhurst, New Jersey
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George C. Hixon, San Antonio, Texas
Christian Holmes, Enron Ventures Corporation, Houston, Texas
Walter Howes, EBI Capital Group, Washington, D.C.
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Juanita Kreps, Duke University, Durham, North Carolina
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James W. Mooring, Cadwalader, Wickersham and Taft, Washington, D.C.
Bettye Martin Mussham, Gear, Inc., New York, New York
J.K. Nicholas, The Parthenon Group, London and Boston, Massachusetts
Patrick Noonan, The Conservation Fund, Arlington, Virginia
Jimmy W. Page, Atlanta, Georgia
Elizabeth B. Reid, Bedford Hills, New York
John C. Reid, The Edison Project, New York, New York
Douglas F. Rohrman, Lord, Bissell and Brook, Chicago, Illinois (Chairman)
Elizabeth Rooks, Research Triangle Foundation, Research Triangle Park, North Carolina
Truman T. Semans, Alex Brown and Sons, Baltimore, Maryland
Truman T. Semans, Jr., U.S. Department of Treasury, Washington, D.C.
Bartow S. Shaw, Jr., Shaw, M.Cleod, Belser & Hurlbut, Inc., Sumter, South Carolina
Thomas A. Shepherd, Shepherd Miller, Inc., Fort Collins, Colorado
Ronald J. Slinn, Slinn & Associates, Princeton, New Jersey (Emeritus member)
James A. Spangler, Spangler Environmental Consultants, Inc., Raleigh, North Carolina
Fred Stanback, Stanback Co., Inc., Salisbury, North Carolina
Peter W. Stroh, Stroh Brewery Company, Detroit, Michigan
LaDane Williamson, Ocean Harbour Golf-Real Estate, Ocean Isle Beach, North Carolina
Plato S. Wilson, High Point, North Carolina
George M. Woodwell, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts

Alumni Council, Nicholas School of the Environment
Joe Aldy, President's Council of Economic Advisors, Washington, D.C.
Ray Clark, President's Council on Environmental Quality, Washington, D.C.
Jeff Dye, New Orleans, Louisiana
Peter Griffith, North American Collection & Location by Satellite, Largo, Maryland
Lynne Rhodes Hawkes, Cary, North Carolina
Craig Hedman, International Paper, Bainbridge, Georgia
Barrett B. McCall, Larson & McGoey, Mobile, Alabama
James B. Miller, USDA Forest Service, Washington, D.C.
Thomas Dwight Nager, U.S. Forest Capital, Chapel Hill, N.C.
Timothy H. Profeta, Alexandria, Virginia
Nancy D. Ragland, NOAA/NOS, Silver Spring, Maryland
Susan M. Regier, North Carolina Division of Parks and Recreation, Raleigh, North Carolina
James A. Spangler, Spangler Environmental Consultants, Inc., Raleigh, North Carolina
Lori Sutter, NOAA Coastal Services Center, Charleston, South Carolina
Nancy Tammi, Public Service Electric & Gas Company, Newark, New Jersey
Keith Wertz, RTI Center for Environmental Analysis, Research Triangle Park, North Carolina
Judy Fuquay Whiting, NationsBank Corp., Charlotte, North Carolina

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Sandra Taylor Kaupe, Palm Beach, Florida
William A. Lane, Jr., Dunspaugh-Dalton Foundation, Inc., Coral Gables, Florida
Henry O. Lineberger, Jr., Raleigh, North Carolina
Norwood A. Thomas, Jr., Wilbanks, Smith & Thomas, Norfolk, Virginia
Elizabeth Thrower, Vero Beach, Florida, and Nantucket, Massachusetts
Wayne F. Wilbanks, Wilbanks, Smith & Thomas, Norfolk, Virginia
Calendar*

2000

August
21 Orientation for fall semester—Durham
21-25 Registration of new and nonregistered returning students
28 Fall semester classes begin—Durham
28 Orientation for fall semester—Marine Laboratory
30 Fall semester classes begin—Marine Laboratory

September
8 Drop/ add ends

October
9-10 Fall break
25 Registration begins for spring semester, 2001

November
17 Registration ends for spring semester, 2001
18 Drop/ add begins
22 Thanksgiving recess (begins at 12:40 p.m. Wednesday)
27 Classes resume

December
1 Fall semester classes end
2-10 Graduate reading period
11-16 Final examinations
16 Fall term ends at Marine Laboratory

2001

January
8 Orientation for spring semester
9 Registration of new and nonregistered returning students
10 Spring semester classes begin—Durham and Marine Laboratory
24 Drop/ add ends

March
2 Session 1 of Beaufort-2-Bermuda at Marine Laboratory ends
11-18 Spring Break
15 Session 2 of Beaufort-2-Bermuda at Marine Laboratory begins
28 Registration begins for fall semester, 2001

April
13 Registration ends for fall semester, 2001
14 Drop/ add begins
20 Spring semester classes end
21 Graduate reading period begins
29 Graduate reading period ends
30 Final Examinations begin

May
5 Final Examinations end
5 Spring term ends at Marine Laboratory
13 Commencement
14 First summer term begins at Marine Laboratory

June
15 First summer term ends at Marine Laboratory

July
9 Second summer term begins at Marine Laboratory

August
10 Second summer term ends at Marine Laboratory

*The dates in the calendar are tentative and subject to change.
TO THE PROSPECTIVE STUDENT

In 1991, Duke University signaled a new approach to education and research in marine and terrestrial ecosystems, earth sciences, and human-environment interactions with the inauguration of the School of the Environment. The School of the Environment’s mission of providing education, research and service toward the understanding of basic environmental processes unites two centers of excellence with long and distinguished histories at Duke -- the former School of Forestry and Environmental Studies and the Marine Laboratory. The school, with its unprecedented commitment to education and research addressing the quality of the Earth’s environment and the sustainable use of its natural resources, is uniquely positioned in the context of American higher education to lead the way in solving complex environmental problems in a rapidly changing world. The school became the Nicholas School of the Environment in 1995.

The programs of the Nicholas School of the Environment are based on the premise that the most challenging global environmental problems are so complex that they cannot be solved effectively within the context of a single discipline. Science can provide crucial research and data, but cannot supply the process for bringing that information to bear on the creation of regulatory policy; policy studies alone are often in danger of fostering the implementation of solutions with inadequate scientific bases; proposed solutions to environmental challenges that ignore the economic forces that will inevitably come to bear on them have little chance of success. An interdisciplinary approach is absolutely mandatory.

The Nicholas School of the Environment at Duke University, then, is committed to bringing together around crucial global problems the best scholars from the wide range of academic disciplines necessary to produce real, workable solutions to these problems, as well as to producing environmental managers and scholars who will become the leaders in these areas in years to come.

Our graduates are among the leaders of the nation’s largest environmental consulting firms and industries with environmental interests, as well as the public agencies and nonprofit organizations that monitor, manage and regulate natural resources and the environment. We have proven that we are a leader in the field of environmental education at all levels of higher learning.

Our objective, however, is not merely research published or students graduated. It is wise and sustained management of our natural resources and a better environment for this and future generations. We invite you to join us in pursuit of these goals.

Norman L. Christensen, Jr.
Dean, Nicholas School of the Environment
General Information
Introduction

The mission of the Nicholas School of the Environment is education, research, and service to understand basic environmental processes and to protect and enhance 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 problems confronting society, through excellence in natural resource and environmental education and research.

The school’s emphasis is on defining objectives for natural resource science and management, understanding the interrelated constraints—physical, biological, chemical, ecological, economic, legal and social—and devising and testing alternative management solutions. This approach to natural resource education is pursued through research, formal courses, field studies and seminars, and informally through interaction with practicing professionals by a variety of means.

Research and problem solving are integral to the 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 are also encouraged to involve themselves in real world problems. As part of their professional degree requirements, students must complete a master’s project requiring independent research and problem analysis.

Teaching and research in the Nicholas School of the Environment are focused within the following curriculums: coastal environmental management; environmental toxicology, chemistry and risk assessment; forest resource management; resource ecology; resource economics and policy; water and air resources; the ocean sciences; and the earth sciences. These programs are designed for students drawn from a wide variety of undergraduate backgrounds in the natural and social sciences, forestry, engineering, business and environmental studies. Program requirements enable all students to acquire the basic technical skills, scientific knowledge, insight and methods of analysis for resolving natural resource and environmental problems.

As a professional school within a private university, the Nicholas School of the Environment is able to foster independent consideration of natural resource and environmental issues without the political pressures often brought to bear upon public institutions. As part of a major research university, the school is able to add a significant dimension to teaching and research through cross-campus interdisciplinary degree programs, faculty appointments, and cooperative projects.

Additional enrichment is available through relevant departments at neighboring universities, as well as through agencies and institutions at the Research Triangle Park and in the Beaufort-Morehead City area. These opportunities for study and professional interaction place Duke in an enviable position among schools of resource science and management and greatly enhance the quality of its programs.
Alumni of the Nicholas School of the Environment hold leadership positions in public agencies, environmental and forestry consulting firms, private industry, and not-for-profit organizations throughout the nation and the world.

History

Duke University developed from Union Institute, a small school established in 1838 in Randolph County, North Carolina. The name was changed to Normal College in 1851, and in 1859, to Trinity College. The college was moved to Durham in 1892. With the establishment of the James B. Duke Indenture of Trust in 1924, Trinity College became Duke University. At the outset, the university developed around a core of undergraduate programs.

In 1932, forestry instruction was offered for students of Trinity College, and in 1938 the School of Forestry was established as a graduate professional school under the direction of Dean Clarence F. Korstian. The Master of Forestry and Doctor of Forestry degrees were offered initially and later the A.M., M.S., and Ph.D. were offered through the Graduate School. The school's forestry program has been fully accredited by the Society of American Foresters since 1939.

Dr. Korstian 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. During the 1930s the faculty of the school was gradually expanded to include a number of research foresters who made substantial contributions to forestry in the Southeast. This faculty established and brought early recognition to the school.

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 name was changed to the School of Forestry and Environmental Studies and a new degree was added, the Master of Environmental Management.

Duke University's 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 and through the subsequent efforts of Dr. Pearse and others, the land was acquired for the Duke University Marine Laboratory. Construction began and by 1938 the first buildings were erected. Originally, the laboratory served only as a summer training and research facility. Today, it operates year-round to provide training and research opportunities to about 3,500 persons annually, including undergraduate, graduate and professional students enrolled in the university's academic programs; visiting student groups who use the laboratory's facilities; and scientists who come from North America and abroad to conduct research.

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 is an unprecedented university commitment to interdisciplinary education and research in environmental science, policy, and management. It is 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 alums Peter and Virginia Nicholas.

Location

Duke University is situated on the outskirts of Durham, a city of over 198,000 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 Marine Laboratory is located 180 miles to the east of Durham, on Pivers Island within North Carolina's Outer Banks, adjacent to the historic town of Beaufort. The school is thus ideally situated near areas of ecological
and topographic diversity which 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 the native southern pines.

The southern Appalachians are widely known for their unusual history, picturesque topography, and wide range of flora and fauna. Here the typical hardwood forests which dominate at lower elevations give way to forests of spruce and fir at higher elevations. The region's numerous recreation areas are widely used for hiking, fishing, skiing, and other outdoor activities.

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 the native pines. Coastal wetlands and estuaries, now recognized as one of the nurseries of world fisheries, offer abundant and valuable natural resources. North Carolina's Outer Banks and the barrier islands of the other southeastern states serve as protection for 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, 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 housed in the Levine Science Research Center, an interdisciplinary research facility situated at the corner of Science Drive and Research Drive on the West Campus. The building includes state-of-the-art classrooms, research laboratories and instrumentation supporting both teaching and research for the programs offered by the school. A lounge, reading room, and computer laboratories are provided for students. Fully equipped modern teaching and research facilities for the ocean sciences are available at the school's coastal campus in Beaufort, N.C.

Computer Facilities. Duke's Computer Assist Center works in partnership with members of the university community to enable them to achieve their academic and research goals through computing. The center provides access to a variety of computing facilities and services through DukeNet, a high-speed data network, and various types of telecommunications linkages. The center maintains extensive MS-DOS/ Windows and Macintosh personal computer and DEC workstation facilities at a number of locations on the Durham campus and at Beaufort. All laboratories and clusters are equipped with either dot matrix or laser printers and several are connected to the campus telecommunications network. Electronic mail services are available for faculty and graduate students.

Other services include access to the Internet data network and the Cray Y-MP/ 432 and massively parallel computing at the North Carolina Supercomputing Center and other supercomputer centers. Access to Duke's IBM ES/ 9000 mainframe computer is also available through the Computer Assist Center.

Libraries. The combined university libraries, including the main Perkins Library and twelve other school or branch libraries, contain over 4,200,000 volumes. About 150,000 volumes are added annually. The collection includes about 9,500,000 manuscripts and over 2,000,000 public documents.

The Biology-Forestry Library, located in the Biological Sciences Building, contains over 170,000 volumes and receives nearly 1,000 periodicals related to natural resources and the environment.
The Pearse Memorial Library on the Beaufort campus is a branch of the Duke library system. It holds approximately 23,000 volumes with a concentration on the marine sciences and subscribes to 55 scientific journals. Support services include interlibrary loan and on-line literature search capabilities. Cooperative agreements provide access to the libraries of the National Oceanic and Atmospheric Administration, National Marine Fisheries Service, University of North Carolina Institute of Marine Sciences, and the University of North Carolina at Wilmington.

Greenhouses and the Phytotron. Adjoining the Biological Sciences Building on Duke's West Campus are excellent facilities for biological investigations under controlled conditions. The phytotron contains 50 separately controlled growth chambers and greenhouses which can be used to grow plants under a variety of environmental conditions. The phytotron is one of few such facilities in the United States.

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

Coastal Resources. The Beaufort-Morehead City area provides location for five facilities that collectively house one of the higher concentrations of marine scientists in the nation. These are the University of North Carolina's Institute of Marine Sciences, the North Carolina State University Seafood Laboratory, the North Carolina Aquarium at Bogue Banks, North Carolina Division of Marine Fisheries; and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service, Beaufort Laboratory. This concentration of marine scientists provides a critical mass for the pursuit of science and education.

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 in 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.

The Duke Forest

The Duke Forest comprises about 8,000 acres of land in five major divisions and several smaller tracts. A 10-minute walk from campus will take one well into many parts of the Durham Division, and a network of roads and fire trails makes almost all areas of the forest easily accessible.

The forest lies primarily in Durham and Orange counties, 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. 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.

The Duke Forest, as it is known today, had its origins in the mid-1920s when the university administration bought many small farms and interspersed forest land as buffer areas for the main campus and as an investment for the future. The forest was placed under intensive management in 1931 by Dr. Clarence Korstian, its first director. In its early development, several basic objectives were emphasized: (1) demonstration
of timber management techniques on a practical and economic basis, (2) development of an experimental forest for research in the sciences associated with timber growing, and (3) development of the area as an outdoor laboratory for students of forestry.

Modification of these early objectives has arisen, in part, through a greatly increased interest and dependence on the forest for research in the areas of zoology, botany, and ecology by faculty and students at Duke and neighboring universities. Background information useful to researchers is provided by the forest; it covers such features as soils, topography, inventory, plantation, and cultural records as well as a bibliography of past and current studies. Current work on problems associated with developmental pressures at the urban-rural interface and integrated approaches to natural resource management have multiplied the forest’s value and benefit as a resource.

The forest also serves in an educational and recreational capacity for residents of the Durham and Chapel Hill communities. Hiking, picnicking, jogging, and nature study are particularly popular pastimes.

This natural outdoor laboratory is an invaluable supplement to the instructional, research, and recreational facilities of the school, the university, and the region. The Duke Forest—in terms of its size, diversity, proximity to campus, and more than sixty years of accumulated research data is a natural resource unequaled at any other academic institution.
Faculty
Core Faculty

Paul A. Baker, Ph.D., Professor of Geology; B.A., Geology, University of Rochester; M.S., Geology, Pennsylvania State University; Ph.D., Earth Sciences/Marine Geology, University of California, San Diego.
E-mail: pbaker@eos.duke.edu

The primary theme of Dr. Baker's research is the geochemistry of fluids and sediments, especially for the purposes of understanding sedimentary diagenesis, the depositional history of sediments, or the reconstruction of past climate. Some of Dr. Baker's work on modern processes is done at sea utilizing oceanographic research vessels. Typically, this may include observations of pore-fluid geochemistry and sedimentology of materials collected by box coring, piston coring or deeper drilling. Some of his work on modern processes is done in the laboratory by experimental hydrothermal syntheses of common diagenetic mineral phases and observation of the conditions of their formation. His studies of ancient rocks utilize more traditional procedures: measuring and sampling of stratigraphic sections in the field and complete mineralogical, chemical, and isotopic analyses of these samples in the laboratory. Because of the diverse nature of the methodology employed for these studies, Dr. Baker (by necessity and by choice) is a geological generalist.
Richard T. Barber, Ph.D., Harvey W. Smith Professor of Biological Oceanography and Professor of Botany and Zoology; B.S., Zoology and Botany, Utah State University; Ph.D., Biological Science, Stanford University.  
E-mail: rbarber@duke.edu  
Dr. Barber's research in carbon cycling by ocean processes has implications for climate regulation. At Duke he investigates the interrelationship of large-scale thermal dynamics and ocean basin productivity, emphasizing (1) how biological and physical processes contribute to the exchange of carbon dioxide between the ocean and the atmosphere and (2) how the "biological pump" transfers carbon into the deep sea. With current field work being carried out on cruises in the southern ocean, his research group is focusing on the role of physical conditions in regulating primary production and phytoplankton performance. He is also investigating the role of a single micronutrient, iron, in the regulation of primary production in a part of the ocean, the equatorial Pacific, where a high nutrient/low chlorophyll character persists despite physical and chemical conditions which otherwise favor high productivity.  
He is in residence at the Marine Laboratory.

Celia J. Bonaventura, Ph.D., Professor of Cell Biology; B.A., Zoology, San Diego State University; Ph.D., Biochemistry, University of Texas, Austin.  
E-mail: bona@duke.edu  
Most of Dr. Celia Bonaventura's research is in the area of structure/function relationships of oxygen and electron-transport proteins. This continues to be her primary area of research, with an increasing focus on environmental perturbations of structure and function. Her research makes use of structural assays and complementary measurements of rapid reaction kinetics and equilibria, using UVMS and fluorescence spectroscopy and spectroelectrochemistry. Through comparison of human proteins with proteins of species inhabiting diverse environments, studies by Dr. Bonaventura and collaborators have increased the understanding of structural mechanisms that allow respiratory proteins to satisfy widely different physiological and environmental demands. Her current research concerns aspects of environmental toxicity associated with free-radical interactions with respiratory proteins and structural alterations of respiratory proteins that are indicative of exposure to xenobiotics.  
She is in residence at the Marine Laboratory.

Joseph Bonaventura, Ph.D., Professor of Cell Biology; B.A., Zoology, San Diego State University; Ph.D., Biochemistry, University of Texas, Austin.  
E-mail: joeb@duke.edu  
Dr. Joseph Bonaventura's research involves marine organisms found in diverse environments. Biochemical studies on the structural and functional diversity of these organisms have been shown to be paralleled by diversity at the molecular level. Red cells and respiratory proteins of marine organisms are being studied in order to increase the understanding of molecular adaptations and the mechanisms that give rise to functional flexi-
The kinetics and equilibria of ligand binding to hemoglobins, hemocyanins, and cytochrome c oxidase are studied with emphasis on the reactivity of these proteins as regulated by metabolic effectors. These studies are complemented by work in the Protein Engineering and Technology Laboratory where properties of chemically modified, crosslinked, and immobilized forms of biologically active molecules are characterized. Recent research concerns the development of a synthetic blood substitute for humans. The project involves a detailed study of structure-function relationships in the human hemoglobin molecule and includes site-directed mutagenesis of hemoglobin genes. A new focus concerns the biochemistry of nitric acid in the human body and the development of a hypothesis of how this simple molecule might act as a regulator of the biosphere.

He is in residence at the Marine Laboratory.

**Alan E. Boudreau, Ph.D., Associate Professor of Geology; B.S., Geology, University of California; M.S., Geology, University of Oregon; Ph.D., 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 on the Archean Stillwater complex in Montana. Although the classic bodies such as the Stillwater Complex have been extensively studied for many years, there is still little agreement on how the rocks formed. Besides the intriguing problems proposed for the crystallization of magmas, these intrusions are host to important mineral reserves of Cu, Ni, Cr, Ti and the platinum-group elements.

Much of Boudreau's recent work has investigated the degassing history of these intrusions and the role of volatiles in the formation of the platiniferous ore zones hosted by both the Stillwater Complex and the Bushveld Complex in South Africa. He and his coauthors have shown that the halogen geochemistry of Stillwater and Bushveld hydrous mineral phases is distinctly much more Cl-rich than are seen in other, barren, layered intrusions. Current work is investigating the details of the stratigraphic variation of the halogens and the possibility of redistribution of Cl-complexed trace elements.

Another set of studies has focused on the mechanisms by which igneous layering may develop. These attempt to show that many examples of igneous layering may develop slowly over time and have more textural affinity with metamorphic differentiation layering.

**Norman L. Christensen, Jr., Ph.D., Professor of Ecology; B.A., M.A., Biology, California State University, Fresno; Ph.D., Biology, University of California, Santa Barbara.**  
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Dr. Christensen is interested in the effects of disturbance on the structure and function of populations and communities. Ongoing studies include an analysis of patterns of forest development following cropland abandonment as these are affected by environment, stand history, and plant demographic patterns. This research focuses on the historical data sets and resources of the Duke Forest. He is also conducting research on the southeastern coastal plain and western Sierra Nevada focused on a comparison of biogeochemical and community responses to varying fire regimes. These studies are aimed at understanding the evolutionary and ecosystem consequences of fire and the application of such information in the development of wilderness management and policy protocols.
In addition, Dr. Christensen is conducting research on the use of remote sensing systems, such as synthetic aperture radar, to evaluate long-term changes in forest ecosystems.

James S. Clark, Ph.D., Professor of Botany and of Earth and Ocean Sciences; B.S., Entomology, North Carolina State University; M.S., Forestry, University of Massachusetts; Ph.D., 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 how recurrent drought has affected vegetation cover and fire in the Northern Plains and how aridity and fire have shaped the composition of North American temperate and boreal forests during recent millennia. Long-term experiments and monitoring studies in the southern Appalachians demonstrate how disturbance and climate gradients control the dynamics of 20th century forests. 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 pine forests.

Dr. Clark has authored over 70 refereed scientific articles and edited the book Sediment Records of Biomass Burning and Global Change (Springer, 1997). His results have been reported in newspaper articles, including the New York Times, and in public and commercial radio interviews.

Dr. Clark is recipient of ESA’s William Skinner Cooper Award (1988) for his research on barrier beach dynamics and George Mercer Award (1991) for studies of climate change and fire. For excellence in teaching and research he was one of 15 scientists recognized by President Clinton with the National Science Foundation’s five-year Presidential Faculty Fellow Award (1994). In 1998 he was named an Aldo Leopold Leadership Fellow by the Ecological Society of America. He has served on editorial boards for Ecology and Ecological Monographs (1996-1999), Annual Reviews of Ecology and Systematics (1998 - ), and Global Change Biology (1994 - ) and on NSF Advisory panels for Ecology (1992 - 1997) and Earth System History (1994). He chaired ESA’s Mercer Award Committee, and he served on the Science Advisory Board of the National Center for Ecological Analysis and Synthesis. He is the current vice-president for Science of the Ecological Society of America.

Dr. Clark holds joint appointments in Earth and Ocean Sciences and Botany.

Bruce H. Corliss, Ph.D., Professor of Earth & Ocean Sciences; B.A., Geology, University of Vermont; M.S., Oceanography, University of Rhode Island; Ph.D., Oceanography, University of Rhode Island.
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Dr. Corliss was on the staff of the Woods Hole Oceanographic Institution for six years before joining the Department of Geology in 1984. As a geological oceanographer, he is interested in Cenozoic paleoceanography and studies marine microfossils and deep-sea sediments. 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. A study of Cenozoic sedimentation in the Pacific was based on a synthesis of sedimentological, geochemical, and paleontological data from a red clay sequence. A second sedimentological study dealt with carbonate sedimentation beneath the Antarctic Circumpolar Current. Dr. Corliss’ 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.

Larry B. Crowder, Ph.D., Stephen Toth Professor of Marine Biology; B.A., Biology and Mathematics, California State University, Fresno; M.S., Ph.D., Zoology, Michigan State University.
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Dr. Crowder’s research centers on predation and food web interactions, mechanisms controlling recruitment variation in fishes, and on population 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 is a member of the Program Management Committee for SABRE (South Atlantic Bight Recruitment Experiment), a NOAA-funded project that focuses on identifying the unique characteristics of survivors of a cohort of fishes, then links those characteristics to physical or biological variability. He has also been involved in population modeling and data analysis to address various management scenarios for threatened and endangered species. He and his students have developed life-history population models to address various management problems including exotic species introductions, acidification, habitat modification, bycatch and harvest for both freshwater and marine fishes.

He is in residence at the Marine Laboratory.

Richard T. Di Giulio, Ph.D., Professor of Environmental Toxicology; B.A., Comparative Literature, University of Texas; M.S., Wildlife Management, Louisiana State University; Ph.D., Wildlife Biology, Virginia Polytechnic Institute and State University.
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Dr. Di Giulio’s research group in environmental toxicology is chiefly involved with integrated basic and applied research in aquatic biochemical toxicology. Basic studies focus on xenobiotic metabolism and modes of action in lower vertebrates and invertebrates, particularly fishes. Results of these studies are used to develop sophisticated, sensitive biochemically based indices (biomarkers) of environmental quality. He is particularly interested in the application of free radical biology theory to the elucidation of mechanisms of contaminant metabolism and toxicity in aquatic animals, mechanisms, promutagen activation and DNA damage, mechanism of reproductive and developmental toxicity and mechanisms of adaptation to environmental contaminants.
Richard B. Forward, Jr., Ph.D., Lee Hill Snowdon Professor of Zoology; B.S., Biology, Stanford University; Ph.D., Biology, University of California, Santa Barbara.
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Dr. Forward and his students investigate the behavior and physiology of estuarine and coastal zooplankton. This includes the photobehavior, photophysiology, biological rhythms, diurnal vertical migration, and horizontal migration of crustacean and fish larvae. Past studies have worked with crustaceans and chaetognaths to determine the effects of temperature, salinity, and feeding on phototaxis and geotaxis, salinity perception, and polarized light perception. Field studies have looked at horizontal and vertical distributions as related to environmental factors. Additional studies involve rhythms in egg hatching by crustaceans. Types of rhythms, flexibility, and the involvement of peptide pheromones are being considered.
He is in residence at the Marine Laboratory.

Jonathan H. Freedman, Ph.D., Assistant Professor of Environmental Toxicology; B.A., Microbiology, Rutgers University; M.S., Ph.D., Molecular Pharmacology, Albert Einstein College of Medicine.
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Dr. Freedman's research program is directed toward understanding the regulatory processes controlling an organism's response to environmental stress. In particular, he is interested in how individual cells and whole organisms respond when they are exposed to toxic concentrations of transition metals. His current focus is directed toward understanding how cadmium induces the expression of dozens of different genes, which encode proteins with functions ranging from repairing intracellular damage to DNA, lipids, and proteins to activating signaling cascades. He is investigating these processes using as a model system the microscopic soil nematode Caenorhabditis elegans. C. elegans is an excellent model organism for studying the affects of environmental toxins on development, signal transduction, and gene regulation in a whole organism. Results from this research will help elucidate:
- Mechanisms of transition metal-induced disease, developmental abnormalities, and carcinogenesis.
- How organisms adapt to increasingly toxic environments.

A second area of research focuses on understanding the mechanism that controls the expression of the low molecular weight, metal-binding protein metallothionein. Multiple signaling pathways, including those involved in metal regulation, development, and cell-specificity, must coordinately interact to activate metallothionein transcription. Regulatory processes controlling metal-inducible expression of the metallothionein genes in cultured cells and C. elegans are being examined. In vivo techniques, including the generation of transgenic nematodes, in situ hybridization, immunofluorescence, and gene structure analysis are being used to monitor gene activity, RNA accumulation, and protein expression. Defining these mechanisms are essential to understanding metal-responsive gene regulation and the roles of transition metals in human carcinogenesis.
Ronie Garcia-Johnson, Ph.D., Assistant Professor of Environmental Policy; B.A., History and Literature, Harvard University; Ph.D., Political Science, University of Michigan. E-mail: rgarcia@duke.edu

Dr. Garcia-Johnson studies global environmental politics and policy. She is especially interested in understanding the ways transnational actors (including government bureaucrats, activists in non-governmental organizations, business consultants, scholars, and multinational corporation executives) diffuse environmental ideas and values and shape the prospects for international cooperation. Her new book is based on case studies of the chemical industry in the United States, Brazil and Mexico. She is currently planning a project to investigate (and perhaps participate in) the transnational dissemination of pollution prevention policy approaches in Latin America. She is also a contributor to a forthcoming book about gaining access to sources in fieldwork.

Peter K. Haff, Ph.D., Professor of Geology and Civil and Environmental Engineering; B.A., Physics, Harvard University; Ph.D., Physics, University of Virginia. E-mail: haff@eos.duke.edu

Dr. Haff applies quantitative modeling techniques including computer simulation to describe and predict the course of natural geological processes that occur on the surface of the earth. His research interests include the physics of blowing sand, the motion of sand dunes, the mechanics of sedimentary bedforms, and the transport of sedimentary particles by flowing water. Field work being carried out by Dr. Haff on desert pavements in the southwest US shows that these ancient geomorphic surfaces are dynamically active today. Understanding the dynamics and history of desert pavement provides a framework for assessing the stability of these extensive desert landforms and for interpreting paleoclimatic events that have influenced their development. Dr. Haff is also studying the effects of human disturbance on natural landscapes. Field experiments and observations are being carried out in the Mojave Desert in California in an attempt to assess the future prospects for this desert environment as human activity there continues to expand.

Patrick N. Halpin, Ph.D., Assistant Professor of the Practice of Landscape Ecology; B.A., International Studies, MPA, International Management, George Mason University, Ph.D., Environmental Sciences, University of Virginia. E-mail: phalpin@duke.edu

Dr. Halpin’s research interest is in landscape ecology, GIS and remote sensing, and international conservation management. His research activities include spatial and statistical analysis of vegetation structure and climate-vegetation interactions; simulation modeling of vegetation dynamics; Geographic Information Systems analysis; ecological applications of remote sensing; and protected area management analysis. Dr. Halpin is currently participating as an investigator in research projects sponsored by the USEPA, NASA, NBS, and EPRI. These projects involve the spatial simulation of forest vegetation cover and environmental conditions in boreal forests of North America, mixed forests of the Southeastern Pied-
mont, Southern Appalachian Mountain forests and mixed conifer forests of the Sierra Nevada. A central focus of these projects has been the development of techniques for the more realistic inclusion of topographic moisture controls of forest patterns and fire regimes in these ecosystems. Dr. Halpin also has a special research interest in the application of GIS and spatial analysis techniques to environmental management of international protected areas, and has recently worked on global change analysis in tropical regions.

Gary S. Hartshorn, Ph.D., Professor of the Practice of Tropical Ecology; B.S., Biology, Moravian College; M.S., Botany, North Carolina State University; Ph.D., Forest Resources, University of Washington.

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Dr. Hartshorn is president and CEO of the Organization for Tropical Studies (OTS), a 56-member consortium of universities and research institutions headquartered at Duke. OTS owns and operates three biological field stations in Costa Rica, offers graduate field courses in Brazil, Costa Rica and Peru as well as an undergraduate study abroad program in Costa Rica.

Dr. Hartshorn maintains long-term research interests in tropical forest dynamics, biodiversity conservation, dominance-diversity patterns and sustainable forest management.

Robert G. Healy, Ph.D., Professor of Environmental Policy; B.A., M.A., Ph.D., Economics, University of California, Los Angeles.

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Dr. Healy works on land-use and environmental policy in the United States and developing countries. Before coming to Duke in 1986, he was senior associate at The Conservation Foundation/World Wildlife Fund in Washington, D.C. His past research has resulted in books on state land-use planning, coastal zone management in California, rural land markets, national forest policy, resource and environmental problems of agriculture, and environmental policy in developing countries. He has a continuing interest in land use policy in fast-growing areas, particularly the U.S. South and rural areas affected by rapid migration or by tourism. Dr. Healy teaches courses on land-use and environmental policy and on conservation and sustainable development in the Third World.

Zbigniew J. Kabala, Ph.D., Associate Professor of Civil Engineering and of Environment; M.A., Civil Engineering, Water Resources Program, Princeton University; MS, Numerical Methods and Programming, Adam Mickiewicz University, Poznan, Poland; MS, Civil Engineering, Technical University of Poznan, Poznan, Poland; Ph.D., Civil Engineering and Operations Research, Water Resources Program, Princeton University.

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Dr. Kabala's principal research interests cover stochastic and deterministic theory of fluid flow and contaminant transport in saturated and unsaturated heterogeneous porous media, theory of related measurements, field and laboratory studies in subsurface hydrogeology, sto-
Stochastic fields and processes, numerical and analytical methods and sensitivity analysis. Dr. Kabala's current research focuses on developing new measurement techniques for characterization of porous media, recovering contaminant release histories from current plume observations and stochastic modeling of water and solute transport in saturated and unsaturated heterogeneous formations and cracking soils. Among his novel aquifer characterization techniques are the dipole-flow test (DFT), the dipole-flow test with a tracer (DFTT), and the transient flowmeter test (TFMT).

Dr. Kabala co-directs the Center for Multi-Scale Modeling and Distributed Computing at Duke. He is a member of an editorial board for Journal of Stochastic Environmental Research & Risk Assessment, the North Carolina Water Resources Research Institute’s Technical Committee and a number of professional organizations, including American Geophysical Union and American Society of Civil Engineers.

After graduation from Princeton in 1988, Dr. Kabala held one-year postdoctoral appointments at the Massachusetts Institute of Technology in the Ralph M. Parsons Laboratory and at the University of California-Berkeley in the Department of Soil Science. He was then appointed an assistant professor of hydrology in the Department of Soils and Environmental Sciences at the University of California-Riverside. Dr. Kabala joined the Duke faculty in the summer of 1994.

Jeffrey A. Karson, Ph.D., Professor of Geology; B.A., Geology, Case Institute of Technology; M.S., Ph.D., Geology, State University of New York, Albany.
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Dr. Karson joined the Duke faculty in January 1986 after 7 years as a member of the scientific staff at Woods Hole Oceanographic Institution. The central theme of his research is structural and tectonic analysis of rift and transform plate boundaries. His approach involves the systematic collection of geological data in order to determine the geometry, chronology, and mode of formation of outcrop-scale deformation structures and their relation to crustal processes that operate on a regional scale. In order to gain insights into the evolution of rifts and transforms, Dr. Karson has worked in several different environments. In the East African Rift System, detailed structural studies define the geometry and kinematics of active rifting and the birth of a rifted continental margin. Investigations of the ocean-continent transition and coastal dike swarms of the Tertiary East Greenland volcanic rifted margin are underway in collaboration with the Danish Lithosphere Center. Along the Mid-Atlantic Ridge and East Pacific Rise, spreading centers and intervening transform faults are examined from the perspective of the submersible ALVIN and various other seafloor mapping tools. Studies of ophiolite complexes, ancient oceanic lithosphere exposed in mountain belts, reveal the deep structure of crust and upper mantle produced by seafloor spreading. Integrating these diverse studies has proven to be useful in developing new models of crustal deformation in extensional and strike-slip tectonic regimes.
Prasad S. Kasibhatla, Ph.D., Associate Professor of Environmental Chemistry; B.S., Chemical Engineering, University of Bombay; M.S., Ph.D., Chemical Engineering, University of Kentucky.
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Dr. Kasibhatla has fifteen years of experience in tropospheric chemistry and transport modeling. His modeling studies have focused on elucidating the factors affecting regional air quality and the global atmospheric budgets of reactive nitrogen compounds, ozone, carbon monoxide, and sulfur compounds. One particular area of interest for Dr. Kasibhatla is the effects of anthropogenic emissions on atmospheric composition and reactivity, as well as on marine and terrestrial ecosystems.

Gabriel G. Katul, Ph.D., Associate Professor of Hydrology; B.E., Civil Engineering, American University of Beirut; M.S., Civil Engineering, Oregon State University; Ph.D., Civil Engineering, University of California, Davis.
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Dr. Katul's research focuses on hydrology and fluid mechanisms in the environment. In particular, he is interested in heat and water transport in the vadose zone and its importance in characterizing surface layer turbulence. He has carried out many laboratory and field experiments to characterize the parameters of heat and momentum transport mechanisms across the land-atmosphere interface and to determine their relationship to the local and regional hydrologic budget.

Recent work has centered on various aspects of hydrology and environmental fluid mechanics such as (1) heat and momentum fluxes over complex watershed terrain, (2) heat and water movement in unsaturated field soils, (3) the structure of turbulence close to the land-atmosphere interface, and (4) the impact of hydrologic processes on the spatial structure of soil moisture content.

Richard F. Kay, Ph.D., Professor of Biological Anthropology and Anatomy and of Environment; B.S., Anthropology and Zoology, University of Michigan; M. Phil., Ph.D., Geology and Geophysics, Yale University.
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Dr. Kay's current research interests center on the evolutionary history of the Order Primates. He is especially interested in further documenting the fossil history of Neotropical monkeys, whose history is particularly 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.
Robert O. Keohane, Ph.D., James B. Duke Professor of Political Science and of Environment; B.A., Social Sciences, Shimer College; Ph.D., Political Science, Harvard University.
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Dr. Keohane's research focuses on the role of international institutions, including international environmental regimes such as the Montreal Protocol on Substances that Deplete the Ozone Layer and organizations such as the Global Environment Facility. He is interested in the conditions under which such institutions form and gain membership and authority. His research is also designed to explore how such institutions can become effective in promoting concern about the environment, facilitating international environmental cooperation, and strengthening national environmental policies. A recent project, Institutions for Environmental Aid (ed. Keohane and Levy) explored the operation of institutions designed to promote environmental protection in poor countries by transferring resources from richer ones. His current research includes participation in a project on global environmental assessments, which is designed to explore the conditions that affect these exercises, and their effects on environmental policy and behavior. He also works on other issues involving the roles played by institutions in American foreign policy and world politics more generally.

William W. Kirby-Smith, Ph.D., Associate Professor of the Practice of Marine Ecology; B.S., Biology, University of the South; Ph.D., Zoology, Duke University.
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Dr. Kirby-Smith's research interests involve effects of land development on estuarine water quality, invertebrate zoology, benthic ecology and estuarine ecology. His recent research projects include the following: (1) ecology of rock outcrop communities on the continental shelf; (2) effects of salt marsh modifications on plant, invertebrate, fish and bird communities; (3) influence of pine plantation drainage on water quality and benthic invertebrates in receiving estuarine headwaters; (4) effects of agricultural development upon hydrology, water quality and biology in estuarine headwaters; and (5) the fate of fecal coliform bacteria in storm water runoff and estuarine headwaters. Additional research interests include the physiology of suspension feeding and its ecological consequences in estuaries. He is in residence at the Marine Laboratory.

Emily M. Klein, Ph.D., Associate Professor of Geology; B.A., English, Barnard College; M.A., Geology, M. Phil., Ph.D., Geology, Columbia University.
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Dr. Klein's research focuses on the geochemistry of ocean ridge basalts, using diverse tools of major and trace element and isotopic analyses. The goals of her research are to understand the processes that lead to the creation of the ocean crust, the physical and chemical characteristics of the sub-ridge mantle, and the ways that the Earth evolves chemically through time. Her work ranges from global-scale studies of basalt composition and their correlation with physical parameters of the ridge to detailed studies of basalts collected using the Alvin submersible.
Dr. Klein's current research projects include mapping and sampling expeditions to the Chile Ridge, which is currently being subducted beneath the Chile Trench, and geochemical studies of dike, gabbro and lava samples collected during an Alvin dive program to the Hess Deep rift in the equatorial Pacific. Other on-going or recently completed projects include analyses of basalts from the Pacific-Antarctic Ridge, the Mid-Atlantic Ridge, the East Pacific Rise and the Australian-Antarctic Discordance.

Kenneth R. Knoerr, Ph.D., Professor of Environmental Meteorology and Hydrology; B.S.F., Forestry, University of Idaho; M.F., Ph.D., Forestry, Yale University.
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Dr. Knoerr's historical research interests have been in environmental meteorology and hydrology, concerned with a number of issues related to the management of forest lands. For many years his research emphasized the processes by which forests interact with the atmosphere. This research emphasized the development of physical models for plant-environment interaction. In addition, there was an extensive micrometeorological experimental effort to collect data to help validate these models.

Recently his research has focused on an investigation of forest fires where unexpected fire behavior entrapped firefighters, often with the loss of some lives. This unexpected fire behavior can be the result of unexpected weather events, or the result of not understanding the potential flammability of the forest fuels. This is a retrospective investigation of more than 100 fires in this century to evaluate the common causes of these entrapments.

Randall A. Kramer, Ph.D., Professor of Resource and Environmental Economics; B.A., Economics, University of North Carolina; M.E., Economics, North Carolina State University; Ph.D., Agricultural Economics, University of California, Davis.
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Dr. Kramer's research focuses on benefit cost analysis, the role of natural resources in economic development and the economics of ecological services. Two projects in Indonesia are focused on the economics of tropical and coastal resources. One study in northern Sulawesi is focused on the effects of human population growth and migration on the sustainable use of coastal resources. This study is also examining how public and community based fisheries management affects economic activity. A second set of studies in Indonesia is on the economics of protected areas, with an emphasis on nature-based tourism, agricultural and forest extraction in buffer zones and watershed protection benefits. In North Carolina, Dr. Kramer's current work is concentrated on water resource issues. One study is examining economic and ecological criteria for selecting sites for wetlands restoration. Another current project is investigating public attitudes toward water quality protection on the Catawba River in western North Carolina.
Michael L. Lavine, Ph.D., Associate Professor of Statistics and Decision Sciences and of Environment; B.S., Mathematics, Beloit College; M.S., Mathematics, Dartmouth College; Ph.D., Statistics, University of Minnesota.
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Dr. Lavine holds joint appointments at Duke in statistics (primary) and the environment (secondary). His primary research interests are in robust, nonparametric and spatial Bayesian statistical theory and environmental statistical applications.

Edward D. Levin, Ph.D., Associate Professor in Psychiatry and Behavioral Sciences; B.A., Psychology, University of Rochester; M.S., Physiological Psychology, University of Wisconsin; Ph.D., Environmental Toxicology, University of Wisconsin.
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Dr. Levin is Chief of the Neurobehavioral Research Lab in the Psychiatry Department of Duke University Medical Center. He is also Director of the Duke University Integrated Toxicology Program. His primary academic appointment is as Associate Professor in the Psychiatry Department. He also has a secondary appointment in the Pharmacology Department at Duke. His primary research effort is to understand basic neural interactions underlying cognitive function and to apply this knowledge to better understand cognitive dysfunction and to develop novel therapeutic treatments.

Elwood A. Linney, Ph.D., Professor of Microbiology and of Environment; B.S., Engineering Physics, Univ. of Illinois; M.S., Biophysics, Michigan State University; Ph.D. Molecular Biology, Univ. of California, San Diego.
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Dr. Linney’s laboratory focuses upon signal transduction during embryogenesis. Previously the laboratory focused upon mouse embryogenesis but recently the laboratory has directed its efforts on the zebrafish model so that live gene expression could be captured using transgenic zebrafish models, fluorescent reporter genes and fluorescence microscopy. Transgenic fish are being produced via DNA microinjection and through pseudotyped retroviral vector infection of zebrafish embryos. The laboratory has produced several transgenic fish models which express green fluorescent protein reporter genes in response to retinoids and estrogens. These models are being used to
study the role of these signal transduction pathways during development. In addition, the models are being examined to determine whether they could be used as biosensors for environmental toxicants that impact upon the retinoid and estrogen pathways. Through these model systems one should be able to examine the direct effects of environmental toxicants on gene expression in live, developing organisms. Since other species of small fish have uniquely positive properties for toxicological studies, these transgenic techniques are now being applied to other fish models such as Fundulus heteroclitus.

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Dr. Livingstone studies the circulation and chemical composition of lakes in tropical Africa and how the distribution and abundance of organisms are affected by them. The aim is to understand tropical lakes as climatically-controlled ecological systems, and especially how the environment controls the properties of lake sediments. This understanding is used with cores taken from lake sediments to work out the history of changing climate and changing vegetation. The ultimate aim is two-fold: to understand global climatic change and to see how the climatic history of Africa has affected the plants and animals that live there. Among the most interesting of those organisms are Homo sapiens and its hominid ancestors.

M. Susan Lozier, Ph.D., Associate Professor of Physical Oceanography; B.S., Chemical Engineering, Purdue University; M.S., Chemical Engineering, Ph.D., Oceanography, University of Washington.
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Dr. Lozier's research interests lie in the general area of mesoscale and large-scale ocean dynamics. Specifically, she is interested in the Lagrangian aspects of ocean circulation, cross-frontal exchange processes and climate dynamics. Her approach to the study of these topics ranges from the application of numerical models to the analysis of observational data, with the focus on the testing and development of theory.

Currently, Dr. Lozier is studying the decadal variability of the North Atlantic Ocean, using historical hydrographic data from the period 1904 to 1990. A major objective of this work is to identify climatic anomalies during the past century and to determine the dynamics that govern their propagation. The Mediterranean outflow and the Labrador Sea are areas of particular interest. Current work is also focused on how local instabilities convolute a shelfbreak front and lead to mixing of shelf and slope waters.
Lynn A. Maguire, Ph. D., Associate Professor of the Practice of Environmental Management; A.B., Biology, Harvard University; M.S., Resource Ecology, University of Michigan; Ph.D., Ecology, Utah State University.
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Dr. Maguire's current research uses a combination of methods from decision analysis, environmental conflict resolution and social psychology to study environmental decision making. Dr. Maguire focuses on collaborative decision processes where values important to the general public and stakeholders must be combined 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 of environmental decision making - how well the mechanisms used to involve the public achieve social justice goals. Dr. Maguire and her students have been applying these approaches to collaborative decision processes for public land management and for water quality management in North Carolina and elsewhere.

Peter E. Malin, Ph.D., Professor of Seismology and Professor of Civil and Environmental Engineering; B.S., Geophysics, Stanford University; M.S., Marine Geophysics, Stanford University; Ph.D., Seismology, Princeton University.
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Dr. Malin joined Duke Geology in 1991 after more than a decade as a research seismologist at the University of Southern California and the University of California. His interests include tectonics, seismic wave propagation, and earthquakes, with current focus on central California. Since seismic waves are inseparable from the geology in which they originate and travel, his research has become increasingly interdisciplinary, emphasizing the application of structural and mechanical models to seismic observations. Current projects at Duke include the mechanics of the San Andreas fault at Parkfield, the seismotectonics of the Coso Geothermal area, and seismic exploration of the southern Sierra Nevada, Owens Valley, and San Joaquin regions. The Duke-associated downhole seismometer networks at Parkfield and Coso have revealed patterns in seismicity that suggest the interaction of aseismic and seismic fault slip. Along with several other universities, the Duke seismology group determined the location of crossed, 300 km long refraction profiles in the Sierra Nevada/Death Valley region in 1993. The seismic networks offer the chance for hands-on study of seismicity and earthquake mechanics. The active seismic profiling projects provide experience with seismic imaging of crustal structure.

Carol A. Mansfield, Ph.D., Assistant Professor of Environmental Economics; B.A., Economics, Yale University; Ph.D., Economics, University of Maryland.
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Dr. Mansfield's research interests include the areas of environmental and public economics, with an emphasis on quantitative analysis. Her current research focuses on the use of contingent valuation surveys to price environmental resources and the individual decision-making processes. This work has two primary goals. The first is to evaluate how people react to hypothetical survey questions and whether their answers contain informa-
tion that is useful to policy makers. The second is to explore alternatives to the standard economic model of decision making and the implications for environmental policy.

A second area of current research focuses on land use change and land preservation. The projects combine ecological and economic modeling approaches.

**Patricia D. McClellan-Green, Ph.D., Assistant Research Professor; B.S., M.S., Biology, East Carolina University; Ph.D., Toxicology, North Carolina State University.**

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Dr. McClellan-Green studies gene regulation and expression by aquatic organisms in response to xenobiotic exposure. Research is under way to determine the mechanism of PAH and PCB mediated gene regulation in fish. Other areas of interest include the identification and characterization of various cytochrome P-450s in aquatic organisms and the genetic regulation of select P-460 genes. She is in residence at the Marine Laboratory.

**Margaret A. McKean, Ph.D., Associate Professor of Political Science and of Environment; B.A., Political Science and Asian Studies, University of California at Berkeley; M.A., Far Eastern Studies, Harvard University; Ph.D., Political Science, University of California at Berkeley.**

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Dr. McKean’s initial interests in environmental issues focused on Japan’s political response to serious pollution problems. She then turned to a consideration of environmental problems as collective action dilemmas and of environmental resources as common-pool goods subject to problems of underprovision and depletion. Her work on the Japanese experience at managing forest commons led to a broader interest in the relationship between property rights and environmental outcomes in both developing and developed worlds, in both past and present.

She served as a member of the National Academy of Sciences panel on Common Property and Environmental Management (1983-1987), helped to launch the International Association for the Study of Common Property in 1989 and was that organization’s fifth president in 1995-1996.

Her current research is aimed at learning when and where common property regimes may be used to enhance environmental efficiency and under what conditions governments become willing to devolve property rights onto communities and individual citizens.

**Marie Lynn Miranda, Ph.D., Assistant Professor of the Practice of Environmental Policy; A.B., Economics and Mathematics, Duke University; M.A., Ph.D., 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. Her most recent work combines economic theory with environmental chemistry and ecology to develop better methods for monetizing the environmental costs associated with alternative energy choices.
Dr. Miranda also 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. Dr. Miranda has also conducted extensive research on the effectiveness of market-based incentives and pollution prevention policies on the management of domestic solid waste. She teaches courses on introductory environmental policy, United States environmental policy and a senior capstone course titled "Endocrine Disruptors in the Environment."

A. Brad Murray, Ph.D., Assistant Professor of Geomorphology and Coastal Processes; B.A., Journalism, University of Minnesota; B.I.S., General Science, University of Minnesota; M.S., Physics, University of Minnesota; Ph.D., Geology, University of Minnesota.
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Dr. Murray is interested in many surficial processes and patterns, including rivers and a range of desert, arctic and alpine phenomena. His recent efforts have focused on coastal geomorphology and near-shore processes. The near-shore 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 along-shore and cross-shore currents. Dr. Murray approaches such systems with different perspectives and uses different techniques than have been employed traditionally. Drawing on lessons from nonlinear dynamics and the emergent phenomenon viewpoint, he looks for possibly simple, large-scale interactions that could explain complex behaviors. He uses relatively simple, cellular-automata-like models that incorporate only the interactions hypothesized to be important to determine if they are sufficient to produce the phenomena.

Another aspect of Dr. Murray's research involves evaluating models of complex systems, for which linear statistics concerning the system's behavior may not sensitively reflect the interactions that produced them. He applies and develops nonlinear data analysis techniques to sensitively test how realistic model interactions are.

Dr. Murray is currently applying these methods to beach and surf zone problems, but plans to widen his focus onshore and offshore, to include studies of currents and sediment transport beyond the surf zone, as well as the formation and evolution of large-scale shoreline features.

Michael K. Orbach, Ph.D., Professor of the Practice of Marine Affairs and Policy; B.A., Economics, University of California, Irvine; M.A., Ph.D., Cultural Anthropology, University of California, San Diego.
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Dr. Orbach's research interests are in the application of social and policy sciences to coastal and ocean policy and management. His work uses a cultural, or human, ecology perspective to analyze human behavior in coastal and ocean environments. His current research projects include (1) the development and application of limited entry and effort management systems to marine fisheries; (2) the formation and socioeconomic impact of marine minerals policy; (3) marine mammal and endangered species-fisheries conflicts; and (4) citizen involvement in coastal and ocean policy.

Dr. Orbach specializes in the application of science to the policy and management process. He is in residence at the Marine Laboratory.
Ram Oren, Ph.D., Associate Professor of Ecology/Ecophysiology; B.S., Forest Resource Management, Humboldt State University; M.S., Ph.D., Forest Ecology, Oregon State University.
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Dr. Oren’s research examines the effect of environmental and climatic conditions on individuals of many tree species. Depending on the sensitivity of species in each forest, forests respond to variation in the environment by changing water, carbon dioxide and energy flow between the biosphere and atmosphere.

With his graduate students, Dr. Oren quantifies the components of water flux in forest ecosystems, and the influence of certain biotic and abiotic factors on these components. Climate variability, including variations in air temperature, vapor pressure deficit, incoming radiation and soil moisture, and environmental change, including elevated atmospheric carbon dioxide, affect intra and inter annual patterns and amounts of water used by forest ecosystems and their spatial distributions. These variations influence the temporal and spatial partitioning of incoming radiation between latent and sensible heat and the amounts of carbon dioxide taken from, or released to, the atmosphere.

Using a local mass balance approach and detailed measurements of water flux and driving variables in the soil, plants and the atmosphere in forests from Brazil to Alaska, Dr. Oren’s group evaluates the likely responses of different forest ecosystems to environmental change.

Ronald D. Perkins, Ph.D., Professor of Earth Sciences; B.S., Geology, University of Cincinnati; M.S., Geology, University of New Mexico; Ph.D., Geology, Indiana University.
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Dr. Perkins came to Duke University in 1968 after spending 6 years as a Research Geologist with Shell Development company. He continues his association with industry through consulting activities and in the teaching of short courses primarily in the fields of carbonate facies analysis diagenesis. Dr. Perkins’ current research interests are focused on the Pleistocene and Holocene carbonates of the Turks and Caicos Islands in the British West Indies and oil field analogs. He and his co-workers have recently described oolite deposition in settings far removed from the shelf margin where they are generally considered to form. His students have recently conducted studies on the mineralogy and pore water chemistry of schizohaline pond sediments on West Caicos and the evolution of a Holocene carbonate mound near the island of Providenciales. Studies by students on ancient carbonates are also encouraged to provide better integration between modern sediment studies and ancient analogs. More recently these studies have included projects on the Cambro-Ordovician Knox of the Southern Appalachians, and the Jurassic Smackover Limestone of the Gulf Coast.
Orrin H. Pilkey, Ph.D., Research Professor and James B. Duke Professor Emeritus of Geology; B.S., Geology, Washington State College; M.S., Geology, University of Montana; Ph.D., Geology, Florida State University.

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Dr. Pilkey's research centers on both basic and applied coastal geology, focusing primarily on barrier island coasts. Off Wrightsville Beach, NC, advantage is being taken of a petrographically distinct beach replenishment sand to determine paths of sand transport on the shoreface. Another ongoing project involves a detailed study of the evolution of salt marshes along various shoreline types in Pamlico and Albemarle Sounds. The goal is to understand how salt marshes in various geological settings will respond to a future rise in sea level and how this impacts on management strategies for salt marshes.

Recently, Dr. Pilkey's group, along with INGEO-MINAS, carried out the first phase of a study of the Colombian Pacific Coast barrier island chain. Future studies will involve detailed coring of selected individual islands to determine how barrier islands evolve in tectonically active areas completely away from the influences of humans.

A related study is carried out under the auspices of the Program for the Study of Developed Shorelines (PSDS). Such studies have included a review of the national beach replenishment experience on all 3 U.S. coasts and analysis of the validity of replenished beach engineering design parameters.

The PSDS group is currently exploring, from a geologic viewpoint, methods for mitigating hurricane damage on barrier islands. The PSDS is also analyzing the numerical models used by coastal geologists and engineers to predict the movement of beach sand, especially on beach replenishment projects.

Lincoln F. Pratson, Ph.D., Assistant Professor of Sedimentary Geology; B.S., Geology, Trinity University; M.S., Oceanography, University of Rhode Island; M.Ph., Ph.D., Geology, Columbia University.

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Dr. Pratson joined the Nicholas School of the Environment's Division of Earth & Ocean Sciences in fall 1998 coming from the Institute of Arctic and Alpine Research of the University of Colorado where he was a Research Scientist for two years. Prior to that, he was a research scientist at Lamont-Doherty Earth Observatory of Columbia University for three years, which is also where he received his Ph.D.

Dr. Pratson's research revolves around the role of sedimentary processes in shaping 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. These range from seafloor mapping using multibeam bathymetry, side-scan sonar imagery, and shallow cores, to sequence stratigraphy based on seismic reflection and borehole data constrained in some instances by gravity measurements.

Dr. Pratson also develops numerical 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. At present, he is working with researchers at the St. Anthony Falls Laboratory of the University of Minnesota using a new experimental tank to investigate the interplay between sediment supply, sea level change and subsidence in creating sedimentary sequences.
Joseph S. Ramus, Ph.D., Professor of Biological Oceanography; A.B., Ph.D., Botany, University of California, Berkeley. E-mail: jramus@duke.edu
Dr. Ramus's research includes the study of physical forcing of primary productivity in coastal plains estuaries. The research seeks a match between physiological response and the temporal frequency of physical drivers, the phasing of the organism with its environment. Another of Dr. Ramus's interests involves biotechnological research which includes extracellular polysaccharides produced by marine microphotoautotrophs. Two aspects are under investigation: (1) environmental regulation of carbon partitioning; i.e., the diversion of newly fixed carbon from growth (new photosynthetic machinery) to disposable heteropolysaccharides (viscoelastic biopolymers), and (2) drag reducing properties of the biopolymers in pipe flow.
A third area under investigation is photoacclimation and photoinhibition in seaweeds and seagrasses. Of specific interest are macromolecular changes in the photosynthetic apparatus, the dynamic range of change and the effect of change on growth rate. He is in residence at the Marine Laboratory.

Andrew J. Read, Ph.D., Assistant Professor of the Practice of Marine Mammalogy; B.S., M.S., Ph.D., Zoology, University of Guelph. E-mail: aread@duke.edu
Dr. Read studies the life history and conservation biology of dolphins, porpoises, and other marine mammals. He conducts life history research through longitudinal studies of individuals in coastal populations and cross-sectional studies of samples from strandings or incidental catches in commercial fisheries. In these studies, he focuses attention on how animals partition energy among the competing demands of growth, maintenance and reproduction.
He also examines the impacts of human activities on populations of marine mammals and attempts to find solutions to such conflicts. In particular, he studies the effects of removals from populations caused by incidental mortality in commercial fisheries. This work is multifaceted and involves examination of animal behavior around nets, modification of fishing gear to minimize mortality, and demographic analyses of the effects of incidental catches.
He is in residence at the Marine Laboratory.

Kenneth H. Reckhow, Ph.D., Professor of Water Resources; B.S., Engineering Physics, Cornell University; M.S., Ph.D., Environmental Science and Engineering, Harvard University. E-mail: reckhow@duke.edu
Dr. Reckhow's research activities have focused on the development, evaluation, and application of models for the management of water quality. In particular, he is interested in the effect of uncertainty on model specification, parameter estimation, and model applications. Recent work has expanded this theme to consider the effect of scientific uncertainties on water quality decision making.
Among the problems that Dr. Reckhow's research group has examined are lake eutrophication, toxic substances, and acid rain. Past work on eutrophication has centered on the development and evaluation of empirical models, estimation of prediction
uncertainty using first order error analysis and Monte Carlo simulation, and a decision analytic approach to lake management. Current work by Dr. Reckhow and his students concerns probability (Bayes) networks and pattern recognition for eutrophication modeling.

**Curtis J. Richardson**, Ph.D., Professor of Resource Ecology; B.S., Biology, State University of New York at Cortland; Ph.D., Ecology, University of Tennessee.
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Dr. Richardson’s research interests in applied ecology center on long-term ecosystem response to large-scale perturbations such as acid rain, toxic materials, trace metals, flooding or nutrient additions. He has specific interests in wetland ecosystems, phosphorus nutrient dynamics in wetlands and the effects of environmental stress on plant metabolism and growth. Major research efforts have focused on wetlands as nutrient sinks and transformers. The central hypothesis being tested is that wetland ecosystems function as natural sinks (i.e., nutrient removal systems) for downstream ecosystems.

His current research activities include:
- The effects of agricultural runoff and hydrologic alterations on Everglades nutrient cycling and storage.
- Wetland restoration and its effects on regional water quality and nutrient biogeochemical cycles.
- Development of ecosystem metrics as indices of wetland restoration success.
- The effects of highway construction on wetland functions.
- Wetland development trends in the southeastern United States.
- The effects of wetland land development on regional hydrologic flux and water quality.

The objectives of his field research are to test ecological principles and develop new approaches to environmental problem solving. The goal of these studies is to provide predictive models to aid in the management of ecosystems.

**Daniel D. Richter**, Ph.D., Associate Professor of Forest Soils and Ecology; B.A., Philosophy, Lehigh University; Ph.D., Forest Soils, Duke University.
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Dr. Richter’s research objectives are centered on understanding and quantifying soil change that is affected by forest development and land use over timescales of decades and centuries. His work is directed at quantifying how ecosystem processes control the chemistry of soils, drainage waters and plant productivity. The responses of poorly buffered soils are of most interest, most particularly extremely weathered, acidic Ultisols that are common to the southeastern United States and to the forests of the humid tropics. His research objectives are pursued both individually and cooperatively with scientists from several disciplines. His primary educational objectives are to help students develop an understanding of and appreciation for ecological functions of soil and forest ecosystems through lectures, seminars, field trips, and indoor and outdoor laboratories.
Daniel Rittschof, Ph.D., Associate Professor of Zoology; B.S., Ph.D., Zoology, University of Michigan.
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Dr. Rittschof’s research interests involve chemical communication systems. His studies include external and internal molecular mediation of behavior (chemical ecology). At present, test systems are marine and include crustaceans (true crabs, hermit crabs and barnacles), molluscs and fish. Studies span the gamut from practical (nontoxic antifouling coatings, fish foods and fish feeding stimulants) to purely basic (larval release pheromones, designer peptides with biological activity, hermit crab shell attractant cues, hormonal control of feeding behavior, and enzymatic activities in crustacean and gastropod saliva). The driving theme of the work is the evolution of chemical communication systems and their components.
He is in residence at the Marine Laboratory.

Stuart Rojstaczer, Ph.D., Associate Professor of Geology and Civil and Environmental Engineering; B.S., Geology, University of Wisconsin; M.S., Geology, University of Illinois; Ph.D., Applied Earth Sciences, Stanford University.
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The broad aim of Dr. Rojstaczer’s research is to understand better the role of subsurface fluid flow in geologic and human-induced hazards. A subsidiary interest is in the development of new techniques to determine elastic and fluid flow properties of the Earth in situ.
Dr. Rojstaczer and his students have recently examined many research topics including: land subsidence in the San Joaquin-Sacramento Delta (a region critical to water supply in California); groundwater flow induced by tectonic activity along the San Andreas Fault; the mechanics of geysers; measurement of air permeability in the field; rates of flow and residence times of fluids in karst; and interpolation of permeability structure in the presence of sparse data.
Central to the approach of examining these problems is the integration of field-derived data with theory. The research frequently requires the use of novel field collection techniques or the use of conventional techniques in novel settings. The field data is used to constrain quantitative models that describe the physical and chemical processes underlying the observations.
He is director of the Center for Hydrologic Science.

William H. Schlesinger, Ph.D., James B. Duke Professor of Biogeochemistry and of Environment; A.B., Biology, Dartmouth College; Ph.D., Ecology and Systematics, Cornell University.
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Dr. Schlesinger’s research interests span the field of global change science, focusing on human-induced changes in the global biogeochemical cycles. He is the principal investigator for the Free Air Carbon Dioxide Enrichment (FACE) Experiment in the Duke Forest - a project that aims to understand how an entire forest ecosystem (vegetation and soils) will respond to growth in elevated CO2. He has also worked extensively in desert ecosystems and their response to global change - often leading to soil degradation and desertification.
Currently, he serves as Principal Investigator for the NSF-sponsored program of Long Term Ecological Research (LTER) at the Jornada Basin in southern New Mexico.
Past work has taken him to diverse habitats, ranging from Okefenokee Swamp in southern Georgia to the Mojave Desert of California. He is the author or co-author of over 125 scientific papers and the widely-adopted textbook *Biogeochemistry: An Analysis of Global Change* (Academic Press, 2nd ed. 1997). His research has been featured on NOVA, CNN, NPR, and on the pages of *Discover*, *National Geographic*, the *New York Times*, and *Scientific American*.

Dr. Schlesinger holds a joint appointment in the Department of Botany and the Nicholas School’s Division of Earth & Ocean Sciences.

**Paul Steinberg**, Ph.D., Visiting Assistant Professor; B.A., Biological Sciences, University of California at Santa Barbara; M.P.A., Environmental Policy, Harvard University; Ph.D., Environmental Studies (Political Economy and Policy Analysis), University of California at Santa Cruz.

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Dr. Steinberg studies the political dynamics of environmental policy-making in developing countries, particularly with respect to issues of global concern. His topical interests include biodiversity conservation, sustainable development, transnational social movements, political science research methods, and the role of developing countries in international environmental affairs. Dr. Steinberg is currently writing a book entitled, *Third World Environmental Leadership*, based on an analysis of biodiversity policy-making in Costa Rica and Bolivia over the past four decades. Another recent project provides a logical and empirical critique of the assumption that developing countries are too poor to care about environmental protection absent foreign financial inducements. Dr. Steinberg has served as an advisor to the World Conservation Union (IUCN) and the California Institute for Public Affairs and has worked for the Natural Resources Defense Council, Pesticide Action Network International and the US Peace Corps in Liberia, West Africa.

**Craig A. Stow**, Ph.D., Visiting Assistant Professor of Water Resources; B.S., Environmental Technology, Cornell University; M.S., Marine Sciences, Louisiana State University; Ph.D., Environmental Modeling, Duke University.

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Dr. Stow’s research interests focus on the application of statistical modeling techniques to assist with management decisions in aquatic ecosystems. His work has included assessments of sediment-water nutrient interactions in lakes, patterns of contaminant bioaccumulation in Great Lakes fishes, and the effect of observation error on parameter estimation and model prediction. Dr. Stow’s current research includes a study of food-web effects and fish growth rates on PCB bioaccumulation in Lake Michigan, a study of nutrient loading patterns in the Neuse River estuary, and an assessment of phosphorus levels in the Florida Everglades.
John W. Terborgh, Ph.D., James B. Duke Professor of Environmental Science; B.S., Biology, M.S., Ph.D., Plant Physiology, Harvard University.
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Dr. Terborgh's interests lie in the fields of tropical ecology and conservation. At different times in his career he has studied birds, primates, herbs, and forest trees, and has directed student projects involving butterflies, lizards, amphibians, and crocodilians. The common denominator in all this work has been the goal of solving problems of general ecological interest using a comparative approach. Some typical comparisons have involved seasonal patterns in resource utilization by forest primates, habitat use by Amazonian birds, and latitudinal variation in the structure of mature forests. Applications of ecology to conservation have increasingly become a central theme of his work. He regards as particularly important the need to understand the many consequences of habitat fragmentation, especially those related to the disruption of trophic level processes.

Jerry J. Tulis, Ph.D., Adjunct Associate Professor of Environmental Studies; B.S., Bacteriology, University of Illinois; M.S., Medical Microbiology, Loyola University; Ph.D., Radiobiology, Catholic University of America.
E-mail: tulis001@mc.duke.edu
Dr. Tulis is primarily interested in the detection, amelioration, and prevention of adverse health effects in the occupational and environmental setting as a result of exposure to biohazardous agents and materials. Specifically, he is interested in (1) the improvement of indoor environments from the viewpoint of bioaerosols, including the identification and control of harmful aerosols composed of opportunistic and pathogenic microorganisms, biological toxins, and allergens; (2) the mitigation of hazardous waste using bioremediation technology; (3) research on the development of biocidal materials; (4) the development of preventive measures to limit zoonotic infections in various zoologic and field operations; and, (5) the control of mycotoxin production resulting from the growth of various saprophytic fungi in the agricultural setting. His current research involves studies on the growth-promoting potential of fungal contaminants of fiberglass duct lining and duct board, and nationwide risk assessment studies for the EPA on occupational and environmental biohazards in various workplaces, including laboratories, Superfund sites, and marine operations.

Dean L. Urban, Ph.D., Assistant Professor; B.A., Botany and Zoology, M.A., Wildlife Ecology, Southern Illinois University; Ph.D., Ecology, University of Tennessee.
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Dr. Urban's research interest is in landscape ecology: the development and implications of landscape pattern. He uses simulation models to explore the interplay of abiotic environmental templates (temperature, moisture gradients), biotic processes (plant demography, competition, dispersal), and disturbances (including human land use) in governing forest dynamics in mountain landscapes. One current project uses a model as a framework for comparisons among forests in the Oregon Cascades, the Sierra Nevada of California, the White Mountains of New Hampshire, and the southern Appalachians of North Carolina.
Building on his work in forests, Dr. Urban is also interested in wildlife communities in patchy landscape mosaics. His focus is on how landscape pattern and metapopulation processes interact to generate landscape-scale patterns in biodiversity. One emphasis of this research is to use models, interfaced with geographic information systems, to explore alternative forest management strategies.

Carel P. van Schaik, Ph.D., Professor of Biological Anthropology and Anatomy and of Environment; B.S., Biology, M.S., Ethology and Plant Ecology, Ph.D., Ethology, Utrecht University.
Email: cschaik@duke.edu
Dr. van Schaik is a tropical ecologist and ethologist with Duke’s Department of Biological Anthropology and Anatomy. His ecological research focuses on fungivores in tropical rain forests and their response to resource seasonality and disturbance. He is also interested in strategies of conserving biological diversity.

Dharni Vasudevan, Ph.D., Assistant Professor of Environmental Chemistry; BS, Environmental Engineering Science, Massachusetts Institute of Technology; MSE, Environmental Engineering, Johns Hopkins University; Ph.D., Environmental Chemistry, Johns Hopkins University.
Email: dharni@duke.edu
Dr. Vasudevan is interested in the fate of anthropogenic and naturally occurring organic compounds in aquatic environments. Her research focuses on interfacial processes—adsorption, dissolution and surface-assisted transformations—in surface waters (particle/water interface) and subsurface environments.
An understanding of the relationship between an organic compound’s chemical structure and its environmental properties is emphasized. Her current research concerns the interaction between crystalline and amorphous mineral surfaces (oxides and clay minerals) and organic ligands that mimic natural organic matter (NOM) and chemical precursors and products of the pharmaceutical, dyestuff and agrochemical industries.
Research plans include the application of these results to develop design criteria for green/benign chemicals that are less persistent in the environment; to explore NOM-mineral surfaces interactions related to biogeochemical processes; and to develop treatment and remediation strategies for organic compounds.

Email: wiener@faculty.law.duke.edu
A member of the Duke Law School faculty, Mr. Wiener is interested in the interplay of science, economics, and law in addressing environmental and human health risks. Before coming to Duke, he worked in the area of 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. He also helped organize the environmental component of the Americorps national service program. His policy work and writing have addressed topics including climate change, forests conservation, risk, biotechnology, mass torts, and incentives in regulation and litigation. He attended the Rio Earth Summit in 1992. In 1997 he was elected President-elect of the Society for Risk Analysis, Research Triangle Chapter.
Robert L. Wolpert, Ph.D., Associate Professor of Statistics and Decision Sciences and of Environment; A.B., Mathematics, Cornell University; Ph.D., Mathematics, Princeton University. Email: rwolpert@stat.duke.edu

A member of Duke’s Institute of Statistics and Decision Sciences, Dr. Wolpert is interested in the theory and foundations of statistical inference and in the application of advanced mathematical, numerical and statistical methods to the modeling and study of environmental and biological systems. His current research stresses the study of model selection, model validation, and uncertainty analysis for environmental simulation and risk-assessment models. Originally trained as a mathematician specializing in probability theory and stochastic processes, he was drawn to statistics by the interplay between theoretical and applied research.
Extended Faculty

S. Marshall Adams, Ph.D., Adjunct Professor; B.S., Wildlife Biology, M.S., Zoology, North Carolina State University; Ph.D., Marine Science, University of North Carolina at Chapel Hill.

Dr. Adams is principal investigator of several large projects at Oak Ridge National Laboratory related to effects of environmental stress on aquatic ecosystems. His research interests are in the general areas of environmental impact assessment and biological indicators of aquatic ecosystem health.

Dianne Ahmann, Ph.D., Adjunct Assistant Professor; B.A., Biochemistry and Molecular Biology, Harvard College; Ph.D., Biology, Massachusetts Institute of Technology.

Dr. Ahmann’s research concerns the roles of microorganisms in the biogeochemical cycling of metals and trace elements. Her current research investigates the physiology and ecology of anaerobic arsenic-respiring bacteria which gain energy by coupling organic carbon oxidation to arsenic reduction in a process analogous to the energy-yielding oxygen reduction carried out by aerobes.

Marius Brouwer, Ph.D., Adjunct Professor; B.S., Biology, M.S., Biochemistry and Microbiology, Ph.D., Biochemistry, University of Groningen, The Netherlands.

Dr. Brouwer heads the toxicology section at the University of Southern Mississippi Institute for Marine Sciences/ Gulf Coast Research Laboratory. His research interests center around the study of the dual role of metals and oxygen as essential and toxic elements in biological systems, using marine organisms as experimental animals.

Russell C. Cattley, Ph.D., Adjunct Assistant Professor; B.S., Rutgers University; M.S., Clemson University; V.M.D., University of Pennsylvania; Ph.D., University of North Carolina.

Dr. Cattley’s areas of scientific interest are chemical carcinogenesis and toxicologic pathology. He serves as associate manager of the Cancer Program at the Chemical Industry Institute of Toxicology located in the Research Triangle Park.

Fei Chai, Ph.D., Adjunct Assistant Professor; B.S., Shandong College of Oceanology, P.R.China; M.A., Princeton University; Ph.D., Duke University.

Dr. Chai is assistant professor of oceanography at the School of Marine Sciences, University of Maine. He is currently involved in research collaboration with Professor Barber of the Nicholas School.

Yi Chao, Ph.D., Adjunct Assistant Professor; B.S., Atmospheric Physics, University of Science and Technology of China; M.A., Geophysical Fluid Dynamics, Ph.D., Atmospheric and Ocean Sciences, Princeton University.

Dr. Chao’s research interests seek to improve our understanding of the general circulation of the ocean and to determine its role in the Earth system and global climate. He is a member of the technical staff at the Jet Propulsion Laboratory of the California Institute of Technology.

Sherri L. Cooper, Ph.D., Adjunct Assistant Professor; B.S., Botany, Duke University; M.S., Marine Studies, University of Delaware; Ph.D., Physical Geography, Johns Hopkins University.

Dr. Cooper’s interests include using paleoecological tools to re-create the history of water quality and vegetation changes in aquatic systems and watersheds, related to both climatic influences and anthropogenic effects. Her specialities include estuarine systems and diatom analysis. Current research is focused on the recent history of the Everglades, to recreate the vegetation, water quality, and fire history over the past 200 years for use in restoration plans.
Michael P. Dieter, Ph.D., Adjunct Professor; B.S., University of Notre Dame; M.A., Ph.D., Zoology, University of Missouri.

Dr. Dieter is a physiologist and science editor for Environmental Health Perspectives at the National Institute of Environmental Health Sciences. His research interests lie in the area of environmental toxicology of metals, mammalian toxicology and carcinogenesis, and cellular biochemistry and physiology.

George R. Dubay, Ph.D., Adjunct Assistant Research Professor; B.S., Chemistry, Fairfield University; Ph.D., Physical Organic Chemistry, Duke University.

Director of instrument operations in Duke's chemistry department, Dr. Dubay is interested in mass spectrometry methods to identify and quantitate environmental contaminants and biochemically interesting compounds.

David S. Ellsworth, Ph.D., Adjunct Assistant Professor; B.S., Biological Sciences, Cornell University; Ph.D., Forestry, University of Wisconsin, Madison.

Dr. Ellsworth currently participates in research in the Duke Forest concerning the physiological effects of carbon fluxes on pines under ambient and elevated inputs of carbon dioxide. He is a plant physiologist in the biosystems and process sciences division of Brookhaven National Laboratory.

Dale A. Gillette, Ph.D., Adjunct Professor of Geology; B.A., Astronomy, M.S., Ph.D., Meteorology, University of Michigan, Ann Arbor.

Dr. Gillette, physical scientist at the NOAA Air Resources Laboratories, is interested in eolian processes and has concentrated on mechanisms of wind erosion and applications to geology and ecology. He has provided information on many of the mechanisms of wind erosion.

Milton S. Heath, Jr., J.D., Adjunct Professor; A.B., Harvard University; LL.B., J.D., Columbia University.

Dr. Heath specializes in environmental and natural resource law and administration, and the legislative and other governmental aspects of resource development. He is on the faculty of the Institute of Government at the University of North Carolina at Chapel Hill.

George R. Hendrey, Ph.D., Adjunct Professor; B.A., Zoology, M.S., Water and Air Resources, Ph.D., Limnology, University of Washington.

Dr. Hendrey is head of the Biosystems and Process Sciences Division at Brookhaven National Laboratory and co-director of the Forest-Atmosphere Carbon Transfer and Storage (FACTS) project operating in the Duke Forest. His primary research interests are in ecology and the development of integrated field experiments for ecosystem analysis.

Thomas P. Holmes, Ph.D., Adjunct Professor; B.S., M.S., Agricultural Economics, University of Connecticut; Ph.D., Economics, 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, N.C. His research focuses on the application of nonmarket valuation methods to problems of forest ecosystem protection and conservation in the United States and Brazil.

Peter A. Howd, Ph.D., Adjunct Assistant Professor; B.A., Geology and Economics, Williams College; M.S., Ph.D., Oceanography, Oregon State University.

Dr. Howd's studies focus on how waves and currents interact to determine the evolution of beach morphology, and how changing global weather patterns may alter the evolution of undeveloped shorelines. Having once served on the Nicholas School of the Environment's faculty at the Duke Marine Laboratory, he is now on the faculty of the Department of Marine Science, University of South Florida.
Eric S. Kasischke, Ph.D., Adjunct Assistant Professor; B.S., Natural Resources, M.S., Remote Sensing, Ph.D., Remote Sensing and Forest Ecology, University of Michigan.

Dr. Kasischke is a research engineer in the Earth Sciences division of the Environmental Research Institute of Michigan. His research revolves around two primary interests: utilization of airborne and satellite imagery to study characteristics and patterns of change in forested landscapes, and development of methods to monitor the location, areal extent and damage of fires in Alaskan boreal forests.

Gregory L. Kedderis, Ph.D., Adjunct Associate Professor; B.S., Chemistry, Worcester Polytechnic Institute; Ph.D., Biochemistry, Northwestern Medical and Dental School.

Dr. Kedderis' research interests include mechanisms of toxicity of drugs and xenobiotics; genotoxicity and chemical carcinogenesis; xenobiotic oxidation by cytochromes P450; biotransformations of chemicals; enzymology; and the relationship between chemical dosimetry and biological effects. He is a Scientist II at the Chemical Industry Institute of Toxicology, Research Triangle Park.

E. Ann LeFurgey, Ph.D., Adjunct Associate Research Professor; B.S., Biology, Chemistry, Maryville College; M.S., Ph.D., Marine Sciences, University of North Carolina, Chapel Hill.

Director of the analytical electron microscopy facility in Duke University Medical Center's Department of Cell Biology, Dr. LeFurgey is a cell physiologist with interest in the mechanisms of toxic injury in cells elicited by metals and organic pollutants. Her laboratory is one of few worldwide which focuses on the application of quantitative electron probe x-ray microanalysis and imaging to problems in environmental health and toxicology.

Steven T. Lindley, Ph.D., Adjunct Assistant Professor; B.A., Aquatic Biology, University of California, Santa Barbara; Ph.D., Botany and Geology, Duke University.

Dr. Lindley is an ecologist in NOAA's National Marine Fisheries Service at the Southeast Fisheries Science Center, Tiburon Laboratory, California. His research interests focus on ecosystem and population ecology, numerical modeling, and application of stable isotopes as tracers of ecological processes.

Douglas J. Lober, Ph.D., Adjunct Assistant Professor; B.A., History, Yale University; M.B.A., Finance, Columbia University; M.F.S., Environmental Economics and Policy, and Ph.D., Forestry and Environmental Studies, Yale University.

Dr. Lober is a research analyst for an investment firm in the Boston area. His research interests include the integration of business and the environment from a management perspective, pollution prevention, waste management, and environmental policy.

D. Evan Mercer, Ph.D., Adjunct Associate Professor; B.S., Biology, B.S., Zoology, University of Texas; M.S., Forest Ecology, University of Michigan; Ph.D., Natural Resource Economics, 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 interests are 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.

Brian C. Murray, Ph.D., Adjunct Associate Professor; B.S., Economics and Finance, University of Delaware; M.S., Ph.D., Resource Economics and Policy, Duke University.

Dr. Murray is a senior economist at the Research Triangle Institute's Center for Economics Research. His areas of specialization include economic analysis of environmental policies and programs, analysis of industry structure and competition, and economic modeling of land use.
John Nagy, Ph.D., Visiting Research Scientist; B.S., Physics, Massachusetts Institute of Technology; Ph.D., Experimental High Energy Physics, University of Pennsylvania.

Dr. Nagy’s research interests focus on environmental physics; effects of radiation and energy system effluents on human health and natural ecosystems; and hardware and software related to automated control, data acquisition, and diagnostics for scientific experiments.

Subhrendu Pattanayak, Ph.D., Adjunct Assistant Professor; B.A., Economics, University of Delhi; M.S., Econometrics, Purdue University; Ph.D., Environmental and Natural Resource Economics, Duke University.

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. He models farm households’ passive or active use and valuation of forest resources, including ecosystem services, in national parks in Indonesia, Brazil, and Madagascar, and on agroforestry plots in the Philippines. His primary research interests are in the application of micro-econometrics to economic evaluation of environmental and resource policies, and issues at the intersection of economic development and environmental protection.

Narendra P. Sharma, Ph.D., Adjunct Professor; B.S., Agricultural Economics, University of Hawaii; M.S., Agricultural Economics, Rutgers University; M.E.M., Environmental Management, Duke University; Ph.D., Agricultural Economics and Economic Development, Virginia Polytechnic Institute and State University.

Principal economist at the World Bank in Washington, D.C., Dr. Sharma is the primary author of the bank’s forest policy. His research interests are in applied economics, project design and policy analysis. He has worked in developing countries on policy issues related to conservation and sustainable development, poverty, natural resource management, and policy dialogue. His current research focuses on quantification of environmental impacts and local participation.

Laura K. Snook, Ph.D., Adjunct Assistant Professor; B.A. History, Grinnell College; M.F.S., Tropical Forestry, Doctor of Forestry, Forest Ecology and Silviculture, Yale University.

Dr. Snook is primarily interested in the application of ecological knowledge to the management and conservation of forests. Her research has focused on forest stand dynamics, disturbance ecology, and silviculture as well as social forestry and forest conservation. She has worked in highland (fir and pine), montane, and lowland tropical forests in Mexico, and has ongoing research projects in the mahogany forests of Mexico, Belize, and Brazil.

Arthur J. Spivack, Ph.D., Adjunct Associate Professor; B.S., Massachusetts Institute of Technology; Ph.D., Massachusetts Institute of Technology and Woods Hole Oceanographic Institution.

Dr. Spivack’s current research interests are the development and application of isotope geochemical methods. General areas of application include the reconstruction of mantle/ocean/atmospheric chemical evolution, atmospheric CI chemistry, mid-ocean ridge hydrothermal systems and ocean margin pore fluid chemistry.

Harold Karl Steen, Ph.D., Adjunct Professor; B.S., Forestry, M.F., Ph.D., History of Conservation, University of Washington.

Dr. Steen’s research interests are the political and economic development of modern forestry concepts and policies, and the history of conservation and land use as related to current forest land issues. He is the former director of the Forest History Society at Duke University.
Panchabi Vaithiyanathan, Ph.D., Assistant Research Professor; B.S., M.S., Geology, Ph.D., Environmental Science, Jawaharlal Nehru University.

Dr. Vaithiyanathan's research activities have focused on understanding the biogeochemical cycling of nutrients and trace metals in aquatic systems. He has carried out laboratory and field research in Indian rivers, Chesapeake Bay estuaries, Canadian shield lakes, and floodplains of the Parana River and the Florida Everglades. His recent work has centered on the impacts of agricultural runoff on the nutrient dynamics in the Everglades. He is a senior scientist at the Duke Wetland Center laboratory in Florida.

John J. Vandenberg, Ph.D., Adjunct Assistant Professor; B.A., Biology, The College of Wooster; M.S., Ph.D., Biophysical Ecology, Duke University.

Dr. Vandenberg's current research interests are in health risk assessment methodology and application and the evaluation of risk assessment techniques for hazardous air pollutants. He is director of the Research to Improve Health Risk Assessments program in the Office of Research and Development, United States Environmental Protection Agency, Research Triangle Park, NC.

David N. Wear, Ph.D., Adjunct Professor; B.A., Botany, University of Montana; M.F., Resource Systems Science, Duke University; Ph.D., Forest Economics, 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.


A member of the Duke Law School faculty, Mr. Wiener is interested in 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, forests conservation, risk, biotechnology, mass torts, and incentives in regulation and litigation.

Reiner Zimmermann, Ph.D., Adjunct Assistant Professor; B.S., Botany, M.S., Ecology and Biogeography, Ph.D., Physiological Plant Ecology, University of Bayreuth, Germany.

Dr. Zimmermann is a member of the technical staff at the Jet Propulsion Laboratory/California Institute of Technology in Pasadena. His primary research interests are comparative studies of water use by vegetation along a latitudinal gradient from boreal to tropical forest types and the relationships between dielectric properties, tree water status canopy structure, and its detection with synthetic aperture radar.

Faculty Emeriti

Roger F. Anderson, Ph.D., Professor Emeritus
Cazlyn G. Bookhout, Ph.D., Professor Emeritus
John D. Costlow, Ph.D., Professor Emeritus
George F. Dutrow, Ph.D., Professor Emeritus
John W. Gutknecht, Ph.D., Professor Emeritus
S. Duncan Heron, Ph.D., Professor Emeritus
Benjamin A. Jayne, Ph.D., Professor Emeritus
James Granville Osborne, B.S., Professor Emeritus
Orrin H. Pilkey, Ph.D., Professor Emeritus
William R. Sizemore, Ph.D., Professor Emeritus
William J. Stambaugh, Ph.D., Professor Emeritus
James G. Yoho, Ph.D., Professor Emeritus

Faculty Emeriti 47
Degrees

Duke University offers undergraduate, professional, and research programs in several areas of study related to natural resources and the environment. A Bachelor of Arts degree with a major in environmental sciences and policy or geology is offered through Trinity College of Arts and Sciences. Master of Environmental Management (M.E.M.) and Master of Forestry (M.F.) degrees are offered by the Nicholas School of the Environment; and the Ph.D. degree is offered in the Department of the Environment of the Graduate School. The Master of Arts (A.M.) is available through the Graduate School for individuals wishing to pursue graduate study in the environment in conjunction with a J.D. degree in the School of Law. Students generally are not admitted to the Department of the Environment as candidates for a terminal Master of Science (M.S.) degree (except in Earth & Ocean Sciences); however, the M.S. may be awarded as part of a doctoral program.

The Distinction Between Professional and Graduate Degrees. The degrees offered through the Nicholas School of the Environment (M.E.M. and M.F.) are professional degrees. They are intended mainly to provide students with the broad education and experience necessary for careers in natural resource and environmental management. The professional degrees emphasize applied science, economics, policy, and quantitative methods of problem analysis and decision making.

The Master of Environmental Management degree is designed to develop expertise in planning and administering the management of the natural environment for maximum human benefit with minimum deterioration of ecosystem stability. M.E.M. degree candidates choose one of five programs of study: Coastal Environmental Management; Environmental Toxicology, Chemistry and Risk Assessment; Resource Ecology; Resource Economics and Policy; or Water and Air Resources.

The Master of Forestry degree concentrates on forest and associated resources, including timber, water, biodiversity, and recreation and their management from an ecological and economic point of view. The graduate with a M.F. degree is qualified for employment as a professional forester in an administrative or staff position with federal and state agencies, industries, consulting firms, and other organizations concerned with forest and land management. The Forest Resource Management program is offered under the M.F. degree. This program is accredited by the Society of American Foresters.

Each M.E.M. or M.F. student completes a masters project, both as a written paper and as an oral presentation. The masters project topic often stems from internship work.

Students planning careers primarily in university teaching and research are urged to follow a course of study in the Graduate School. The graduate degrees are appropriate for students desiring to concentrate their study and research within a well-defined subject area. Students usually pursue fewer and more advanced topics to a greater depth than do students in professional degree programs. Graduate School students emphasize 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 Ph.D. candidates as research assistants. The prospective Ph.D. student should consult the Bulletin of the Graduate School for more detailed information.
Individually designed programs of study related to natural resources and the environment are possible under either the professional or graduate degrees, with faculty approval.

**Requirements for the Professional Degrees**

A total of 48 units is required for either the Master of Environmental Management (M.E.M.) or the Master of Forestry (M.F.) degree. At least 36 units and at least 3 semesters must be completed in residence at Duke. No more than 12 units may be completed through independent study off campus. All students must pay full tuition for four semesters, regardless of residence. Transfer credit is not accepted.

Students’ programs consist of a combination of regular courses, independent projects, and seminars. A master’s project of 4 to 6 units is required of all students. Course work in other departments of the university and at nearby institutions is available to strengthen students’ education in special areas.

A full semester load is 12 units, which should ordinarily consist of a combination of regular courses, independent projects, and the master’s project. Many students take more. Permission of the student’s advisor is required to take more than 15 or fewer than 9 units in a semester.

**ONE-YEAR MASTER OF FORESTRY OPTION**

Students who have an undergraduate degree in forestry may earn a Master of Forestry degree with only 30 units of credit. To be admitted to 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.

**SPECIAL DEGREE TRACK FOR PRACTICING PROFESSIONALS**

The Nicholas School of the Environment offers a special professional master’s degree track, through the Senior Professional Program, that allows a reduced term of residency.

Candidates with at least five years of work experience in an environmental field may be admitted to the Nicholas School of the Environment as part-time students. These professional degree candidates must spend one semester at Duke enrolled in regular, graduate level courses. Up to 15 units of credit are taken during this time. The remaining 15 or more units of credit required for a Master of Forestry or Master of Environmental Management degree may be earned through continuing education intensive courses, independent study, and a master’s project. Candidates have five years from the date of acceptance to complete the credit requirements.

Specific degree requirements for students in the Senior Professional Program, including required courses and the number of academic units necessary to complete the degree, are established by the student’s advisor upon evaluation of the individual’s previous education, work experience, and career goals.

**ENVIRONMENTAL SCIENCE AND MANAGEMENT FELLOWS PROGRAM**

The Nicholas School of the Environment has partnered with the National Urban Fellows Inc. to offer a special program to outstanding minority applicants. The 21-month fellowship involves an academic year of study in the Nicholas School and a 12-month mentorship assignment with a senior environmental scientist or administrator. To qualify for this fellowship, applicants must have a strong undergraduate academic background, demonstrated leadership ability, be a U.S. citizen and have a minimum of five years of experience in the environmental field. For more information and an application, contact National Urban Fellows Inc., 55 West 44th Street, Suite 600, New York, NY 10036 or telephone 212-921-9400.
Concurrent Degrees

Master of Environmental Management and Master of Forestry. Students desiring to earn both the M.E.M. and the M.F. degree can do so by planning their courses appropriately. The requirements for earning both degrees are as follows:

1. The student must qualify for either the M.E.M. or M.F. degree by earning 48 units of credit under the requirements set forth above.
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. The masters 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 problems. To integrate training in these management techniques more effectively into the curriculum, the Nicholas School of the Environment has developed a cooperative arrangement with Duke's Fuqua School of Business. 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 school are required to receive the M.E.M. or M.F. degree. A typical program sequence would involve spending the first year in the Nicholas School of the Environment followed by a year in the Fuqua School of Business and concluding with the final year of combined work in both schools. There is, however, flexibility in which program the student commences study.

These concurrent degrees stress concepts, analytical reasoning, and the basic methodologies of management science, while providing the student with a knowledge of current problems in the natural resource industries. Managerial economics, resource economics, organization theory and management, accounting, information and control, resource management, the legal environment, and 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 must apply to and be accepted by each of the respective schools. 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, N. C. 27708-0104.

Master of Public Policy. As issues concerning natural resources and the environment have become of increasing significance to the nation, there has developed a corresponding need for well-trained policy analysts who can provide timely and appropriate information and analysis to resource policy makers. To meet this need a unique concurrent degree has been developed in cooperation with the Terry Sanford Institute of Public Policy. Students pursue a Master of Environmental Management or Master of Forestry degree and a Master of Public Policy. Doctoral candidates in forestry and the environmental sciences are also eligible to undertake the Master of Public Policy.
The concurrent degree takes two and one-half years to complete. The first year is typically devoted to study in the Terry Sanford Institute of Public Policy, and the second year and a half is typically spent in the Nicholas School of the Environment. At least 36 units of credit within the school are required to receive the M.E.M. or M.F. 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.

This 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.

Students must apply to and be accepted by both the Nicholas School of the Environment and the Institute. For detailed information on the public policy degree, write to Director of Graduate Studies, Terry Sanford Institute of Public Policy, Duke University, Box 90240, Durham, N. C. 27708-0240.

**Juris Doctor in Environmental Law.** 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 or Master of Arts and Juris Doctor degrees.

For students in the concurrent M.E.M./J.D. program, the Nicholas School of the Environment requires 36 units of credit. The School of Law requires 72 units of law credit and awards 12 units for work done in the Nicholas School of the Environment.

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. M.E.M./J.D. candidates must apply to and be accepted by both the Nicholas School of the Environment and the School of Law.

For students in the concurrent A.M./J.D. degree, 30 units of credit are required in the Department of the Environment of the Graduate School, of which 24 must be graded, and 72 units in the School of Law. Further information is available from the Director of Graduate Studies. A.M. students are not required to write masters projects.

For information on the law degrees, prospective students should write to the School of Law, Admissions Office, Duke University, Box 90393, Durham, N.C. 27708-0393.

**Masters of Arts in Teaching.** Over the last several decades, international concern for protecting our ecosystem has led to an increased understanding of the need to broadly educate citizens on the challenges facing our environment. This increased awareness is demonstrated through the development of numerous education programs aimed at K-12 students as well as to 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 need by earning a Master of Environmental Management (M.E.M.) and a Master of Arts in Teaching (M.A.T.) degree.

Students must complete 36 units of credit in the Nicholas School of the Environment, including a master's project. For the M.A.T. degree, students will complete 30 units of credit, including the full-year internship.

For the M.A.T. degree, students will complete all requirements for the North Caro-
lina teaching licensure in comprehensive science. Competencies required by the state will be met through undergraduate courses taken prior to admission to Duke, science courses taken as part of the M.A.T., or courses taken as part of the M.E.M.

Students will normally enroll in the M.A.T. program prior to enrolling in the M.E.M. program.

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 M.A.T. 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. The individual program of study will require additional preparation in the sciences and education in addition to a full-year teaching internship under the direction of a mentor.

Questions concerning the M.A.T. degree should be addressed to the Director of the Master of Arts in Teaching Program, Duke University, Box 90093, Durham, N.C. 27708-0093; telephone (919) 684-4353.

Other Concurrent Degrees. 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 36 units of credit and normally be in residence for three semesters.

To gain acceptance of a specially designed concurrent degree, the student must show an official acceptance from another certified graduate degree program. In order to receive the M.E.M. or M.F. degree, the student must have completed 36 units of credit, the master's project, all program area requirements, and all the degree requirements for the other degree program (with an official transcript of work completed). For additional information concerning special concurrent degrees, applicants should consult the Office of Enrollment Services.

Graduate Degrees

The Doctor of Philosophy (Ph.D.) degree in disciplines related to earth and ocean, environmental and marine sciences is administered by the Graduate School of the university; however, the bulk of the instruction, research, and advising connected with it takes place in the Nicholas School of the Environment. Policy and procedures for admission, general requirements for degrees, registration, and academic regulations are given in detail in the bulletin of the Graduate School and are not repeated here.

Qualification of Students. Students seeking admission to the Graduate School must have received an A.B. or B.S. 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 graduate education and of the school's mission, the student's undergraduate record must evidence the capability and motivation to carry out independent study and research at an advanced level.

Admission. Applicants for Ph.D. are encouraged to use The Graduate School's electronic application. The address is http://www.gradschool.duke.edu. For those applicants who are not able to access the Internet, applications may be obtained from The Graduate School Admissions Office, Duke University, Box 90065, Durham, NC 27708-0065. It is important to emphasize that an individual faculty member must accept responsibility for advising an applicant before admission can be offered. Therefore, individuals considering application are encouraged to send inquiries about specific
degrees and programs of study to the appropriate area of the Nicholas School in which their potential advisor resides. The brief summaries of individual faculty research interests at the beginning of this bulletin should help you decide where you should send your inquiry. Direct contact with individual faculty is also encouraged. To facilitate this, each faculty member's e-mail address is provided at the end of the statement of research interests.

Inquiries about programs and research in earth and ocean sciences should be sent to the Director of Graduate Studies, Division of Earth and Ocean Sciences, Nicholas School of the Environment, Box 90227, Duke University, Durham, NC 27708-0227 (E-mail: bouldreau@eos.duke.edu).

Inquiries about programs and research in environmental natural and social science on the Durham campus should be sent to the Director of Graduate Studies, Nicholas School of the Environment, Box 90328, Duke University, Durham, NC 27708-0328 (E-mail: nettleto@duke.edu).

Inquiries about programs and research in environmental natural and social science at the Marine Laboratory in Beaufort should be sent to the Director of Graduate Studies, Nicholas School of the Environment, Duke Marine Laboratory, 135 Duke Marine Lab Road, Beaufort, NC 28516-9721 (E-mail: ritt@duke.edu).

Any of the above three contact points can arrange to have application materials sent to the applicant. Information about the Nicholas School of the Environment, its various degree programs and the faculty research interests can also be found at the following three World Wide Web addresses: www.env.duke.edu, www.geo.duke.edu and www.env.duke.edu/ marinelab/ marine.html. Applicants should refer to the current Bulletin of Duke University Graduate School for the requirements for the various degrees offered by the Graduate School.

The priority application deadline is December 31. However, applicants are encouraged to apply by December 1, if possible. Applications postmarked after this deadline will not be considered until all on-time applications have been processed. Applications received by December 1 require a $65 application fee, as opposed to $75 for those received after that date.

Undergraduate Degree in Environmental Sciences and Policy

A Bachelor of Arts degree with a major in environmental sciences and policy is available to Duke undergraduates interested in the interdisciplinary study of environmental issues. The major permits students to combine studies in the natural sciences and engineering with courses in the social sciences and humanities around general focus areas and themes. The major is specifically designed for students with career objectives such as environmental law, policy, management, or planning and an interest in environmental issues that cross traditional disciplinary boundaries. Courses for the major are taught by more than sixty Duke professors in nineteen cooperating departments and schools.

Students interested in the Environmental Sciences and Policy Program should consult the Duke University Bulletin of Undergraduate Instruction, available from the Office of Undergraduate Admissions, for further information. The program is administered through Trinity College of Arts and Sciences; a member of the Nicholas School of the Environment faculty serves as director.

Undergraduate Degree in Geology

A Bachelor of Arts degree with a major in geology is available to Duke undergraduates interested in all branches of the earth sciences including coastal geology, environmental geology, hydrology, geochemistry, geomorphology,
geophysics, paleontology, petrology, sedimentology, and marine geology. The degree requirements emphasize a broad knowledge of both geology and the associated physical sciences. An option is available for one semester of study at the Duke University Marine Laboratory in Beaufort, N.C., to fulfill elective requirements for the degree.

Students interested in the Geology Program should consult the Duke University Bulletin of Undergraduate Instruction, available from the Office of Undergraduate Admissions, for further information. The program is administered through Trinity College of Arts and Sciences; a member of the Nicholas School of the Environment faculty serves as director.

**Nondegree, Special Status**

Persons interested in pursuing graduate or professional studies in natural resources not leading to a degree may apply for nondegree, special status. Such students may take from 3 to 12 units of course work each semester; they are registered with the university as a student with appropriate privileges and they receive transcripts of work completed for each semester in residence. If the student later applies for admission into a regular degree program, some of the courses may count toward the degree. Students wishing to study for only one or two semesters or to do postdoctoral work should apply for nondegree, special status. Additional requirements are contained in a later section on admissions.
Academic Regulations
Planning
The responsibility for the specific content of the academic plan of study rests with the student. A thorough familiarity with and understanding of the regulations contained in this bulletin as well as other sources provided by the school are essential to sound planning.

During the fall term each student is assigned a permanent faculty adviser. The adviser should be consulted in planning a course of study. Other members of the faculty, particularly those concerned with the plan of study, should also be consulted on an informal basis. Reassignment to another adviser can be obtained, but only when approved by the assigned adviser and the prospective adviser.

Registration
Entering students who register for the Master of Environmental Management or Master of Forestry degree will receive instructions by mail from the Nicholas School of the Environment a few weeks before the start of the fall term. Registration should be completed during the orientation week. Students in residence register for succeeding semesters at times scheduled in the university calendar.

Registration is approved by the adviser and completed by the student using a telephone 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 will be completed.

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

Change of Registration. With approval of the adviser, the student can change registration for a period of ten days at the beginning of each semester.

Refunds. Tuition refunds are governed by the policy stated in the chapter on financial information.

Graduate School Registration. Students in Ph.D. degree programs initiate registration through the director of graduate studies of the Nicholas School of the Environment and complete it through the telephone registration system. Registration requirements and procedures are described in the Bulletin of the Graduate School.

Reciprocal Agreements. Students enrolled full-time in the Nicholas School of the Environment or in the Graduate School during the regular academic year may enroll
for six hours of credit per semester at the University of North Carolina in Chapel Hill, North Carolina State University in Raleigh, or North Carolina Central University in Durham provided that they are also registered for at least six hours of credit at Duke during the same semester. Similarly, graduate students in these schools may take up to six hours per semester at Duke. A student enrolled for two or more courses during a summer at Duke may take one of the courses at one of the neighboring institutions under the reciprocal agreement. 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.

**Immunization Requirement**

The North Carolina immunization law requires students entering a college or university in the state to be immunized against the following diseases: 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. A list of courses to be offered during a particular term, as well as schedules of courses offered in other departments at Duke and at neighboring universities, are available from the Office of Enrollment Services prior to registration for that term.

**Independent Study.** All students are expected to place increasing emphasis on independent study as they near completion of residence. Independent study can involve many different topics and students register to take independent study credit under Environment 299. Several students can work together under the supervision of a faculty member by registering for Environment 200.

**Master's Project.** All students must complete a master's project of 4 to 6 credits. The project should be identified during the first term of study and initiated during the second and third 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 adviser and has been received by the school's

**Enrollment Services Office.** 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 on actual natural resource or environmental problems. If desirable, arrangements can be made by the student or the school for consultation with other organizations concerning the scope and objectives of the project. Students maintain close contact with their advisers 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 final draft of the project must be delivered to the adviser prior to October 1 for those graduating in December, prior to March 1 for those graduating in May, and prior to August 1 for those graduating in September. The adviser is responsible for critical assessment and grading.

**Auditing.** Students registered for a full course load may audit courses free of charge. Otherwise, the audit fee is $850 per course. In classes where 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.
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.

Intensive Courses. For the special intensive courses, students may register during the semester two weeks prior to the first day of the course. Students may not register for more than two intensives in a semester without permission of their adviser 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 adviser must be retaken if failed. Courses prerequisite to more advanced courses the student wishes to elect 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.

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. The normal registration to reach the required minimum units of credit is 12 units per semester, although a variation from 9 to 15 units is common. Students must have the permission of their adviser 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.

Summer Registration. Professional degree candidates are normally not required to register for summer courses. However, a student who wants to supplement his or her graduate work with courses during the summer may do so through the Duke University telephone registration system. The cost is at the part-time rate per unit, and a summer health fee is assessed for students studying on campus. Summer registration does not affect the number of units, semesters in residence, or flat-fee tuition for the regular academic year.

Grades

The grading system used in the Nicholas School of the Environment and the Graduate School is as follows: E (exceptional); G (good); S (satisfactory); F (failing); I (incomplete); Z (continuing).

The grades of P (pass) and F (fail) are used in the Nicholas School of the Environment 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.

The grade of Z is assigned for an independent project or a master's project which extends over a period of more than one semester; a final grade is given upon completion of the project. Credit hours for a course completed on a pass/ fail basis are creditable toward the master's degree as long as the course is not required in the student's major area of study. Permission for the pass/ fail option must be obtained in writing from the instructor upon registration for a course.

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 a grade of Incomplete is assigned by an instructor 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 of the Environment may extend the time for completion of the course requirements. If, in the judgment of the professor and the student's adviser, 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.** Any course for which a failing grade is received must be retaken or replaced with a substitute course. A substitute course requires the approval of the student’s adviser and the education committee. 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 (see the sections on probation and dismissal and automatic dismissal).

**Probation and Dismissal.** Students are subject to dismissal from the school under any one or a combination of the following factors:
1. no grades higher than S during the first semester of study;
2. less than 6 units of G and/or E grades during the first full year of study;
3. a grade of F in any course at any time.

An appeal may be submitted through the adviser to the education committee to continue study under a probationary status. Probationary terms, set by the adviser, must be specific in the appeal and the appeal must be approved by the education committee. If probationary terms are met, the student will be returned to regular status. If probationary terms are not met, the student will be dismissed. Students will not be awarded degrees while on probationary status.

**Automatic Dismissal.** A student is automatically dismissed upon failure of more than one course.

**Honor Code**

The Nicholas School of the Environment advocates the highest standard of professional ethics and academic integrity. Students and faculty have developed an honor code for the school which is distributed to all students prior to matriculation and discussed during orientation.

**Academic Irregularities**

All cases falling outside the regular policies and procedures of the school are referred to the education committee for decision. The work of the committee includes review and decision regarding course requirements for graduation, student probation and withdrawal, student petitions for waivers of degree requirements, and all actions which deviate from established academic regulations.

A student who desires to petition the committee should do so by writing to the chairman. 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 chairman.

**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. Transcripts of credit are issued only by the Office of the University Registrar, 103 Allen Building. 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, either full-time or part-time, 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. 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 must make a written request to do so. For refunds upon withdrawal, see the chapter on financial information.

Application for the Degree

Even if degree plans are tentative, a candidate for a degree must file an application for the degree at the designated time for each semester. The application for the degree 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 file a new application.

Graduation

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 file a notification with the dean, not later than four weeks prior to commencement, seeking permission 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 withdrawal from the university.
Professional Programs
In the Nicholas School of the Environment, emphasis is placed on maintaining the highest standards of scholarship and on relevance to contemporary needs in natural resources study and research.

The school emphasizes three broad conceptual areas in its instruction and research: natural resource and environmental science, resource economics and policy, and quantitative methods of analysis and decision making. Regular courses, intensive courses, seminars, and special studies are offered in each of the three areas. Preparation for professional employment requires a higher degree of specialization than is characterized by this framework, however. Hence, six programs of study have been designed by the faculty to assure professional competence in some aspect of natural resources while offering adequate breadth of educational experience. One of these programs, Forest Resource Management, is offered under the Master of Forestry degree. The remaining five: Coastal Environmental Management; Environmental Toxicology, Chemistry, and Risk Assessment; Resource Ecology; Resource Economics and Policy; and Water and Air Resources are offered under the Master of Environmental Management degree.

Ph.D. candidates may also use these programs as a foundation for their course work. Qualified students who have interests outside of the structured programs are permitted to design individual programs of study. Pursuit of an individual program requires preparation of a comprehensive statement of objectives and specification of each of the program components: major courses, quantitative courses, seminars, electives, and a master's project. All individual programs of study are subject to approval by the education committee. Students who wish to pursue an individual program of study must request approval of their program by the end of their second semester of enrollment.

Program Requirements

Each of the school’s professional programs requires the completion of 48 units of graduate credit. These units are distributed among a set of core courses constituting the major, quantitative courses, electives, a master's project, and seminars relevant to the program's objectives. These broad categories are discussed briefly below, and major (core) courses are listed for each program. More specific information about requirements for any one of the programs can be obtained from the Office of 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 C toward their degree requirements.

Major (Core) Courses. Each program requires a series of core courses in the major area of study. These courses are specified or, in some cases, elective within the limits of the program emphasis.

Quantitative and Analytical Courses. All programs require 6 to 12 units in quantitative and analytical methods related to natural resource analysis, modeling, and management.

Elective Courses. Elective courses are available to give the student flexibility in developing his or her course of study. These credits are used to add depth to the major area of study or to develop a second area of expertise. Students who select the Resource
Economics and Policy program and who have not had previous training in a natural resource area must use at least three of their elective courses to meet this requirement.

**Master's Project.** A master's project constituting 4 to 6 units of credit is required. These projects take the form of individual or small group research efforts related to some area of natural resource management.

**Seminars.** All students are required to participate in seminars in their program area for 1 unit of credit. During their last semester in residence, students present the results of their master's project in a school-wide symposium.

### Coastal Environmental Management

The Coastal Environmental Management (CEM) 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 and state agencies, industry, consulting firms, and nonprofit organizations. The program also provides a firm foundation for future Ph.D. studies.

The first year of the program is usually spent on the Durham campus fulfilling the required courses in areas such as natural resource economics, general environmental policy, ecology, and methodological skills. The second year is usually spent in residence at the 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 in the coastal and marine environment, and for interaction with coastal and marine constituencies and policy makers in the application of science to policy. Potential for participation in the policy-making process are emphasized throughout the program.

The Coastal Environmental Management program is offered under the Master of Environmental Management degree. The program provides an educational background in ocean science and coastal ecosystems and in natural resource and environmental policy as it applies to coastal and marine issues. Students may use electives and additional coursework to accommodate a second emphasis in one of the other program concentrations offered within the school.

**Core Courses.** ENV 276 Marine Policy; ENV 270 Resource and Environmental Economics; one additional policy course; one ecology course; and two ocean science courses.

### Environmental Toxicology, Chemistry, and Risk Assessment

The Environmental Toxicology, Chemistry, and Risk Assessment (ETCRA) program is concerned with the transport and fate, effects, and risks of pollutants to natural ecosystems and human users of those systems, as well as linkages between ecological and human health. ETCRA is a multidisciplinary program incorporating the concepts, information bases, and methodologies of ecology, toxicology, environmental chemistry, and risk assessment. The goal of the program is to produce scientists and environmental managers with a solid foundation in the principles underlying pollutant fates and impacts, 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.

Duke offers exceptional opportunities for training in environmental toxicology, chemistry, and risk assessment. Environmental toxicology is a key component of the university-wide Integrated Toxicology Program. Additionally, the ETCRA curriculum
Environmental toxicology, chemistry, and risk assessment is offered under the Master of Environmental Management degree. Students in the program are required to take a common core of courses that includes environmental toxicology and chemistry, ecology, environmental economics and policy, and statistics and risk assessment. Additionally, students are encouraged to develop a concentration in one of four specializations: environmental toxicology, environmental chemistry, environmental risk assessment, or occupational/environmental health and safety. A research track is available in this program.

Core Courses. ENV 212. Environmental Toxicology; ENV 240. Fate of Organic Compounds in the Aquatic Environment or ENV 242. Environmental Aquatic Chemistry or ENV 279. Atmospheric Chemistry: Principles and Processes; one course in epidemiology or risk assessment; one course in ecology; one course in environmental economics, policy, or law; and one course in statistics.

Forest Resource Management

The Forest Resource Management (FRM) program integrates forest ecology and management within an educational program that also emphasizes related environmental fields. The program builds knowledge in basic forest ecology and management and integrates this knowledge with a foundation in a wide range of potential specialization areas. This distinctive approach is brought about by coordination of a core set of forestry coursework in quantitative measurement, dendrology, silviculture, ecology, economics, sampling, and management; in combination with electives in resource-oriented courses such as soils, hydrology, air and water quality, biological conservation, and physiology; statistical and modeling analysis; and courses in 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 ecologic and management systems. Within the program, students have the flexibility to gain depth in an area of specialization. Consequently, students may acquire skills that qualify them for positions in forest products industries, conservation organizations, government agencies, nonprofit organizations, and other groups involved with the use and conservation of forests. Students can develop credentials for employment by jointly completing this program and also a Master of Environmental Management degree in the Nicholas School of the Environment, a Master of Business Administration degree in the Fuqua School of Business, a Master of Public Policy degree in the Terry Sanford Institute of Public Policy or a Juris Doctor degree in the Law School. The program can provide an excellent foundation for the Ph.D. and a career in research.

Forest Resource Management is offered under the Master of Forestry degree. Students may use electives and additional coursework to accommodate a second emphasis or a second master's degree (MEM) in another program area within the school.

Core Courses. ENV 201. Forest Resources Field Skills; ENV 205L. Silviculture: Ecological Management of Forest Systems; ENV 206. Forest Vegetation Sampling; ENV 213. Forest Ecosystems; ENV 270. Resource and Environmental Economics; plus one additional course in each of three broad categories: forest resource principles, practices, and management.
Resource Ecology

The specific objective of the Resource Ecology (RE) program is to train professionals for management or technical support positions with state or federal natural resource agencies, non-profit conservation and environmental organizations, regional planning bodies, resource management companies, and consulting firms. Graduates of the program have practical experience with the analysis of ecological problems such as species conservation, flooding, habitat restoration, disturbance and mitigation of wetlands, integrated pest management, soil conservation, and mining reclamation.

A strong background in quantitative methods is required of students in this program, as it is for other programs offered by the school. Mathematical and conceptual models are invaluable in clarifying and solving environmental problems. They are essential to describe basic biophysical and biogeochemical processes, to test hypotheses, and to predict and interpret the response of ecosystems to management and disturbance.

To promote specialization within an otherwise broad field, the program has four tracks: biological conservation, forest ecology, landscape ecology, and wetland ecology and management. The student selects a track that best matches their interests; this decision helps to determine core coursework and electives.

Resource Ecology is offered under the Master of Environmental Management degree. Students may use electives and additional course work to accommodate a second emphasis in another program area within the school.

Resource Economics and Policy

Society long has had laws and institutions aimed at regulating the use of natural resources such as forests, wetlands, wildlife, water, and minerals. During the past few decades, new institutions have been developed to deal with problems of water and air pollution, toxic substances, and related areas of environmental degradation. These institutions demand a professional who has the necessary expertise to staff both public and private decision-making bodies.

The Resource Economics and Policy (REP) program is designed to train decision makers and those who advise them. The program emphasizes the basic methods needed by the professional for analyzing existing policy and for testing the possible outcome of new environmental and resource policy being considered by public and private agencies. The program is highly analytical and is oriented toward the analysis of contemporary national and international environmental problems.

Decision making in natural resource and environmental policy 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 methods required for using knowledge from the physical, biological, and social sciences to arrive at a decision.

Courses relevant to renewable and nonrenewable natural resources may be part of the student’s educational background or may be planned as part of the master’s degree. For the natural resource decision maker, the most important social sciences are resource and environmental economics, political science, and legal analysis. Economics includes environmental economics, the economics of public goods and externalities, public finance, and the intertemporal allocation of natural resources. Political science includes the behavior of administrative agencies, regulatory agencies, and legislative bodies. Legal analysis emphasizes the allocation of resources as reflected in property rights and environmental risks as reflected in torts. Quantitative methods, an essential component of this program, include statistical inference, benefit-cost analysis, and geographic information systems.
Resource economics and policy is offered under the Master of Environmental Management degree. Students may use electives and additional course work to accommodate a second emphasis in another program area within the school. Specializations are also available in international environmental policy, and marine and coastal zone management policy.

Core Courses. ENV 270L. Resource and Environmental Economics; ENV 274. Resource and Environmental Policy; and one of the following: LAW 327. Environmental Law; ENV 281 Resource and Environmental Law, or LAW 241. Environmental Law (UNC).

Doctoral Program. Students accepted for a doctoral program in resource economics and policy must have significant previous training in economics, political science or another social science. Doctoral candidates in resource and environmental economics must take substantial course work in Duke's Department of Economics and pass the department's qualifying examinations in economic theory. Doctoral candidates in resource and environmental policy must take substantial course work in political science, public policy or political economy in relevant departments at Duke or cooperating universities.

Water and Air Resources

The program in Water and Air Resources (WAR) enables students to obtain a scientific understanding of the basic physical and chemical processes affecting these natural resources and trains students to apply this understanding, together with quantitative, analytical and statistical techniques, to the management of these resources. Emphasis is placed on understanding the following: effects of land resource management on water quality; water quantity and transport; water and atmospheric chemistry; and air pollution.

Course work 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 those concerned with watershed hydrology; stream and lake water quality; water 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 others in water and air resource management, and economic analysis.

Graduates of the program have the skills to become analysts or consultants for private industry and public agencies 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.

Water and Air Resources is offered under the Master of Environmental Management degree. Majors in the program can select an area of concentration: water resources, air resources, or a combination of water and air resources. Students may use electives and additional course work to accommodate a second emphasis in another program area within the school. A research track is available in this program.

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; plus three additional courses in the area of concentration.
Professional Versus Graduate Admissions

The student contemplating postbaccalaureate study at Duke in natural resources and the environment or geology enters either the Nicholas School of the Environment or the Graduate School depending on the choice of degrees. The professional degrees, consisting of the Master of Environmental Management (M.E.M.) and Master of Forestry (M.F.), are administered by the Nicholas School of the Environment. Students wishing to earn either of these professional degrees should apply directly to the school. Those wishing to earn a Doctor of Philosophy (Ph.D.) or Master of Arts (A.M.) degree should apply to the Graduate School. This chapter describes application to Nicholas School of the Environment professional degree programs.

Admission to the Nicholas School of the Environment

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 is open to men and women 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. Admission as a special or nondegree 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;
2. At least one introductory course in calculus;
3. A statistics course that includes descriptive statistics, probability distributions, hypothesis testing, confidence intervals, correlation, simple linear regression, and simple ANOVAs;
4. A working knowledge of microcomputers for word processing and data analysis.
Each program requires additional courses or recommends additional preparation, as follows:

- Coastal Environmental Management: microeconomics;
- Environmental Toxicology, Chemistry, and Risk Assessment: significant undergraduate education in biology and chemistry, with a course in organic chemistry required;
- Forest Resource Management: microeconomics, introductory ecology;
- Resource Ecology: microeconomics, introductory ecology;
- Resource Economics and Policy: microeconomics;
- Water and Air Resources: microeconomics; undergraduate training in chemistry recommended.

Although students without the level of preparation described above may be accepted for admission, it is expected that deficiencies will be made up prior to enrollment in the Nicholas School. 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 M.E.M. or M.F. degree.

**Admission Criteria.** Admission to the Nicholas School of the Environment is highly selective. Academic performance as an undergraduate, scores on the Graduate Record Examination, and work experience are the primary factors considered in the application review process. Recommendations, the statement of educational goals, extracurricular activities, and other information requested on the application also provide a basis for selection.

The admissions committee considers each applicant as an individual. It attempts to evaluate 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 work experience are encouraged to apply since work experience strengthens an application.

**Application Procedures.** Application for admission to the Master of Environmental Management and the Master of Forestry degrees is made through the Office of Enrollment Services of the Nicholas School of the Environment. All correspondence should be addressed as follows: Office of Enrollment Services, Nicholas School of the Environment, Duke University, Box 90330, Durham, N.C. 27708-0330.

Students are admitted at the beginning of the fall term, and spring term, provided that space is available. For the fall, 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 and no guarantee is made that applications received after the February 1 priority deadline will be considered.

Students who, because of unusual circumstances, wish to begin their studies in January should complete their application no later than October 15 prior to their matriculation.

Each applicant must submit the following before action can be taken. It is preferable that all materials be submitted together.

1. application form;
2. two copies of transcripts from each undergraduate and graduate school attended;
3. three letters of recommendation;
4. scores on the general (verbal, quantitative, and analytical) test of the Graduate Record Examination, taken within the last five years;
5. a nonrefundable application fee of $65 prior to January 1 and $75 after January 1.
6. certificate of financial responsibility and TOEFL scores, if the applicant is an international student;
7. undergraduate dean's approval for students applying through the Cooperative College Program.

Application Forms. No applicant will be considered until the completed application form and all related documents are received by the Office of Enrollment Services. 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 a concept of the value of professional education to the applicant's career plans and expectations.

Transcripts. Two copies of official transcripts of all undergraduate and graduate study should be sent to the Office of Enrollment Services in the application package in sealed envelopes that have been signed across the flap by the registrar of the institution attended.

Letters of Recommendation. Each applicant is required to submit three letters of recommendation, preferably on the form supplied with the application. These letters should be sent in the application package in sealed envelopes that have been signed across the flap by the writer. These recommendations provide the admissions committee with evaluations of the applicant's past performance in academic and employment related situations. Although recommendations from any source are acceptable, it is preferable that as many as possible come from college instructors.

Graduate Record Examinations. All applicants for degree programs must take the general test (verbal, quantitative, and analytical) of the Graduate Record Examination (GRE). 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, N.J. 08540. Applicants are requested to send copies of their reports to the Office of Enrollment Services but official reports from the Educational Testing Service are required before admission decisions can be made.

Application Fee. A nonrefundable application fee of $65 prior to January 1 and $75 after January 1 is required of all applicants. A personal check, money order, or cashier's check made payable to Duke University is acceptable. Applications will not be officially received or processed until the required fee has been paid.

Additional Procedures for International Students. Each year the Nicholas School of the Environment welcomes a number of international students among its professional and graduate candidates. Applicants from other countries must meet the same criteria as applicants from the United States. 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. 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, N.J. 08540-6151; telephone 609-771-7100. In cases where an appli-
cant’s TOEFL score is low, the applicant may be accepted on the provision that he/she complete an intensive English language program. Students found to lack necessary competences 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.

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.

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 school are encouraged to do so. The visit presents an excellent opportunity for the applicant to ask questions, gain insight into the school, and bring items of concern to the attention of the admissions committee. 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 and faculty are frequently away from campus. During the middle of the fall semester and near the beginning of the spring semester, formal visitation programs are hosted by the Office of Enrollment Services of the Nicholas School of the Environment. Interested individuals should contact that office at (919) 613-8070 for additional information.

Each year representatives of the school travel throughout the country to visit undergraduate schools. Applicants from the cooperative colleges should check with their program adviser for details of these visits. Applicants from other institutions interested in meeting with a representative of the school should write or call the Office of Enrollment Services. In addition, it is sometimes possible to arrange an interview with an alumnus, particularly where distance precludes travel to Durham. In all of these situations the emphasis is on exchanging information with the applicant.

For further information or to arrange a school visit, applicants may write to the Office of Enrollment Services or call (919) 613-8070.

Deferred Admission. Normally, applicants are admitted only to the class for which they have applied. However, a deferral of admission may be granted for the applicant to gain experience or to strengthen academic qualifications for graduate study or for other valid reasons. Except in unusual circumstances, a deferral of admission cannot be granted for more than one year. Deferral is granted on an individual basis. The size of each class frequently precludes open-ended guarantees of future admission; however, applicants with substantial reasons for deferring the start of graduate work are encouraged to send a request to the Office of 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.

Application Deadlines for the Professional Programs. Application forms and all other information required to complete the application and to allow a student to be considered for admission should be submitted to the Office of Enrollment Services by February 1 for the fall term and by October 15 for the spring term. All candidates for admission should make arrangements to complete the Graduate Record Examinations well in advance of these deadlines.
Offers of admission for the fall semester, including financial aid awards, are mailed to accepted students in March and offers of admission for the spring semester are mailed in late October. Decisions on applications received after the February 1 deadline are held until May and are made on an individual basis according to the availability of student spaces and financial assistance.

Response to Offer of Admission. When admission is approved, the applicant will receive an offer of admission and an acceptance form. 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 Enrollment Services. Failure to respond by the stated deadline may result in cancellation of acceptance.

Admission as a Senior Professional Program Participant

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 15 for the spring term. Normally, degree candidates in the Senior Professional Program take the required semester in residence during the term following admission.

Degree candidates enrolled through the Senior Professional Program are not eligible for financial assistance from the Nicholas School of the Environment. They may, however, be eligible for federally funded student loans during semesters of full-time enrollment.

Admission to the Graduate School

Applications for Admission to Ph.D. degree programs should be obtained from and returned to the Dean of the Graduate School, Duke University, Box 90065, Durham, N.C. 27708-0065. Applicants to these programs must follow the procedures and meet the deadlines specified by the Graduate School. Initial inquiries and questions concerning fields of study are best directed to the director of Graduate Studies, Nicholas School of the Environment. In addition, prospective students are urged to write directly to professors whose research interests match their own to discuss opportunities. Although the priority application deadline for the Graduate School is December 31, applicants are encouraged to apply by December 1.

Admission with Nondegree Status

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

Estimated Expenses for the Academic Year. The following approximate costs, applicable in 1999-2000, are indicative of costs that can be expected by M.E.M. and M.F. candidates; Ph.D. students should consult the Bulletin of the Graduate School.

Tuition ($9,450 per semester) $18,900
Student health fee ($222 per semester) $444
Student government fee ($9.50 per semester) $19
Recreation fee ($25 per semester) $50
Housing $4,200
Food $3,400
Books and supplies $810
Transportation $1,050
Motor vehicle registration
  automobile $76-186
  motorcycle $42

In addition to these necessary expenses, the student will incur others 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 $26,000 to $32,000 for the academic year. Students with families naturally will have higher expenses.

Flat-fee Tuition. The flat-fee 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

*The figures contained in this section are projections and are subject to change.
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.

Students in the two-year M.E.M. and M.F. programs will pay the flat-fee tuition for four semesters. Students in one of the concurrent degree programs will pay the flat fee for those semesters in which they are registered as full-time students in the Nicholas School of the Environment. Students in the concurrent M.E.M./M.F. program pay the flat-fee tuition for a minimum of five semesters. Students in the one-year M.F. degree option will pay the flat fee for two semesters.

If the student is permitted to be enrolled part time (fewer than 9 units), he or she will be charged per unit of credit ($850 per unit for the 1999-2000 academic year).

Students who wish to earn additional credits during the summer will be charged at the part-time rate per units of credit. 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 1999-2000) 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 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. If full payment is not received, a late payment charge as described below will be assessed on the next invoice and certain restrictions as stated below will be applied. Students interested in arranging a payment plan should contact Tuition Management Services, 42 Valley Road, Newport, R.I. 02842-6376; telephone 800-722-4867.

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. The penalty charge will be at a rate of 1.25 percent per month (15 percent per annum) 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, if delayed for reasons beyond the individual’s control, are treated as a credit on the student’s invoice until the loan payment is received.

Restrictions. An individual will be in default of this agreement if the total amount due is not paid by the due date. An individual who is in default 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 withdrawal 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 defined as the total school charges times the remaining portion 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 is after the 60 percent point in the period of enrollment. Sample refund calculations are available from the 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:

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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

This schedule also applies to housing charges of students moving from university housing to off-campus housing. The student health fee will not be refunded except when withdrawal occurs before classes begin. In the event of death, a full refund of tuition and fees will be granted.

**Late Registration.** Students who register at a date later than that prescribed by the university must pay a fee of $25 at the bursar's office.

**Audit Fee.** Students registered for a full course load may audit courses without charge. Otherwise, audit fees are $850 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 $30 fee that covers the request of transcripts. Transcripts cannot be issued by the Nicholas School of the Environment.

**Housing Charges.** On-campus housing for professional and graduate students is available on a limited basis. Questions regarding costs should be addressed to the Office of Housing Administration, Duke University, Box 90451, Durham, N.C. 27708-0451.

**Motor Vehicles.** Motor vehicles parked on campus must be registered with the parking services office. Registration must be completed within five days after operation on campus begins. The proper registration decal should be displayed on the vehicle. The automobile registration fee is $76 in ungated lots and $186 in gated lots. Motorcycle registration is $42.

**Student Health Fee.** All students are assessed a fee for the Student Health Service. For the fall and spring, the fee is $444 ($222 per semester). For the summer, the fee is $71 per term.

**Medical Insurance.** All resident students are automatically billed for health insurance at the rate of $778 per year (single student cost). Family plans are more and are available through the university bursar's office. A student who is covered under a family, group or individual major medical policy must sign a waiver form indicating that he/she does not wish to be covered by the university student insurance policy. All foreign students are required to register for student insurance (and for the family plan if they have a spouse or children living in Durham) unless they have valid documentation indicating major medical coverage acceptable in the United States.

**Tuition and Fees for the Summer.** For M.E.M. and M.F. students who wish to take additional credits during the summer, registration is charged per unit of credit ($850 per unit in summer 2000). The summer student health fee and audit fee are listed above. Information on fees, housing, policies and procedures related to the Duke University summer session is available from the Office of Summer Programs, The Bishop's House. Students who are interested in summer study in Beaufort should consult the Bulletin of the Nicholas School of the Environment Marine Laboratory.

**Recreation Fee.** A mandatory fee of $50 per academic year ($25 per semester) 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 a fee of $25 per semester, plus a $10 application 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 pursuing either the professional degrees (M.E.M. or M.F.) or the graduate degrees (Ph.D.). Students enrolled through the Senior Professional Program are not eligible for school supported financial assistance but may be eligible for federally funded student loans.

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. 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 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. For graduate students, it is the policy of the school to provide financial assistance through university funds for three years; it is expected that Ph.D. candidates will obtain research grants to fund their study past the third year. 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.

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 G and/or E 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.

Graduate degree candidates should review the Bulletin of the Graduate School for details regarding satisfactory progress for their degree program.

SCHOLARSHIPS

University Scholarships. A limited number of scholarships are awarded each year to selected students who are pursuing either professional or graduate degrees. Awards are made on the basis of academic qualifications and professional or scientific promise. Amounts of awards vary.

FELLOWSHIPS

C.G. Bookhout Scholarship Fund. The Bookhout Scholarship provides financial assistance to juniors, seniors, or beginning graduate students with a professional interest in the natural sciences.

Rachel Carson Graduate Fellowship. A fellowship is awarded to a selected student who is conducting research related to some aspect of the Rachel Carson Estuarine Research Reserve.

Barbara L. Dannenberg Endowment Fund Fellowship. A fellowship is awarded to a selected student, preferably in the field of ecology, who is involved in undergraduate education. The award ranges up to 9,000.

Doris Duke Environmental and Natural Resource Fellowships. Made possible by the Doris Duke Charitable Foundation, fellowships are awarded to 10 Doris Duke Fellows annually for two years of study at the Nicholas School of the Environment.

Environmental Science and Management Fellows Program. The Nicholas School of the Environment has partnered with the National Urban Fellows Inc. to offer a special program to outstanding minority applicants. The 21-month fellowship involves an academic year of study in the Nicholas School and a 12-month mentorship assignment with a senior environmental scientist or administrator. To qualify for this fellowship, applicants must have a strong undergraduate academic background, demonstrated leadership ability, be a U.S. citizen and have a minimum of five years of experience in the environmental field. For more information and an application, contact National Urban Fellows Inc., 55 West 44th Street, Suite 600, New York, NY 10036 or telephone 212-921-9400.

Federal Paper Board Company Fellowship. A fellowship is awarded each year to a selected student interested in a career in industrial forestry. The stipend ranges up to $3,000 per year.

Virlis L. Fischer Fellowship. A fellowship is awarded each year to a second-year Master of Environmental Management or Master of Forestry candidate with demonstrated financial need. The stipend is determined by the amount of endowment income each year.

Forestry and Environmental Studies Endowment Fund Fellowships. Made possible by a grant of the Cordelia S. May Charitable Trust, this fund currently provides multiple fellowships in the area of wetland research and restoration.

Leroy B. George Fellowship. A fellowship is awarded to a selected student from the Haywood or Buncombe counties or the Hendersonville, North Carolina, school systems. Second preference is given to a student from the southern Appalachian region. If a qualified student cannot be identified within the region the fellowship may be awarded to a student in the school who has a demonstrated interest in resource and environmental education and planning. The amount of the fellowship is approximately $4,000 per year.

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Charlotte H. and Robert Hay Endowment Fellowship. A fellowship is awarded annually to a selected student in forestry or environmental studies. The award ranges from $3,000 to $4,000.

Richard E. Hug Fellowship. A fellowship is awarded to a selected student who is pursuing a Master of Environmental Management or Master of Forestry degree. The stipend ranges up to $2,000 per year.

Melanie Elizabeth Lynn Memorial Scholarship. The Melanie Elizabeth Lynn Memorial Scholarship provides financial assistance to female graduate students for summer academic coursework.

Mary Derrickson McCurdy Graduate Fellowship. A fellowship is awarded to a selected student who is conducting research at the Nicholas School of the Environment Marine Laboratory.

Andrew W. Mellon Foundation Fellowship. Fellowships are awarded each year to selected students pursuing master’s or Ph.D. degrees. Stipends range from $1,000 to $5,000 a year.

Muchnic Foundation Endowment Fellowship. A fellowship is awarded each year to a selected student who has demonstrated financial need. The award ranges up to $2,000.

Nicholas School of the Environment Alumni Association Fellowship. Fellowships are awarded each year to selected students who are pursuing a Master of Environmental Management or Master of Forestry degree. The students must have completed one year of study. The amount of the fellowships is set at $2,000 per year.

Nicholas School of the Environment Alumni Association Minority Fellowship. A fellowship is awarded to a selected minority applicant for the Master of Environmental Management or Master of Forestry degree. The amount of the award is determined by the endowment income each year.

Elizabeth Reid Endowment Fund. Income from this fund is currently used for a fellowship for a selected student. The award is in the $2,500 range.

Robert Safrit Graduate Fellowship. A fellowship is awarded to a selected student who is conducting research in some aspect of marine science at the Nicholas School of the Environment Marine Laboratory.

Thomas and Anne L. Shepherd Endowment Fund. Income from this fund is currently used for multiple fellowships in the $3,000 to $11,000 range.

Harvey W. Smith Graduate Fellowship in Biological Oceanography. A fellowship is awarded to a selected student who is conducting research in biological oceanography at the Nicholas School of the Environment Marine Laboratory.

John and Blake Sullivan Endowment Fund. Income from this fund may be used for fellowship support of a selected student. Awards range up to $1,300.

James F. West Endowment Fund. Income from this fund is currently used for fellowships in the $3,000 to $8,000 range.

Frederick K. Weyerhaeuser Forest History Fellowship. This fellowship is available campus-wide to graduate students who wish to study broadly in the area of forest and conservation history. The annual stipend is $11,000. Inquiries should be made to the Forest History Society, 701 Vickers Avenue, Durham, N.C. 27701.

Sara and Lewis Zirkle Fellowship. Fellowships are awarded to selected students pursuing master’s or Ph.D. degrees. The stipend is determined by the amount of the endowment income each year.

INTERNSHIPS

David Brower Scholarship. Made possible by Dan and Bunny Gabel, the David Brower Scholarship provides a summer stipend for professional degree students so that
they may serve as interns in grassroots environmental organizations that exemplify David Brower’s uncompromising commitment to the environment.

**Whitney Lawson Chamberlin Memorial Internship.** Established by the family of Whitney Lawson Chamberlin, a first-year student at the Nicholas School of the Environment, the internship is awarded to a selected student to explore the interplay between business and the environment.

**Champion International Corporation Intern/Scholarship Program.** The Champion International Intern/ Scholarship program includes both an internship and scholarship. It provides first year M.E.M students an opportunity to compete for a paid summer internship with Champion and $10,000 tuition support for second year study.

**Doris Duke Internships.** Made possible by the Doris Duke Charitable Foundation, these internships are awarded to 10 Doris Duke Fellows for work with nonprofit conservation organizations or public sector agencies for 11 weeks each summer.

**Kuzmier-Lee-Nikitine Endowment Fund.** Established by family and friends in memory of Kerrie Hamilton Kuzmier, Stephen Farrow Lee, and Pavlik Andre Nikitine, the Kuzmier-Lee-Nikitine Endowment supports an international internship project each summer.

**Stanback Internships.** Made possible by Fred and Alice Stanback, the Stanback Internship program awards 30 or more conservation and policy internships each year for work with selected environmental organizations.

**ASSISTANTSHIPS**

**Assistantships for the Professional Degree Candidate.** Assistantships may be awarded to a select number of professional 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 10 hours a week on their assigned project. Assistantships require a regular schedule for work 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.

The hours of assistance may limit the number of credit hours for which a student may register. Normally, professional students who receive assistantships for 10 hours per week are limited to 12 units of credit per semester. Exceptions require the permission of the student’s adviser.

Most assistantships are paid by the school on the monthly payroll. For the 1999-2000 academic year, the award for 10 hours of assistance was $2,700. 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 stipends are paid on a biweekly or monthly basis.

**Teaching Assistantships for Ph.D. Candidates.** Each year a selected number of Ph.D. 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 ($1,422 per month in 1999-2000) requires up to 15 hours of work per week during the 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. While receiving a school-funded Teaching Assistantship, students are expected to devote their major effort on course work and research and are required to serve each semester as a teaching assistant.

These graduate assistants may be retained by the faculty through research funding for the remaining three months of the summer.

Typically, the Ph.D. candidate is assigned to a member of the faculty to work on a particular research project under his or her direction and/or to provide teaching assistance. Furthermore, the research undertaken is normally a part of the student’s graduate program and serves as a basis for the doctoral dissertation.
Graduate assistants are required to maintain a regular schedule of work as determined by the faculty member to whom each is assigned.

**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 Ph.D. 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 Ph.D. dissertation. However, in some instances this may not be the case and the students pursue dissertation research in a related area of study.

The academic year stipend is salary for research involving up to 20 hours per week. Some research assistantships require full-time service during the summer. A regular schedule of research under the direction of the principal investigator must be maintained.

**Work-Study.** Work-study funds are administered for student employment through the Office of 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 should file the Free Application for Federal Student Aid (FAFSA).

**Application for Awards for the Entering Student**

Application for awards 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 Enrollment Services on or before February 1 prior to enrollment.

**Notification and Acceptance of Awards.** Recipients of awards are notified in March. Completed applications received after the February 1 priority deadline will be considered if vacancies occur at a later date.

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 school that all awards offered can 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**

In terms of a needy student being able to afford the graduate program of his or her choice, federally insured student loans are often necessary and useful. Students should consider the nature of the loan and the positive and negative aspects of future loan payments, as well as 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 from a college or university counseling and placement center or financial aid office. No loan application will be processed without the FAFSA form having been submitted to the central processor. In addition, federal law requires, in some cases, verification of income and other information.

**Federal Stafford Loans.** Federal Stafford Loans of up to $18,500 ($8,500 subsidized and $10,000 unsubsidized) are available for eligible graduate/professional students. For loans made to new borrowers, interest is calculated at a variable rate, not to exceed 8.25 percent. Students who have outstanding loans retain their current interest rate. If a student is eligible for a subsidized Federal Stafford Loan, the interest is paid by the federal government while the student is enrolled in school. Interest on unsubsidized
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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 of the Environment’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 $18,500 for an academic year.

To obtain a Federal Stafford Loan, students may apply to either a state agency or a bank that participates in the program. A partial listing of lenders is available from the school’s Enrollment Services Office.

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 be desired or needed.

Federal Carl Perkins Loans. Loans through the Federal Carl Perkins program are administered through the university for students who qualify under the federal guidelines. The student must qualify as needy by the FAFSA form and in need of additional 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.

Duke Signature Select Loans. For students who need more funds than are available through the Federal Stafford Loan and the Federal Carl Perkins Loan programs, the University offers the Duke Signature Select Loan program. Through this program, students can borrow up to $12,500 without a co-signer or up to the cost of education (minus other aid received) with a co-signer. The interest rate on this loan is T-bill plus 2.5 percent while the student is in school and T-bill plus 3.1 percent during repayment. Repayment begins 6 months after graduation or dropping to less than half-time enrollment. Applications can be obtained by contacting the Office of Enrollment Services in the Nicholas School at (919) 613-8070.

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, requirements, and restrictions.
General Information

The Duke 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, coastal environmental management, marine biotechnology and marine biomedicine. The laboratory operates year-round to provide training, educational, and research opportunities to about 3,500 persons annually, including undergraduate, graduate and professional students enrolled in the university's academic programs; 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.

The resident faculty represent the disciplines of oceanography, marine biology, marine biomedicine, marine biotechnology, and coastal marine policy and management.

Location and Natural Environment

The Duke Marine Laboratory is situated on Pivers Island within the Outer Banks of North Carolina, only 150 yards across the channel from the historic town of Beaufort. A bridge connects the island with US Highway 70, making the laboratory readily accessible by automobile. Other transportation to the area consists of airline service via regional airports (New Bern, Kinston, and Jacksonville).

Beaufort is the third oldest town in the state and is surrounded by fishing and agricultural communities. The area is well known for its historic and scenic attractions as well as being a seaside resort. Cape Lookout National Seashore Park and the Rachel Carson Estuarine Research Reserve are within easy boating distance.

The area’s system of barrier islands, sounds, and estuaries is rich in flora and fauna, and diverse habitats, including rivers, creeks, mud flats, sand beaches, dunes, marshes, salt marshes, cypress swamps, bird islands, and coastal forests, making the area a haven for both nature lovers and those interested in the pursuit of marine science.

The laboratory is within range of both the temperate and tropical species of biota. The edge of the Gulf Stream oscillates between 30 and 40 miles offshore, with reefs on the wide continental shelf. A great variety of phytoplankton, seaweeds, seagrasses, and marsh grasses may be found in the area. Common animals include the blue crab, squid, shrimps, snails, clams, echinoderms, jellyfish, hydroids, sponges, polychaetes, sea urchins, starfish, brittle stars, sand dollars, skimmers, terns, gulls, herons, sea turtles, dolphins, and many species of fish. All provide ample opportunity for study and research and are readily accessible on foot, by car, or by boat.

The Beaufort-Morehead City area provides location for five other laboratories that collectively house one of the higher concentrations of marine scientists in the nation. These are the University of North Carolina’s Institute of Marine Sciences, the North Carolina State University Seafood Laboratory, the North Carolina Aquarium at Bogue Banks, North Carolina Division of Marine Fisheries; and the National Oceanic and Atmospheric Administration’s National Marine Fisheries Service, Beaufort Laboratory. This concentration of marine scientists provides a critical mass for the pursuit of science and education.
The Beaufort Experience

The Duke Marine Laboratory is an academic community, and the self-sufficient nature of its residential life serves well those who wish to study or to conduct research. The academic programs are limited to eighty students per regular academic semester (spring or fall) and one hundred per summer term, offering an unparalleled small-group learning experience. Although recreational opportunities are ample, the distractions are limited, allowing both student and researcher to become totally involved in the pursuit of marine science. Both students and researchers alike find that the Marine Laboratory has an invitingly open, friendly, and relaxed atmosphere that draws many back year after year. This community feeling, the potential for total immersion in learning, and the beauty of the natural environment have contributed to what has been called "The Beaufort Experience."

Teaching and Research Facilities

The Duke Marine Laboratory's modern physical plant consists of twenty-three buildings, including four dormitories, a large dining hall, one residence, a student commons, a storehouse for ship's gear, classroom laboratories, six research buildings, and a maintenance complex. The Marine Laboratory 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 for the National Science Foundation by the Duke/University of North Carolina Oceanographic Consortium.
The laboratory also maintains an electronics shop, workshop, stockroom, and purchasing department.

Each research laboratory building is air-conditioned and equipped with running seawater through a PVC system. There are tanks, water tables, aquaria, autoclaves, ovens, and outdoor continuous-flow growth facilities. In addition to commonly used laboratory equipment, the following are available: refrigerated centrifuges, fluorometers, spectrophotometers, balances, pH meters, both compound and inverted microscopes equipped with cameras and Nomarski optics, both fume and laminar flow hoods, liquid scintillation counter, constant temperature equipment, and HPLC.

The Marine Laboratory houses three Sun Sparc stations as well as two Duke University public access clusters, MAC and IBM-PC, all connected to the Internet. Available for use are thirteen 586-based workstations and two Power PCs with word processing and statistics programs.

The laboratory operates an AT-compatible computer for processing and analysis of static and moving images. Static images captured with a video camera and Targa-M8 framegrabber board can be analyzed by means of the JAVA software (Jandel Scientific). Graphical and printed output of results is possible using an HP 7475A plotter or an HP LaserJet printer. Moving images are recorded on video tape and analyzed using the Motion Analysis System (Celltrack Motion Analysis ExpertVision System, Motion Analysis Corp.). A video processor in an IBM/AT-compatible computer tracks objects and calculates direction of movement, velocity, and rate of change of direction. Statistical and graphics programs allow final processing of these data.

Color printing and scanning services are also available on the island.

Research and teaching facilities also include the I. E. Gray Library-Auditorium which houses the Pearse Memorial Library, a branch of the Duke library system providing access to print and electronic resources that support interdisciplinary education and research with a primary focus on the marine environment. Electronic resources include online full-text journals, and the Duke online catalog. The library currently subscribes to 60 research journals and maintains holdings of approximately 23,000 volumes. Two NT workstations with laser printing capability and a general access photocopier are provided for public use.

The library actively participates in interlibrary loan and document delivery arrangements with the triangle universities and other national and international academic institutions and research centers. Additional cooperative agreements exist with the National Ocean Service Center for Coastal Fisheries and Habitat Research, the University of North Carolina Institute of Marine Sciences, and the University of North Carolina at Wilmington.

Opportunities for Students

The resident faculty offer a wide variety of graduate courses in the marine sciences that are appropriate for students planning careers in basic or applied research and/or teaching, environmental management or policy sciences, or environmental health sciences. Courses are offered during both the academic year and the summer. Many Environment courses are cross-listed with the Graduate School Departments of Botany, Cell Biology, Public Policy Studies and Zoology. Graduate research or individual study courses are also offered. Most of the summer courses carry 4 or 6 units of credit and include laboratory and direct field or shipboard experience.

Students have access to all laboratory facilities and the opportunity to meet visiting scientists from around the world. Room and board are available, and summer tuition scholarships are offered on a competitive basis.

Further information and application materials may be obtained from the Admissions Office, Duke University Nicholas School of the Environment Marine Laboratory, 135 Duke Marine Lab Road, Beaufort, N.C. 28516-9721; telephone (252) 504-7502.
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 Hydrologic Science

Director: Stuart Rojstaczer, Associate Professor of Hydrology, Nicholas School of the Environment and Department of Civil and Environmental Engineering

From global climate change to flooding to hazardous waste storage, the science of hydrology plays a key role in many problems facing society. Hydrology is the study of the hydrologic cycle and its components on land. Rivers, lakes, plants, soils, rocks and snow and ice provide the storages for water on land. Hydrologists are concerned with the magnitude and chemistry of these storages over time and space and the rate of transfer of water from one storage to another. Key transfer processes include river flow, groundwater flow, evaporation, transpiration and soil moisture flow. Studies of these storages and transfer processes allow us to examine a variety of environmental problems and devise solutions for them.

The Center for Hydrologic Science, established in 1996 with funds from the provost's Common Fund, serves as an integrating center for hydrology research and graduate level hydrology education at Duke University. The Center's interdisciplinary nature reflects the interdisciplinary nature of the field of hydrology. The Center draws faculty
Research Centers

and their associated students and post-doctoral researchers from three schools at Duke: Arts and Sciences, Engineering and the Nicholas School of Environment. Many faculty hold joint professorships in two of the three schools.

Research specialties of the faculty include:

- Contaminant hydrology
- Environmental geophysics
- Forest hydrology
- Geomorphology
- Hydrogeology
- Mathematical models of multi-phase transport
- Micrometeorology
- Nutrient cycling
- Pollutant transport
- Remediation strategies
- Sediment transport
- Soil physics
- Surface chemistry
- Watershed hydrology

The broad range of faculty expertise in hydrology allows graduate students to obtain well balanced training in the classroom.

The center offers fellowships for graduate study in hydrology and organizes a lecture series that attracts speakers of international stature. Monthly colloquia are organized for student and faculty presentations from Duke as well as the nearby University of North Carolina at Chapel Hill and North Carolina State University in Raleigh. For students engaged in Ph.D. research the center offers a Certificate in Hydrology that is granted in addition to the Ph.D. degree in their host department.

The center is housed in the Old Chemistry Building on the Duke campus. The mailing address is Nicholas School of the Environment, Duke University, 106 Old Chemistry, Box 90230, Durham, N.C. 27708-0230; telephone (919) 681-8160, Internet http://www.hydro.duke.edu.

Center for Resource and Environmental Policy Research

Director: Robert G. Healy, Professor, Nicholas School of the Environment

The Duke University Center for Resource and Environmental Policy Research is committed to objective and timely analyses of critical natural resource and environmental issues, both national and international. The center was developed in response to recognition of the many conflicts developing over competitive use of natural resources and consequent legislative regulation.

Because contemporary resource-environmental problems are deeply embedded in the social, economic, and political fabric of the country, they are in need of careful and deliberate study. It is in the national interest that such issues be examined in a setting conducive to independent thought with appropriate regard for timeliness of results and conclusions. The Center for Resource and Environmental Policy Research is a unit of Duke University designed specifically to provide the proper setting for such an approach.

Among the current research topics are:

- Land use planning and rural development
- Soil and water resources policy
- Forest economics and policy
- Environmental risk analysis
- International resource and environmental policies
- Coastal zone management

90 Research Centers
Selected current and proposed research activities are:
- Study of ecological and economic criteria for successful wetland restoration
- Effects of agricultural runoff on Everglades nutrient cycling and storage
- Water management strategies to sustain ecological integrity of the Everglades
- Assessment of wetland ecosystem functional response to highways
- Using radar from remote sensing platforms to calibrate and verify surface hydrology models in Big Cypress National Preserve
- Integrating ecological wetland functions and human wetland values
- Functional assessment of constructed wetlands versus natural wetlands
- Paleoenvironmental studies of wetlands and estuaries, such as the history of vegetation changes in the Florida Everglades and the history of water quality in the Neuse and Pamlico estuaries
- Wetland hydrology, paleohydrology and hydrologic evolution

The Wetland Center is housed in the Levine Science Research Center on the Duke campus. The mailing address is Nicholas School of the Environment, Duke University, Box 90333, Durham, N.C. 27708-0333; telephone (919) 613-8008, Internet http://www.env.duke.edu/wetland/. The Center also maintains an Everglades research laboratory near West Palm Beach, Florida.

Forest Resources Center
Director: Daniel D. Richter, Associate Professor, Nicholas School of the Environment

The objective of the Center for Forest Resources is to promote and conduct research and education that increases the ability to understand, use, and conserve forest resources.
ecosystems. This research is conducted worldwide and is motivated by a broad number of issues, including the balance of use and conservation, ecosystem sustainability, species diversity, air pollution effects, water and carbon cycling, conflict resolution over management alternatives, policy analyses, and economic valuation of commodity and non-commodity goods and services.

Duke's location in the USA South provides researchers and students with a special perspective of forestry ecology and management. The region is the world's most productive for forest wood products. Sustaining this enormous economic and ecosystem productivity depends upon long-term ecosystem dynamics that are strongly governed by a past in which these ecosystems have been intensively used and frequently degraded by agricultural practices, and a future in which improved management is critical to develop. Improving the water quality, soil capability, wildlife habitat, and overall management of these forest ecosystems are subjects of various studies.

Duke research on the southern forest is internationally regarded and includes the Korstian-Christensen studies of forest succession in the Duke Forest, the four-decade study of forest-soil biogeochemical sustainability at the Calhoun Experimental Forest in South Carolina, and the large collaborative project with Brookhaven National Laboratory to investigate effects of carbon dioxide on pine ecosystems in the Duke Forest.

The center benefits the school's educational activities in forest ecology, general ecology, silviculture, soil sciences, hydrology, modeling, and environmental social sciences. Center activities include periodic discussions, guest speakers or forums. Ultimately, the center aims to fund student research, fellowships, and visiting professorships.

The Forest Resources Center is a founding organization of the Southern Center for Sustainable Forests, an organization that promotes technical analysis of controversial issues related to forest management.

Marine/Freshwater Biomedical Center

Director: Celia Bonaventura, Professor, Nicholas School of the Environment

The Marine/Freshwater Biomedical Center of Duke University is a problem-oriented center that is nationally and internationally recognized for its contributions to environmental health. It integrates unique facilities and faculty expertise available on the Beaufort and Durham campuses of Duke University and applies this powerful collective strength to challenging problems of human and environmental health significance, with a focus on the adverse effects associated with the toxicity of metals and free radicals. Research advances by center investigators increase the understanding of underlying toxic mechanisms, so that good human and environmental health choices can be made.

The center is distinguished by its record in biotechnology, its interdisciplinary programs, and its effectiveness in advancing marine and freshwater model systems for mechanistic studies. It is unique in its intellectual setting, providing a bridge between Duke's nationally recognized School of Medicine, Nicholas School of the Environment and Marine Laboratory. In its physical setting it draws effectively on the institutes and industries of the Research Triangle of North Carolina. Through its interactive workshops and outreach efforts the center communicates research findings on marine and freshwater aspects of environmental health problems to the clinical and research arms of the medical community, policy makers and the public at large.

The specific aims of the center are to:

- Support and enhance the distinctive mechanistic research programs of Center investigators, drawing on the physical and intellectual resources of the Beaufort and Durham campuses of Duke University and other North Carolina institutions.
• Provide a cohesive framework for interdisciplinary interactions, information exchange and innovative technological development for improved environmental health research.
• Aid in the development and use of marine and freshwater model systems for mechanistic human and environmental health studies, with a focus on metal and free-radical toxicity.
• Enhance the application of state-of-the-art facilities and methodologies to both individual and collective environmental-health research programs.
• Provide community outreach and education that informs scientists, policy makers and the public at large about environmental health issues and research advances.

Feasibility studies are conducted to explore the advantages of various experimental approaches and to encourage innovative research.

Students interested in working with members of the center's participating faculty should direct their first inquiry to the Admissions Office, Duke University Marine Laboratory, 135 Duke Marine Lab Rd., Beaufort, NC 28516-9721; telephone (252) 504-7502. It should be noted, however, that the center does not grant degrees. Graduate students are enrolled in the degree programs of the respective department or school of their mentors.

Researchers may direct their inquiries to the office of the Marine/ Freshwater Biomedical Center, telephone (252) 504-7508. Dr. Celia Bonaventura serves as center director.

Program for the Study of Developed Shorelines

Director: Orrin Pilkey, James B. Duke Professor of Earth Sciences, Nicholas School of the Environment

The Duke University Program for the Study of Developed Shorelines was established in 1985 within the Department of Geology. The program takes a worldwide view of modern coastal processes and geologic hazards.

A wide variety of research projects are directed under the auspices of this program, whose ultimate goal is the examination of the geologic basis for managing developed shorelines in a time of rising sea-level.

Present projects include:
• The study of the basis for prediction of beach replenishment success.
• Hurricane property damage mitigation on barrier islands.
• Evaluation of numerical models used to predict sand movement.
• Shoreface processes.

Research assistantships and other forms of support are available through the program.

The Program for Developed Shorelines is housed in the Old Chemistry Building on the Duke campus. The mailing address is Nicholas School of the Environment, Duke University, Box 90230, Durham, N.C. 27708-0230; telephone (919) 684-4238.
Alternative Educational Opportunities
The Center for Environmental Education

Using the unique interdisciplinary perspective of the Nicholas School of the Environment, the Center for Environmental Education strives to improve knowledge and understanding of environmental processes for audiences beyond higher education. Through executive education and K-12 initiatives, the Center serves as a bridge linking faculty, research and facilities with environmental professionals, K-12 educators, and students.

Executive Education

Through the Center for Environmental Education, the Nicholas School of the Environment offers a series of courses designed for environmental professionals, and consequently invaluable to full-time NSOE students pursuing careers in resource management, policy, economics, and environmental science. Students are given the opportunity to combine academic theory with real-world application through advanced coursework and the exchange of ideas and information with environmental professionals from diverse backgrounds.

Executive education is organized into intensive week-long modules or one-to-three-day seminars and workshops on specific issues. Most of these courses are designed at the request of specific organizations. NSOE students may register for intensive courses based on the available space. Visit the Executive Education link of the NSOE web page for a full description of currently available courses (http://www.env.duke.edu/execed.html).

K-12 Outreach

The Center for Environmental Education strives to raise the level of environmental literacy in future generations through programs that aim to improve the understanding of complex environmental issues among K-12 educators, environmental educators, and local students. The links to communities beyond the University provide graduate students with environmental education opportunities in local schools and organizations while improving skills in communicating about environmental issues and topics to general audiences, teaching/training, problem-solving, and translating technical information.

Current Programs bring together the Center’s commitment to empowerment of educators, community service, and inquiry-based learning about environmental issues. K-12 Community Outreach initiatives have partnered NSOE with local elementary schools to provide elementary students with environmental educational opportunities and to provide local schools with support. The Teacher-Researcher Partnership pairs Duke researchers with K-12 educators in order to facilitate the translation of cutting edge NSOE research to the K-12 arena. The semi-annual Coca-Cola Seminar series features current issues in environmental science and education for communities in academia, K-12 education, interpretation, and environmental education. The Compaq Resource Center is a storehouse of environmental education resources available for graduate students and
other educators. The MAT/MEM program provides pre-service teachers with the opportunity to have the same rigorous foundation for teaching environmental science that environmental professionals have for practicing.

**Intensive Courses and Workshops**

Through the Center for Environmental Education, the Nicholas School of the Environment offers a series of continuing education intensive courses that are appropriate for both practicing professionals and advanced full-time students who are pursuing careers in resource management, policy and environmental science. The intensive courses are designed to allow regular students to blend theory with practical experience as well as to allow experienced professionals to update theory and methodology. Recognized subject matter specialists provide instructional resources not normally available to the university community. The result is an enriched educational experience through the exchange of ideas and information by participants of diverse backgrounds.

The continuing education intensive courses are typically organized into week-long modules. A course consists of one or two modules, each a discrete unit of study which may be taken alone for credit. In two-part courses, however, the first week may be a prerequisite to the second.

Based on available space, Nicholas School of the Environment students (M.F. and M.E.M. degree candidates) may register for the intensive courses two weeks prior to the first day of the course on a first-come, first-served basis; students in their second year of study are given priority. One unit of credit may be earned for each week of an intensive course. Students may not register for more than two intensive courses in a semester without special permission from their adviser and the continuing education program director.

Courses in the continuing education intensive course series are listed in a special section in the chapter “Courses of Instruction” in this bulletin. A brochure containing complete information on the courses to be offered during a semester may be obtained from the school office by calling 919-613-8082.

The Center for Environmental Education also offers one- to three-day seminars and workshops on issues in environmental science. These are sometimes custom-designed at the request of specific organizations and sometimes are open enrollment in format. Please contact the Center for Environmental Education at 919-613-8082 for further information.

**Programs in K-12 Education**

The Center for Environmental Education strives to improve understanding of complex environmental issues among educators in primary and secondary education to raise the level of environmental literacy in future generations of citizens. Graduate and professional students wishing to improve their knowledge about environmental education and provide service to our communities through their environmental science knowledge can take advantage of a number of programs offered by the center. Interdisciplinary Curriculum Applications projects link Nicholas School graduate students with elementary school teachers to expand the dissemination of environmental content to traditional science and math curriculum as well as the realms of language arts, literature, social studies, and health. The Teacher/Researcher Partnership pairs high school teachers with Nicholas School researchers and students to transfer new environmental research technologies to the classroom. The biennial Coca-Cola Seminar Series is an emerging storehouse of educational products and resources for use by graduate students, faculty and staff. The MAT/MEM Program gives pre-service teachers an opportunity to combine a Master of Environmental Management with a Masters of Teaching.
Cooperative Colleges

The Cooperative College Program is designed to coordinate the education of students in selected undergraduate schools with graduate programs in the broad area of resources and environment offered at Duke. Students are accepted for either of two degrees, the Master of Forestry (M.F.) or Master of Environmental Management (M.E.M.). Although the program is designed to accommodate a wide range of undergraduate backgrounds, experience indicates that it is best suited to majors in one of the natural or social sciences, pre-engineering, business, natural resources, or environmental science.

The program accepts students after three years of undergraduate study. With appropriate guidance, highly qualified students can reach a satisfactory level of preparation for graduate work at Duke in three years of coordinated undergraduate study. The baccalaureate degree is awarded by the undergraduate school after the student has earned enough units at Duke to satisfy the requirements of the undergraduate institution. Minimum time required to complete the bachelor’s degree is two full-time semesters at Duke. After four semesters at Duke, in which a minimum of 48 units of credit is earned, students may qualify for one of the professional master’s degrees.

A student interested in entering the Cooperative College Program should apply to one of the participating schools, a list of which is available from the Nicholas School of the Environment Office of Enrollment Services. Students applying for admission to Duke after the third year of study should do so by February 1 of the third 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. If the student is applying for a 3-2 program, he or she must also submit a letter from the undergraduate dean approving the application.

Duke/University of North Carolina Oceanographic Consortium

The Duke/University of North Carolina Oceanographic Consortium operates a 135-foot oceanographic research vessel, the R/V Cape Hatteras. The ship operates both on the continental shelf and in the deep sea in the western North Atlantic, concentrating in the region between Nova Scotia and the Caribbean. The ship is a member of the academic research fleet supported by the National Science Foundation for the purpose of providing oceanographic research opportunities to investigators. R/V Cape Hatteras is used for training at sea by the universities that make up the Oceanographic Consortium (Duke, North Carolina State, UNC-Chapel Hill, UNC-Wilmington, UNC-Greensboro, and East Carolina). The consortium also manages the acquisition and maintenance of oceanographic instrumentation used aboard the R/V Cape Hatteras, and holds annual meetings of ocean sciences staff from member institutions at the Duke Marine Laboratory. Inquiries concerning the use of the research vessel should be directed to Quentin Lewis Jr. (252) 504-7580 or quentin@duke.edu.

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 through time. Although its major focus is North America, the society is involved with a network of forest historians worldwide. In 1984, it became affiliated with Duke University and moved its headquarters to Durham.

The society emphasizes the utility of history to decision making in both the public and private sectors. The society believes that most currently held opinions are strongly influenced by perceptions of the past and that a clear understanding of what really
happened, as today’s issues evolved, is a vital component in the process of making prudent choices.

Five major emphases enable the society to achieve its goals: a quarterly journal, Environmental History, research and publication, archival collecting, library and reference, and education and outreach.

Environmental History is co-published quarterly with the American Society for Environmental History. Its refereed articles, book reviews, and bibliographic listings enable investigators to keep current with the field. Research and publications, supported largely by grants, focus on topics that are important today and are also significant historically. Among the current topics are the history of forest and wildlife science, sustainable forestry, international forestry, forest economics, forestry on Native American lands, wood as an energy source, forest taxation, and industrial forestry research.

The collection of archival materials has been a major effort since the society was founded. Included in the archives are the records of the American Forestry Association, American Forest Institute, National Forest Products Association, and the Society of American Foresters. The society’s library and reference staff provide convenient access to the extensive literature of the field. Students and faculty of the university are welcome to use these valuable resources. The president is available for teaching and advising assignments at the Nicholas School of the Environment. The society also provides the F.K. Weyerhauser Fellowship for a graduate student studying forest and conservation history.

Inquiries regarding the facilities and services offered by the society may be addressed to President, Forest History Society, 701 Vickers Avenue, Durham, N.C. 27701; telephone (919) 682-9319; http://www.lib.duke.edu/forest/.

Integrated Case Studies for Wetlands and Coastal Management

The case study approach to graduate education affords the student an opportunity to develop analytical and management skills through a close look at problems in wetland and coastal resources. Case studies are used in class instruction in both traditional and intensive courses in several of the school’s study areas.

In addition to utilizing completed case studies as course materials, students also have the opportunity to participate in the research and preparation of new case studies. The process of case preparation brings one in contact with professionals, businessmen, and others and offers a bridge between the academic curriculum and practical experience. This experience and the contacts made in the process of case research are valuable assets in securing employment.

The case studies are termed “integrated” case studies in natural resource analysis because they result from the cooperative efforts of a team of investigators comprising resource-ecologists, -economists, and -planners, as well as political scientists, sociologists, and others. The team approach is used in recognition of the fact that the successful analysis and resolution of the nation’s complex resource and environmental problems requires a holistic perspective. Optimally, this results in an exploration of the full ramifications of utilizing natural resource systems.

Case study formats have varied. For example, projects have resulted in color and sound 16mm films, simulation games and workshop conferences, as well as written reports. Typical issues addressed by past case studies include highway wetland siting issues, hazardous waste disposal in wetlands, development of a coastal wetland management plan, development of the Duke Forest wetland restoration site, and the development and management of restored wetlands.

Financial assistance, in the form of research fellowships, is available to qualified students interested in case study analysis. Up to 6 units of academic credit may be earned
for case study work. Proposals for case studies are developed in consultation with the student's faculty adviser and the case studies director, Curtis J. Richardson.

**Integrated Toxicology Program**

The Nicholas School of the Environment participates in Duke University's graduate program in toxicology. The Integrated Toxicology Program operates under a specific charter to develop holistic and innovative approaches to toxicology training for Ph.D. students and postdoctoral fellows.
Research in environmental toxicology within the Nicholas School of the Environment focuses on molecular and biochemical aspects of pollutant metabolism, adaptation, and modes of toxic action. The majority of this work employs freshwater, marine, and terrestrial organisms as toxicological models. The goals of toxicological research in the school are to achieve a fundamental understanding of processes governing the fates and effects of contaminants in the environment, and to elucidate linkages between human and ecosystem health. In order 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 studies, the student is experienced in the design, execution and interpretation of current research in environmental toxicology. Completion of this training program at the Ph.D. level provides career opportunities in academia, industry, and research laboratories.

Training in environmental toxicology is also available to professional students in the Nicholas School of the Environment through the Master of Environmental Management program in environmental toxicology, chemistry, and risk assessment. M.E.M. students have access to courses in the Integrated Toxicology Program curriculum and receive training appropriate for careers in industry, consulting firms, and government agencies concerned with the understanding and management of hazardous substances.

Students seeking admission to the program as a Ph.D. candidate make initial application to the Graduate School for admission to participating departments, including the Department of the Environment. Fellowships are available to outstanding students.

Interaction with Professionals

Using discretionary funding from a variety of sources, the Nicholas School of the Environment sponsors a Distinguished Visitor Series to bring outstanding guests to visit the school. The major focus of the visitor's day on campus is a seminar on current environmental and natural resource management concepts, practices, and policy. Topics and speakers are selected in accordance with interests of faculty and students to reflect national and international issues. Speakers are drawn from the senior administrative ranks of public agencies, industries, nonprofit organizations, and the consulting field. Each presentation is accompanied by an informal luncheon or small group meetings with students and faculty, which permit continued discussion.

In addition to the Distinguished Visitor Series, the grants help to support other courses and activities that meet the objective of the exchange of ideas between practicing natural resource professionals and university students and faculty. These activities include an environmental seminar series, a forest utilization field trip to industry facilities in the South, and a western field trip.

The school recognizes the importance of graduate and professional student participation in professional organizations and makes available a limited amount of discretionary funding for activities that enhance the student's educational experience. Grants are available on a competitive basis for individuals who wish to attend or present papers at conferences and scientific meetings.

International Studies

The Nicholas School of the Environment has a history of contribution to international education and research. Graduates of the school, many of them foreign nationals, hold significant positions in many countries in multinational corporations, United States government agencies, or resource and conservation organizations that have global responsibilities. Members of the faculty have served overseas in programs of teaching and research, in both the developed and developing parts of the world.
The contemporary need for greater attention to international studies has led the school to develop professional associations and curriculum options for students who wish to combine international interests with study of natural resources and the environment. Duke University is a member of the South Atlantic States Association for Asian and African Studies and the Organization for Tropical Studies. On campus, an active Center for International Studies, Center for Tropical Conservation, and Center for International Development Research provide a rich array of educational and research opportunities with global emphasis. Within the Nicholas School of the Environment there is an active student international environmental study group. The potential exists for student participation in international projects through competition for grants and fellowships. In addition, students in the school may elect area studies or languages to further their understanding of global issues and cultures.

The school welcomes foreign students and considers an international student body of value to the learning environment. Qualified foreign students in Trinity College and in graduate and professional schools of the university are admitted to courses in the school, subject to the approval of the student’s adviser and the course instructor.

Internships

An internship with a public agency, corporation, consulting firm, or conservation organization is a valuable part of graduate professional education. The Nicholas School of the Environment Office of Career Services works with natural resource professionals to develop paid intern opportunities for professional and graduate degree candidates. Most students pursue internships during the summer between their first and second years of study, although internships may be taken at other times and for a longer duration. Many students use the intern experience as a basis for the master’s project. Further information may be obtained from the school office.

Professional Skills Development

In addition to regular courses and seminars, the Nicholas School of the Environment offers a series of optional professional development lectures and workshops to prepare students for professional employment. Topics for these modules include field and laboratory techniques, communications skills, project organization and management, and teamwork skills. The schedule and detailed information concerning the series is made available to students during the academic year by the director of professional studies. A modest amount of credit is available for participation in these modules. In addition, there is a modest matching fund to help students defray the cost of skills training offered outside the school.
Career Services

The Nicholas School of the Environment operates its own Office of Career Services for all graduate and professional students and alumni of the school. Assistance is given to students in finding summer employment and internships, permanent employment upon graduation, and mid-career changes of employment.

Career Planning Seminars. Individual counseling and group workshops are provided by a professional staff member to assist students in the development of job search strategies and skills, resume preparation, and interviewing techniques. Presentations by employers and alumni of the school enable students to discuss employment options with practicing natural resource professionals.

Internships. Practical experience is central to our educational process. Although the Nicholas School of the Environment does not require internships, students are strongly encouraged to explore career options and enhance their professional training through paid internships with public or private sector natural resource employers. The Office of Career Services has information on a variety of options and special internship programs that students may consider when arranging practical training. See also the section on internships in the chapter, Additional Educational Opportunities.

Job Search Assistance. The Office of Career Services maintains a current listing of employment opportunities from private industry; local, state, and federal governments; universities; and nonprofit organizations. Career planning and employment resource materials are housed in the office. Both current students and graduates are encouraged to use the alumni network established for gaining career information and employment contacts.

A resume book is published annually by the school and distributed nationally to potential employers. Students are encouraged to prepare and submit resumes, with the assistance of the professional staff, for publication. Employer response to the resume book has been favorable, and many students have received initial contacts and invitations to interviews as a result.

The career services office also invites representatives from a number of firms and government agencies from throughout the country to visit the school or participate in job fairs to interview students for internships and permanent positions. Students are strongly urged to begin formulating their job-hunting strategies and implementing the job search early in the second year of study.

Employment Offers. The success experienced by degree candidates in securing employment serves as a strong testimony to the value of graduate professional study at Duke. Students are advised to gear their education to a specialized area in order to increase their marketability. Toward this goal, every effort is made to assist each student in securing a paid summer internship appropriate to his or her field of study and geographic preference. Local organizations often select Nicholas School students for positions during the academic year, adding to the base of career-related experience.
Beginning salaries vary, depending upon the educational specialization, capabilities, and prior experience of the candidate as well as the type of organization and geographical region in which he or she is employed. For recent graduating classes, beginning salaries have ranged from $24,000 to more than $53,000 annually with candidates having some prior experience and/or advanced quantitative skills commanding the higher figures. For 1998 graduates the mean salary was $36,500.

Graduates of the school have an excellent record of finding challenging, satisfying employment within their areas of interest. A large percentage of recent graduates have accepted positions with environmental consulting firms, government agencies and industry. Others work with nonprofit conservation organizations and international development organizations. A few graduates pursue additional degrees.

The market for natural resource managers is strong for our graduates, yet competitive. In both the private sector, where environmental divisions are being established within traditional corporations, and in the public sector, where policy-making bodies increasingly face environmental concerns. Environment graduates are prepared through focused study, research and career-related experience for positions in management, consulting, research, policy and planning, and technical applications. International organizations utilize natural resource managers; students interested in international employment usually benefit from experience such as that gained through the Peace Corps or extended international internships during their academic programs.

A Broad Horizon

The variety of organizations that employ Nicholas School of the Environment graduates demonstrates the breadth of training in natural resources and the environment available at Duke. The following is a list of selected employers of 1994 to 1998 graduates.

Consulting Firms
ABB Environmental Services
ABT Associates
Arthur Andersen Environmental Services
Blasland, Bouck & Lee
Cadmus Group
Dewberry & Davis Companies
Dames & Moore
Earth Tech Inc.
Eastern Research Group Inc.
EC/ R Inc.
Ecology and Environment Inc.
ENSR Consulting & Engineering
ENVIRON
ERM Inc.
Forest Resource Consultants Inc.
Hagler Bailly
Hart Partners Inc.
ICF Kaiser International
Industrial Economics
Intertox Inc.
Jellinek, Schwartz and Connolly
Larson & McGowin Consulting Foresters
Parsons Engineering Science
Project Performance Corporation
Radian International
Roy F. Weston
SAIC
TetraTech Inc.
Versar Inc.

Federal Government
Federal Energy Regulatory Commission
National Marine Fisheries
National Oceanic & Atmospheric Organization
National Park Service
US Bureau of Land Management
US Coast Guard
USDA Forest Service
US Department of Energy
US Environmental Protection Agency
US Fish & Wildlife Service
US General Accounting Office
US Geological Survey
US Postal Service
Industry
3M Company
Amerada Hess Corporation
ARCO International Oil & Gas Company
Champion International Corporation
E.I. du Pont de Nemours
ENRON
Exxon Corporation
Fetzer Vineyards
Flying J Inc.
Home Depot
IBM
International Paper Company
Procter & Gamble
Shacklee Corporation
Southern Natural Gas Company
Toyota Motor Sales USA Inc.
Westvaco Corporation
Wisconsin Electric Power Company
Xerox

Not-for-Profit/NGO/PVO
American Bear Association
Brookings Institute
Center for Resource Solutions
Chesapeake Bay Foundation
Chesapeake Research Consortium
Conservation International
Council on Economic Priorities
Ecological Society of America
Ford Foundation
Interrain Pacific
National Wildlife Federation
Natural Resources Defense Council
RainForest Alliance
Research Triangle Institute
The Nature Conservancy
Wildlife Habitat Council
World Resources Institute
Worldwatch Institute
World Wildlife Fund

State/Local Government
Atlantic States Marine Fisheries Commission
California Resources Agency
Florida Coastal Management Division
Florida Game & Fish Commission
Hampton Roads Planning District
Maine Department of Planning
New England Fishery Management Council
North Carolina Department of Environment & Natural Resources
North Carolina Coastal Management Division
Orange County Marine Institute
South Carolina Sea Grant
Texas Natural Resources Conservation Commission
Washington Department of Natural Resources
West Virginia Natural Heritage
Housing

While limited housing is available on campus, most students in the Nicholas School of the Environment join the annual scramble to find a place to live off campus. The university is very much a part of the urban environment that is Durham, but the campus is not an urban one. It is not traversed by streets with housing and businesses. Consequently the perimeter of the West Campus is densely developed with apartment complexes, and the East Campus is adjacent to a neighborhood of large, early twentieth-century homes, some of which have been converted to apartments. Free bus service is available between the two campuses.

The Department of Housing Management operates an off-campus housing service which consists of a staff person who 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 arrange viewings. However, a student maintained web site at www.duke.edu/web/n-watch does provide this type of information. Similarly, the Office of Enrollment Services in the Nicholas School of the Environment maintains a listing of houses and apartments popular with students in the school as well as a list of entering students who are interested in finding roommates. These lists are mailed to students during the summer.

Services for Students

Communications. Upon entrance to the Nicholas School, students are issued an Email address. Email is recognized as an official means of communication within the University. Students are encouraged to check their Email frequently.

Medical Care. The main components of the student health service include the University Health Services Clinic, located in the Pickens Building on West Campus, and the student infirmary in Duke Hospital South. Emergency transportation, if required, can be obtained from the Duke campus police. The facilities of the university health services clinic are available during both regular and summer sessions. The facilities of the student infirmary are available only from the opening of the university in the fall until graduation day in the spring.

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.

The university has an Accident and Sickness 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 Accident and Sickness Insurance Plan by signing a statement to this effect. Each full-time student in residence must purchase this student health insurance or indicate the alternative arrangement.

The Student Accident and Sickness Insurance Plan provides protection twenty-four hours a day during the twelve-month term of the policy. Students are covered on and off the campus, at home, while traveling, and during interim vacation periods. For additional fees a student may obtain coverage for a spouse or spouse and children. Term of the policy is from opening day in the fall.

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

Counseling and Psychological Services. 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. Individual evaluation and brief counseling/therapy as well as skills development seminars are covered by student health fees. There are no additional charges to the student for these services.

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

Career Development Center. The Career Development Center, located in Page Building on West Campus, offers a number of integrated services that address a range of student needs from indecision about career choices to assistance with the post-graduate job search. Although many of the services are designed primarily for undergraduates, graduate and professional students are also encouraged to register with the center and use its resources as their career plans evolve.

Students who are unsure of their career plans can obtain confidential counseling to help them better understand themselves and clarify career goals. Individual appointments with counselors are available, as are group workshops, testing, and computerized career guidance programs.

The Career Resources Library, 217 Page, has resources to help students choose careers or further training and education, as well as self-help materials for improving study techniques, time management, test-taking and reading comprehension.

The Office of Placement Services, 110 Page, serves as a liaison between Duke students and potential employers. Services offered include placement seminars and workshops, on-campus interviewing opportunities with employers and graduate/professional schools, position vacancy notices, a library of employer resources, and individualized placement counseling. To participate in job interviews scheduled throughout the year, students must be registered with the office and have assembled a permanent file.

In addition, the school maintains its own Office of Career Services. For further information, see the Career Planning and Placement section in this bulletin.
International Adviser. The International Office handles governmental matters for students from abroad such as statements of attendance for home governments, issuance of United States immigration forms for re-entry 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 adviser soon after arrival. The International Office is located at 300 Alexander Avenue.

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 center and in the nearby West Campus Union.
Student Organizations and Activities

Sports. Students are welcome to use such recreational facilities as the swimming pools, tennis courts, golf course, track, jogging course, handball and squash courts, gymnasia, 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.

FOREM Club. The FOREM Club is the student organization for coordination of the school's social functions, community service, and intramural team participation. FOREM is an acronym for Forestry and Environmental Management. Annual functions of the club include a Christmas party, Christmas tree sale, Field Day, and year-end banquet.

Student Advisory Committee. The Student Advisory Committee, an elected student group in the Nicholas School of the Environment, meets regularly with the dean and faculty representatives to discuss courses and curriculum, programs, and long-range goals of the school.

Graduate and Professional Student Council. The Graduate and Professional Student Council is the university-wide representative body for students registered in the various professional schools and departments of the Graduate School. The council provides a means of communication among graduate students, presents graduate student concerns to the administration, and selects students for membership on university committees. Representatives from the Nicholas School of the Environment are elected annually by the student body.

Professional and Scientific Societies. Students are encouraged to participate in one or more professional or learned societies appropriate to their academic interest. Many of these societies are interested in participation by students and offer a lower fee to encourage student membership. Student chapters of the Society of American Foresters, International Society of Tropical Foresters, National Association of Environmental Professionals, the American Water Resources Association and the Society of Environmental Toxicology and Chemistry are active in the school.

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 which meets regularly and a new facility to house Jewish student life activities has recently been built on campus.

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 University Museum of Art, which has some excellent permanent collections, is located on East Campus.

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. Duke University is committed to the free and vigorous discussion of ideas and issues, which the University believes will be protected by its harassment policy.

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 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 Bertie Belvin (room A142 LSRC) who serves as Harassment Prevention Coordinator for the school or from the Office of the Vice-President for Institutional Equity, room 0044 Bryan Center.
Courses of Instruction
Course offerings are subject to change. The student should consult the current university course schedule for listings of courses to be offered each semester.

Environment General Courses (ENV)

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. Variable credit. Staff

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. 2 units. Richter

202. Microbial Ecology. Interactions of microorganisms with the biotic and abiotic components of their aquatic, terrestrial, and atmospheric environments. Topics include membrane structure, motility and chemotaxis, biodegradation of organic compounds, aerobic and anaerobic respiration, biogeochemical cycling, phototrophy, and specialized symbioses of nitrogen-fixing bacteria with legumes, cellulolytic bacteria with termites and ruminants, and chemolithotrophic bacteria with hydrothermal vent organisms. Prerequisites: university-level general chemistry and biology. 3 units. Staff

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. 3 units. Staff

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. 4 units. Oren

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. 4 units. Staff

207. Forest Pest Management. Fundamentals of entomology and plant pathology as appropriate to understanding the impacts of insects and diseases on forest productivity and their assessment for integration into 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. This approach seeks to develop predictive capabilities in long-range pest management and decision making. 3 units. Stambaugh

207L. Forest Pest Management. Same as 207 with laboratory which is largely field oriented to focus on diagnostics and impact analysis. 4 units. Stambaugh

208. Estuarine Ecosystem Processes. A study of the physical, chemical, and biological processes that control the structure of estuarine communities. Emphasis on field and laboratory techniques and data interpretation. Not open to students who have taken Biology 128L. (Given at Beaufort.) Prerequisite: ecology, systematics, or field biology course or consent of instructor. C-L: Marine Sciences. 4 units. Kirby-Smith

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. C-L: Marine Sciences. 3 units. Crowder (Beaufort) and Rubenstein (visiting summer faculty)

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. 3 units. Di Giulio

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. 3 units. Richter

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 and the equivalents of Environment 251 and 351, or consent of instructor. 3 units. Urban

215. Environmental Plant Physiology. Examination of tolerance, limiting factors, nutrition, and other ecological physiology concepts used in evaluating plant
responses to multiple environmental stresses. Discussion of procedures for and examples of monitoring physiological responses to environmental perturbations and resource manipulation. 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. 3 units. Staff

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. C-L: Biology 215, Botany 215, and Zoology 215. 3 units. Terborgh

218L. **Barrier Island Ecology.** An integration of barrier island plant and animal ecology within the context of geomorphological change and human disturbance. Topics include: barrier island formation and migration, plant and animal adaptations, species interactions, dune succession, maritime forests, salt marshes, sea level rise, conservation policy, and restoration ecology. Field trips to many of the major North Carolina barrier islands. Strong emphasis on field observation and independent research. (Given at Beaufort.) Prerequisite: Biology 25L or equivalent; suggested: course in botany or ecology. C-L: Biology 218L, Botany 218L, and Marine Sciences. 4 units. Evans, Peterson, and Wells (visiting summer faculty)

219L. **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. Open to undergraduates only under Biology 129L. (Given at Beaufort fall and summer and at Bermuda, spring.) Prerequisite: introductory biology. C-L: Marine Sciences and Zoology 203L. 4 units. Crowder or Kirby-Smith (Beaufort); Lipschultz, McKenna, and Smith (Bermuda)

221. **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. 3 units. Richter

222L. **Physical Processes in Coastal Environments.** The physical processes of beaches, the inner continental shelf, and in estuaries, in the context of their implications for the biological and geological environments. Topics drawn from the origin of waves, currents, tides, turbulence, and mixing transport of sand and larvae. Applications to biomechanics and coastal erosion, and to marine ecology, coastal zone management, and water quality. (Given at Beaufort.) Prerequisite: Mathematics 31 and 32. C-L: Geology 201L and Marine Sciences. 4 units. Staff

225L. **Coastal Ecotoxicology and Pollution.** Principles of transport, fates, food-web dynamics and biological effects of pollutants in the marine environment. Laboratory to stress standard techniques for assessing pollutant levels and effects. (Given at Beaufort.) Prerequisites: introductory chemistry and biology. C-L: Marine Sciences. 4 units. Kenney

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. C-L: Marine Sciences. 3 units. Read or staff

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. C-L: Marine Sciences. 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. C-L: Marine Sciences. 4 units. Crowder, Wyneken (visiting summer faculty), or staff

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. C-L: Marine Sciences and Zoology 250L. Variable credit.

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); six units (summer). (Given at Beaufort.) Prerequisites: Biology 25L; and Chemistry 11L, 12L. C-L: Marine Sciences and Zoology 255L. Variable credit. McClanahan-Green (spring); Rittschof (fall and summer)

230L. Weather and Climate. Overview of the science of meteorology and principles of climatology, especially as applied to problems in ecology and natural resource management. Emphasis on the processes and characteristics of weather phenomena and local and regional climates. General introduction to sources of climatic data and climatic data analysis. Includes laboratory. 4 units.

231. Ecological Theory and Data. Goals and contributions of ecological theory. Formulation of models and applications to data. Topics include demography, population growth, community interactions, food webs, metapopulations, disturbance, structure, stochasticity, chaos, and patchiness. Model development, analysis, and interpretation. Discussions focus on classical and current primary literature. Analysis of data using SPlus, making use of likelihood models, bootstrappin, and Bayesian approaches. Prerequisites: one year each of calculus and statistics. C-L: Botany 268 and Zoology 268. 3 units.

232. Microclimatology. Introduction to the micrometeorological processes. Discussion of the integration of these processes and the resulting microclimates in the rural (forest, field, and water surface) and urban environments. Methods for modification of the microclimate. Offered on demand. C-L: Biology 232 and Botany 232. 3 units.

Statistical handling and preparation of hydrologic data, simulation and prediction models, introduction to groundwater flow, laboratory and field sampling methods. 4 units. Katul


237L. Field Botany of North Carolina’s Wetlands. A survey of the flora of North Carolina’s wetland habitats with emphasis on plant identification in the field. Field trips to mountain, piedmont, and coastal wetlands. Examination of all groups of plants including bryophytes, ferns, and seed plants. Wetland habitats include swamps, bogs, pocosins, and brackish sites. Information on the floristics of the southeastern United States botanical nomenclature, systematic relationships of wetland plants, and an overview of wetland vegetation. Prerequisite: one course in plant diversity or systematics, or consent of instructor. C-L: Biology 242L and Botany 242L. 3 units. Shaw and Wilbur

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. 3 units. Mihaich and Vandenberg

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. C-L: Civil Engineering 240. 3 units. Dubay and Vasudevan

242. Environmental Aquatic Chemistry. Principles of chemical kinetics and equilibria applied to quantitative description of the chemistry of lakes, rivers, oceans, groundwaters, and selected treatment processes. Equilibrium and steady state models applied to processes such as acid-base chemistry, the carbonate system, coordination chemistry, precipitation and dissolution, oxidation-reduction, adsorption. Prerequisite: university-level general chemistry within last four years. C-L: Civil Engineering 242. 3 units. Staff
243. Environmental Biochemistry. Introduction to the (macro)molecules of life and fundamental metabolic pathways. Topics are presented in the context of environmental perturbations. Fundamental aspects of energetics, proteins, enzymes, carbohydrates, lipids, and nucleic acids. Emphasis on mechanisms of adaptation, molecular controls, and responses to toxicants. (Given at Beaufort.) Prerequisite: organic chemistry. C-L: Cell Biology 243 and Marine Sciences. 3 units. C. Bonaventura

244L. Molecular and Cellular Processes in Marine Organisms. Joint research projects on the adverse effects of environmental pollutants on marine organisms at the cellular and molecular level. Research methodologies include: spectroscopy (UV/VIS, fluorescence, and atomic absorption); subcellular fractionation; protein purification and characterization using chromatography and electrophoresis; analysis of pollutant-induced damage to proteins, membranes, and DNA; measurement of activity of enzymatic defense systems. Lectures cover molecular mechanisms of damage and damage control, and concepts that underlie the methods to be used. (Given at Beaufort.) Prerequisite: organic chemistry. C-L: Cell Biology 244L and Marine Sciences. 4 units. C. Bonaventura and Mcclellan-Green

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. 3 units. Staff

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. 3 units. Staff

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. C-L: Civil Engineering 248. 3 units. Vesilind

249. Environmental Molecular Biology. Introduction to molecular techniques and gene regulation as they apply to environmental issues. Topics include basic cloning strategies and methods, DNA/RNA/protein separation and hybridization, polymerase chain reaction, in vitro mutagenesis, and protein expression. Student presentations illustrate how molecular technologies such as the creation of genetically engineered organisms address environmental problems. Prerequisite: introductory biology. 3 units. Freedman

250L. Form, Function, and Adaptation of Plants. The structural and developmental basis for the major functions of the plant body including energy harvest, mechanical support, transport, and storage. Structural adaptations to important environmental stresses. Emphasis on underlying biomechanical/physical principles. Prerequisite: Biology 25L; suggested: either Biology 110L, 140L, 149, or 152. C-L: Biology 250L and Botany 250L. 4 units. Staff

255. Applied Regression Analysis. Linear regression using both graphical and numerical methods. Model construction, critique, and correction using graphical residual analysis. One- 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. C-L: Statistics 242. 3 units. Staff
2565. **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.) C-L: Marine Sciences. 2 units. Staff

257. **Environmental Experimental Design.** The principles of statistical experimental design used to set up experiments in environmental science and to analyze data from such experiments. Topics include analysis of variance and covariance, blocking, random versus fixed effects, repeated measures, power, impact assessment, and adaptive management. Prerequisite: Statistics 210B, or equivalent. C-L: Statistics 241. 3 units. Burdick

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. 1 unit. Edeburn

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. 1 unit. Richter

263. **Environmental Economics: Quantitative Methods and Applications.** Uses envirometrics (mathematical programming, multivariate statistics, and simulation techniques) to address environmental problems; properties of economic instruments for externality problems developed with programming models; regression and maximum likelihood techniques used in nonmarket valuation; and simulation in applied benefit and cost analysis. Prerequisite: Economics 149. C-L: Economics 263. 3 units. Staff

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. 2 units. Katul

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. 1 unit. Richter

269S. **Advanced Topics in Marine Ecology.** Theoretical concepts from population, community, and evolutionary ecology will be linked to observations and experiments to enhance understanding of the structure and function of marine systems. Current topics in marine ecology (for example, marine food web dynamics, species interactions, life history strategies, fisheries ecology, conservation biology). Discussions based on readings from the primary literature with emphasis on developing critical and synthetic skills. Each student will prepare a research proposal in NSF format. May be repeated. (Given at Beaufort.) C-L: Marine Sciences and Zoology 264S. 2 units. Crowder

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. C-L: Economics 270 and Public Policy Studies 272. 3 units. Kramer

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. C-L: Economics 272. 3 units. Mansfield

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. C-L: Economics 261 and Public Policy Studies 261. 3 units. Conrad

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.) C-L: Marine Sciences. 3 units. Orbach

274. Resource and Environmental Policy. Development of a policy analysis framework for studying resource and environmental policy. Political institutions, interest group theory, public choice theory, role of economics in policy analysis, ethics and values. Application to current and historical United States policy issues. C-L: Public Policy Studies 274. 3 units. Staff

275S. Protected Areas, Tourism, and Local 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. 3 units. Healy

276. Marine Policy. 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.) C-L: Marine Sciences and Public Policy Studies 197. 3 units. Orbach

279. Atmospheric Chemistry: Principles and Processes. Provides a broad overview of the science of oxidant chemistry in the atmosphere. Basic physical and chemical concepts relevant to the understanding of atmospheric chemistry will be presented and several contemporary topics will be 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. 3 units. Kasibhatla

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: Environment 251 or equivalent. 3 units. Kramer

281. Environmental Law. Examination of contemporary environmental law and its common law antecedents in the context of the American legal system. Objectives are to provide basic training in analyzing cases and statutes, applying knowledge in a classroom setting, and using a law library. 3 units. Heath

282S. Environmental Ethics. Selected topics involving values and the environment, for example, extending morality to nature, rights of future generations, environmental aesthetics, diversity and stability, ideological biases in ecological knowledge. Consent of instructor required. C-L: Philosophy 289S. 3 units. Cooper

283. Corporate Environmental Management and Strategy. Examines management theories, frameworks, tools, and concepts which can be used to gain the value-added from environmental performance. The course is organized around three themes: competitive aspects of environmental performance; management systems, tools, and approaches to integrate business and the environment; and environmental stakeholder management. C-L: Business Administration 435. 3 units. Staff

284S. Seminar in Land Use Policy. Selected topics in United States land policy. Content varies each offering, but may include regulatory innovations, management of public lands, urban growth management, and landscape protection. Term paper and class presentations required. 1 to 3 units. Variable credit. Healy


290. Physical Oceanography. Introduction to the dynamic principles of ocean circulation with an emphasis on large temporal and spatial scales of motion. Topics include wind-driven and density-driven flow, western boundary intensification, mid-ocean, shelf, and tropical circulations. Prerequisites: Mathematics 31 and 32 or consent of instructor. C-L: Geology 203 and Mechanical Engineering 290. 3 units. Lozier

291. Geological Oceanography. The geology of ocean basins, including origin, bottom physiography, sediment distribution, and sedimentary processes. Not open to students who have taken Geology 206S. (Given at Beaufort.) C-L: Geology 205 and Marine Sciences. 3 units. Staff

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. Only open to undergraduates under Biology 114L. Four units (spring); six units (summer). (Given at Beaufort and Bermuda.) Prerequisite: introductory biology. C-L: Marine Sciences. Variable credit. Ramus or staff (Beaufort); Nelson and Steinberg (Bermuda)

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. C-L: Marine Sciences. 3 units. Barber
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. 3 units. Stow

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 and summer or at Bermuda, spring.) Prerequisite: Biology 25L. C-L: Marine Sciences and Zoology 274L. Variable credit. Dimock (Beaufort) or Kirby-Smith (Beaufort); Barnes and Coates (Bermuda)

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. 2 units. Maguire

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

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. Variable credit. Staff

303. Principles of Ecological Modeling. Design, implementation, analysis, and interpretation of ecological models. Combination of lectures, student-moderated discussions, and computer lab exercises. Prerequisites: Biology 110L or equivalent and Environment 251 or equivalent. C-L: Botany 303. 3 units. Reynolds and Urban

307. Ecophysiology of Productivity and Stress. Exploration of principles governing stand growth and its response to a variety of stresses. Emphasis on climate, soil resources, and competition. Stresses and their reliefs determined by pollution and the availability of resources as modifiers of the physiological properties of trees. 3 units. Oren

309. Seminar on Key Wetland Ecology Issues. Wetland functions, hydrology, biogeochemistry, decomposition, community habitat, and productivity are discussed in an ecosystem context along with current management issues. Topics vary each semester and cover such areas as wetland restoration, constructed wetlands for wastewater treatment, and wetland delineation. Students will be expected to make oral presentations as well as critique advanced readings in class. May be repeated. 2 units. Richardson

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. 3 units. Richardson

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. 3 units. Di Giulio

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. C-L: Pharmacology 314. 1 unit. Abou-Donia

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. C-L: Pharmacology 315. 1 unit. Levin

316. Case Studies in Environmental and Forest Management. Drawing on their previous course work, students will analyze environmental problems from ecological, economic, ethical, and sociopolitical perspectives. Students work in teams to (1) research and present to the class reviews of selected topics in environmental problem solving, and (2) develop and analyze management alternatives for local environmental problems. The teams present their projects in written and oral form. Prerequisite: second-year graduate/professional; ecology or forestry, economics, quantitative methods; or consent of instructor. 4 units. Maguire

317. Topics in Tropical Ecology and Conservation. Discussion of current issues and ideas at the interface between basic and applied science. Lectures, seminars, and discussion with student participation. Prerequisite: Environment 217 or equivalent. 2 units. Terborgh

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. 3 units. Di Giulio and Freedman

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. 1 unit. Richter

330L. Environmental Monitoring and Instrumentation. Methods of measuring and monitoring the earth's physical environment with emphasis on water and air resources. Characteristics and uses of contemporary sensors, measurement and data acquisition systems. Methods of obtaining and processing computer compatible data records. Includes laboratory. Offered on demand. C-L: Botany 330L. 4 units. Knoerr


340. Biohazard Science. Philosophy of safety; etiology, infectivity, and transmissibility of disease; immunity and resistance; occupational and nosocomial infections; aerobiology; biotechnology; disinfection and sterilization; biocontainment and facility design; and safety management. Prerequisite: general microbiology or consent of instructor. 3 units. Tullis
341L. Methods in Biohazard Science. Fundamentals of disinfection, sterilization, and biocidal materials methodology; inactivation kinetics and dosimetry; medical waste management; mutagenicity, pyrogenicity, and PCR testing; laminar flow cabinet certification; microbiologic surface and air sampling; respirator assessment; laboratory audits and regulatory compliance. Prerequisite: Environment 340 or consent of instructor. 4 units. Staff

342. Bioaerosols. Principles of aerobiology; sick-building syndrome and building-related illness; ventilation, filtration, and humidification systems; chemical and biological pollutants; health effects; sampling and assessment of bioaerosols; remediation measures; handling indoor air quality perceptions. Consent of instructor required. 2 units. Thomann and Tulis

343. Hazard Management, Law, and Ethics. Economics and ecology; survey of federal and state laws; legal basis for regulation; enforcement, including inspections and audits, permits and licensing, and citations, injunctions, and penalties; management accountability; ethics in science and medicine; risk assessment and management; policy development and implementation. Consent of instructor required. 3 units. Warren

351. Computer-Based Map Analysis with Geographic Information Systems. Introduction to computer-based map analysis systems (geographic information systems). Use of map algebra in computer analyses of spatially distributed map information. Applications in analyzing and solving natural resource management problems. 3 units. Halpin

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. 3 units. Urban

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. Variable credit. Halpin and Urban

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. 3 units. Halpin and Urban

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. 3 units. Katul
357. *Satellite Remote Sensing for Environmental Analysis.* Environmental analysis using satellite remote sensing. Theoretical and technical underpinnings of remote sensing (multi-spectral image analysis, classification, and georectification) coupled with practical applications (land cover mapping, change analysis, ground truth techniques). Strong emphasis on hands-on processing and analysis of satellite and digital photogrammetric imagery in a UNIX workstation environment. Consent of instructor required. 3 units. Halpin

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. 3 units. Urban

363. *Economics of Natural Resource Damage Assessment.* Topics vary each semester offered. C-L: Economics 363. 3 units. Staff

372. *Advanced Theory of Environmental and Natural Resource Economics.* The application of economic concepts to private- and public-sector decision making concerning natural and environmental resources. Topics include modeling externalities and public goods, design of policy instruments, management of renewable and nonrenewable resources, welfare theory and valuation methods, and environmental risk. Prerequisites: Economics 301 and 302 or consent of instructor. C-L: Economics 372. 3 units. Mansfield

373. *Topics in Environmental and Natural Resource Economics.* Examination of current research in environmental and natural resource economics, building on the theory of environmental and natural resource economics developed in Economics/Environment 372. Includes selected topics from Economics/Environment 372 and other quantitative and theoretical issues pertinent to prevailing research in environmental economics. Prerequisite: Economics/Environment 372 or consent of instructor. C-L: Economics 373. 3 units. Mansfield

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: Environment 251 or equivalent. 3 units. Maguire

388. *Seminar in Resource and Environmental Policy.* Discussion of the political, legal, and socioeconomic aspects of public and private action in environmental quality control and management. Consent of instructor required. Variable credit. Staff


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. Variable credit. Maguire
398. **Program Area Symposium.** Required symposium in each program area. Students present master’s project research. Pass/ fail grading only. 1 unit. Staff

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. Variable credit. Staff

**Environment Intensive Courses (ENV)**

258. **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. Intensive. Variable credit. Burak

286. **Land Conservation Strategies.** Knowledge, information, and identification of available resources to enable a volunteer or experienced professional to complete a land acquisition for conservation purposes. Consent of instructor required. Intensive. 1 unit. Staff

288. **Medicine for the Third World Traveler.** Basic medical skills for participants in research and exploration in underdeveloped countries. Overview of health concerns; food and water-borne diseases; vector-borne, parasitic, and other infections; trauma and skin problems; and resources and preparation for travel. Hands-on experience offered where needed. Consent of instructor required. Intensive. 1 unit. M ayens

311. **Identification and Delineation of Jurisdictional Wetlands.** Course combines both classroom lectures and field exercises covering soil chemistry, soil taxonomy, hydric soil indicators, Munsell color charts, hydrophytic plant communities, wetland hydrology, use and interpretation of the 1987 U.S. Army Corps of Engineers Wetlands Delineation Manual, and field measurements techniques. Primary emphasis on field identification and jurisdictional wetlands. Consent of instructor required. Intensive. 1 unit. Richardson


380. **Translating Ideas and Concepts into Implementable Environment and Natural Resources Management Projects.** Applied course using an interdisciplinary and multisected approach focusing on project identification, proposal writing, preparation, project component definition, implementation, and sustainability, including economic analysis incorporating social, economic, and environmental benefits and costs. Basic concepts and principles drawn from these sciences will be used to define problems, examine options, and develop solutions. Intensive. 1 unit. Sharma

386. **Implementation of the National Environmental Policy Act on Federal Lands and Facilities.** Overview of NEPA content, case law, and current issues. Discussion of methods of implementing regulations, conducting and processing an environmental impact analysis, determining the proper level of documentation to fully record and disclose results. Intensive. 1 unit. Clark
387. 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 program director required. Intensive. 1 unit. Magness

ENVIRONMENT COURSES CURRENTLY UNSCHEDULED

223L. Behavioral Ecology
245. Ecology of Microorganisms
252L. Statistics and Data Analysis in Earth and Ocean Science
267S. Conservation Biology of Marine Mammals

268. Advanced Topics in Nearshore Processes

Earth and Ocean Sciences (GEO) Courses

Information about below 200-level Earth and Ocean Sciences (GEO) courses can be found in the Duke University Bulletin of Undergraduate Instruction.

200. Beach and Coastal Processes. The study of sedimentary processes and geomorphology of nearshore environments with emphasis on both developed and undeveloped barrier island systems. 3 units. Staff

201L. Physical Processes in Coastal Environments. The physical processes of beaches, the inner continental shelf, and in estuaries, in the context of their implications for the biological and geological environments. Topics drawn from the origin of waves, currents, tides, turbulence, and mixing transport of sand and larvae. Applications to biomechanics and coastal erosion, and to marine ecology, coastal zone management, and water quality. (Given at Beaufort.) Prerequisites: Mathematics 31 and 32. C-L: Environment 222L and Marine Sciences. 4 units. Staff

202. Beach and Island Geological Processes. Field seminar in the evolution of beaches and barrier islands with emphasis on the interaction of nearshore processes with the trappings of man. Consent of instructor required. (Given at coast on two weekends.) C-L: Marine Sciences. 2 units. Staff

203. Physical Oceanography. Introduction to the dynamic principles of ocean circulation with an emphasis on large temporal and spatial scales of motion. Topics include wind-driven and density-driven flow, western boundary intensification, mid-ocean, shelf, and tropical circulations. Prerequisites: Mathematics 31 and 32 or consent of instructor. C-L: Environment 290 and Mechanical Engineering 290. 3 units. Lozier

204. Nearshore Processes and Geomorphology. Phenomena resulting from waves, wave momentum (radiation stress), and wave interactions. Includes oscillatory flow, long period (infragravity) motions, and mean currents. Nearshore sediment transport and possible origins of beach and nearshore topographic features. Consent of instructor required. 3 units. Murray

205. Geological Oceanography. The geology of ocean basins, including origin, bottom physiography, sediment distribution, and sedimentary processes. Not open to students who have taken Geology 206S. (Given at Beaufort.) C-L: Environment 291 and Marine Sciences. 3 units. Staff

206S. Principles of Geological Oceanography. Geological aspects of the ocean basins including coastal to deep water sediment types and sedimentation processes, sea floor physiography, and environmental problems. Not open to students who have taken Geology 206. Consent of instructor required. 3 units. Baker
2075. Analysis of Coastal Engineering Models. A critical evaluation of the assumptions and principles underlying coastal engineering mathematical models used to predict the behavior of beaches. Involves classroom discussion of both the geology and engineering modeling literature. Consent of instructor required. 3 units. Staff

2095. Climate Dynamics and the Paleoclimatic Record. Introductory readings and reviews of modern physical climatology followed by extensive readings covering the record of past climatic change, concentrating on latest Quaternary and Holocene time. Topics include the global energy balance, the hydrologic cycle, general circulation of the atmosphere and oceans, climate modeling, future climate change, and the known record of paleoclimate (from marine and lake sediments, corals, soils, ice cores, etc.). Some background in physical sciences recommended. 3 units. Baker

210. Interpreting Earth History and Resources in Sedimentary Basins. Sedimentary basins as records of past climate, catastrophic events, and the evolution of life on earth. Groundwater, fossil fuels, and vital ores. Ways that sediment is delivered to and distributed within basins. Lab/computer demonstrations and field trips to see sediment dynamics and accumulation in action, then applied in interpreting the evolution of sedimentary basins. Interpretation, in the context of sequence stratigraphy, involving analysis of seismic data, well logs, and, potentially, outcrops in the Guadalupe Mountains (West Texas). 3 units. Pratson

211S. Beach, Barrier Island, and Shoreface Processes. Selected readings in nearshore oceanography and barrier island processes. Topics include mechanics of barrier island origins and evolution; fair weather and storm wave, current, and sediment transport processes on the shoreface; and critiques of coastal modeling. Consent of instructor required. 3 units. Murray

2195. Erosion. Empirical and process-based approaches to description and prediction of sediment transport and erosion. Includes study of USLE, landscape evolution models, overland flow, gully formation, debris flows, landsliding, bedload and suspended load transport in rivers, and aeolian transport. Principles illustrated through case studies. Prerequisite: Geology 41 or consent of instructor. 3 units. Haff

220S. Regional Geomorphology of the United States. Origin, nature, and significance of natural features of the earth's surface, with focus on regional studies within the United States. Four main geographical areas emphasized each year from among Great Plains, Rocky Mountains, Colorado Plateau, Basin and Range, Columbia and Snake River Plains, Pacific Coast and Mountain System, Interior Mountains and Plateaus, Appalachian Mountains and Plateaus, Atlantic and Gulf Coastal Province. Prerequisites: open to graduates and advanced undergraduates with consent of instructor. 3 units. Haff

221. Hydrogeology. Theory of groundwater flow and solute transport with application to geologic processes, water resources, and water quality. Prerequisites: Chemistry 12L, Mathematics 103, and Physics 42L or consent of instructor. 3 units. Rojstaczer

222. New Perspectives and Methods in the Earth Sciences. Nonlinear dynamics and related approaches to understanding, modeling, and analyzing physical systems, with emphasis on applications in the earth sciences. Consent of instructor required. 3 units. Murray

223. Computational Methods in the Hydrologic Sciences. Solution techniques for partial differential equations commonly used to describe hydrological processes. Methods of analysis of spatial and temporal hydrologic data. Prerequisite: knowledge
of computer language, introductory statistics, math through partial differential equations. 3 units. Rojstaczer

230S. Advanced Structural Geology. Stress and strain emphasizing geometric, kinematic, and dynamic analysis of micro structures and mesoscopic structures. Prerequisite: Geology 130L or consent of instructor. 3 units. Karson

2335. Oceanic Crust and Ophiolites. Structure, tectonics, petrology, and geochemistry of oceanic spreading environments and ophiolite complexes. Prerequisites: Geology 106L and 130L or consent of instructor. 3 units. Karson

236S. Lithosphere Plate Boundaries. Plate tectonics and the geological and geophysical expression of orogenic belts, spreading centers, transform faults, subduction zones. Prerequisite: Geology 130L or consent of instructor. 3 units. Karson

239S. Advanced Topics in Structural Geology and Tectonics. Selected topics related to deformation of rocks ranging from microstructure to plate tectonics. Prerequisite: Geology 130L or consent of instructor. 3 units. Karson

250. Applied Mathematics for the Environmental and Earth Sciences. Overview of quantitative methods used in modeling and data analysis of environmental and geologic problems. 3 units. Staff

252. Geophysics and Crustal Dynamics. A quantitative survey of the earth’s seismology, gravity, magnetism, heat flow, and internal dynamics. Derivation of the basic equations of geophysics and geodynamics. The locations and mechanics of earthquakes; seismotectonics and crustal dynamics, the earth’s internal layers, the gravitational attraction of mountains, the magnetic properties of rocks, the cooling of the earth, and the basics of continental drift. Original research project required. Prerequisite: upper division or first-year graduate standing in science or engineering. 3 units. Malin

257S. Practical Experience in Modern Seismic Profiling I: Data Acquisition. First of a three-course sequence in the application of seismic profiling in geological investigations for research, resource, and environmental purposes; includes field trip to participate in a small scale (1/2 mile sq) 3D seismic reflection profiling campaign in central Texas. Background topics including basic methods and theory of seismic data acquisition, samples of the field trip observations studied for quality and evidence of useful signals for subsurface imaging. Prerequisite: one 100-level course in geological sciences. 3 units. Malin

258S. Practical Experience in Modern Seismic Profiling II: Data Processing. Second of a three-course sequence in the application of seismic profiling in geological investigations for research, resource, and environmental purposes; signal processing step necessary to process portions of the 3D seismic reflection profiling from central Texas into interpretable images of the geology. Background topics include basic methods and theory of seismic data processing; focus on applying these methods to the field data. Prerequisite: Geology 257S. 3 units. Malin

259S. Practical Experience in Modern Seismic Profiling III: Geological Interpretation. Third of a three-course sequence in the application of seismic profiling in geological investigations for research, resource, and environmental purposes; the geological meaning and significance of the processed 3D seismic reflection profiles collected in central Texas as part of Geology 257S. Background topics including the basic methods of seismic data interpretation; focus on developing testable alternative hypotheses about the geology/hydrology/stratigraphy of the field site. Prerequisite: Geology 258S. 3 units. Malin

269. Thermodynamics of Geological Systems. Introductory thermodynamics applied to geologic problems through understanding of phase equilibrium.
270. Sedimentary Geochemistry. Chemistry of aqueous solutions and authigenic minerals in sedimentary systems. Prerequisites: Chemistry 12L and Mathematics 32. 3 units. Boudreau

271. Isotope Geochemistry. Theory and applications of stable and radioactive isotope distributions in nature. Prerequisites: Chemistry 12L and Mathematics 32. 3 units. Baker

272. 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. Prerequisite: Chemistry 12L or equivalent. C-L: Biology 272 and Botany 272. 3 units. Schlesinger

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. 3 units. Boudreau and Klein

285S. Layered Intrusions. Survey of layered igneous intrusions and current theories on crystallization and other processes in mafic magmas. Offered alternate years. Prerequisites: Geology 105L and 106L or consent of instructor. 3 units. Boudreau

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

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

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

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

321L. Methods in Hydrogeology. Field and laboratory methods for investigation of applied hydrogeology problems. Must be taken concurrently with Geology 221. Open to graduate students only. 1 unit. Rojstaczer

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

EARTH AND OCEAN SCIENCES (GEO) COURSES CURRENTLY UNSCHEDULED

208S. Paleoceanography

237S. Structure and Evolution of the Appalachian Orogen
Courses Taught at the Marine Laboratory
Biology (BIO)

10L. Marine Biology. Physical and chemical characteristics of marine ecosystems and the functional adaptations of marine organisms to these systems. Lectures, field trips, and laboratories. For students not majoring in a natural science. (Given at Beaufort.) C-L: Marine Sciences. One course. Kenney

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.) Prerequisite: introductory biology; suggested: a policy and/or introductory ecology course. C-L: Marine Sciences. One course. Crowder (Beaufort) and Rubenstein (visiting summer faculty)

114L. 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. One course (spring); one and one-half courses (summer). (Given at Beaufort and Bermuda.) Prerequisite: Biology 25L. C-L: Marine Sciences. Variable credit. Ramus or staff (Beaufort); Nelson and Steinberg (Bermuda)

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. C-L: Marine Sciences. One course. Barber

125L. 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. Students are encouraged to enroll for Biology 109 Conservation Biology and Policy concurrently. (Given at Beaufort.) Prerequisite: introductory biology. C-L: Marine Sciences. One course. Crowder, Wyneken (visiting summer faculty), or staff

126. Marine Mammals. Ecology, social organization, behavior, acoustic communication, and management issues. Focus on marine mammals in the southeastern United States (for example, bottlenose dolphin, right whale, West Indian manatee). (Given at Beaufort.) Prerequisite: introductory biology. C-L: Marine Sciences. One course. Read or staff
126L. Marine Mammals. Laboratory version of Biology 126. Laboratory exercises consider social organization and acoustic communication in the local bottlenose dolphin population. (Given at Beaufort.) Prerequisite: introductory biology. C-L: Marine Sciences. One course. Read or staff

127L. Marine Microbial Ecology. Microbial physiology, diversity, and growth within the context of biogeochemical processes. How biological processes and the ecological structure control the cycling of carbon, nitrogen, and phosphorus in the ocean. Field trips and laboratories investigating microbial processes in the open ocean and coral reefs of Bermuda. (Given in Bermuda.) Prerequisites: introductory biology and chemistry. C-L: Marine Sciences. One course. Bates and Carlson (Bermuda)

128L. Estuarine Ecology. A study of the biological, physical, and chemical processes that structure estuarine communities. Field and laboratory techniques and data interpretation are considered. Not open to students who have taken Environment 208L. (Given at Beaufort.) Prerequisites: introductory biology and chemistry. C-L: Marine Sciences. One course. Kirby-Smith

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 Zoology 203L. (Given at Beaufort fall and summer and at Bermuda, spring.) Prerequisite: introductory biology. C-L: Marine Sciences. One course. Crowder or Kirby-Smith (Beaufort); Lipschultz, and Smith (Bermuda)

132S. Marine Biodiversity. Marine biodiversity in a biological context. Topics include defining and measuring diversity, molecular methodologies, symbiotic organisms, relative diversities of major marine habitats, human impacts, and conservation practices. (Given at Bermuda.) Prerequisite: introductory biology. C-L: Marine Sciences. Half course. Barnes and Coates (Bermuda)


150L. Physiology of Marine Animals. Environmental factors, biological rhythms, and behavioral adaptations in the comparative physiology of marine animals. One course (fall); one and one-half courses (summer). (Given at Beaufort.) Prerequisites: Biology 25L and Chemistry 12L. C-L: Marine Sciences. Variable credit. Forward

155L. Biochemistry of Marine Animals. Functional, structural, and evolutionary relationships of biochemical processes of importance to marine organisms. One course (fall and spring); one and one-half courses (summer). (Given at Beaufort.) Prerequisites: Biology 25L; and Chemistry 11L, 12L. C-L: Marine Sciences. Variable credit. McClellan-Green (spring); Rittschof (fall and summer)

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

190. 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. A maximum of three courses of 190, 191, 192, 193T, 194T, and 197T may count toward the biology major. Half course. Staff

191, 192. 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. A maximum of three courses of 191, 192, 193T, and 194T may count toward the biology major. One course each. Staff

193T, 194T. Tutorial. For junior and senior majors with consent of director of undergraduate studies and supervising instructor. Three courses of 191, 192, 193T, and 194T, maximum. One course each. Staff

197T. Tutorial. For junior and senior majors with consent of director of undergraduate studies and supervising instructor. A maximum of three courses of 190, 191, 192, 193T, 194T, and 197T may count toward the major. Half course. Staff

295S, 296S. Seminar. Variable credit. Staff

**BIOLOGY COURSES CURRENTLY UNSCHEDULED**

113L. Behavioral Ecology

Botany (BOT)

295S, 296S. Seminar. Credit to be arranged. Variable credit. Staff

359, 360. Research in Botany. Individual investigation in the various fields of botany. Credit to be arranged. C-L: Marine Sciences. Variable credit. All members of the graduate staff

Cell Biology (CBI)

210. Independent Study. Research resulting in a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. Descriptions of specific areas may be obtained from the director of graduate studies. Consent of director of graduate studies required. One course or 3 to 9 units each. Variable credit. Staff

Environment (ENV)

See the Environment General Courses section beginning on page 115, for descriptions of upper-level Environment courses taught at the Marine Laboratory.

121. Climate Change: A Global Perspective. Introduction to the scientific basis for prediction of global environmental change with emphasis on change in surface temperature, sea level, precipitation, and tropical cyclone activity. (Given at Bermuda.) Prerequisite: one year of chemistry. C-L: Marine Sciences. One course. Malmquist and Murnane (Bermuda)

1225. Climate-Related Hazards and Humanity. The roles of science, politics, and business in quantifying and managing risks associated with climate-related hazards such as hurricanes. (Given at Bermuda.) C-L: Marine Sciences. Half course. Malmquist (Bermuda)

132S. Current Topics in Oceanography and Marine Biology. Topics such as the Iron Hypothesis, toxic algal blooms, and UV light considered through readings in the primary literature and student presentations. (Given at Bermuda.) Prerequisite: introductory biology. C-L: Marine Sciences. Half course. Staff (Bermuda)


140. A Scientist’s Perspective on Environmental Principles, Policy, and Legislation. Bermuda’s ecological, economic, sociopolitical systems, and environmental legislation as both a case study and as a comparative microcosm. Topics include: ecosystem conservation, natural resource management, pollution and waste management, and energy conservation and management. (Given at Bermuda.) C-L: Marine Sciences. One course. Bates and Connelly (Bermuda)

191, 192. 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 qualified juniors and seniors with consent of instructor and director of undergraduate studies. One course each. Staff

191A, 192A. 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 qualified juniors and seniors with consent of instructor and director of undergraduate studies. Half course each. Staff

ENVIRONMENT COURSES CURRENTLY UNSCHEDULED

134L. Biological Cycles in the Ocean

Earth and Ocean Sciences (GEO)

See the Earth and Ocean Sciences courses section beginning on page 129, for descriptions of upper-level geology courses taught at the Marine Laboratory.

191, 192. 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 only to qualified juniors and seniors by consent of director of undergraduate studies and supervising instructor. One course each or 3 units each. Staff

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 substantive paper or written report containing significant analysis and interpretation of a previously approved topic. Open to qualified juniors and seniors upon approval of the departmental faculty. One course or 3 units. Staff

Zoology (ZOO)

353, 354. Research. To be carried on under the direction of the appropriate staff members. Hours and credit to be arranged. C-L: Marine Sciences. Variable credit. Staff

360, 361. Tutorials. An approved academic exercise, such as writing an essay or learning a research skill, carried out under the direction of the appropriate staff members. Hours and credit to be arranged. Variable credit. Staff