Environmental Sciences

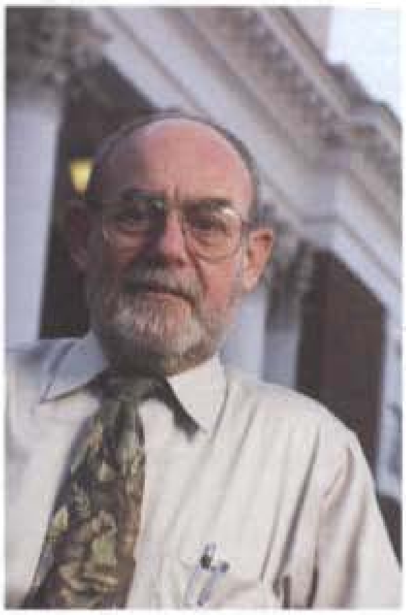
AT THE UNIVERSITY OF VIRGINIA

2007–2008 ANNUAL REPORT

The cover shows a panoramic mosaic of images from Hog Island, 20 km off the coast of Virginia's Eastern Shore. Images are captured by an automated webcam several times per day and transferred via a wireless network to departmental servers for archiving and display. They are used for monitoring wildlife habitat use, vegetation phenology, and landscape change.

You can view additional images at http://ecocam.evsc.virginia.edu/select_panimage.php.

Letter from the Chair



There is no better measure of a department's success than its ability to attract and retain the highest-quality faculty. For a school of our size, with just 24 tenure-track faculty and 10 research scientists, our faculty's record of achievement is exceptional.

This year, Jim Galloway was one of two scientists sharing the Tyler Prize, considered the Nobel Prize of the environmental sciences. Jim was also elected this year as a fellow of the American Geophysical Union and, like his colleagues Jack Crosby, George Hornberger, Bill Ruddiman, and Hank Shugart, has been designated a highly cited researcher by the Institute for Scientific Information. Highly cited researchers—the 250 most frequently cited in their field—comprise less than one-half of one percent of all publishing scientists.

The high standards that current faculty maintain make the department attractive to the nation's best environmental scientists. Mike Pace, another highly cited researcher, joined the ranks of our senior faculty during the 2007–2008 academic year. An eminent aquatic ecologist, Mike will soon be presented the G. Evelyn Hutchinson Award from American Society of Limnology and Oceanography.

At the same time, the department continues to add young scientists with outstanding records. This year, Laura Moore, a specialist in coastal geomorphology, and Matt Reidenbach, a hydrologist, chose to build their careers at U.Va.

In addition to their individual achievements, having a stable faculty of this quality has enabled us to sustain a series of unusually long-term initiatives that include the Shenandoah Watershed Study and the Virginia Coast Reserve Long-Term Ecological Research site. The data sets that have been assembled as part of these projects—extending back several decades—provide an invaluable baseline in the effort to understand the consequences of climate change.

In short, the Department of Environmental Sciences has built one of the foremost programs of its kind in the nation. With further funding from the department's supporters, we plan to build on these strengths, enlarging our faculty and giving policy makers the tools and the information to address the environmental challenges that are upon us.

JAY ZIEMAN, *Chair*

Galloway Wins Tyler Award

This has been quite a year for Jim Galloway. He was elected a fellow of the American Geophysical Union, joined the select company of environmental scientists and conservationists who have won the Tyler Prize, and published two articles in *Science*, one as lead author. These accolades point not only to the quality of his work but also to the urgency of finding better ways to manage reactive nitrogen.

Jim Galloway and Harold Mooney shared 35th Tyler Prize for Environmental Achievement.

Standing under the Nitrogen Cascade

Nitrogen is the seventh element in the periodic table and the most abundant of the five elements that are necessary for life. The percentage of reactive nitrogen, the form of nitrogen usable by most organisms, is quite small, however, and, until recently, fairly stable. Lightning and nitrogen-fixing bacteria add to our supply of reactive nitrogen, a process that is offset by natural denitrification processes.

Over the past hundred years, human intervention has upset this balance. Professor Jim Galloway has devoted three decades to tracing anthropogenic nitrogen as it courses through the environment, a phenomenon he and his colleagues call the "nitrogen cascade."

Fossils fuels are the first new source of reactive nitrogen. Reactive nitrogen that had previously been sequestered underground in some fossil fuels is being released into the atmosphere at an increasing rate, along with reactive nitrogen formed from nitrogen and oxygen gas during their combustion.

The second source is synthetic fertilizer. In 1908, Fritz Haber, a German chemist, discovered a way to tap the atmosphere's vast reservoir of nitrogen gas and convert it into compounds plants can use. The innovation, called the Haber-Bosch process, produces ammonia, the raw material for making nitrogen fertilizer. Today more than a third of the world's population depends on synthetic fertilizer for the food it eats—and Haber won a Nobel Prize for the discovery. The problem is that this fertilizer is not taken up very efficiently. Most of the fertilizer applied to crops ultimately leaks into the environment. The same is true for meat. Most of the nitrogen fed to animals passes through and is not incorporated into the animal products we eat.

When you're a diabetic, excess sugar in your bloodstream circulates through your body, damaging

Figure A

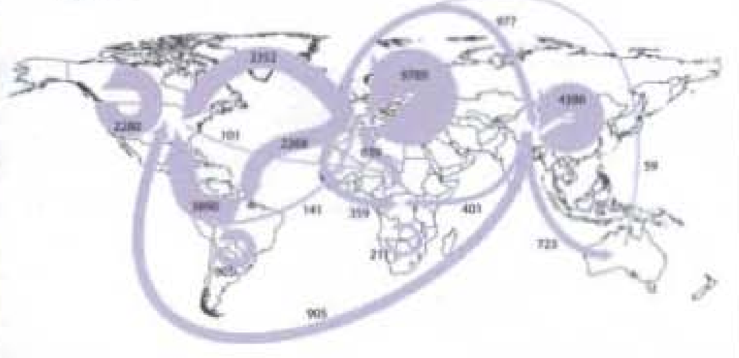


Figure B

organs in a variety of pernicious ways. Excess reactive nitrogen in the environment works in much the same way. It increases ozone levels in the lower atmosphere, causing respiratory diseases and reducing crop yields. It is returned to land in the form of precipitation that acidifies soils, lakes, and streams. It joins the reactive nitrogen from agricultural runoff and sewage as it makes its way to the coastal oceans, exciting algae blooms that damage fisheries. As a final insult, oceanic nitrogen is converted to nitrous oxide, a long-lasting greenhouse gas and a destroyer of ozone in the upper atmosphere.

Galloway and his colleagues have recently been tracing the economic transport of reactive nitrogen, which parallels its environmental transport and exacerbates its effects. Since the advent of globalization, about 25 percent of the reactive nitrogen produced each year is involved in economic transport. A typical example: fertilizer manufactured in the Middle East is sent to Europe, where it is used to grow grain, which is sent to Brazil to feed pigs, which are then exported to the Netherlands to be slaughtered and processed into ham. At each step of the way, reactive nitrogen leaks into the environment in more concentrated amounts than aquatic or atmospheric transport.

From the point of view of nitrogen management, these large localized effects at least have the benefit of serving as targets for change. "As you follow the movement of nitrogen through the supply chain," Galloway asserts, "the points where intervention would be most effective become increasingly clear. They provide a starting place for addressing the problem."

Jim Galloway on Being a Tyler Prize Winner and Developing a Nitrogen Strategy

Q. Tyler Prize winners include people like Anne and Paul Ehrlich, Jane Goodall, George Schaller, C. Everett Koop, Thomas Lovejoy, and Jared Diamond. Did you ever think you would find yourself in their company?

A. I had heard that I had been nominated for the prize, but I honestly never thought much about it because I didn't think winning the Tyler was even remotely possible. The laureates are people I hold in the highest regard. It is truly humbling to be included in that community.

Q. Your share of the prize is $100,000. Do you have any special plans for it?

A. I'm going to use it to help develop a nitrogen footprint calculator, which can be useful in a number of ways. It can help people better understand their relationship to the environment and make better choices about their individual resource use. And it can provide policy makers with the information they need to manage nitrogen use on a large scale.

Q. You were the founding chair of the International Nitrogen Initiative (INI). What was your purpose in establishing it?

A. Our goal was to better understand the flow of nitrogen worldwide so that policy makers could manage it more effectively. We built the INI around regional centers because we recognized that one aspect of the mismanagement of nitrogen is that it is distributed inefficiently. There are still parts of the world that need additional nitrogen to support their population.

Q. How are you feeling about the future?

A. I'm optimistic. I am convinced that just as human ingenuity gave us the ability to create ammonia from its elements in 1908, this same ingenuity will provide us with mechanisms to manage nitrogen much more efficiently, without decreasing our ability to produce food.

Figure C

Nitrogen contained in internationally traded (A) fertilizer (31 Tg N), (B) grain (12 Tg N), and (C) meat (0.8 Tg N). Data are for 2004 and are in units of thousands of tons. Minimum requirements for drawing a line are 50,000 tons N, 20,000 tons N, and 10,000 tons N for fertilizer, grain, and meat, respectively.

Research Integration

The world that seems so familiar and so natural to us actually reflects the interplay of biological, geological, and atmospheric forces that act at a variety of scales—of time, space, and amplitude. Understanding all the factors that contribute to our familiar world and that determine whether it will change or remain as we have always known it requires the ability to share information and ideas.

John Porter's work with ecological metadata language is making it easier for scientists to share data sets.

Sharing Information

Data is the feedstock of scientific discovery. When attempting to understand complex environmental systems, the more data scientists have at hand and the more sources of data they have available, the more far-reaching their conclusions can be.

For the last two decades, Research Associate Professor John Porter has been dedicated to managing the data gathered by scientists working at the Virginia Coast Reserve Long-Term Ecological Research (VCR-LTER) site so that it is accessible to other researchers. A key to this effort is finding a common language to describe metadata, the "data about data" that a researcher needs to understand and use the data gathered by another scientist. "We have gathered an immense amount of data about the environment," Porter says. "Access to metadata increases the likelihood of our making the best possible use and reuse of this information."

During the 1990s, Porter worked with groups of other information managers that devised the initial specifications for a metadata standard for environmental studies. These were ultimately developed into the Ecological Metadata Language (EML) in 2002. All LTER sites are now in the process of converting their metadata to EML, an enormous task.

For researchers, having these kinds of tools at their disposal can be incredibly powerful. From the LTER Data Catalog, researchers can pinpoint research projects that complement their own. "For example, you can locate data about a species of interest that was collected by other researchers, in diverse and distant habitats," Porter points out. "And once you find the data set, you can compare it with your own data, allowing you to test the generality of your conclusions or to formulate new theories." Currently, there are 6,045 LTER data sets online and the number is growing weekly.

The existence of the EML platform gives information managers like Porter a solid base for writing programs that facilitate data analysis. For instance, Porter has written a program that automatically generates EML data from a given data set and translates it into a statistical program that can be used by researchers. He has also created Web forms that researchers can use to create an EML document. "Having EML makes efforts like this possible," Porter notes. "It enables data to be reused and recycled in ways that have the potential to reshape science. It sets the stage for new ways to synthesize research and for new discoveries."

Sharing Ideas

The dedication of the Anheuser-Busch Coastal Research Center (ABCRC) in 2006 marked the beginning of a new era for the Virginia Coast Reserve Long-Term Ecological Research (VCR-LTER) program. With its wet and dry laboratories, the $2.5 million facility gave VCR-LTER scientists a well-equipped base for extended research, enabling them, for instance, to analyze samples on site and return to the field the next day with fresh insights.

While the ABCRC has indeed enabled researchers to interact more efficiently with the natural world, it has also made it much easier for them to interact more efficiently with each other. "One way of looking at the center is that it is a way of connecting people in productive ways," says Professor Dave Smith, the department's associate chair.

Smith cites the example of the annual VCR-LTER All-Scientists Meeting, which had been hosted by the department each year in Charlottesville. In 2008, it was held at the ABCRC, a more appropriate setting. Scientists also take advantage of the relative seclusion that the center provides to write proposals and papers together. "The ABCRC is a comfortable place for researchers to work and meet," notes Research Assistant Professor Art Schwarzschild, the ABCRC site director. "It's close to their field sites and far from the distractions of their college campuses."

The ABCRC has also proven the ideal setting for forging connections with the surrounding community. It made it possible for the VCR-LTER, in conjunction with the Virginia Zone Coastal Management Program, to launch a seminar program that gives the public the opportunity to learn more about the environmental research conducted at the ABCRC. Topics in the series include the VCR-LTER's seagrass restoration project in Hog Island Bay, potential impacts of climate change at the reserve, and the effect of sea level rise on migratory birds. "This is one of the very few opportunities for the local public to learn firsthand from the scientists actually doing the research about projects being conducted in their backyard," says Schwarzschild.

The ABCRC has also enabled the VCR-LTER to strengthen its ties to local school systems. With support from the National Science Foundation, the VCR-LTER has been heavily invested in educational outreach to the Northampton County Public Schools through the Schoolyard LTER program. The opening of the ABCRC gave the VCR-LTER the ability to expand these programs. One of the first was the Research Experience for High School Students (REHS) program, a summer internship program. The students work closely with a graduate student and a faculty member conducting research at the VCR-LTER, while developing their own independent research projects.

"Our goal is to get as many people as possible—of all ages—involved with the center," says Smith. "It's the most efficient and exciting way we know to create and share new knowledge."

Art Schwarzschild has played an important role in the success of educational initiatives at the VCR-LTER.

Global & Extraterrestrial Research

In 1972, astronauts aboard Apollo 17 took a photograph of the Earth that framed the planet against the immeasurable expanse of space. This startling image provided visceral confirmation that the idea we call the environment applies not merely to our immediate surroundings but also to an immense, interlocking system of physical and biological forces. Starting from this planetary perspective, members of the department are engaged in pioneering projects to help us understand how the environment of our planet—and other planets—evolves.

Perfecting Destiny

In the years since the Apollo 17 astronauts pointed their Hasselblad at the Earth, NASA has launched scores of satellites that have greatly expanded our knowledge of our planet. At the request of the federal government, the National Research Council (NRC) of the National Academies issued a decadal plan in 2007 for NASA and NOAA, laying out earth science missions for the two organizations to undertake between 2010 and 2020. Among the 17 satellites that the committee called for, one of the most ambitious and most complex was dubbed DESDynI. Hank Shugart, the W. W. Corcoran Professor of Environmental Sciences, is part of the team charged with ensuring that DESDynI realizes its scientific destiny.

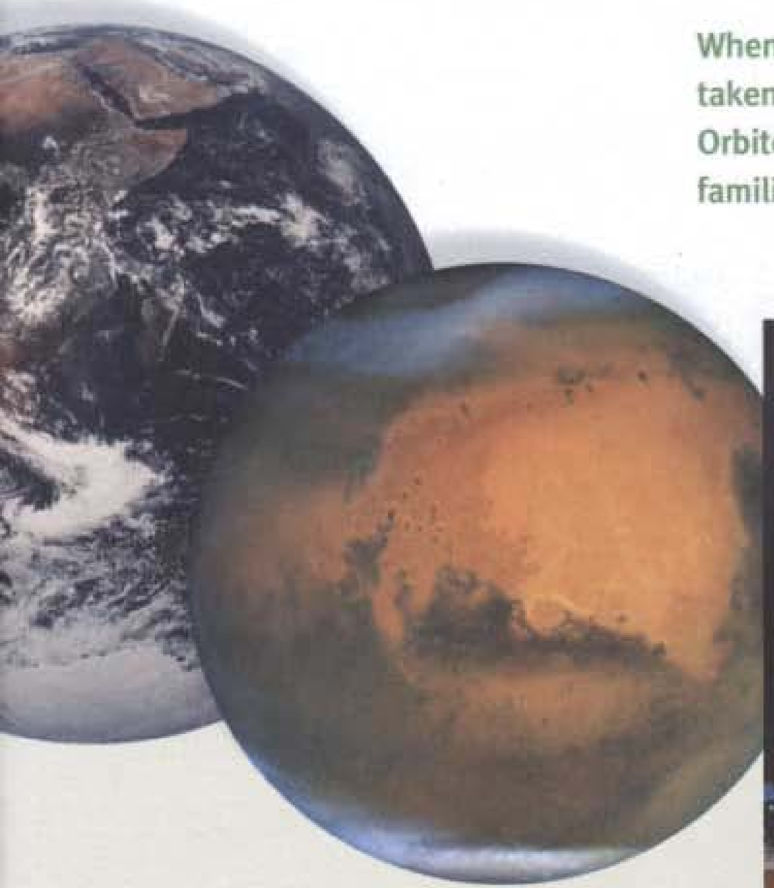
Hank Shugart is helping to develop DESDynI, an earth science satellite combining InSAR and LIDAR into a single platform.

DESDynI, which stands for Deformation, Ecosystem Structure, and Dynamics of Ice, will carry two advanced sensor systems: interferometric synthetic aperture radar (InSAR) and light detection and ranging (LIDAR). In part, the awkward pun in the program's name reflects the disparate nature of the three projects that the NRC believed would best take advantage of these two technologies.

The first is to characterize the effects of changing climate and land use on species habitats and carbon budgets, Shugart's area of expertise. Shugart is a systems ecologist who focuses on simulation modeling of forest ecosystems. Over the last decade, Shugart has played key roles in a number of NASA earth science missions. When the decadal plan was issued, he was the science chair of a mission that the Jet Propulsion Laboratory was developing to use InSAR and LIDAR to measure carbon in the biomass. This project was absorbed into DESDynI, and became the source of the "ecosystem structure" part of its moniker.

DESDynI will also be used to detect telltale surface deformation in areas of the world prone to earthquakes, volcanic eruptions, and landslides. These measurements could provide early warning of any of these natural disasters, potentially saving tens of thousands of lives. Finally, DESDynI will use InSAR to track variations in ice flow patterns and velocities, important constraints on their dynamic response to climate change. This knowledge will help to determine how fast society must adapt to sea level changes.

"Combining the spatial continuity of InSAR and the precision and directness of LIDAR into a single platform that meets the requirements of each of these missions is challenging work," says Shugart, who now sits on DESDynI's science board. Nonetheless, he remains enthusiastic about DESDynI's potential once these issues are resolved. "This is a Hubble-scale effort," he says referring to the orbiting telescope, "and it could have Hubble-scale results."



When scientists look at the pictures of Mars taken by spacecraft like the Mars Reconnaissance Orbiter, they find counterparts to many of the familiar landforms we find on Earth.

By helping scientists understand how water shaped the Martian landscape, Alan D. Howard is shedding light on climate conditions on the red planet billions of years ago.

Martian Modeling

Seeing the Earth for what it is—as one planet among many—not only provides a fresh vantage point for understanding the forces that shape its environment but also helps us understand that these forces are not unique to us. When scientists look at the pictures of Mars taken by spacecraft like the Mars Reconnaissance Orbiter, they find counterparts to many of the familiar landforms we find on Earth. For instance, there are meandering rivers and river deltas, though the quantity of water needed to produce them vanished billions of years ago.

While the very ambitiousness of the National Research Council's decadal plan for earth sciences demonstrates that we still have a great deal to learn about our home planet, the considerable knowledge that we have accumulated—and its sheer accessibility—gives us an excellent starting point for understanding the hydrological conditions needed to produce these river valleys and other hydrogeomorphic features. Accordingly, Professor Alan D. Howard starts by developing models that account for the creation of specific features on Earth, which he validates using knowledge of our own climate history. He then adjusts them for Martian conditions, shedding light on eras when water was more abundant on the red planet.

Among other projects, Howard is trying to understand the relationship between evaporation and runoff from precipitation that would lead to an impact crater overflowing and creating an overflow channel. He began by testing a flow routing model on analogous terrain on Earth, the Great Basin Region of the American Southwest. He entered relevant climate data, both for present conditions and during the Pleistocene period 50,000 years ago, and it accurately tracked the fluctuations in the size of the lakes that occupy these basins. He is now applying his model to conditions on Mars. "If we start with what we know about the landforms and run the model, we can make inferences about past climatic conditions," he says. Ultimately, he plans to couple the model with global atmospheric circulation models being developed for early periods of Martian history.

Regional Research

Most people intuitively think about the environment on a regional scale. For casual observers, the characteristics of a particular part of the world—its climate, flora, and fauna—make up a familiar, static self-evident whole. For environmental scientists, the regional scale is much more dynamic. It is on the regional level that local phenomena, amplified many times over, interact with global forces.

The Adirondack Park

The Adirondack Park invites superlatives. This publicly protected region in northeast New York is the size of neighboring Vermont. It is the largest park in the contiguous United States, the largest National Historic Landmark, and the largest area protected by any U.S. state. It is defined by the Adirondack Mountains—there are more than 40 peaks over 4,000 feet—but is equally well known for its thousands of lakes, whose beauty led the tycoons of the Gilded Age to build elaborate summer camps on their shores.

When Professor Mike Pace began visiting these lakes several decades ago, many of them no longer supported the abundant fisheries that had made them legendary with anglers. When the prevailing winds from the Midwest rise over the mountains, the water vapor in the air condenses and precipitates out of the air. From the 1960s on, this precipitation carried increasing loads of sulfur and nitrogen compounds generated by the growing cohort of Midwest power plants. The acid rain that resulted eventually overcame the natural buffering capacity of the soil and lowered the pH in some lakes to the point where the fish populations began to disappear. While the Clean Air Act of 1990 was relatively successful in lowering sulfur levels, nitrogen deposition still remains a problem.

With support from the National Science Foundation, Pace is developing a way to determine the relationship between nitrogen deposition, the structure of the watershed in which it falls, and the chemistry of the lakes in that watershed. He wants to understand how nitrogen movement in these watersheds is affected by such factors as spatial disposition and the structure and composition of wetlands and why nitrogen deposition has more impact on some lakes than others. His study has implications for managing the park's wilderness areas—which account for one-sixth of the park—as well as for the 55 percent of the park that is in private hands.

"We are taking advantage of the very extensive GIS mapping of Adirondack watersheds conducted by the agencies in the area," Pace says. "Our challenge is to combine this GIS information with a number of the leading models for nitrogen deposition." He will compare the results with water chemistry samples he took from hundreds of lakes during the summers of 2006 and 2007, a process that will lead to further refinement of these essential management tools.

Opposite page: Using a floatplane, Mike Pace sampled the water chemistry of hundreds of lakes in the Adirondacks.

Left: Matt Reidenbach's analysis of water flow over coral reefs in the Red Sea has enabled scientists to gain a better understanding of their sources of nutrition.

"If we are to protect the Red Sea reefs, we have to understand the environmental factors that are essential to their health."

Red Sea Coral Reefs

The coral reefs of the Red Sea are under siege. Recreational divers have damaged branching corals and stirred up sediment. Overfishing has depleted the herbivorous fish that eat algae that might grow on the coral. And careless boaters of all sorts have ground their vessels on the reef creating gashes that may take a century or more to repair.

"If we are to protect the Red Sea reefs, we have to understand the environmental factors that are essential to their health," says Assistant Professor Matt Reidenbach. One of the most important is access to nutrients they need to survive and flourish.

Coral has a symbiotic relationship with single-celled algae called zooxanthellae, which live in the tissue of coral polyps. These algal cells carry out photosynthesis and produce excess organic nutrients that the coral polyps use. Some scientists estimate that corals can get up to 90 percent of their nutrients from their zooxanthellae symbionts.

Algae are not coral's only source of nutrients, however. Thanks to research that Reidenbach and his colleagues have conducted, scientists now understand that corals derive a significant amount of nutrients from the water around them. A hydrologist, Reidenbach has tracked the flow and turbulence of the water that carries these nutrients to coral in the Red Sea. "Corals do an amazing job pulling nutrients out of water," Reidenbach says. "This activity, which can take place both day and night, complements the nutrients obtained from their zooxanthellae during the daytime." His work helps ecologists determine how much of the water-borne nutrients the reef takes up and identify the sources of these nutrients.

The Red Sea coral reefs, in common with reefs all over the world, face additional damage from rising carbon dioxide levels in the atmosphere. Bleaching events are associated with warmer temperatures caused by greenhouse gases. To make matters worse, approximately 50 percent of this atmospheric carbon dioxide is ultimately deposited in the oceans, which are growing more acidic as a result. As pH declines, the stress on the coral increases. In the Red Sea and elsewhere in the world, Reidenbach is using his understanding of water flow and turbulence to create a better understanding of how carbon dioxide is distributed around and through reefs.

Local Research

The environment is like an organism. If you want to understand how it functions—and why it flourishes under some conditions and not others—you must drill down to the level of its DNA and learn how essential biological, physical, and chemical processes combine to create the world around us.

Barrier Islands on the Loose

At this point, it is a foregone conclusion that the world's barrier islands will bear the brunt of sea level rise. Currently, however, no one quite understands the key factors that will determine whether an island chain migrates landward and maintains its integrity or disintegrates under the force of the rising oceans. Assistant Professor Laura Moore's study of a cross section of North Carolina's Outer Banks, based on a 25-kilometer stretch of Hatteras Island, is designed to shed light on the issue.

Using GEOMBEST, a morphological-behavior model, she is trying to identify the variables that most influence an island's survival. GEOMBEST simulates the evolution of morphology and stratigraphy in a cross-shore grid that includes the continental shelf, nearshore, beach, and coastal hinterland.

As Moore notes, the Outer Banks is an ideal place to conduct these sensitivity studies because a great deal of the field work has already been done. "We have a wide array of geological data, including geophysical records and cores," Moore says. Moore has loaded this data into GEOMBEST, creating a plausible base case that simulates the evolution of this Hatteras Island cross section over 8,500 years. She then modified the variables, one parameter at a time.

Among other results, she found that the amount of sediment available to an island is a crucial determinant of its fate. Like most phenomena in nature, barrier islands tend toward a state of dynamic equilibrium. As sea levels rise and if sediment supply is limited, the island begins to migrate shoreward, churning up the underlying substrate and generating the sand it needs to retain its integrity.

A number of factors determine the success of this process. If sea level rises rapidly, the rising waters may outpace the island's ability to erode the substrate, causing the island to fail. The slope and composition of the substrate are also critical. For instance, if the substrate has a high proportion of silt to sand, the island may not gain the sand it needs.

Moore is optimistic about the survival of the Outer Banks. "If we let them go, they will most likely maintain themselves because of their sandy substrate," she says. Given our penchant for perching second homes on their shores, it is not certain that we are ready to let that happen.

The Biology of Air Pollution

As a scientist, Manuel Lerdau thinks globally and acts locally. "Knowing how organisms work is the first step in understanding how they change the world," he says. "The more we know about local mechanisms, the better our predictions about phenomena on different scales."

For instance, Lerdau is studying the biological mechanisms that regulate methanol emissions in plants. Methanol is the most abundant plant-derived compound in the atmosphere and has a major effect on hydroxyl radical concentrations as well as on photochemical ozone formation. Methanol is produced at high levels in leaves as they develop in the spring—a phenomenon that is well studied—but it is also released by mature leaves, though at a slower rate. In fact, the cumulative amount of methanol emissions over the course of a summer can be significant. Working in the greenhouse and in the field at the department's Pace Plantation, Lerdau and graduate

Laura Moore's work illuminates the factors that enable barrier islands to adapt to changes in sea level.

student Patty Oikawa are trying to identify the mechanisms that control its release by mature leaves. "If we are to fully grasp the atmospheric impacts of methanol, we must understand in detail how methanol generation is regulated and why, for instance, we see large amounts of methanol some summers and not others."

Lerdau has also been intrigued by the large-scale effects of invasive species. "Because invasive species are so disruptive," he says, "they make great case studies for examining how the characteristics of a species, amplified many times over, affect ecosystems."

Along with Jonathan Hickman from Stony Brook University in New York and Shilang Liu, a graduate student at Harvard, Lerdau is studying one of the most successful and pernicious of the invasive species, kudzu. Since its introduction, it has spread across seven million acres in the Southeast. Lerdau and his colleagues have discovered another less visible but no less serious consequence of this infestation—higher levels of ozone. Kudzu is extremely efficient at transforming atmospheric nitrogen into a form that nourishes the plant. Combine the nitric oxide released from the soil around the plants and abundant isoprene released by its leaves, add sunlight, and the result is ozone. "If you want to understand the ozone problem in the southeast United States, you have to understand plant biology," he says.

The Rise and Fall of Salt Marshes

Salt marshes filter excess nutrients from the water, buffer the mainland from the force of storms, and nurture large colonies of wildlife—but they are also terribly fragile. Their existence depends on a balance being sustained among changes in sea level, subsidence, and surface accretion.

Partnering with Sergio Fagherazzi of Boston University, Professor Patricia Wiberg and Professor Karen McGlathery are attempting to quantify the factors responsible for changes in salt marsh areas in the intertidal zone. With this information, they will produce a model to predict the fate of salt marshes under different climate scenarios. The project is funded by the Department of Energy.

"Right now, we are not sure of the sequence of events that may lead a salt marsh to change size," Wiberg says. "There are many factors, from intensity of the prevailing winds to the activities of burrowing crabs, that may play a role." Another challenge the research team faces is accounting for differences in morphology, depending on whether the marshes are growing or eroding, that occur at the transition between salt marsh and tidal flats.

Over the course of 18 months, the group has collected data from four sites in Hog Island Bay, a lagoon within the Virginia Coast Reserve. The marshes at three of the sites are eroding while the fourth is growing. On each site, they established two transects perpendicular to the salt marsh tidal-flat boundary and measured progradation or erosion at the marsh edge, marsh vegetation, wave height, and tidal velocity. Measurements of deposition rates on the marsh platform and sediment properties began this fall.

They will enter this data into a model that Fagherazzi has developed and test its results against their observations. Once the model is validated, they will run it under different scenarios of sea level rise, subsidence, and increase of storminess. "The advantage of the model is that it enables us to put together and understand the complex interplay of forces that determines whether a marsh grows or disappears," Wiberg says.

In his research, Manuel Lerdau often turns to invasive species because they dramatically illustrate how the characteristics of an organism, amplified many times over, can change an ecosystem.

Working with Karen McGlathery and Sergio Fagherazzi (Boston University), Pat Wiberg is developing a model to understand the forces that determine whether a salt marsh grows or disappears.

Awards, Appointments, & Publications

Undergraduate Students

The department recognizes fourth-year students who have done outstanding work in each of the environmental sciences. This year, the Mahlon G. Kelly Prize in ecology went to **Kelly E. Bowman**, the Michael Garstang Atmospheric Sciences Award went to **Caroline P. Normile**, and the Wilbur A. Nelson Award in geology went to **Christina L. Woods**.

Selected as Distinguished Majors were **Caroline P. Normile** and **Christine S. Okano**.

The Bloomer Award provides a $1,500 grant to a rising fourth-year undergraduate majoring in the department with a focus on geology. This year's winner was **Nicholas C. Radko**.

Spencer M. Ingram received the Trout Unlimited Award, established by the Thomas Jefferson Chapter of Trout Unlimited for "significant contributions to research concerning cold-water fisheries or related ecosystems."

Michelle M. Henry was one of 80 students nationwide to receive a 2008 Udall Scholarship, which will support her research on climate and diet in South Africa. She also received a Harrison Undergraduate Research Award from the University to support this project.

Amanda Schwantes received a $1,500 award from the College of Arts & Sciences and a $2,500 Raven Society Fellowship for study in Costa Rica.

This year's Wallace-Poole Prize for the fourth-year student majoring in environmental sciences with the highest grade point average went to **Luis A. Crouch**.

Thushara Gunda was this year's recipient of the Richard Scott Mitchell Scholarship, which provides $1,500 to a rising fourth-year student who is focusing on geology and who has taken petrology and mineralogy. Gunda, the president of the Environmental Sciences Organization, was selected to participate in the Smithsonian National Museum of Natural History summer 2008 Research Training Program.

Graduate Students

Lixin Wang won the Maury Environmental Sciences Prize. Established by Dr. F. Gordon Tice in 1992, it is the department's premier award. Wang was also among 22 students who received the Award for Excellence in Scholarship from the Office of the Vice President for Research.

David M. Hondula was selected as a National Science Foundation Graduate Research Fellow, which provides three years of support for dissertation work.

Ami L. Riscassi was awarded a three-year Science to Achieve Results (STAR) fellowship from the Environmental Protection Agency.

Two graduate students won awards at the eighth annual Robert J. Huskey Research Exhibition, open to all students in the Graduate School of Arts & Sciences. **Meredith Ferdie** placed second in the physical sciences and mathematics paper competition and **Keir S. Soderberg** placed second in the physical sciences and mathematics poster competition.

Virginia A. Seamster and **Laura K. Reynolds** received the Thomas Jefferson Conservation Award, which supports basic research related to the conservation of the Earth's resources.

Lyndon D. Estes and **Thomas J. Mozdzer** were honored for making outstanding graduate student presentations at this year's Environmental Sciences Research Symposium.

Meredith Ferdie won the department's Fred Holmsley Moore Teaching Award. This award is funded by an endowment set up by Fred H. Moore along with matching donations from Mobil Oil Company.

The department offers a series of awards honoring outstanding graduate students in each specialty of environmental sciences. This year, **Rishiraj Das** earned the Graduate Award in Ecology, **Ami L. Riscassi** won the Graduate Award in Hydrology, **David M. Hondula** won the Graduate Award in Atmospheric Sciences, and **Michael L. Tuite** won the Arthur A. Pegau Award in Geology. **Dirk J. Koopmans** received the Robert Ellison Award for Interdisciplinary Studies.

Matthew H. Long won the Joseph K. Roberts Award. It is given to a student who presents the most meritorious paper on geology at a state, national, or international conference.

David B. Knight received the Graduate Student Research Publication Award.

This year, **Kimberly K. Holzer** and **Michael S. Long** won Moore Research Awards. The award is based on merit and was initiated to help sponsor the dissertation and thesis work of environmental sciences graduate students.

Luke W. Cole, **Sabrina N. Foster**, **Gerald V. Frost**, **Dirk J. Koopmans**, **Ami L. Riscassi**, **Katherine L. Tully**, **Maria T. Van Dyke**, and **Kirby Webster** received Exploratory Research Awards. These awards were initiated to support preliminary research leading to a thesis or dissertation proposal.

The Michael Garstang Award supports graduate student research in interdisciplinary atmospheric sciences. This year, the award went to **Keir S. Soderberg**.

Staff

Charlotta Wriston received the Environmental Sciences Organization Award, while **Lelia A. Gibson** won the Graduate Student Association Award.

Chair's Awards were presented to **Cynthia B. Allen** and **Margot T. Miller**.

Faculty

We are proud to have 12 faculty members serving in an editorial capacity on 22 journals.

Linda Blum continues to serve on the National Research Council Committee on Independent Scientific Review of the Everglades Restoration Project. She is also a member of the National Research Council Committee on Earth Surface Processes.

David Carr successfully directed Blandy Experimental Farm until the hiring of a permanent director and continues as curator of the Orland E. White Arboretum.

Jack Cosby was once again designated a highly cited researcher by the Institute for Scientific Information in ecology/environmental science. Highly cited researchers are the 250 most frequently cited in their field and comprise less than one-half of one percent of all publishing researchers.

Stephan De Wekker was named a University Teaching Fellow for the upcoming year and received the Professor as Writer award.

Paolo D'Odorico served as associate editor for *Water Resources Research* and chaired the Ecohydrology Committee of the American Geophysical Union. He was appointed to the Rivanna River Basin Commission by the mayor of Charlottesville.

Robert Dolan served the University as a member of the Jefferson Scholars National Selection Committee.

William Emanuel served as program scientist for NASA's Terrestrial Ecology Program within the Carbon Cycle and Ecosystems Focus Area of the Science Mission Directorate.

Michael Erwin was cochair of the Avian Influenza Symposium in Barcelona and a member of the Advisory Board for the International Shorebird Reserve Network.

José D. Fuentes edited the *Journal of Geophysical Research—Atmospheres*. He was chair of the Gordon Research Conference on Biogenic Hydrocarbons and was a member of the National Science Foundation's panel on the Integrative Graduate Education and Research Traineeship program. He also served as a member of the International Science Committee for NASA's Global Precipitation Measurement Mission. Fuentes has also been active in efforts to attract more minorities to the sciences and to the geosciences in particular. He initiated graduate development activities with colleagues from Howard University and has been a member of delegations to historically black colleges and universities under the auspices of U.Va. Provost Tim Garson.

James N. Galloway was awarded the 2008 Tyler Prize for Environmental Achievement, elected a fellow of the American Geophysical Union, and appointed the Sidman P. Poole Professor of Environmental Sciences by the Board of Visitors. He was named a highly cited researcher by the

Institute for Scientific Information in three separate categories: ecology/environmental science, geosciences, and engineering. The Galloway et. al. 2004 *Biogeochemistry* paper is the third-most-cited paper in ecology/environment published in the last two years. Galloway was a member of the Environmental Protection Agency's Science Advisory Board and the Board of Trustees of the Bermuda Biological Station for Research. He also chaired the International Nitrogen Initiative.

Bruce Hayden served as the principal investigator, senior scientist, and senior advisor for the National Science Foundation's National Ecological Observatory Network.

Janet S. Herman received the Distinguished Service Award from the Hydrogeology Division of the American Geophysical Union. She was a past chair of the Hydrogeology Division and associate editor of *Water Resources Research*, which is published by the union. She was also a member of the Faculty Senate Executive Council at the University of Virginia.

George M. Hornberger was named one of five Outstanding Scientists and Industrialists by Virginia Gov. Timothy Kaine. He was also elected a fellow of the Geological Society of America. He served on a number of policy-making committees. He was a presidential appointee to the U.S. Nuclear Waste Technical Review Board and was a member of the National Research Council's Committee on Hydrologic Science. He chaired the National Research Council's Board on Earth Sciences and Resources and was president of the Hydrology Section of the American Geophysical Union. He was also a member of the advisory board for Stanford University's School of Earth Sciences. Hornberger was named as a highly cited researcher by the Institute for Scientific Information in ecology/environmental science and engineering.

Alan D. Howard was appointed to several review panels. He was a member of National Science Foundation's Review Panel on the Dynamics of Coupled Natural and Human Systems as well as its Review Panel on Geomorphology and Land Use Dynamics. In addition, he served on NASA's Review Panel on Outer Planets Research.

William Keene was on the board of directors of the Canadian Surface Ocean–Lower Atmosphere Study and served on the advisory group for the U.S. Surface Ocean–Lower Atmosphere Study. Both projects were sponsored by the International Geosphere-Biosphere Programme. In Charlottesville, he was a member of the board of directors of the Thomas Jefferson Emergency Medical Services Council.

Deborah Lawrence codirected the U.Va.'s Environmental and Biological Conservation Program. She was a member of the scientific advisory committee of the TROPI-DRY international research network and an expert assessor of international standing for the Australian Research Council. In addition, she served as associate editor of *Ecology*.

Manuel Lerdau was associate editor of *the Journal of Geophysical Research—Biogeosciences* and of *Oecologia*. He is a longstanding member of the editorial review board of *Quarterly Review of Biology* and a member of the Scientific Committee on Problems of the Environment: Element Interactions Symposium. Lerdau is also a member of the Domain 2 Executive Committee of the National Ecological Observatory Network (NEON) and co-author (with N. Bourg of Smithsonian Institute) of Domain 2 rationale/proposal for relocatable sites. This document will lead to the placement of the NEON site at Blandy Experimental Farm.

Stephen A. Macko was named a fellow of the European Association for Geochemistry and the Geochemical Society. He is a member of the Committee on Education & Human Resources of the American Geophysical Union, the Committee on Education of the European Geosciences Union, and the Panel on Geobiology of the National Science Foundation. Macko served as associate editor of a number of publications: *Amino Acids, The Scientific World: Isotopes in the Environment*, and *Science of the Total Environment*. Macko was a finalist for the State of Virginia Outstanding Faculty Award.

Karen J. McGlathery served as the lead principal investigator on the Virginia Coast Reserve Long-Term Ecological Research (VCR-LTER) site, which was re-funded for years 21–26. She sat on the LTER Science Council and was associate editor of *Ecosystems*. In addition, she is a member of the National Science Foundation's Committee of Visitors, Centers of Excellence for Research in Science and Technology program.

Aaron L. Mills was a member of the editorial board of *Geobiology* and served on the National Science Foundation's Review Panel for the Hydrological Sciences. In addition, he sat on the Advisory Committee of the Appalachian College Association.

Jennie Moody was the University of Virginia's representative to the University Corporation for Atmospheric Research. She was part of a team that received an Outstanding Scientific Paper Award from the National Oceanic and Atmospheric Administration.

Laura Moore was a member of the Coastal Working Group, Community Surface Dynamics Modeling System. She was also a contributing author to *Final Report of Synthesis and Assessment Product 5.3* issued by the U.S. Climate Change Science Program.

Michael Pace served as associate editor of *Ecosystems* and of *Frontiers in Ecology and Evolution*. He chaired the Scientific Committee of the 30th Congress of the International Association of Theoretical and Applied Limnology, which was held in Montreal.

John Porter was a member of the User Working Group for the Oak Ridge National Laboratory Distributed Active Archive Center and trained information managers from Taiwan for the International Long-Term Ecological Research Network.

G. Carleton Ray was a member of the County of Albemarle Natural Heritage Committee and the Scientific Advisory Committee of the Bahamas National Trust for Places of Historic Interest or Natural Beauty. He has been a longtime member of the editorial board of *Aquatic Conservation*.

T'ai Roulston served on the U.S. Civilian Research & Development Foundation science team, fostering collaborations between U.S. and Middle Asian environmental scientists.

Todd Scanlon received a National Science Foundation Faculty Early Career Development (CAREER) Award, the foundation's most prestigious award for young faculty. He was also a University of Virginia teaching fellow.

Herman H. Shugart was the chief scientist for the Northern Eurasian Earth Science Partnership Initiative and served on the editorial board of the *Eurasian Journal of Forest Research*. He was also on the mission steering committee coordinating the development of a new NASA environmental satellite surveying forests, ice, and geological deformation. In addition, he was associate editor of *Global Change Biology* and represented the University of Virginia on the Ecology Section of the Board on Natural Resources at the National Association of State Universities and Land-Grant Colleges. Shugart was named as a highly cited researcher by the Institute for Scientific Information in ecology/environmental science. He was also a member of the Board of Directors of the University of Virginia Press.

David E. Smith was a member of the Network Education Committee and the Executive Committee of the Long-Term Ecological Research Network and represented the University on the Virginia Sea Grant Policy and Oversight Board as well as its Academic Advisory Committee. He was interim director of the Global Mammal Assessment Project (a partnership of U.Va., Conservation International, and the International Union for the Conservation of Nature).

Robert J. Swap was international co-coordinator for the Fire-Land-Atmosphere Regional Ecosystem Studies, conducted under the auspices of the International Geosphere-Biosphere Programme's Integrated Land-Ecosystem-Atmosphere Processes Study. He was an invited participant in the U.S. State Department-sponsored Global Dialogues on Emerging Science and Technology (GDEST) program in Africa titled "Geospatial Data and Analysis for Sustainable Development." Swap, who served as the University's special assistant for international research, received the 2008 Z Society Distinguished Faculty Award. He represented the efforts of the University and its environmental sciences programs in South Africa at a number of meetings with the Department of State, the U.S. Agency for International Development, the World Bank, the World Wildlife Fund, the National Academy of Sciences, and Conservation International.

Vivian Thomson was vice chair of the Virginia Air Pollution Control Board and director of the University's initiative in Panama.

Patricia Wiberg served as associate editor of the *Journal of Sedimentary Research* and the lead guest editor of a special issue of *Continental Shelf Research*. She chaired the American Geophysical Union's Information Technology Committee as well as the Marine Working Group of the National Science Foundation's Community Surface Dynamics Modeling System (CSDMS). She was also a member of the CSDMS Executive Committee. Wiberg was selected to be one of four distinguished lecturers for the National Science Foundation's MARGINS program.

2007–2008 Publications

Annual report of published peer-reviewed papers, book chapters, and books by faculty and graduate students for 2007–2008 academic year (Summer 2007, Fall 2007, Spring 2008)

Alcaraz-Segura, D., J. Cabello, J. Paruelo, and M. Delibes. 2008. Use of descriptors of ecosystem functioning for monitoring a national park network: A remote sensing approach. *Environmental Management* (July 2008), doi:10.1007/s00267-008-9154-y.

Alcaraz-Segura, D., J. Cabello, J. Paruelo, and M. Delibes. 2008. Trends in the surface vegetation dynamics of the national parks of Spain as observed by satellite sensors. *Applied Vegetation Science* 11 (4): 431–440, doi:10.3170/2008-7-18522.

Alcaraz-Segura, D., G. Baldi, P. Durante, and M. Garbulsky. 2008. Análisis de la dinámica temporal del NDVI en áreas protegidas: Tres casos de estudio a distintas escalas espaciales, temporales y de gestión. *Ecosistemas* 17 (3).

Alcaraz-Segura, D. 2008. Remote sensing of ecosystem functioning in the Iberian Peninsula: Groundworks for biodiversity conservation in the face of global change effects. PhD diss., Universidad de Almeria, Spain.

Alfieri, L., P. Claps, **P. D'Odorico**, F. Laio, and T. Over. 2008. An analysis of the soil moisture feedback on convective and stratiform precipitation. *Journal of Hydrometeorology* 9 (2): 280, doi:10.1175/2007JHM863.1.

Aranibar, J. N., I. C. Anderson, **H. E. Epstein**, **C. J. W. Feral**, **R. J. Swap**, J. Ramontsho, and **S. A. Macko**. 2007. Nitrogen isotope composition of soils, C3 and C4 plants along land use gradients in southern Africa. *Journal of Arid Environments* 72 (4): 326–337, doi:10/1016/j/jaridenv.2007.06.007.

Ashton, I., and **M. Lerdau.** 2008. Tolerance to herbivory, and not resistance, may explain differential success of invasive, naturalized, and native North American temperate vines. *Diversity and Distributions* 14 (2): 169–178, doi:10.1111/j.1472-4642.2007.00425.x.

Bade, D. L., S. R. Carpenter, J. J. Cole, **M. L. Pace**, E. S. Kritzberg, M. C. Van De Bogert, R. M. Cory, and D. M. McKnight. 2007. Sources and fates of dissolved organic carbon in lakes as determined by whole-lake carbon isotope additions. *Biogeochemistry* 84 (2): 115–129, doi:10.1007/s10533-006-9013-y.

Berg, P., H. Røy, **P. L. Wiberg**. 2007. Eddy correlation flux measurements: The sediment surface area that contributes to the flux. *Limnology and Oceanography* 52 (4): 1672–1684.

Berg, P., D. Swaney, S. Rysgaard, B. Thamdrup, and H. Fossing. 2007. A fast numerical solution to the general mass-conservation equation for solutes and solids in aquatic sediments. *Journal of Marine Research* 65 (3): 317–343.

Bolster, C. H., and **G. M. Hornberger**. 2007. On the use of linearized Langmuir equations. *Soil Science Society of America Journal* 71: 1796–1806, doi:10.2136/sssaj2006.0304.

Brilli, F., C. Barta, A. Fortunati, **M. Lerdau**, F. Loreto, M. Centritto. 2007. Response of isoprene emission and carbon metabolism to drought in white poplar (*Populus alba*) saplings. *New Phytologist* 175 (2): 244–254, doi:10.1111/j.1469-8137.2007.02094.x.

Cabello, J., **D. Alcaraz-Segura**, A. Altesor, M. Delibes, E. Liras, S. Baeza. 2008. Funcionamiento ecosistémico y evaluación de prioridades geográficas en conservación. *Ecosistemas* 17 (3).

Carpenter, S. R., W. A. Brock, J. J. Cole, J. F. Kitchell, and **M. L. Pace**. 2008. Leading indicators of trophic cascades. *Ecology Letters* 11 (2): 128–138, doi:10.1111/j.1461-0248.2007.01131.x.

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Cook, B. I., G. B. Bonan, S. Levis, and **H. E. Epstein**. 2008. Rapid vegetation responses and feedbacks amplify climate model response to snow cover changes. *Climate Dynamics* 30 (4): 391–406, doi:10.1007/s00382-007-0296-z.

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Crusius, J., **P. Berg**, and **D. J. Koopmans**, L. Erban. 2008. Eddy correlation measurements of submarine groundwater discharge. *Marine Chemistry* 109 (1–2): 77–85, doi:10.1016/j.marchem.2007.12.004.

Daanen, R. P., D. Misra, and **H. E. Epstein**. 2007. Active-layer hydrology in nonsorted circle ecosystems of the Arctic tundra. *Vadose Zone Journal* 6: 694–704, doi:10.2136/vzj2006.0173.

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Smith, J. J., **R. Dolan**, and H. Lins. 2006. Hurricane history of the North Carolina Outer Banks (USA), 1586 to 2004. *Shore & Beach* 74 (3): 19–23.

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