ENVIRONMENTAL SCIENCES
AT THE UNIVERSITY OF VIRGINIA
2009–10 ANNUAL REPORT

THE DEPARTMENT OF
ENVIRONMENTAL SCIENCES

Established in 1969, the University of Virginia's Department of Environmental Sciences was one of the first to look at fundamental environmental processes from a multidisciplinary perspective and the first in the nation to offer undergraduate, master's, and doctoral degrees in environmental sciences. Today, the faculty includes winners of the prestigious Tyler and Hutchinson awards as well as five professors who are among the most highly cited researchers in their fields.

Departmental field stations and facilities include the Anheuser-Busch Coastal Reserve Center in Oyster, Virginia, home of the National Science Foundation–sponsored Virginia Coast Reserve/Long-Term Ecological Research program, the Virginia Forest Research Facility in nearby Fluvanna County, and Blandy Experimental Farm near Front Royal, Virginia.

On the cover: Walruses congregate on "broken pack" in the Bering Sea from February to April to court, mate, and rest. Photo by G. Carleton

FROM THE CHAIR

This department was founded on the recognition that answers to critical questions about the environment necessarily span traditional disciplines. While expertise in a specific field or subfield is fundamental to advances in science, it can provide just one piece of the puzzle. The whole picture emerges only when a number of pieces are fitted together. It is impossible to understand how rising sea level affects coastal barrier islands, for instance, without putting together a team that includes, at a minimum, climatologists, ecologists, hydrologists, and geomorphologists. While the old paradigm for research was the individual scientist working alone, today it is an interdisciplinary network of scientists pursuing a shared research agenda.

Thanks to our department structure's—which brings together ecology, geosciences, hydrology, and atmospheric sciences—this kind of collaboration is second nature here. It is fundamental to the vitality of such continuing projects as the Virginia Coast Reserve/Long-Term Ecological Research program and the Shenandoah Watershed Acidification Study. It also enables us to leverage our expertise by joining forces with scientists from other institutions around the world.

This report documents a number of these interdisciplinary projects—such as Amato Evan's efforts to understand the effect of dust blown off the Sahara Desert on the hurricane season in the North Atlantic, and Peter Berg's work to design a better instrument to measure oxygen fluxes in the water immediately above the seafloor. And it highlights the accomplishments of Hank Shugart, who has been engaged throughout his career in interdisciplinary science designed to view ecosystems from a regional perspective.

As we look toward the future, we hope to strengthen our ability to build joint programs with other departments and schools at the University, to reinforce the program of interdisciplinary research at our field stations, and to provide a more diverse educational experience for our undergraduate and graduate students. Given the complexity of the environmental challenges we face, the ability to transcend the boundaries of individual fields is critical. Support from friends of the department will play a critical role in allowing us to reach these goals.

Patricia Wiberg, Chair

AN ADVOCATE FOR

Over the course of his career, Hank Shugart, the W. W. Corcoran Professor of Environmental Sciences, has assembled a roster of collaborators that conservatively numbers in the thousands. His field—big-picture ecology—demands cross-disciplinary partnerships. But it is equally true that others are eager to work with him because of the quality of his work. In addition to being a member of the Russian Academy of Sciences, Shugart is one of five department members who are designated as highly cited researchers by the Institute for Scientific Information.

THE SYNTHESIZER

For **Hank Shugart** the path to big-picture ecology started with birds. Trained as a field ornithologist, he was among the first to use statistical methods to predict where a particular species might be found. "Studying birds led me to issues of habitat, and since birds migrate, eventually to regional ecological dynamics," he says. "It seemed to me to be a logical progression. If you really want to understand birds, you have to address these larger questions."

Although Shugart never left birds behind—a recent book is titled *How the Earthquake Bird Got Its Name*—he became increasingly involved in synthesizing large quantities of information. This synthetic impulse led him directly to modeling, which gave him the opportunity to combine inputs from a variety of sources into a single, dynamic image. While at the University of Tennessee, he created his first forest model and received a grant from the National Science Foundation to build a set of models based on different conceptual frameworks and to compare them with each other. This work led to his groundbreaking book *A Theory of Forest Dynamics*.

In the course of his career, Shugart has developed a series of highly regarded simulations that describe changes in forest structure and composition over time in response to both internal and external sources of perturbation. "One of the things I enjoy about working on these models is that I get involved with specialists who know much more about a given field than I could ever hope to," he says. The models Shugart has developed are applied at spatial scales ranging in size from small forest gaps to entire landscapes and at temporal scales of years to millennia.

"One of the things I enjoy about working on these models is that I get involved with specialists who know much more about a given field than I could ever hope to."

BIG-PICTURE ECOLOGY

GETTING THE BIG PICTURE ON THE PAGE

Shugart's interest in synthesis naturally draws him toward writing books, in addition to the many highly cited articles he's published. "Books are the only way to pull all your ideas together in one place," he explains. "In the process of writing a book, you can wrap your mind around a big, complicated issue."

As Shugart has come more and more to understand, synthesis means moving away from a preoccupation with one's own ideas. His latest book now in press, *Global Changes and the Terrestrial Biosphere: Achievements and Challenges*, includes the perspectives of his scientific forebears as well as those of his contemporaries. "You can describe writing a book as a form of intellectual networking," he says. "My touchstone in this project was Alexander von Humboldt, who was among the first to ask questions about how the planet works."

Shugart has found a novel way to extend this intellectual network into the future; he is deeply involved in mentoring the next generation of young scientists. Over his career, he has supervised forty-five doctoral students and seventeen postdoctoral fellows. "It is extremely satisfying for me to work with young, creative minds, talk about what is essential in their work, and figure out what their next step might be," he says.

The legacy of Hank Shugart's forty-year career can be measured in the forest models he has created, the books and highly cited articles he has written, and the scores of graduate students he has mentored.

SEIZING ON UNINTENDED CONSEQUENCES

Q. *You've been involved in a number of large-scale projects like SAFARI 2000, which brought together hundreds of scientists to study the transport of materials from the land surface in southern Africa to the atmosphere. What's the attraction for you?*

A. Obviously, there's the challenge of taking on a major scientific question and answering it more thoroughly than has been done before and from so many different perspectives.

But I'm also fascinated by the indirect consequences of this type of activity: the networks that take shape as opportunities arise. Thanks to SAFARI 2000, U.Va. was able to establish formal relationships with a group of universities and research stations in the region. This connection subsequently opened doors for faculty and students from other schools at the University to build their own networks. And more than 15 students in environmental sciences received doctoral degrees as a result of the project.

Q. *But ten years later, you seem to have moved on.*

A. That's right. These things have a natural lifespan, and it's important to your growth as a researcher to understand that.

Q. *So what are you working on right now?*

A. For one thing, I'm the principal U.S. scientist for the Northern Eurasia Earth Science Partnership Initiative, which covers much of the old Soviet empire. Russia owns more ecologically preserved carbon than any other nation. If we are going to understand climate change, we need to know more about the relationship between the ecosystems in this region and the atmosphere.

Q. *But this is not a new thing for you?*

A. In the mid-1980s, I spent a month in Stockholm writing a chapter of a book on the effects of climate change on the forests of the world and walked around the city each night discussing these issues with Mikhail Antonovsky, a Russian mathematician. He introduced me to Alexander Isaev, and we worked together to build a unified computer model of the global boreal forest belt. That partnership made me a likely person to play a role in NEESPI. It makes a sort of sense now, but thirty years ago I never could have predicted how these connections would lead to this project.

PARTICIPATING IN **NATIONAL NETWORKS**

Our faculty participate in national and international efforts that create the infrastructure for environmental research and education. The department supports the Virginia Coast Reserve, one of 26 sites that are part of the Long-Term Ecological Research network, and represents the University in the University Corporation for Atmospheric Research, which among other initiatives promotes open access to data for researchers through its Unidata program.

POSITIVE FEEDBACK AT THE LTER

The Virginia Coast Reserve (VCR) is a wonderful place to study coastal barrier ecosystems. This 35,000-acre assemblage of barrier islands, shallow lagoons, and tidal marshes is one of the few areas on the Atlantic Seaboard and Gulf Coast that remains relatively undisturbed. The barrier islands are uninhabited, and population densities in the VCR watersheds are relatively low, preserving water quality. This makes the VCR an ideal place to develop a baseline understanding of natural processes and to track the effects of such phenomena as sea-level rise and invasive species on the environment.

The reserve's integration into the National Science Foundation's Long-Term Ecological Research (LTER) network almost 25 years ago has only amplified and reinforced these advantages. Each researcher adds his or her findings to the LTER database, strengthening its intellectual infrastructure. This record enables successive investigators to place their findings in context and to predict the future with greater confidence.

Karen McGlathery, principal investigator at the Virginia Coast Reserve/Long-Term Ecological Research site, has coordinated efforts with the Virginia Institute of Marine Science and The Nature Conservancy to restore seagrass to the reserve's lagoons.

At the same time, the department, with assistance from funding agencies and donors, has added to the LTER's physical infrastructure. The dedication in 2006 of the $2.5 million Anheuser-Busch Coastal Reserve Center in Oyster, Virginia, with its wet and dry laboratories and dormitories for researchers, has both accelerated and broadened the research program of the LTER. "People from other universities want to come to work at the reserve," says Professor **Karen McGlathery**, the principal investigator for the VCR/LTER. "This makes it easier to bring together multidisciplinary teams to study coastal barrier ecosystems.

One example is the seagrass restoration project being conducted with the Virginia Institute of Marine Science and The Nature Conservancy. Over the last decade, participants in this multi-institutional project have successfully reseeded more than 1,400 acres of the VCR lagoons, enabling scientists to determine the effects of a rapid change back to the ecosystem's original state.

In addition, the VCR/LTER benefits from being part of the LTER network, which includes 26 sites from Alaska to Antarctica. "This is an important advantage for us," McGlathery says. "We can call on data gathered at other sites to expand our perspective to regional or continental scales, enabling us to develop new theories, for instance, about how ecosystems respond to climate change."

Jennie Moody got involved in the Unidata project because she saw that improving access to information would energize atmospheric science research.

PROMOTING DATA ACCESS

For Research Associate Professor **Jennie Moody**, interdisciplinary collaboration comes naturally. A meteorologist, she is interested in understanding the chemistry of the non-urban troposphere—the layer of the atmosphere closest to the earth—and how it may be changing as a result of human activities. Joining forces with atmospheric chemists, she traces physical processes that can shape atmospheric composition at a particular location, providing her colleagues with the essential context to interpret their findings about the chemical evolution of an air mass. "It is essential to understand what part of the chemical fluctuations we observe are due to transport by the atmosphere or changes in the weather," she says. "It's only when we work together that we develop the full picture."

Over time, Moody has worked on progressively larger scales and collaborated with larger groups of people, starting from instrumented towers, moving to balloon and aircraft observations that enable her to forecast or analyze the motion of layers of air over large regions, and most recently employing satellite data. She credits the Unidata project, one of eight programs in the University Corporation for Atmospheric Research (UCAR) Office of Programs, for her ability to participate in these efforts. Unidata is a data facilitator, creating software tools that enable educators and researchers to access real-time or near real-time data from various sources. "The Unidata project has led to the democratization of weather data and the involvement of a larger community of researchers," she says. "Previously, you would have had to work at a major meteorological institution to have access to the information needed to do cutting-edge research."

Moody was involved with the Unidata program as chair of its Users Committee, which addressed issues related to data acquisition and display and hosted summer colloquia for faculty teaching in atmospheric and related sciences. She employs these resources in two classes she teaches, Weather Forecasting and Remote Sensing. Currently, she is the University's representative to UCAR and has recently been elected to its Membership Committee. "The key to UCAR and the Unidata project is openness," she says. "Having open access to data brings a community of people together and spurs them to find creative new ways to advance research and education."

COLLABORATING ON TOOLS FOR **RESEARCH AND EDUCATION**

The questions environmental scientists ask are constrained by the tools they have available to answer them. Quite often the person who conceives of a new tool lacks the precise skills needed to realize it—and so gathers a team of collaborators. This was the experience of Peter Berg, who wanted to create an eddy correlation system to measure oxygen fluxes at the sediment-water interface, and Dave Smith, who was looking for an interactive computer simulation he could use in teaching a course on the Chesapeake Bay and its watershed.

Peter Berg (left) worked with colleagues in Germany to apply eddy correlation techniques underwater.

A NEW TECHNIQUE FOR RESEARCH AT THE OCEAN FLOOR

Peter Berg's is the classic case of a scientist with a clear idea of what he wants to accomplish and a definite understanding of the complementary expertise he needs to reach his goals. Berg is a mathematical modeler who constructs large-scale models of biogeochemical processes above and in the seafloor. He is particularly knowledgeable about modeling transport phenomena and biogeochemical reaction kinetics.

A research associate professor, Berg has worked closely with other scientists to measure dissolved oxygen fluxes across the sediment-water interface, a critical indicator of benthic metabolism and proxy for underwater carbon cycling, but he was well aware of several weaknesses in the methods used to collect these data. Scientists either analyzed sediment core samples in the laboratory or placed chambers over a small section of the seafloor. Both conventional approaches had the disadvantage of changing natural light and flow conditions, thus misrepresenting the metabolic rates by several factors, especially for vegetated or sandy bottoms.

The ideal system would have none of these limitations. It would be noninvasive, yet sensitive and fast enough to measure the slightest fluctuations in oxygen concentration and turbulent flow. With funding from the National Science Foundation and in collaboration with researchers from the Max Planck Institute for Marine Microbiology in Germany, Berg developed an eddy correlation system that meets these criteria.

Eddy correlation systems have long been a staple of atmospheric research, where they have been placed on towers to measure land-air exchanges. Researchers at Max Planck are worldwide leaders in developing oxygen sensors for underwater work. The new system they developed with Berg to measure sediment-water exchanges combines an off-the-shelf instrument to measure velocities in the water column above the sediment and a very fast and precise microelectrode to measure oxygen concentrations. Together, these two devices produce the data needed to compute sediment oxygen uptake. Their system performs these measurements 64 times a second, enough to create a detailed picture of water turbulence. Several companies now produce commercial variants of Berg's system.

One of the advantages of Berg's eddy correlation system is that it can be used in any salt- or freshwater environment. "We're very excited about using the system in places where accurate measurements have been impossible and about adapting it for other types of fluxes besides oxygen." Berg's graduate students are using eddy correlation systems to measure oxygen fluxes over coral reefs, seagrass beds, and in rivers and creeks as a measure of the health of these vital ecosystems.

AN EDUCATION IN COMPLEXITY

The challenges facing our graduates as the twenty-first century progresses are unprecedented in their complexity. If they are to resolve them, they must appreciate how complex systems work, learn to distinguish fact from ideology, and understand how to achieve consensus. The U.Va. Bay Game, an agent-based simulation of the Chesapeake Bay watershed, is designed to achieve all three goals while focusing attention on environmental sustainability. "Our purpose is to try to create environmentally literate people who can go out and make informed decisions about complex issues," says **Dave Smith**, professor of environmental sciences and one of the developers of the game.

The Chesapeake Bay certainly epitomizes complexity. It is the largest estuary in North America, with a tidal shoreline stretching 11,600 miles that is greater than the entire West Coast. It contains more than 15 trillion gallons of water and supports 3,600 species of plants and animals. Through more than 150 major rivers, it drains a watershed of 64,000 square miles that includes parts of six states and the District of Columbia.

Altogether, 17 million people live in this watershed, and their activity has caused a serious decline in the bay's health. The tangled interplay of causes—development, overfishing, and water pollution—and the number of stakeholders mean that there will be no easy, simple path to restore the bay.

Creating a game capable of replicating these factors was necessarily a multi-disciplinary effort. Smith was part of a team of faculty experts from eight schools at the University that unveiled a beta version of the game in 2009. Earth Day 2010 saw one hundred students and twenty residents of the bay area play the first University-wide simulation. Players took on the role of Chesapeake Bay stakeholders, and their collective decisions affected their own well-being as well as the health of the bay. "Before the game started, we asked participants to quantify the relative importance of their personal goals in three areas: environmental sustainability, economic growth, and social cohesion," Smith said. "The game gave us a tool for them to determine whether their choices were consistent with their values."

The game has stimulated the development of a set of three courses—in systems engineering, environmental sciences, and architecture—exploring the intricacies of restoring and sustaining the bay. Students from all three seminars meet together once a week and play the game four times during the semester.

The game has also attracted widespread interest outside the University. Philippe Cousteau, cofounder of the environmental education organization Azure Worldwide, participated in the Earth Day simulation, and IBM has made available its World Community Grid to accelerate development of a more computer-intensive version of the game.

> *"Our purpose is to try to create environmentally literate people who can go out and make informed decisions about complex issues."*

At Earth Day 2010, more than 120 people participated in the University-wide launch of the U.Va. Bay Game, a large-scale simulation of the effects of human activity on the Chesapeake Bay. Dave Smith (top), professor of environmental sciences and one of the game's developers, and Philippe Cousteau (bottom), cofounder of Azure Worldwide, helped lead the event.

AT THE INTERFACE OF **OCEANS AND ATMOSPHERE**

Both Bill Keane and Amato Evan operate at the interface of the ocean's surface and the lower atmosphere, and they are both interested in the effects of aerosols on climate. The sources of these aerosols, however, are dramatically different. Evan studies dust particles generated over land, while Keene looks at the salt spray tossed up by our oceans. Both these approaches are necessary to complete our understanding of climate dynamics.

FROM DUST STORMS TO HURRICANES

Assistant Professor **Amato Evan** makes computer models, an activity that at its core is about quantifying relationships observed in the natural world. As the questions modelers ask grow more ambitious, the range of knowledge required to represent these relationships grows broader as well.

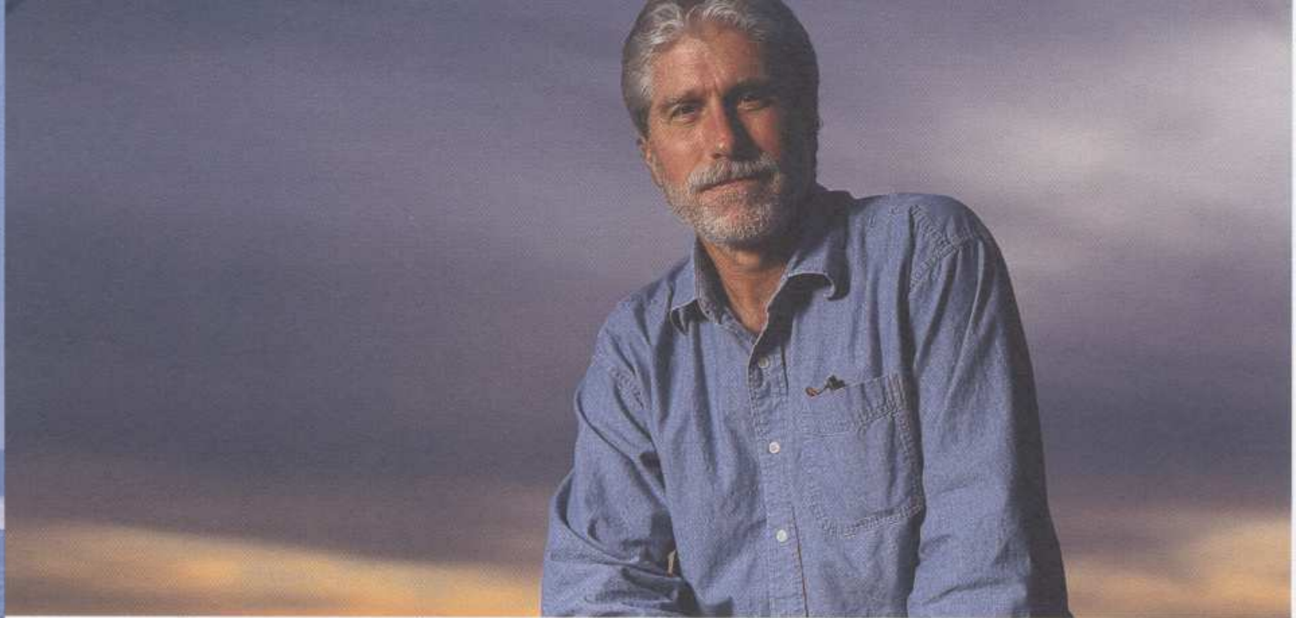
Amato Evan has shown that dust storms blowing off the Sahara can dampen hurricane activity in the North Atlantic.

Evan is an atmospheric scientist focused primarily on the transport of aerosols, in particular microscopic particles from volcanic eruptions and dust storms. Over the last decade, scientists have studied the role of different aerosols in cooling the atmosphere by scattering radiation. Evan is interested in whether aerosols can affect climate by changing the surface water temperature in the oceans. Using satellite data going back to the early 1980s, he has tracked the influence on hurricane formation of the Saharan Air Layer, a body of dry, dusty air that flows westward over the tropical North Atlantic.

"This is the kind of question that would be impossible for a single person to address," Evan says. "It requires people with varied expertise—geochemists, physical oceanographers, satellite meteorologists, and modelers—working together." Evan and his colleagues concluded that there is evidence that shows that the Saharan Air Layer tends to interrupt and suppress hurricane activity through various intersecting mechanisms, one of which is by lowering surface water temperatures.

These processes are complex and vary considerably from year to year. To gain a better appreciation of them, scientists need to consider them on decadal scales. Evan is using proxy measurements, including the concentration of helium isotopes associated with dust in coral reefs off the Cape Verde Islands, to extend the time series back to the 1950s and to improve its resolution.

Evan is also applying his expertise in atmospheric modeling to clouds. He is engaged with colleagues at the Scripps Institution of Oceanography and the Lawrence Livermore National Laboratory to determine how well models being considered for the next Intergovernmental Panel on Climate Change report represent clouds and cloud variability. "Cloud cover is essential in understanding climate change," he says. "The models that best reproduce historical changes in cloud cover have the best predictive ability, yet understanding the historical record is not a simple matter."



In the spray generated by our foaming oceans, Bill Keene sees a major determinant of climate.

CONNECTING WHITECAPS TO CLIMATE

You might not immediately identify the film coating the windows of your beach house as an important driver of climate, but Bill Keene, a research professor, would be quick to point out that you would be underestimating both its ubiquity and its potency.

This film consists mostly of sea-salt aerosols injected into the atmosphere by bursting bubbles from wind-generated waves breaking on the ocean surface. This process is the largest source of aerosol mass in Earth's atmosphere, and these aerosols can persist in the air for more than a week. During this time, they undergo chemical and physical reactions, releasing chlorine, bromine, and other chemicals that in turn react with other atmospheric constituents. Considering that oceans cover 71 percent of the Earth's surface, the effects of these aerosols are hardly negligible. Marine aerosols and their byproducts influence ozone concentrations, sulfur cycling, Earth's radiative balance, and climate.

Keene is interested in virtually every aspect of these aerosols—their formation, their lifecycle, and their influences on other atmospheric constituents and climate. The breadth of his interests requires a revolving team of collaborators, including oceanographers, atmospheric chemists and physicists, and modelers. "You sit down with people interested in the same question, figure out what we need to do next, and then start looking for additional people with the right expertise," he says.

Among his other projects, Keene and his colleagues designed a marine aerosol generator to study the process of aerosol formation and evolution under laboratory conditions. The generator mimics the formation of aerosols by bubbling clean air through flowing seawater. He tested the generator at the Bermuda Institute of Ocean Sciences, comparing the size and composition distributions as well as the photochemical evolution of artificially generated aerosols with those produced naturally. Based on these results, Keene and his student Michael Long developed new modules describing marine aerosol production and evolution for the Community Climate System Model, the United States' major climate modeling initiative.

Keene has most recently deployed a similar generator aboard the National Oceanic and Atmospheric Administration (NOAA) Research Vessel *Atlantis* to evaluate aerosol production over ranges of seawater characteristics in the eastern North Pacific. This study is part of the $20 million CalNex 2010 project, coordinated by NOAA and the California Air Resources Board, to better understand interactions between pollutant emissions and marine-derived constituents in coastal California air.

TARGETED **PARTNERSHIPS**

The more environmental scientists learn about the natural world, the more ambitious the questions they ask and the more likely that answering these questions will exceed the limits of their own expertise. To understand how climate change might affect walrus populations, Carleton Ray called on sea ice dynamicists and meteorologists. To determine how kudzu might affect climate, Manuel Lerdau collaborated with soil microbiologists and atmospheric scientists.

Jerry McCormick-Ray and Carleton Ray, aboard the USGCS *Healy*, are trying to understand the relationship between marine mammals and their environment. Their work helps create a baseline for monitoring the effects of climate change on the Bering Sea.

FOLLOWING A FLOATING LANDSCAPE

Marine ecologist **Carleton Ray** suffers from scientific synesthesia. A synesthete hears a sound and sees a color. Ray's form of synesthesia, while not as dramatic, has proven more productive. He sees sea ice and experiences it as a landscape. This novel frame of reference is helping Ray, a research professor, shed light on the habitat of the seals and walruses that make their home on the ice that covers much of the Bering Sea during winter.

Ray calls these floating landscapes *seascapes*, and they vary by the shape, thickness, and concentration of the ice floes that compose them. As on land, different species prefer different habitats. Walruses, for instance, favor the "broken pack" of the central Bering Sea, which is composed of thick, angular, often ridged ice floes separated by areas of open water. Walruses congregate on this seascape to court, mate, bear calves, and rest. They take advantage of the open water to escape predators or to dive down to the benthos, where they feed on clams and numerous other bottom dwellers.

"Understanding these seascapes gives us an insight into the requirements of the animals that live on them," Ray points out. But unlike ordinary landscapes that evolve slowly over centuries and millennia, the seascapes of the Bering Sea are seasonal. Forming in winter, they are shaped by weather and ocean currents before drifting north to melt in spring. As a result, Ray has built long-term relationships with meteorologists and ice dynamicists to develop a more complete picture of the walruses' habitat.

This work is made more imperative by climate change. "The fastest large-scale effects of climate change are occurring in the Bering Sea," Ray says. "Sea ice has been forming later, breaking up earlier, and diminishing in both extent and thickness." The danger is that climate change will alter the ice habitat faster than walruses can adapt. If it does, how will reduction in the numbers of these animals affect the larger ecosystem?

That's a question that Ray's wife and research partner, senior research scientist **Jerry McCormick-Ray**, is trying to address. "The walrus is a keystone species," she says. As walruses feed, they are constantly plowing up the sediment on the ocean floor, an activity that may affect the diversity and productivity of this ecosystem. While Carleton Ray observes walruses in their habitat, McCormick-Ray samples the benthos and catalogues what she pulls up. "We're both helping to create a benchmark," she says "so that the future effects of climate change can be measured."

Invasive species can transform an ecosystem. As Manuel Lerdau has discovered, that also means changing the composition of the atmosphere.

INVISIBLE EFFECTS OF INVASIVE SPECIES

Kudzu was a really big mistake. Introduced at the Philadelphia Centennial Exposition in 1876 as a forage crop and promoted by the Soil Conservation Service until the 1950s for reducing soil erosion, it has overwhelmed the landscape in many parts of the southeastern United States. Today, it blankets seven million acres, smothering an additional 150,000 acres each year.

The visible effects of kudzu on the landscape are obvious enough. Professor **Manuel Lerdau** is interested in determining if an invasion of this magnitude could also have a not-so-visible impact on the atmosphere. Lerdau is an organismal ecologist who brings to this investigation his ability to understand the leaf-level processes that release volatile organic compounds into the air, but he knew that a full answer would require expertise in such fields as soil microbiology (kudzu is a nitrogen-fixing legume), landscape patterns, and atmospheric chemistry.

"Knowing how organisms work is an essential first step in understanding the world," he says, "but if you want to ask big questions, you need to collaborate with scientists with different sets of expertise and who work on different spatial and temporal scales."

Because kudzu is so efficient at fixing nitrogen, a widespread invasion of kudzu increases emissions of various nitrogen compounds from the soil, including nitrous oxide, a long-lasting greenhouse gas, and nitric oxide, a source of ozone production. To make matters worse, kudzu leaves emit high levels of isoprene, another precursor of ground-level ozone. Add sunlight, and you have a problem.

To determine how big a problem this could be, Lerdau and his colleagues took samples from three sites in the heart of kudzu country, Madison County, Georgia. They then used the GEOS-Chem chemical transport model to evaluate the potential impact of kudzu invasion on regional atmospheric chemistry and air quality. They concluded that as kudzu continues to spread, it can have significant impact on ozone levels. "Kudzu may be as close to a polluting plant as one can find," Lerdau says. They concluded that an extensive kudzu invasion would be responsible for as many as seven more days each summer when ozone levels reach 70 parts per billion. Extended exposure to ozone levels this high can cause respiratory problems even in healthy individuals.

These effects will not likely be confined to the South. As carbon dioxide concentrations in the atmosphere increase, kudzu will grow more luxuriantly, and as the weather warms with climate change, kudzu will continue marching north.

AWARDS, APPOINTMENTS, AND 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 **Kelsey E. Ducklow**, the Michael Garstang Atmospheric Sciences Award went to **Colleen E. Rossier**, the hydrology award went to **Kelly J. Hokanson**, and the Wilbur A. Nelson Award in geology went to **Michelle M. Henry**.

This year's Wallace-Poole Prize for the fourth-year student majoring in environmental sciences with the highest grade point average went to **Thushara Gunda**. She also won the Departmental Interdisciplinary Award and was recognized with an Outstanding Presentation Award at the Environmental Sciences Research Symposium.

Kate E. Abshire, **Thushara Gunda**, **Daniel E. Michaelson**, and **Colleen E. Rossier** were selected Distinguished Majors.

Michelle M. Henry was selected one of 18 Luce Scholars for 2010. The program is designed to enhance the understanding of Asia among potential leaders in American society who, as yet, have no familiarity with this area of the world. Henry will spend next year working on sustainable development issues in Thailand.

Joseph M. Nelson 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.

The Bloomer Scholarship provides a $1,500 award to a rising fourth-year undergraduate environmental sciences major with a focus on geology. This year's winner was **Whitney N. Hawkins**.

Kelly J. Hokanson received the Trout Unlimited Award, which was established by the Thomas Jefferson Chapter of Trout Unlimited for "significant contributions to research concerning cold-water fisheries or related ecosystems."

Julia B. 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.

The University's Harrison Undergraduate Research Awards program is designed to encourage undergraduates to undertake independent research projects with the guidance of a faculty member. Of the thirty-five awards this year, five went to environmental studies majors. They were **Michael J. Downey**, **Mary O. Hutton**, **Avery B. Paxton**, **Sarah E. Peterson**, and **Michelle R. Rehme**.

Bridget Long was awarded the prize for the best presentation by an undergraduate student at the recent Atlantic Estuarine Research Society annual meeting in Atlantic City. Her paper on belowground production of salt marsh grasses was coauthored by Research Associate Professor Linda Blum and John Haywood, a graduate student at East Carolina University.

GRADUATE STUDENTS

The department offers a series of awards honoring outstanding graduate students in each specialty of environmental sciences. This year, **Stesha L. Dunker** earned the Graduate Award in Ecology, **Abinash Bhattachan** won the Graduate Award in Hydrology, **Catherine V. Wolner** won the Arthur A. Pegau Award in Geology, and **Yufei He** won the Graduate Award in Atmospheric Sciences. **Amy E. Grady** received the Robert Ellison Award for Interdisciplinary Studies.

Charles E. Clarkson received the Thomas Jefferson Conservation Award, which supports basic research related to the conservation of the earth's resources.

Wai-Yin Stephen Chan, **Rishiraj Das**, **Laura K. Reynolds**, and **Jacquelyn K. Shuman** were honored for making outstanding graduate student presentations at this year's Environmental Sciences Research Symposium.

The Michael Garstang Award supports graduate student research in interdisciplinary atmospheric sciences. This year, the award went to **David M. Hondula**.

Dirk J. Koopmans 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.

Yo Matsubara received the Graduate Student Research Publication Award.

This year, **Joseph M. Mattistelli**, **Gerald V. Frost**, **Catherine V. Wolner**, and **Qin Yu** won Moore Research Awards. These awards are based on merit and were initiated to help sponsor the dissertation and thesis work of environmental sciences graduate students. **Stesha L. Dunker**, **Michael L. Tuite Jr.**, and **Rebecca L. Yeamans** received Exploratory Research Awards. These awards are meant to support preliminary research leading to a thesis or dissertation proposal.

The Chair's Award was presented to **Luke W. Cole**.

Katherine L. Tully and **Wai-Yin Stephen Chan** were awarded Dissertation Year Fellowships from the Graduate School of Arts & Sciences for 2010–11.

Meredith F. Muth was awarded a Knauss Marine Policy Fellowship, which matches highly qualified graduate students with agencies in the legislative and executive branches of government in Washington, D.C.

Noah E. Egge is the recipient of a Knowles Science Teaching Fellowship. It provides up to five years of funding for exceptional early career teachers.

David A. Lutz was awarded a $40,000 grant from the U.S. Civilian Research and Development Foundation to study the impact of climate change on Russian boreal forests.

Marcia S. Delonge was presented the 2010 Award for Excellence in Scholarship in the Sciences and Engineering, given by the University's Office of the Vice President for Research. Award winners are chosen based on a significant record of peer-reviewed scholarship and/or award-winning presentations at national conferences.

STAFF

Cynthia B. Allen won the Graduate Student Association Award**.**

FACULTY

We are proud to have five faculty members—**Jack Cosby**, **James Galloway**, **Michael Pace**, **William Ruddiman**, and **Hank Shugart**—designated highly cited researchers by the Institute for Scientific Information. Highly cited researchers comprise less than one-half of 1 percent of all publishing scientists.

Linda Blum continues to serve on a number of National Research Council committees, including the Committee on Earth Surface Processes.

Paolo D'Odorico was one of several authors (including colleague Deborah Lawrence) presented with the Ecology Society of America 2009 Sustainability Science Award for their special feature on land use science published in the *Proceedings of the National Academy of Science*. He is the editor of *Geophysical Research Letters* and chair of the Ecohydrology Technical Committee of the Hydrology Section of the American Geophysical Union.

Howard Epstein received the department's Environment Sciences Organization Award**.** He is associate editor of *Plant Ecology* and a reader for *Nature*. He is also codirector of the College Science Scholars Program.

James N. Galloway, the Sidman P. Poole Professor of Environmental Sciences, is U.Va.'s associate dean for the sciences. He continues to serve as a member of the EPA Science Advisory Board and the International Nitrogen Initiative Steering Committee.

Kyle Hanes had an article chosen for evaluation by the Faculty of 1000 Biology, a postpublication peer review site that spotlights the most important articles in the field.

Bruce Hayden is associate editor of the *Journal of Climate Research* and chair of the Long-Term Ecological Research Climate Committee.

Janet S. Herman was named Edward L. Ayers Faculty Fellow in Advising at the University of Virginia for excellence in advising undergraduates and dedication to the undergraduate experience. She serves as associate editor of *Water Resources Research*, which is published by the American Geophysical Union.

Alan D. Howard was awarded the 2010 G. K. Warren Prize by the National Academy of Science for noteworthy and distinguished accomplishment in fluviatile geology and closely related aspects of the geological sciences. The prize is awarded every four years. He serves as vice chair of the Executive Committee of the Earth and Planetary Surface Processes Group of the American Geophysical Union

William Keene is a member of the Executive Council of the Faculty Senate.

Deborah Lawrence was one of several authors (including colleague Paolo D'Odorico) presented with the Ecology Society of America 2009 Sustainability Science Award for their special feature on land use science published in the *Proceedings of the National Academy of Science*. She was the first U.Va. faculty member to be chosen a Jefferson Science Fellow at the Department of State, where she is science adviser to the Office of Global Change and special envoy for climate.

Manuel Lerdau is in his second year as a National Academy of Sciences Kavil Fellow. He serves as associate editor of the *Journal of Geophysical Research—Biogeosciences* and as a review editor of *Oecologia*.

Stephen A. Macko serves as an associate editor of *Amino Acids* and *Science of the Total Environment*. He is also education editor of *EOS*. Macko is a member of the Faculty Senate and the University Committee on Information Technology.

Karen J. McGlathery serves as the lead principal investigator on the Virginia Coast Reserve/Long-Term Ecological Research (LTER) site. She sits on the LTER Science Council and is an associate editor of *Ecosystems*.

Aaron L. Mills is a member of the Faculty of Arts & Sciences Steering Committee.

Jennie Moody is a member of the Board on Oceans and Atmosphere of the Association of Public and Land-grant Universities. She is also the University of Virginia's representative to the University Corporation for Atmospheric Research.

Michael Pace had an article chosen for evaluation by the Faculty of 1000 Biology, a postpublication peer review site that spotlights the most important articles in the field. He is associate editor of *Ecosystems* and *Frontiers in Ecology and Evolution*.

Arnico Panday is a member of the Patan Academy of Health Sciences International Advisory Board in Lalitpur, Nepal.

John Porter is a member of the Long-Term Ecological Research (LTER) Network Information System Advisory Committee.

G. Carleton Ray was recognized as a founding member of the Bahamas National Trust. He is also a longtime member of the editorial board of *Aquatic Conservation*.

Matthew Reidenbach was one of just seven recipients of a 2010–11 FEST Distinguished Young Investigator grant from the University of Virginia. The FEST program is designed to help the University identify some of its most promising young faculty in engineering and science. Reidenbach was also one of six faculty members chosen as a University Teaching Fellow for 2009–10. The fellowship provides support to impressive junior faculty as they refine their teaching expertise while pursuing strong research agendas.

William Ruddiman was presented the 2010 Lyell Medal by the Geological Society of London for his exceptional contribution to research.

Todd Scanlon is associate editor of *Water Resources Research*.

Herman H. Shugart, the W. W. Corcoran Professor of Environmental Sciences, is associate editor of *Research Letters in Ecology* and a member of the editorial boards of the *Eurasian Journal of Forest Research* and the *International Journal of Ecology*. He is a member of the Biological and Environmental Research Advisory Committee in the Office of Science, which is a division of the Department of Energy, and is also a member of the Subcommittee on Earth Sciences of the NASA Advisory Council. Shugart is chief scientist for the Northern Eurasia Earth Science Partnership Initiative. At the University, he serves as a member of the U.Va. Energy Sustainability Group and is president of the Committee on Undergraduate Admission.

David E. Smith is a member of the Virginia Sea Grant (VASG) Research and Extension Advisory Committee and serves as the University's representative to the VASG Policy and Oversight Board. He is a member of the Board of Directors of the Association of Ecological Research Centers and its president-elect. Smith is one of the developers of the U.Va. Bay Game, a massive computer-generated simulation of the human and ecosystem processes in the Chesapeake Bay. He serves the University as a member of the U.Va. Executive Leadership Network, the Facility Management Advisory Board, and the U.Va. Process Simplification Advisory Committee.

Vivian Thomson is vice chair of the Virginia Air Pollution Control Board and director of the University's initiative in Panama. She is also director of the Environmental Thought and Practice interdisciplinary major.

Patricia Wiberg is chair of the department. She also chairs the American Geophysical Union's Information Technology Committee and serves on a committee of the National Research Council. In addition, she is chair of the Marine Working Group of the National Science Foundation's Community Surface Dynamics Modeling System (CSDMS) and a member of the CSDMS Executive Committee.

Henry Wilbur is editor of *American Naturalist*.

2009–10 PUBLICATIONS

Annual report of published peer-reviewed papers, book chapters, and books by faculty and graduate students for the 2009–10 academic year (Summer 2009, Fall 2009, Spring 2010)

Alcaraz-Segura, D., E. Chuvieco, **H. E. Epstein**, E. Kasischke, and A. Trishchenko. 2010. Debating the greening vs. browning of the North American boreal forest: Differences between satellite datasets. *Global Change Biology* 16:760–70. doi:10.1111/j.1365-2468.2009.01956.x.

Anderson, I. C., J. W. Stanhope, A. K. Hardison, and **K. J. McGlathery**. 2010. Sources and fates of nitrogen in Virginia coastal bays. In *Coastal Lagoons: Critical Habitats of Environmental Change*, edited by M. Kennish and H. Paerl. Boca Raton, FL: Taylor & Francis Group, CRC Press.

Austin, M. P., **T. M. Smith**, K. P. Van Niel, and A. B. Wellington. 2009. Physiological responses and statistical models of the environmental niche: A comparative study of two co-occurring *Eucalyptus* species. *Journal of Ecology* 97 (3): 496–507. doi:10.1111/j.1365-2745.2009.01494.x.

Bachmann, C. M., M. J. Montes, R. A. Fusina, C. Parrish, J. Sellars, A. Weidemann, W. Goode, C. R. Nichols, P. Woodward, K. Mcilhany, V. Hill, R. Zimmerman, D. Korwan, B. Truitt, and **A. Schwarzschild**. 2010. Bathymetry retrieval from hyperspectral imagery in the very shallow water limit: A case study from the 2007 Virginia Coast Reserve (VCR'07) Multi-Sensor Campaign. *Marine Geodesy* 33 (1): 53–75. doi:10.1080/01490410903534333.

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Bobbink, R., K. Hicks, **J. Galloway**, T. Spranger, R. Alkemade, M. Ashmore, M. Bustamante, S. Cinderby, E. Davidson, F. Dentener, B. Emmett, J. W. Erisman, M. Fenn, F. Gilliam, A. Nordin, L. Pardo, and W. de Vries. 2010. Global assessment of nitrogen deposition effects on terrestrial plant diversity: A synthesis. *Ecological Applications* 20:30–59. doi:10.1890/08-1140.1.

Bonasoni, P., P. Laj, A. Marinoni, M. Sprenger, F. Angelini, J. Arduini, U. Bonafè, F. Calzolari, T. Colombo, S. Decesari, C. Di Biagio, A. G. di Sarra, F. Evangelisti, R. Duchi, C. Facchini, S. Fuzzi, G. P. Gobbi, M. Maione, **A. Panday**, F. Roccato, K. Sellegri, H. Venzac, G. P. Verza, P. Villani, E. Vuillermoz, and P. Cristofanelli. 2010. Atmospheric brown clouds in the Himalayas: First two years of continuous observations at the Nepal Climate Observatory-Pyramid (5079 m). *Atmospheric Chemistry and Physics Discussions* 10:4823–85.

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Caylor, K. K., **T. M. Scanlon**, and I. Rodriguez-Iturbe. 2009. Ecohydrological optimization of pattern and processes in water-limited ecosystems: A trade-off-based hypothesis. *Water Resources Research* 45:W08407. doi:10.1029/2008WR007230.

Christian, R. R., C. M. Voss, C. Bondavalli, P. Viaroli, M. Naldi, C. A. Tyler, I. C. Anderson, **K. J. McGlathery**, R. E. Ulanowicz, and V. Camacho-Ibar. 2010. Ecosystem health indexed through networks of nitrogen cycling. In *Coastal Lagoons: Critical Habitats of Environmental Change*, edited by M. Kennish and H. Paerl, 73–91. Boca Raton, FL: Taylor & Francis Group, CRC Press.

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Erickson, K. L., **S. A. Macko**, and C. L. van Dover. 2009. Evidence for a chemoautotrophically based food web at inactive hydrothermal vents (Manus Basin). *Deep Sea Research Part II: Topical Studies in Oceanography* 56 (19–20): 1577–85. doi:10.1016/j.dsr2.2009.05.002.

Estes, L. D., P. R. Reillo, A. G. Mwangi, G. S. Okin, and **H. H. Shugart**. 2010. Remote sensing of structural complexity indices for habitat and species distribution modeling. *Remote Sensing of Environment* 114 (4): 792–804. doi:10.1016/j.rse.2009.11.016.

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Hondula, D. M., and **R. E. Davis**. 2010. Climatology of winter transition days for the contiguous USA, 1951–2007. *Theoretical and Applied Climatology*. doi:10.1007/s00704-010-0278-7.

Howard, A. D. 2009. Planetary morphodynamics: Scaling and interpreting sedimentary processes from Earth to Mars and Titan. In *River, Coastal and Estuarine Morphodynamics: RCEM 2009*, edited by C. A. Vionnet, M. H. García, E. M. Latrubesse, and G. M. E. Perillo, 207–16. London: Taylor & Francis Group, CRC Press. ISBN 978-0-415-55426-8.

Jardine, K., T. Karl, **M. Lerdau**, P. Harley, A. Guenther, and J. E. Mak. 2009. Carbon isotope analysis of acetaldehyde emitted from leaves following mechanical stress and anoxia. *Plant Biology* 11 (4): 591–97.

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Ksiazek, K., **K. J. McGlathery**, **L. Reynolds**, **A. C. Schwarzschild**, C. Wilkerson, T. J. B. Carruthers, et al. 2009. Learning about coastal trends: What is the story with seagrasses … and how does it affect me? *Science Activities* 46 (3): 27–31.

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