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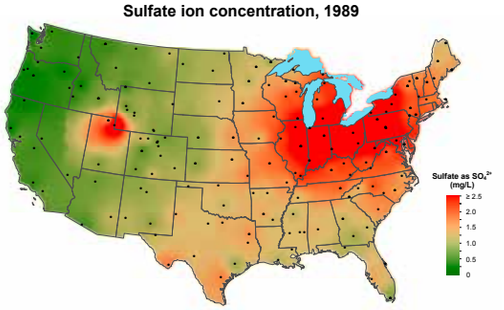

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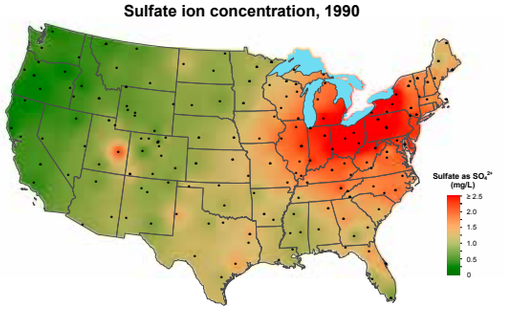

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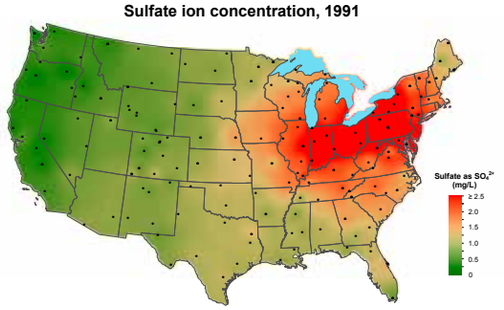

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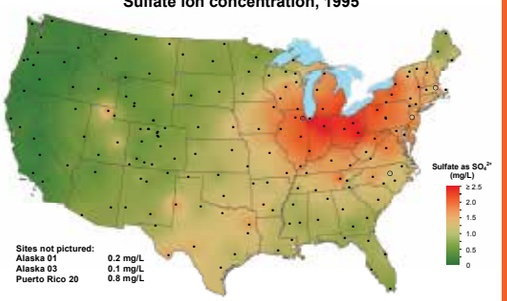

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Alaska 03	0.1 mg/L
Puerto Rico 20	0.8 mg/L

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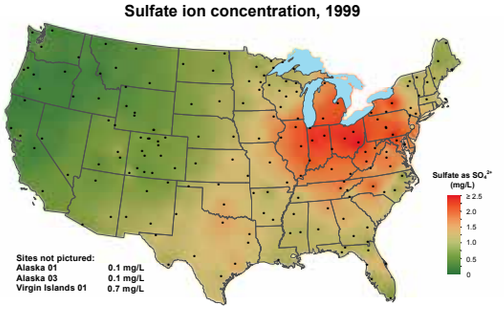
ENVIRONMENTAL SCIENCES

AT THE UNIVERSITY OF VIRGINIA

2013–14 ANNUAL REPORT

Sulfate ion concentration, 1999



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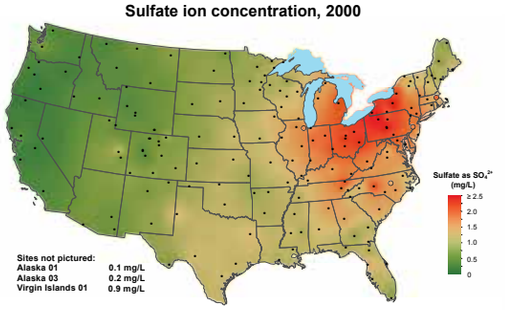

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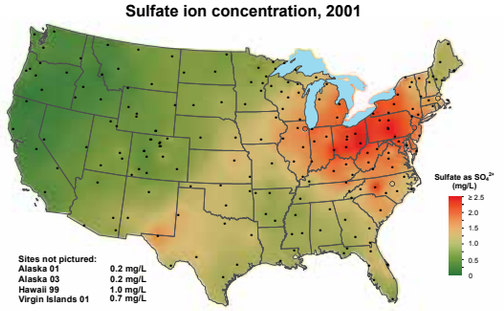

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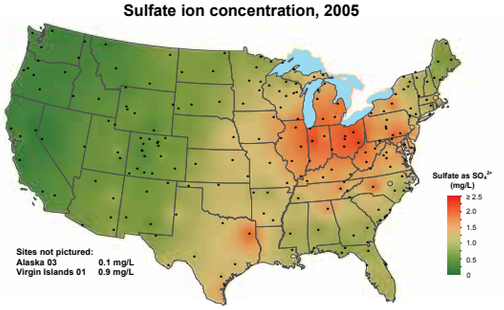

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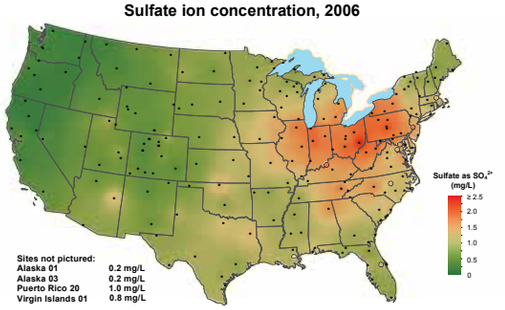

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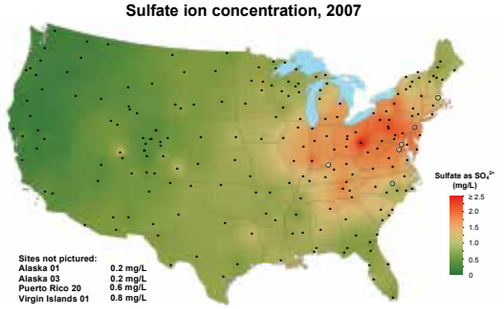

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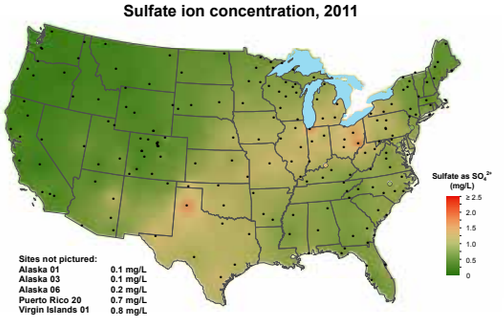

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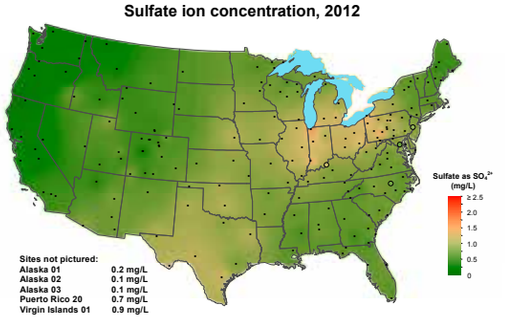

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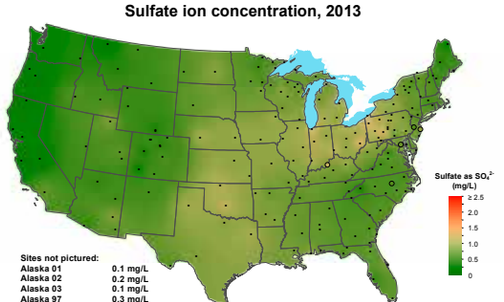

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Alaska 03	0.1 mg/L
Alaska 97	0.3 mg/L
Puerto Rico 20	0.7 mg/L
British Columbia 22	1.0 mg/L
Saskatchewan 21	0.4 mg/L

National Atmospheric Deposition Program/National Trends Network
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THE DEPARTMENT OF
ENVIRONMENTAL SCIENCES

Established in 1969, the University of Virginia's Department of Environmental Sciences was one of the first departments in the nation to look at fundamental environmental processes from a multidisciplinary perspective and the first 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 Research 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 Fluvanna County, and the Blandy Experimental Farm near Front Royal, Virginia.

Printed on 100% recycled paper.
WRITING AND EDITING: Charlie Feigenoff
DESIGN: Roseberries
PHOTOGRAPHY: Tom Cogill unless otherwise noted
COVER IMAGE: Courtesy of National Atmospheric Deposition Program, (NRSP-3) 2007
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FROM THE **CHAIR**

With the publication of each report from the Intergovernmental Panel on Climate Change, it becomes increasingly clear that anthropogenic activities will change the earth's climate significantly over the course of the century. While environmental policy makers remain focused on restraining emissions of greenhouse gases, they have also begun to look ahead to the difficult decisions that must be made as the natural world reconfigures around us. Understanding the resilience of natural systems is fundamental to this effort.

Seen in this light, the work being done by this department of environmental sciences and by departments like it at universities around the world is extraordinarily important. This report highlights some of our activities that shed light on the resilience of natural systems and that help ensure that future decision makers act in ways to safeguard it.

To respond to climate change, we must have a more exact and detailed idea of what it will entail. The experiments with climate models that Deborah Lawrence and Kevin Grise are conducting are doing exactly that. At the same time, through our doctoral program we are training the next generation of researchers who will help refine these models and expand our understanding of the capacity of natural systems to respond in the face of change.

These efforts will only be productive, however, if society is ready to act on this knowledge. Here our undergraduate and master's programs play an important role. Through these programs, we are trying to ensure that public and private organizations have leaders who understand the environmental consequences of their actions and that we have a scientifically literate citizenry prepared to grapple with the challenges of a changing climate.

As I hand my responsibilities as chair to Mike Pace, I do so with deep concern about what the future holds in store for the environment. It is clear that the leadership this department has displayed during the past 45 years will be even more critical in coming decades.

Patricia Wiberg, Chair

Mike Pace, the new chair, is an aquatic ecologist with broad interests in lake, river, and estuarine ecosystems. The American Society of Limnology and Oceanography awarded him its G. Evelyn Hutchinson Medal in 2009.

RESILIENCE—SHENANDOAH WATERSHE

The Shenandoah Watershed Study has demonstrated that the responses of natural systems to natural and anthropogenic change are highly complex.

35 Years of Research and Data

FIFTY YEARS AGO, Gene Likens at Cornell and Herbert Bormann at Dartmouth started the Hubbard Brook Ecosystem Study in the White Mountains of Vermont. Their idea was audacious but simple: instrument a watershed as an outdoor laboratory and, as one of Likens' former postdocs, Professor Jim Galloway, says, "let change happen." Likens and Bormann proposed to measure chemical deposition into the watershed from the atmosphere and determine the fate of those chemicals as they worked their way through the groundwater and were carried away in rivers and streams.

The Shenandoah Watershed Study (SWAS), launched in 1979 by a trio of young faculty members, has emerged as one of the most influential and important programs to follow this example. The initial team consisted of Galloway, George Hornberger, a hydrologist now at Vanderbilt University, and Roger Pielke, currently a researcher at the Cooperative Institute for Research in Environmental Sciences.

Galloway, Hornberger, and Pielke began by monitoring three watersheds in the Shenandoah National Park on a regular basis. Today, SWAS staff members track four park watersheds weekly, sample 68 watersheds in the park and in the George Washington National Forest each quarter, and survey 384 watersheds along the mountain spine of Virginia every decade. Thirty-five years of continuous effort have enabled SWAS to compile a data set that is fertile ground for researchers seeking to understand watershed biogeochemistry and watershed response to natural and anthropogenic change.

Now, at the end of 35 years, the program is moving to new leadership. In January, Ami Riscassi took over from Rick Webb, who had served for almost 30 years as project coordinator. At the end of 2014, Associate Professor Todd Scanlon took the reins as director, replacing Galloway and Research Professor Jack Cosby. Susie Maben, the project's longtime laboratory manager, will remain, anchoring the transition.

TRACKING THE IMPACT OF THE CLEAN AIR ACT

When Galloway thinks back to the early days of the program, he concludes, "Our timing couldn't have been better." During the 1960s and 1970s, power plants, automobiles, and industrial facilities pumped pollutants into the atmosphere at unprecedented levels, and it soon became clear that pollution on this scale had regional and national consequences, not just for the atmosphere but also for waterways. In particular, compounds like sulfur dioxide and nitrogen oxide were mixing with oxygen, water, and other chemicals in the atmosphere to produce acid rain. The acid rain began to alter the pH of streams and lakes—and as they became more acidic, their ecology started to change, often quite rapidly.

In response to this crisis, Congress passed the Clean Air Act in 1970, with major revisions in 1977 and 1990. As these efforts have taken hold over the last 20 years, the deposition of sulfur and nitrogen compounds has decreased dramatically. Over more than three decades, SWAS has been able to document the growing acidification of the watersheds in the years before the Clean Air Act took hold and their recovery since.

By choosing to create a watershed study in Virginia, Galloway and his colleagues were breaking new ground. Hubbard Brook and similar efforts in southeastern Canada and Scandinavia were set in recently glaciated landscapes and focused on lakes. The Virginia mountains had not seen a glacier in more than 100,000 years, and SWAS focused on streams. Equally important, most of the watersheds in SWAS had soils that adsorbed sulfate and its associated acidity. "In the Northeast, sulfates move relatively quickly through the system," Galloway says. "Here, sulfuric acid reacts with the soil, effectively storing some of the sulfur, which is released slowly." As a result, it is taking most SWAS watersheds longer to recover from acidification than their counterparts in the Northeast.

SWAS founding director, Jim Galloway, and his successor, Todd Scanlon

D STUDY

Rick Webb, who retired as SWAS project coordinator after almost 30 years

AN INFLUENCE THAT TRANSCENDS THE SHENANDOAH

The scientific legacy of SWAS is considerable. Most apparent is the record itself, which grows only more valuable with each passing year and which has served as the basis for hundreds of research projects and scores of master's theses and doctoral dissertations. Thanks to SWAS, scientists have a much better understanding of the biogeochemistry of mid-Atlantic mountain watersheds. Monitoring conducted with the Virginia Trout Stream Sensitivity Study has also shed light on how changes in acidification affect habitat. Equally important, the SWAS data set gives the Environmental Protection Agency the ability to demonstrate that the Clean Air Act and its amendments have effectively mitigated the problems of acid deposition.

Thanks to SWAS, scientists also have more-effective research tools. The challenge of trying to understand the natural response to acidification led Cosby to build the Model of Acidification of Groundwater in Catchments (MAGIC), which is now used around the world to study such issues as nitrogen deposition as well as acidification. Because it is a mathematical analog of watershed systems, MAGIC gives researchers the ability to test hypotheses about watershed processes and compare them with observations from the field.

Ami Riscassi, who assumed her position as SWAS project coordinator in January

A PLATFORM FOR UNDERSTANDING CHANGE

One of the advantages of a long-term project like SWAS is that its years of data provide a baseline for analysis when systems change. In the 1980s, gypsy moths infested the region, and dying trees altered stream chemistry dramatically. "The infestation gave us an insight into nitrogen biogeochemistry in the watersheds that we might not have had otherwise," Galloway says.

SWAS's extensive data set also enables scientists to track more gradual events like climate change. Scanlon and Cosby examined temperature data for the main watersheds and discovered that the rise in temperature over the last 35 years tracks the increase in air temperature. Scanlon and Riscassi have plans to expand this work. They are interested in studying the impact of warmer climate on the fertility of the watershed soils and their ongoing ability to buffer acidity. "Our preliminary modeling suggests that warming climate will delay the recovery of these systems," Scanlon says. They are also considering studying the fate of mercury in the watersheds. "Now that mercury is going to be regulated, we foresee an opportunity to measure how these systems recover," Riscassi says. "We have wonderful baseline data and a time-tested approach. We are exploring how we can apply them in new ways."

The ability to pursue these questions ultimately rests on continued support from the project's long-term funders—and here SWAS has been fortunate. "We have had an extraordinary relationship from the inception of the project with the National Park Service and the leadership of Shenandoah National Park," says Scanlon, noting as well that the Environmental Protection Agency, the National Science Foundation, the U.S. Geological Survey, and other public and private organizations have been important sources of funding. "There is so much we can do with our data set," he says. "We hope to both continue and expand these important partnerships into the future."

RESILIENCE—FACULTY

To plan for the future, we must first envision it. Faculty research is helping us do just that.

Taking a Comprehensive View of the Future

During her one-year tenure as a Jefferson Science Fellow at the State Department, Professor Deborah Lawrence saw firsthand how difficult it is for large organizations to take a comprehensive view of issues as complex as climate change. As a science adviser focusing on forests and climate change, Lawrence participated in a number of missions on reducing emissions from deforestation and degradation (REDD). Another group of State Department scientists focuses on food security, even though this issue has implications for forest preservation.

"The earth's land area is finite," she says. "Steps taken to maximize food security may limit actions that can be taken to preserve forests or to grow biofuels, yet we don't understand the consequences of these tradeoffs for climate change."

With support from the University's Office of the Provost, Lawrence has launched the Program of Food, Fuel, and Forests to address these issues. She and an interdisciplinary team of U.Va. faculty members will use the National Center for Atmospheric Research's state-of-the-art climate model to determine how allocating land among food, biofuels, and forests might affect climate. "We would also like to take a step further," she says, "and determine how devoting land in a specific location to a particular use—focusing forest preservation in tropical regions, for instance—would affect these tradeoffs."

Lawrence's approach, based on choices along a continuum, also addresses a drawback with the socioeconomic scenarios that the Intergovernmental Panel on Climate Change (IPCC) publishes. Each of the four scenarios produces a specific increase in global temperatures—ranging from 2 degrees Centigrade in the most optimistic scenario to 8 degrees—and represents a discrete set of conditions. As a result, the IPPC scenarios provide no decision-making framework for moving from one scenario to the next.

In addition, Lawrence and her colleagues are also building in a fourth factor that's not considered by existing models—what different land-use allocations might mean for humanity. Accordingly, the project team includes U.Va. anthropologists, ethicists, economists, and lawyers as well as natural scientists and engineers. "By interpreting climate models through a broadly interdisciplinary lens, we hope to understand not just what might happen in a future world, but what it might mean to live in that world," she says.

Accounting for Clouds

Although the most ephemeral of phenomena, clouds are a major impediment to reducing the margin of error in long-term climate forecasts made by computer models. The accurate integration of clouds in these models is critical because clouds reflect radiant energy from the sun that would otherwise heat the earth's surface. By comparing models with observational satellite data, Assistant Professor Kevin Grise is conducting research that sheds light on the cause of these model errors.

As Grise notes, the issue is one of scale. "Clouds are small-scale features, but the grids modelers use to analyze climate on the earth are quite large—often boxes 100 kilometers or greater on each side. As a result, we rely on statistical approximations to represent them."

Imprecision in these approximations is compounded because clouds are not an isolated, static feature of the atmosphere, but part of a dynamic, interrelated system. Cloud cover in a warming climate is not simply governed by increasing temperature but also by associated changes in atmospheric winds, such as shifts in the location of the jet stream.

Grise has analyzed the way 20 of the global climate models included in phase 5 of the Coupled Model Intercomparison Project treat the differences in cloud formation and radiative heating produced by interannual variability in the midlatitude jet stream over the Southern Ocean, one of the cloudiest regions in the world. This interannual variability is a good starting point for analysis because it approximates the shift in the jet stream that many models predict will occur during the 21st century.

Grise compared the output from these models to satellite observations and found that their output falls into two groups. Both groups have deficiencies in the way they represent observed Southern Ocean clouds, but, on the whole, the second group of models is more realistic.

As a researcher, Grise's purpose is not simply to improve model biases but also to use models as a tool for understanding the physical processes responsible for changes in global temperatures, atmospheric winds, and other aspects of the climate system. "By adjusting the radiative factor associated with the clouds," he says, "I hope to gain some insight into these climate processes and how they work."

RESILIENCE—UNDERGRADUATES

Through our major's program, the department is helping prepare an informed citizenry that can help shape society's response to climate change.

Testing Out a Future

When Bridget Shayka arrived at U.Va., she lost no time signing up for her first environmental sciences class, having already decided in high school that she would major in the field. "I've always loved science," she says. "One of the things that attracted me to environmental sciences is that it draws on a number of scientific disciplines to produce a multidimensional picture of the world."

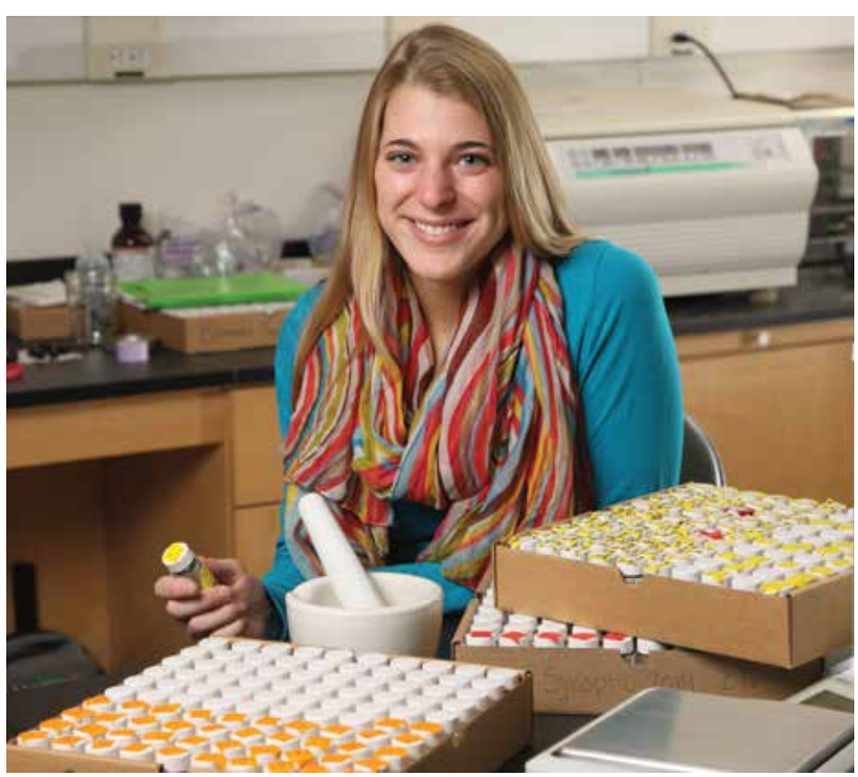
Shayka's experiences as a student at U.Va. only reinforced this view, and she quickly set her sights on pursuing an advanced degree. Before she committed herself, however, she wanted to make sure she understood what being a researcher entailed. "I needed to find out if I liked doing research enough to make it a career," she says.

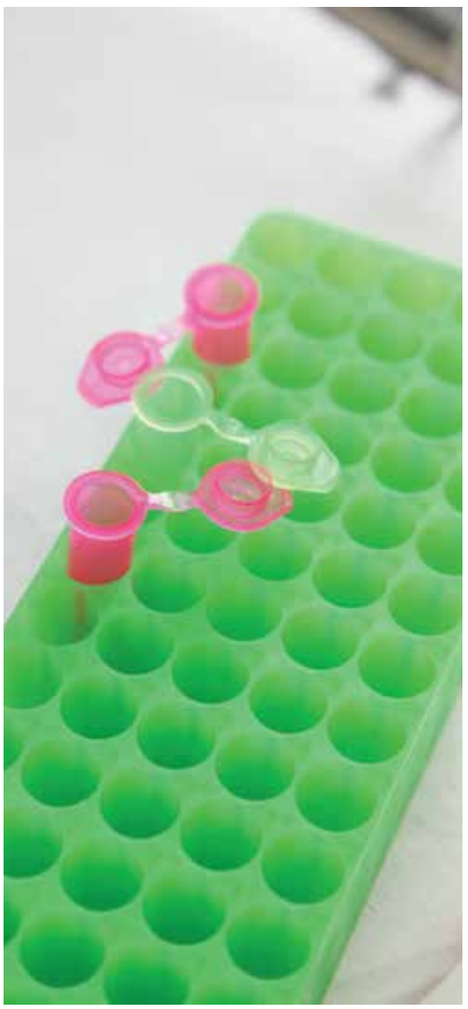
Last spring she volunteered in Professor Karen McGlathery's Coastal and Marine Ecology Lab, sorting seagrass samples. It was a wise choice. The lead principal investigator at the Virginia Coast Reserve Long-Term Ecological Research (VCR LTER) site, McGlathery has been deeply involved in the most successful seagrass restoration effort in the world. It is creating an unparalleled opportunity for scientists to study the effects of expanding seagrass populations on the ecological and hydrological dynamics of coastal lagoons.

The repetitive aspects of her assignment underscored for Shayka the hard work that underlies even the most successful of projects, while whetting her appetite for doing more. A National Science Foundation–sponsored Research Experience for Undergraduates award gave her the opportunity to take on more diverse tasks. Shayka spent 10 weeks last summer at the VCR LTER, living at the Anheuser-Busch Coastal Research Center and helping graduate students and postdoctoral fellows with their projects.

Shayka also had her own miniproject. She took samples of the seagrass to produce root-depth profiles, cutting her samples into two-centimeter segments and separating them into live and dead roots and rhizomes to measure biomass distribution.

"I found I liked being out in the field," she says. "It gave me plenty of opportunity to watch graduate students go through their ups and downs. I know now what I'm getting into, and I really want to do it."





An Immersion in Marine Science

Janet Walker grew up on a farm and has been a competitive swimmer her entire life. Blend these interests, and, at least in Walker's case, the result is a passion for marine science. Taking the January Term study-abroad course Tropical Ecology and Conservation in Belize with Professor Dave Smith and Fred Diehl, an emeritus professor of biology, reconfirmed that passion. "I came back from Belize 100 percent sold on marine science," she says. "Meeting and talking to government officials and scientists there also sharpened my appreciation for the social, economic, and scientific issues that converge when you consider conservation and restoration."

This appreciation only deepened when Walker enrolled in Research Associate Professor Linda Blum's course on Restoration Ecology during her second year. "I was so impressed by the class that I asked her if she had any summer projects I could work on," Walker says. The result: Walker has spent the last two years conducting independent research on the genetic diversity of *Spartina alterniflora* at Upper Phillips Creek, part of the Virginia Coast Reserve Long-Term Ecological Research (VCR LTER) site. *Spartina* is the dominant saltwater marsh grass on the Atlantic Coast.

The project not only may lead to a publishable paper but also has given Walker the opportunity to learn methods of genetic identification. Walker spent the summer after her second year reading deeply in the scientific literature and the following academic year mastering DNA extraction and the polymerase chain reaction, the technique used to amplify DNA so it can be analyzed.

With funding from a Research Experience for Undergraduates grant, she began putting all that preparation to work last summer, taking 250 samples from Upper Phillips Creek and 10 samples each from four other salt marshes in the VCR LTER. She devoted this semester to running the samples and analyzing results. Her goal is to be able to identify the size of the *Spartina* clone at Upper Phillips Creek and provide an overview of the genetic diversity at the four other sites.

"My work sets the stage for studies that could determine if genetic diversity contributes to a marsh's long-term viability," she says. "If so, this would provide a framework for more effectively restoring wetlands."

RESILIENCE—MASTER'S STUDENTS

Our master's degree program is one way that we help ensure that an understanding of environmental systems will guide decision makers at public and private organizations.

At the Intersection of People and Forests

For her master's thesis, Jenny McGarvey traveled across the mid-Atlantic, from West Virginia to New Jersey, visiting 25 stands of old-growth forest. Her purpose was to estimate the capacity of remnant mid-Atlantic old growth to store carbon. Her findings would shed light on the potential of secondary-growth forests to absorb carbon as they mature.

At each site, she laid out several 30-meter plots, measuring all the live trees and deadwood within each, sampling the forest floor and organic horizon soil, and using well-accepted formulas to derive the biomass and stored carbon. She found that these stands store more carbon than previously thought—and that a high percentage of carbon is stored in deadwood. Professor Howie Epstein and Research Assistant Professor Jonathan Thompson advised her on the project, which was supported by the department and the Smithsonian Conservation Biology Institute.

McGarvey found the human dimensions of her work equally rewarding. As part of the preparation for her research, McGarvey contacted landowners to secure their permission to make her measurements. This entailed not only explaining why she needed to visit their land but also describing how her data could help them manage their property more effectively. She found that many of the private landowners she spoke to were pleased to learn that others recognized the ecological importance of the old-growth stands that they had been protecting.

"I found that I really enjoyed making a connection between science and the people who cared for these forests," McGarvey says. "I knew that when I earned my degree, I wanted to find a position that would allow me to continue working in the region with members of the public to promote forest management."

McGarvey's post with the nonprofit Alliance for the Chesapeake Bay has allowed her to do just that. The alliance builds partnerships among stakeholders in the region to protect the streams and rivers flowing into the bay. Because 55 percent of the Chesapeake Bay Watershed is forested, the health of its forests is critical to maintaining water quality. As the organization's forest program manager, McGarvey's responsibilities are varied. She works with the National Forest Service to develop policy and organizes workshops for landowners. She also helps them take advantage of federal, state, and nonprofit programs that provide resources they can use to meet their forest-management goals.

"People who move from research to environmental organizations want to apply what they've learned," McGarvey says. "That's what I'm doing with the alliance. It's fantastic."

Prime Real Estate for Loggerhead Turtles

When loggerhead turtles emerge from the ocean on the east coast of Florida to lay their eggs, they make a series of decisions about where to dig their nests. A number of factors could come into play, including distance from the high-tide line, dune height, and presence of vegetation, but scientists are not sure which ones are most important. Blair St. Ledger-Olson is using data collected by researchers at the Cape Canaveral Air Force Station to find out.

"With sea level rise and climate change, nesting beaches are experiencing a northward shift," St. Ledger-Olson explains. "As loggerheads begin moving to new beaches, the kind of information I'm assembling can help determine the areas of the beach that should be protected because they would make likely nesting areas."

Because there is no public access and little beachfront development, the beaches at the Air Force station are prime nesting habitat for sea turtles. Under the Endangered Species Act, federal agencies like the Air Force are required to take steps to protect and conserve threatened and endangered species. Consequently, each summer the station opens its beaches to researchers and volunteers from the Florida Department of Environmental Protection's Index Nesting Beach Survey. They fan out along the station's 21 kilometers of beach, count the number of sea turtle nests, catalog the nests by turtle species, determine if the nest has suffered inundation or predation, and record GPS data for each one.

St. Ledger-Olson is taking loggerhead data from the 2013 and 2014 surveys and superimposing the GPS data points on a high-resolution GIS map of the barrier island. She will use GIS tools to determine distances from the variables she wishes to study and use linear regression techniques to determine which variables are more important than others. "My goal is to produce a predictive model that can be validated against the survey conducted during the 2015 nesting season," she says. St. Ledger-Olson is working with Professor Hank Shugart, an expert in habit selection and multivariate statistical analysis.

St. Ledger-Olson is the department's Conservation Science Scholar, an award funded by the National Fish and Wildlife Foundation. Fittingly, her project was inspired by a remote presentation that Anthony Chatwin, the organization's marine and coastal conservation director, gave to students in The Practice and Science of Conservation class.

"Tony made the point that the beaches we protect right now are not necessarily going to be the beaches we will need to protect in the future and that we need a way to predict which beaches these will be," she says. "His comments made an impression because my undergraduate work was on the influence of animal behavior on conservation management practices." Chatwin was impressed as well. He has agreed to be an outside committee member on St. Ledger-Olson's thesis committee.

RESILIENCE—DOCTORAL STUDENTS

Our graduate program is preparing the generation of environmental scientists who will face the critical task of addressing climate change issues through the middle of the 21st century.

An Underwater Perspective on Global Trade

Jessica Gephart came to the University of Virginia to study the invasive zebra mussel with Professor Mike Pace, but a course on hydrology with Professor Paolo D'Odorico sent her research in a completely new direction. "I'm a politically engaged person, and Paolo's work on water resources, food supplies, and global trade resonated with me," she says. "Mike has not only allowed me to switch topics, but he has also encouraged my research."

D'Odorico's thesis is that global trade in food is, in effect, a way of shifting water from water-abundant areas of the world to areas of water scarcity. This trade encourages population growth in water-scarce areas, but this growth comes with its own risks. In a time of water shortages elsewhere, local water supplies might not be able to sustain this population.

While researching a paper for D'Odorico's class, Gephart discovered that most existent analyses of water and food security focus exclusively on agricultural products. Wild-capture seafood, which requires a fraction of the water, has not been factored into the equation. "Seafood provides on average 20 percent of the animal protein for people," Gephart says. "This percentage is much higher for coastal developing countries and islands." Gephart is quantifying how much water it would take to replace marine protein with equivalent terrestrial supplies. Her goal is to highlight countries that would not be able to providing adequate protein for their populations if it were not for the water savings they gain from seafood.

The global trade in seafood is one way that these countries can lessen this vulnerability. As Gephart notes, this trade makes up about 10 percent of the food trade globally. This network provides some buffering against local shocks, which may be caused by a fishery collapse or a natural disaster. "Global trade gives you the option of accessing marine protein from other parts of the world in the event of local shocks," she says. "At the same time, becoming dependent on imported seafood makes you more vulnerable to shocks elsewhere."

Gephart is currently identifying case studies and using economic techniques and historical trade data to learn more about how shocks propagate in the trading system as well as the time it takes for countries to recover from them. "In essence, I'm trying to determine the system's resilience," she says.

Carbon Fluxes from Mountainous Soil

Although Jeff Atkins has a longstanding interest in the environment, he didn't originally plan to become an environmental scientist. He earned a degree in literature with a minor in film studies from Western Carolina University. He wasn't entirely successful, however, in repressing his environmental impulses. He wrote a senior paper on the sense of place in the novels of John Steinbeck.

Atkins made the switch five years later, spending a year in the postbaccalaureate program at the University of North Carolina–Asheville to burnish his science skills. "I decided I wanted to do something concrete that would mesh with my strengths and have productive value," he says. He contacted Professor Howie Epstein after reading about his research on Epstein's web page—and Epstein invited him to join his lab.

As a result, Atkins has spent the last three years studying carbon dioxide fluxes from soils in the Weimer Run watershed in the Little Canaan Wildlife Management Area in West Virginia. "We are still unclear about interactions between vegetation and the movement of water and energy in mountainous, topographically complex areas," he says. "The information I gain from my work may be useful in filling a missing gap in climate carbon models and carbon budgets."

Atkins' project complements one that Epstein conducted in Montana. Epstein focused on a forest in a dry area that is dominated by single species of tree—the lodgepole pine. Atkins is investigating a mixed forest in a much wetter part of the country. Working in coordination with the Canaan Valley Institute, Atkins takes samples from 27 plots at three different elevations across the watershed, subdividing these plots into open areas, areas with prominent shrub cover, and closed forests. "We try to break up the forest into smaller pieces to understand the dynamics of the whole," he says.

One of the challenges of field research is that it is impossible for a scientist to control all the conditions—and sometimes this works out for the best. The middle year of Atkins' study was wetter than the years before and after. Atkins found that in wet years carbon fluxes were relatively uniform regardless of elevation and ground cover, while in dry years the presence of shrubs—primarily rhododendrons—had a dramatic effect on the flow of carbon from the soil.

"There are indications that shrubs are expanding across Appalachia, and climate models predict that we should have increased variation in precipitation from year to year across the mid-Atlantic," he says. "Taken together, these changes will have profound effects on the carbon fluxes across the region."

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 Michael Garstang Atmospheric Sciences Award went to **Rachael K. Diniega**, and the Mahlon G. Kelly Prize in ecology went to **Staige E. Davis**. **Alfred B. Hubbard** won the Hydrology Award, and **Catherine A. Peterson** received the Wilbur A. Nelson Award in geosciences.

The Departmental Interdisciplinary Award for the undergraduate major who has excelled in interdisciplinary environmental sciences research was presented to **Rebecca H. Walker**.

Melissa E. Reardon received the Wallace-Poole Prize, awarded each year to the graduating student majoring in environmental sciences who has at least a 3.8 GPA and who is judged the most outstanding student in the class.

Staige E. Davis and **Janice G. Zhuang** were honored for making the best undergraduate student presentations at the 30th annual Environmental Sciences Student Research Symposium. Ms. Davis was also this year's winner of the Joseph K. Roberts Award, given to a student who presents the most meritorious research paper at a national meeting.

To be chosen for the College's Distinguished Majors Program, students must achieve an overall GPA of 3.4 or above. This year, the department selected **Katherine Chamara**, **Staige E. Davis**, **Rachael K. Diniega**, **Alfred B. Hubbard**, and **Rebecca H. Walker** as distinguished majors.

Cassandra L. Cosans was this year's recipient of the Richard Scott Mitchell Scholarship, which provides $1,800 to a rising fourth-year student who is focusing on geoscience and has completed Fundamentals of Geology and two other advanced courses in geoscience, preferably including mineralogy or petrology.

The Bloomer Scholarship provides an $1,800 award to an outstanding undergraduate environmental sciences major with a focus on geology. This year's winner was **Jessica L. Hawkins**.

Each year, the University of Virginia's Harrison Undergraduate Research Awards program funds approximately 40 outstanding undergraduate research projects. In 2014, two environmental science majors were selected for this prestigious program, **Cassandra L. Cosans** and **Rebecca H. Walker**.

Phi Beta Kappa, the most distinguished honor society in the country, offers membership to less than one percent of all undergraduates. The society inducted four environmental sciences majors from U.Va. this year: **Christine E. Wehner**, **Gretchen J. Kozuch**, **Margaret E. Tarmann**, and **Nicholas E. Taylor**.

The Raven Society is the oldest and most prestigious honorary society at U.Va. This year, the society inducted **Rachael K. Diniega** for her outstanding scholarship and service to the University.

This year the U.Va. Parents Committee awarded 16 grants to undergraduate students for public service internships. Two environmental sciences students, **Isabel Greenberg** and **Anna Rollosson**, received these grants.

GRADUATE STUDENTS

Allison M. Leach was the winner of the Maury Environmental Sciences Prize, the department's premier award, established by Dr. F. Gordon Tice in 1992. It recognizes and honors outstanding undergraduate or graduate students for their contributions to environmental sciences, their ability to communicate their findings, and their efforts to promote a better understanding of the environment. Ms. Leach was also the recipient of the Graduate Student Research Publication Award.

Rosemary L. Malfi received the department's Fred Holmsley Moore Teaching Award, bestowed on a graduate teaching assistant distinguished by the ability to instill excitement, wonder, and confidence in students. An endowment set up by Fred H. Moore funds this award, along with matching donations from Mobil Oil Company. The Jefferson Scholars Foundation also named Ms. Malfi its 2015 Jefferson Arts and Sciences Dissertation Year Fellow.

The department offers a series of awards honoring outstanding graduate students in each specialty of environmental sciences. This year, **Allison M. Leach** won the Arthur A. Pegau Award for geoscience, **Adrianna C. Foster** earned the Graduate Award in Ecology, **Kai-Liang Yu** won the Graduate Award in Hydrology, and **Michael V. Saha** won the Michael Garstang Graduate Award in Atmospheric Sciences. **Elizabeth A. K. Murphy** received the Ellison-Edmundson Award for Interdisciplinary Studies.

Established by the Thomas Jefferson Chapter of Trout Unlimited, the Trout Unlimited Award is for "significant contributions to research concerning cold-water fisheries or related ecosystems." This year's recipient was **Jeffrey W. Atkins**.

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

Mark D. Sghiatti and **Jonathan A. Walter** were honored for making the best graduate student presentations at the 30th annual Environmental Sciences Student Research Symposium. Mr. Sghiatti also won the Michael Garstang Award, used to support graduate student research in interdisciplinary atmospheric sciences.

This year, **Jeffrey W. Atkins** and **Kyle A. Emery** won Moore Research Awards. Based on merit, these awards were initiated to help sponsor the dissertation and thesis work of environmental sciences graduate students. **Lillian R. Aoki**, **Brynn S. Cooke**, **Ariel L. Firebaugh**, **Sonja K. Long**, **Abby M. Lunstrum**, **Alexander M. Morgan**, **Matthew P. J. Oreska**, **Olivia M. Stoken**, and **Erin E. Swails** received Exploratory Research Awards, meant to support preliminary research leading to a thesis or dissertation proposal.

STAFF

Margot T. Miller received the Graduate Student Association Award, which recognizes members of the department who, through their efforts, have been particularly helpful to the graduate student body.

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 compose less than 0.005 percent of all publishing scientists.

Thomas H. Biggs won the Environmental Sciences Organization Award, given to a member of the department who has been particularly helpful to undergraduate majors.

Linda Blum received the Atlantic Estuarine Research Society Venerable Clam Award for contributions to estuarine science and service to the society. She is associate editor of *Estuaries and Coasts* and a board member of the Chesapeake Bay Sentinel Site Cooperative. A member of the board of the Coastal and Estuarine Research Federation, she completed her term as its secretary this year. At the University, Professor Blum serves on the Arts & Sciences Faculty Rules Committee.

David Carr is an associate editor of the *American Journal of Botany*.

Robert Davis is an invited contributor to the Intergovernmental Panel on Climate Change. At the University, Professor Davis is a Jefferson Scholars Program adviser.

Stephan De Wekker is an associate editor of the *Journal of Applied Meteorology and Applied Climatology* and serves on the editorial board of *Atmosphere*. He is also the University of Virginia's representative to the University Corporation for Atmospheric Research.

Paolo D'Odorico, the Ernest H. Ern Professor of Environmental Sciences, serves as editor of *Advances in Water Resources*. He is a member of the Provost's Promotion and Tenure Committee and was an organizer of the University's 2014 Water Day Symposium.

Howard E. Epstein is an associate editor of *Ecosphere* and a member of the board of directors of the Arctic Research Consortium. At the University, he is a faculty advising fellow, codirects the College Science Scholars program, serves as a mentor for the Excellence in Diversity Fellows program, and sits on the Global Challenge Working Group of the International Studies Office.

James N. Galloway, the Sidman P. Poole Professor of Environmental Sciences, is a trustee of the Marine Biological Laboratory at Woods Hole, Massachusetts, and continues to serve as a member of the Board of Trustees of the Bermuda Biological Station. He is also a member of the steering committee of the International Nitrogen Initiative, which was developed jointly by the Scientific Committee on Problems of the Environment and the International Geosphere-Biosphere Programme. In addition, he is lead author of the Intergovernmental Panel on Climate Change's Chapter 6, Working Group 1, and a coordinating lead author of the U.S. National Climate Assessment.

Kyle Haynes is an associate editor of *Ecosphere*.

Janet S. Herman is president of the Karst Water Institute and a councilor of the Geological Society of America. This year, she served as an Intergovernmental Personnel Act appointee at the National Science Foundation's hydrology program. She won the 2013–14 Outstanding Faculty Member award from the U.Va. sustainability community in recognition of sustainability efforts in conjunction with the Student Council Sustainability Committee. Professor Herman is a member of the Faculty Advisory Committee on Education Abroad and the University Seminars Review Committee.

Alan D. Howard received three awards this year, two named for G. K. Gilbert, one of the founders of geomorphology. The Geological Society of America presented Professor Howard with the 2013 G. K. Gilbert Award for outstanding contributions to the solution of fundamental problems in planetary geology. The American Geophysical Union presented him with the G. K. Gilbert Award for Geomorphology, which is awarded by the union's Earth and Planetary Surface Processes Focus Group to a scientist who has made significant contributions to the field while promoting an environment of unselfish cooperation in research and the inclusion of young scientists into the field. The department also awarded Professor Howard the Maury-Tice Prize for research excellence. Professor Howard serves as president of the Earth and Planetary Surface Processes Focus Group.

William Keene serves as a task team member for the International Geosphere-Biosphere Programme. He serves as the department's representative to the U.Va. Faculty Senate, where he was appointed the Faculty Senate representative to the University Committee on Sustainability. He is also a member of the General Faculty Council.

Deborah Lawrence was the inaugural winner of the University's Global Programs of Distinction grant, an initiative of the Provost's Office. Professor Lawrence and cowinner **Herman H. Shugart** will lead an interdisciplinary group of faculty collaborating on a climate change mapping and modeling project. She is an adviser to the U.S. Agency for International Development on SilvaCarbon, the U.S. contribution to the GEO Forest Carbon Tracking task, and a trustee of the Virginia Chapter of The Nature Conservancy. At the University, Professor Lawrence is a member of the Global Studies Curriculum Committee and serves the College and Graduate School of Arts & Sciences as a member of the committee charged with hiring 10 new faculty members under a grant from the Andrew W. Mellon Foundation.

Manuel Lerdau was a 2013 climate science fellow of the American Association for the Advancement of Science. He serves as an associate editor of *Biology Letters* (British Royal Society) and is a member of the academic board of the University's Morven Summer Institute.

Stephen A. Macko serves as an associate editor of *Amino Acids* and *Science of the Total Environment*. He is a member of the editorial board of *Environmental and Analytical Toxicology* and the education editorial board of *Eos, Transactions of the American Geophysical Union*. In addition, Professor Macko is a member of the Program Committee of the American Geophysical Union as well as the Committee on Education of the European Geosciences Union. He is a convener of its Geosciences Information for Teachers workshop.

Karen J. McGlathery was appointed the University's inaugural associate vice president for research, sustainability and the environment. She serves as the lead principal investigator of the Virginia Coast Reserve Long Term Ecological Research (VCR LTER) program and sits on the national LTER Executive Council and the Science Council. She is an associate editor of *Ecosystems* and guest editor of a special issue of *Oceanography*. She is also a member of the steering committee of the Mid-Atlantic Coastal Resilience Institute. This year, she was a member of the search committee for the dean of the College and Graduate School of Arts & Sciences.

Aaron L. Mills is a member of the Faculty Senate Steering Committee and the Assessment Advisory Committee.

Michael Pace began his term as department chair in July 2014. He is an associate editor of *Ecosystems* and *Limnology and Oceanography e-Lectures*. He is a coorganizer of the 2015 annual meeting of the Association for the Sciences of Limnology and Oceanography, which will be held in Grenada, Spain.

John Porter received the Chair's Award, which recognizes an individual who has performed extraordinary service to the department. He is a member of the national LTER Network Information System Advisory Committee.

G. Carleton Ray received the 2013–14 NOGI Award for Environment from the Academy of Underwater Arts and Sciences. The award is given to individuals who advocate, study, lobby, or otherwise help to protect the oceans and the life within. He is also a member of the Board of Trustees of the Bahamas National Trust.

Matthew Reidenbach is a member of the Harrison Awards Committee at the University as well as the Jefferson Scholar Undergraduate Selection Committee.

T'ai Roulston is an associate editor of *Ecosphere*.

Todd Scanlon is an associate editor of *Water Resources Research*. He serves as chair of the Horton Grant Selection Committee of the American Geophysical Union.

Herman H. Shugart, the W. W. Corcoran Professor of Environmental Sciences, was the inaugural winner of the University's Global Programs of Distinction grant, an initiative of the Provost's Office. Professor Shugart and co-winner **Deborah Lawrence** will lead an interdisciplinary group of faculty collaborating on a climate change mapping and modeling project. He is associate editor of *Research Letters in Ecology* and a member of the editorial boards of *Ecosystems*, the *Eurasian Journal of Forest Research*, the *International Journal of Ecology*, and the *International Journal of Environmental Protection*. He is also the chief scientist for the Northern Eurasia Earth Science Partnership Initiative. At the University, Professor Shugart serves as a member of the U.Va. Energy Sustainability Leadership Group and the Morven Advisory Committee. He is also a member of the Undergraduate Excellence Committee and the Board of Directors of the University of Virginia Press.

David E. Smith accepted this year's Leveraging Excellence Award from the National Consortium for Continuous Improvement in Higher Education on behalf of the UVA Bay Game U.Va. development team. The award recognizes initiatives where academic and administrative practices have been implemented beyond a single department and have resulted in significant effects on learning. The UVA Bay Game is an interactive game simulation of the Chesapeake Bay watershed, and the team includes members from 11 departments in eight of the University's academic units. Professor Smith serves the University as a member of the Executive Leadership Network, the Facility Management Advisory Board, the Process Simplification Advisory Committee, and the Committee on Undergraduate Admissions.

Vivian Thomson is director of the U.Va. Panama Initiative as well as the Environmental Thought and Practice interdisciplinary major.

Patricia Wiberg completed her term as chair of the department. She received the 2014 Lifetime Achievement Award from the Earth Surface Dynamics modeling community in May 2014 and serves as the steering committee chair of the National Science Foundation's Community Surface Dynamics Modeling System. Professor Wiberg is an associate editor of *ESurf*, the open access journal of the European Geosciences Union.

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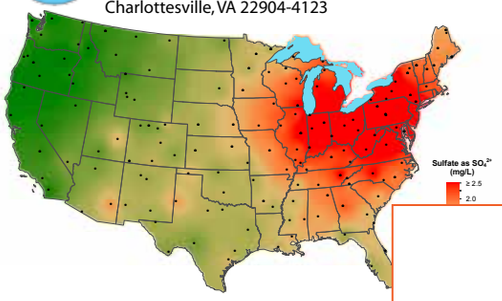
Sulfate ion concentration, 1987



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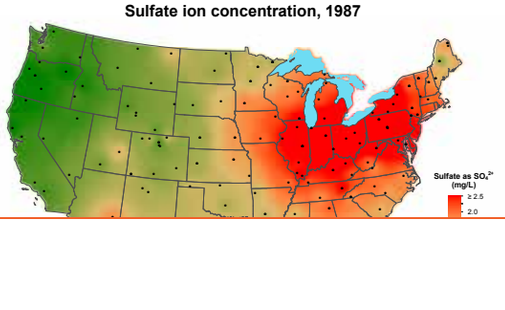

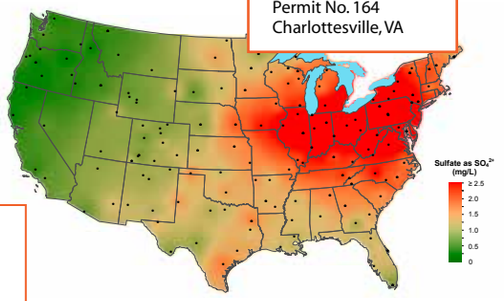

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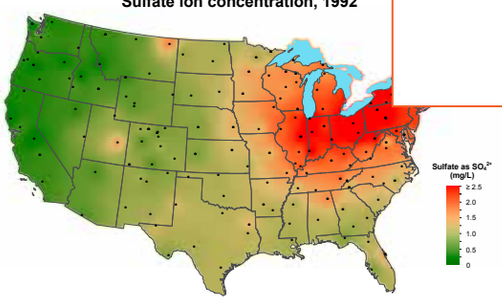

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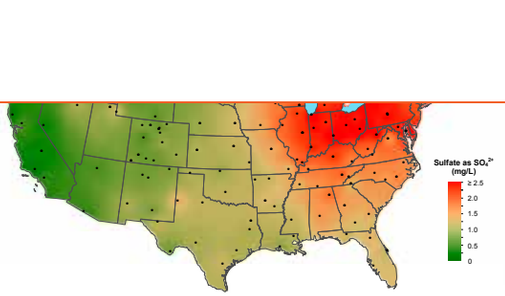

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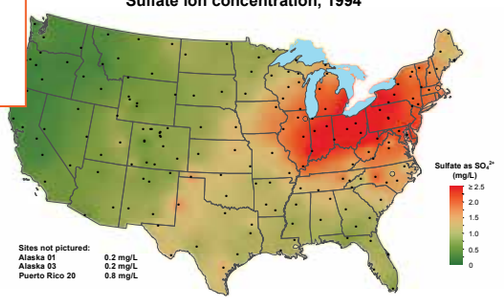

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Alaska 01 0.2 mg/L
Alaska 03 0.2 mg/L
Puerto Rico 20 0.8 mg/L

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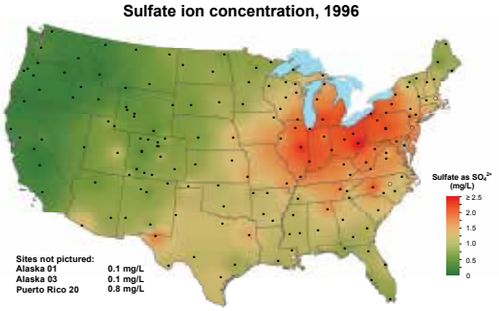

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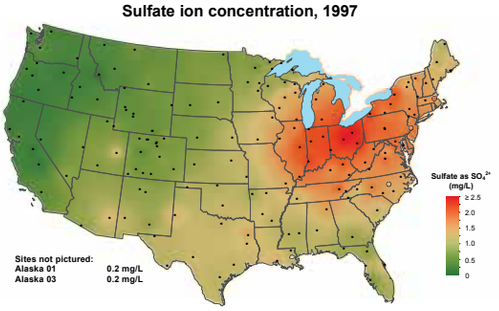

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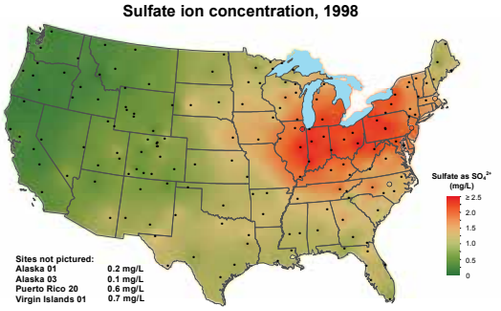

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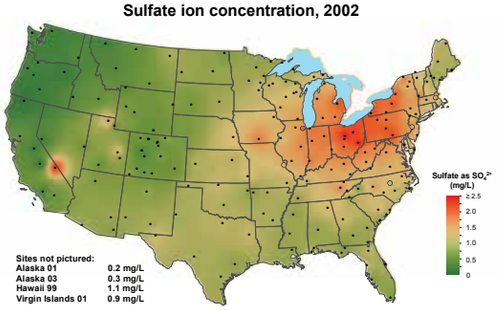
Sulfate ion concentration, 2002



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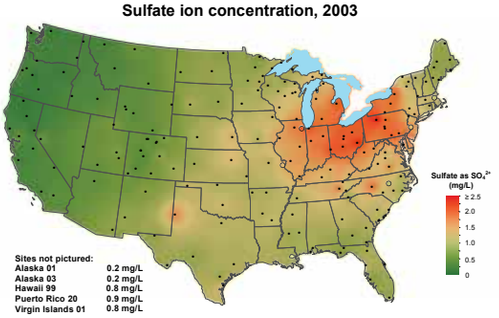

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Hawaii 99 0.8 mg/L
Puerto Rico 20 0.9 mg/L
Virgin Islands 01 0.8 mg/L

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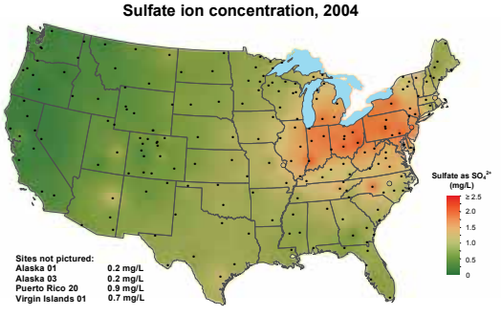
Sulfate ion concentration, 2004



Sites not pictured:
Alaska 01 0.2 mg/L
Alaska 03 0.2 mg/L
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Virgin Islands 01 0.7 mg/L

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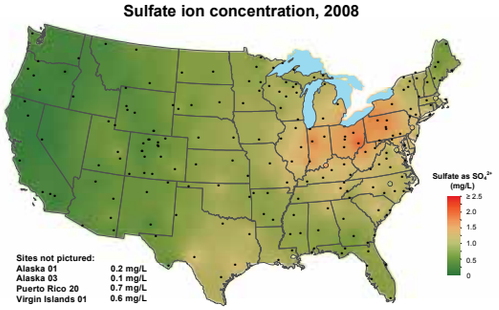
Sulfate ion concentration, 2008



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Alaska 01 0.2 mg/L
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Virgin Islands 01 0.6 mg/L

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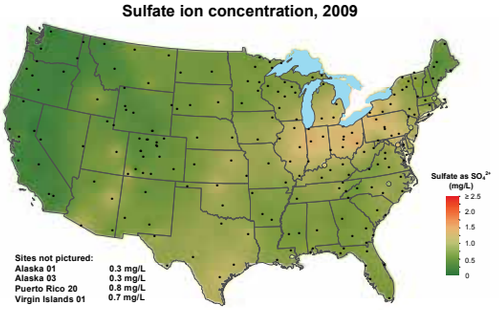
Sulfate ion concentration, 2009



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Virgin Islands 01 0.7 mg/L

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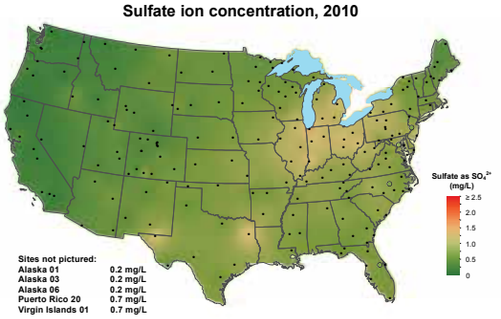

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Virgin Islands 01 0.7 mg/L

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