

# 2010 Annual Report

A YEAR IN REVIEW



*The presence of freshwater macroinvertebrate species like mayflies has long been an indicator of stream health. Scientists are now delving deeper to understand how phosphorus levels might affect freshwater algae and the macroinvertebrates that feed on them.*



## 2010 AT A GLANCE

- A. Backed by a competitive \$4.3 million grant from the National Science Foundation, the University of Delaware and Stroud™ Water Research Center established the Christina River Basin as the sixth Critical Zone Observatory in the United States. Scientists have set out to determine how, and how rapidly, soil erosion and sediment transport through rivers impact the exchange of carbon between the land and the atmosphere, and affect climate — and also how humans are altering these processes.
- B. At the Center, scientists are using DNA to identify fish from Costa Rica and macroinvertebrates from Pennsylvania and California streams. DNA barcoding, which uses a short genetic marker to identify an organism to a particular species, can enhance our understanding of stream invertebrate communities and water quality. Photo: David H. Funk
- C. Center scientists in collaboration with the University of Alabama and Michigan State University have been studying how the size of a stream or river influences the cycling of organic carbon molecules. Investigations involved working in the forested Neversink River watershed of New York.
- D. Streams and rivers continually transport microscopic organic particles that originate from sources such as forests, upland soils, and streambed algae. Center scientists are using outdoor, wooden flumes to assist in determining if these particles are biodegradable, how far downstream they travel, and to what extent they support life in larger streams and rivers.
- E. The Leaf Pack Network® offers a hands-on opportunity for students, educators, conservation workers, and representatives from government agencies both throughout the country and beyond its borders to learn about water quality monitoring. The Firestone Center for Restoration Ecology in Costa Rica served as the hosting site for a recent workshop that was sponsored by the Asociación de Amigos de la Naturaleza del Pacífico Central y Sur (ASANA). Photo: Jamie Blaine
- F. Fish molecular ecologists at the Center are tracking fish from White Clay Creek using fluorescent dye marking in an effort to learn about the effects of riparian habitat on their movement, growth, and survival. Photo: Willy Eldridge
- G. As part of the International Visitor Leadership Program (IVLP), the Center hosted visitors from 20 different countries for a day to learn about the Center's freshwater research and education programs and tour the facilities and grounds. Photo: Dave Arscott
- H. Center scientists traveled to Papua New Guinea to seek evidence of the deposition of river-borne carbon in the Fly River and to meet with villagers in Atkamba to discuss the devastation to their land and water from mining wastes. A custom subbottom sonar unit allowed the scientists to take high-resolution, spatially georeferenced maps to a depth of about 32 feet below the riverbed, which led to the discovery of a paleo-river channel. Photo: Anthony K. Aufdenkampe
- I. From left: Will Milliken, Salomon Romero, and Javier Tinoco, the Center's facilities crew, ensure that Stroud™ Water Research Center buildings and grounds are well-maintained. Photo: David H. Funk
- J. Center scientists expanded a long-term study of stream ecology on the Rio Tempisque and its tributaries to include the streams and rivers that surround the Volcán Orosí of Costa Rica. Measuring the naturally occurring differences in temperature, rainfall, and hydrological characteristics of these waters will yield useful information about how climate change may impact the diverse species that populate the wet, semi-arid, and arid areas of the earth.
- K. During a weeklong program in the Amazonian headwaters of Peru, scientists and educators from the Center introduced the new Spanish-language version of Leaf Pack — the latest development in their ongoing efforts to expand the program across Latin America and ultimately around the world. Photo: Christina Medved



Photo: Gene Miller Photography

## Message

### FROM THE DIRECTOR

#### Stepping Up Together

In a year filled with challenges at home and abroad, the scientists and educators at the Stroud™ Water Research Center stepped up to fulfill our mission to advance global knowledge and stewardship of freshwater:

- We responded to the national call to revive student interest in science by creating Model My Watershed, a multimedia, Web-based teaching tool. We believe that this program, which enables students to explore the impact of land uses on the health of their watersheds, will have the same worldwide impact that the Leaf Pack Network® has had since we launched it 20 years ago.
- We advised the Pennsylvania Department of Environmental Protection (DEP) on updating its regulations for phosphorus in the state's streams — designing and producing a multidisciplinary study which required us to construct 10 indoor streams to gather data.
- We designed and executed a series of complex experiments to help PPL Corporation and the Pa. DEP determine the rate at which a stream or river can be warmed or cooled without threatening stream life.
- We brought world-renowned experts to the Center to help our community better understand water and the issues that affect it. Among them were: Peter Gleick, a MacArthur Fellow, co-founder of the Pacific Institute, and one of the world's leading experts on water issues and water policy, who spoke at our Water's Edge gala; and Wade Davis, an internationally acclaimed expert on threats to the world's cultural and physical biodiversity, who was our 2010 Stroud Memorial Lecturer.
- We laid plans for the first significant expansion of the Center's campus in 20 years, as our board approved plans for the addition of a new building in 2011-2012. This exciting project will provide much-needed space for our education programs and science laboratories.

We have been working on water issues for decades, often when no one else was paying them much attention. Many of our research projects take years to complete, and our patience and perseverance are rewarded in the way each new project adds to our cumulative knowledge of water and streams all over the world. Other projects come to us out of the blue, and we are able to respond quickly because of the flexibility that distinguishes our team approach to science and education.

In each and every case, we act because of our commitment, first to understand the impacts of human activity on one of the world's most valuable resources — its freshwater — and then to create the knowledge that lasting solutions require.

We are able to step up because you, our friends, have long stepped up with us. Your support has enabled us together to make this world — and its water — a little bit better.

*Bruce A. Stroud*

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2010

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Photo: Gene Miller Photography

*Stroud scientists are leading a study that aims to establish a connection between phosphorus, a nutrient lauded for its strength-giving properties, and the changes in aquatic insect and algal communities that indicate deteriorating stream health.*

## Connecting the Dots:

HOW A NEW STUDY MAY REVEAL A LINK BETWEEN  
A LIFE-SUSTAINING NUTRIENT AND LIFE-THREATENED STREAMS

### A Growing Concern

Phosphorus is an essential element to all living things. It's found in soil, water, plants, and even our own DNA. Bones and teeth are made stiff and sturdy thanks to its presence in the form of calcium phosphate. Plants, too, are made more robust. Both flora and fauna flourish when presented with this dual-acting carriage and coachman that both stores and transports energy. Packing a superhero's punch, it spurs growth and enables good health.

But every hero has his Achilles' heel. Although not typically

found in nature independent of human impact, too much phosphorus can be toxic. The mineral's fatal flaw is that it does its job too well. In the human body, phosphorus toxicity can give way to a kind of stiffening in less desirable areas, leading to calcification, or hardening, of organs and soft tissue. Likewise in water bodies, the energy phosphorus carries can become trapped. While phosphorus-containing fertilizers produce hardy plants — much appreciated by farmers, gardeners, and plant growers — they often find their way to freshwater streams and rivers through soil erosion and stormwater runoff, where blooms of filamentous algae burst

onto the scene. Adding to the booster shot are household detergents and cleaning agents, as well as treated sewage, that also journey to waterways.

It is ironic, then, how the energy from this nutrient can take on a sinister quality in even the most vivacious and venerable of streams. That's because unnaturally high concentrations of phosphorus meddle with the fragile balance of aquatic communities.

A healthy stream is a vibrant ecosystem, abuzz with busy insects chowing down on diatom algae, a thin, velvety, and sometimes brown carpet that covers streambeds. However, when phosphorus levels are high, this delicate film disappears, and so do many of the insects. Instead, one finds dense, ropelike algae clusters, often with a blue-green hue. In phosphorus-laden streams, this kind of algae thrives. Mayflies, stoneflies, and caddisflies — aka good insects — do not.

### Algae as a Potential Water Quality Indicator

Whether the survival of these insects is connected to the changes in the algal communities is of great interest to environmental regulatory agencies and the topic of a new Stroud™ Water Research Center study.

Freshwater insects are a fastidious group, and they are commonly used as an unfailing indicator of stream health. Their populations are highest in the most pristine waterways and lowest in, if not absent from, those impacted by deforestation and pollution. In contrast, bad bug populations such as black flies rise in impaired streams.

Dr. John Jackson, senior research scientist and head of entomology at Stroud Water Research Center, estimates that based solely on bug populations, 40 to 50 percent of Pennsylvania's streams and rivers are moderately to severely impaired. Even more sobering is that about 20 percent make the 303(d) list, the Clean Water Act's blacklist of waters in such poor condition as to, under current regulations, not meet sufficient water quality standards.

With so many of Pennsylvania's freshwater systems threatened, agencies like the Pennsylvania Department of Environmental Protection (DEP) are anxious to connect the dots between

pollutants and their sources and the changes pollutants induce in aquatic communities.

"The Clean Water Act can define stream impairment by impacts on fish, invertebrates, and/or algae. These are all valid approaches," says Jackson, "but we will never have the resources to monitor everything, so understanding the connections is important. We know there is a connection between phosphorus and algae, and there is a correlation between phosphorus and insects." However, he cautions, "A correlation is not causation."

### Leaders in Scientific Exploration

To determine whether there is a causal relationship between phosphorus levels and changes in freshwater insect communities, DEP called upon the investigative talents of Stroud Water Research Center scientists who could conduct the research. Finding an answer would require an amalgam of resources that only the Center could provide.

The all-star team led by Jackson included Drs. Thomas Bott, senior research scientist and acting head of microbiology, Denis Newbold, research scientist and head of ecosystems, and Bernard Sweeney, director and senior research scientist. Forming a team that combined research expertise in invertebrates, algae and other microbes, and chemical dynamics was essential in the design and execution of such complex experiments.

*"Our challenge is to provide science that helps us understand cause and effect to determine what in our world are stressors and how those stressors manifest themselves into biological changes."*

— DR. JOHN JACKSON, SENIOR RESEARCH SCIENTIST  
AND DIRECTOR OF ENTOMOLOGY

Scientists are essentially explorers, creative thinkers on a fact-finding mission. But even Lewis had an able partner in Clark. It is only by working and sharing and questioning and problem-solving together that they can unite their respective specialties in search of truth. As is a signature of the Center, collaboration on site gives way to eclectic science that is central to answering interdisciplinary questions.



As in Pidcock Creek in Bucks County, Pa. (pictured above), the algae found in unimpacted streams tend to be a delicate, soft, brownish film that covers streambeds. However, tough, blue-green filamentous algae, like that which is growing in West Branch Neshaminy Creek (pictured on next page), are often found in impacted streams.

For this sophisticated experiment, the scientists needed to replicate natural streams in a controlled, indoor environment, so they drew upon their decades of experience in designing mock streams and their knowledge of how freshwater systems work to engineer 10 20-foot-long stream channels inside their naturally lit greenhouse.

Each channel had to host thousands of good insects of many species just like a real stream, and the Center's proximity to White Clay Creek made the collection of those species possible. The scientists then added a different concentration of phosphorus to each stream channel to measure changes over a gradient of concentrations. Not surprisingly, the higher the concentration of phosphorus, the more the foreboding filamentous algae blossomed both within the channels and on plastic plates awash with the stream waters. After 10 months of faithfully rearing the algae, feeding experiments followed to monitor survivorship, growth, development, and adult size of four bug species, and finally, as the year 2010 came to a close,

the researchers began the protracted process of analyzing their findings. Anticipation for the final results will at last be satisfied in the offing.

"Our challenge," says Jackson, "is to provide science that helps us understand cause and effect to determine what in our world are stressors and how those stressors manifest themselves into biological changes."

That challenge is made all the more momentous in light of the fact that investigating a relationship between phosphorus and insects would not have been possible only a few years ago — all because of the mayfly's mating game.

The laboring mayfly spends nearly all of its on-average 24-hour adult lifespan preparing to fulfill its one life's purpose, reproducing, thus enabling the ancient species to endure. After a series of molts — as many as 30 — when they shed their exoskeletons, adult mayflies will swarm together at dusk over streams and rivers to mate. In nature, swarming is the only



means to procreation for these species, which is problematic for a study like this one that requires several thousand mayflies of equal age. Collecting enough eggs at one time would be impossible. However, in 2003, Entomologist David Funk discovered how to make them mate in the lab.

“That discovery is a direct outgrowth of our dedication to understanding the species’ biology, and it exemplifies the fruit of our labor and creativity at the Center,” says Jackson.

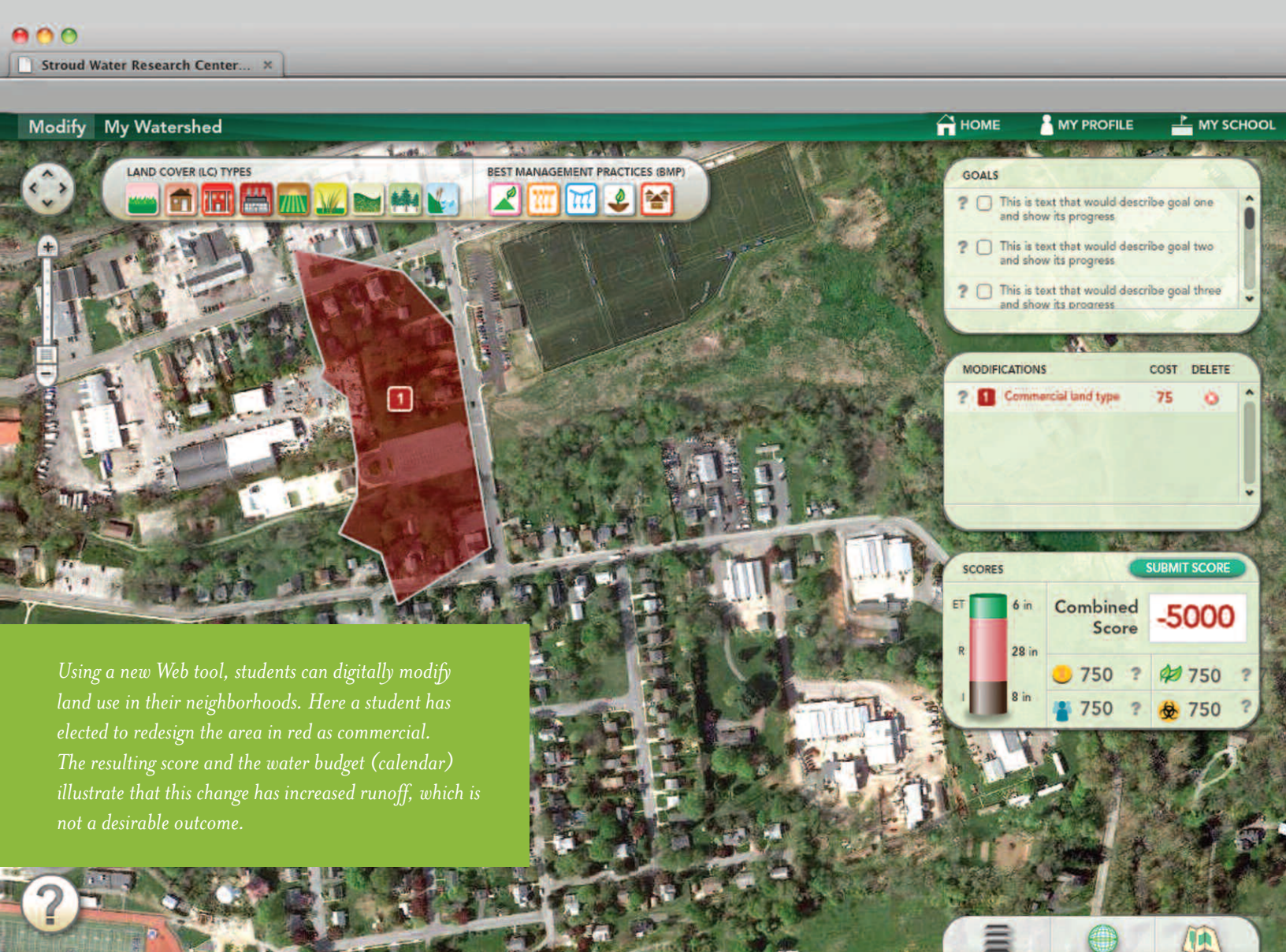
Oftentimes, new discoveries lead to more questions. As the team makes sense of the data, they will attempt to unveil what is lurking within. A positive connection will no doubt provide further evidence of the effects of pollution on water quality, but it will invite more questions such as: What is the mechanism of this negative interaction, are all changes in algae equal, and does the response vary depending on season or the occurrence of erosive storms? A negative result will summon the reality of the smorgasbord effect. Though there is good reason to believe phosphorus levels initiate a domino effect on aquatic communities, there are other forces at work. Waste streams

contain many pollutants, not just phosphorus, and each one adds to the swell of murky waters in a sea of questions.

Whatever the conclusion, this study will bring the team one step closer to understanding how freshwater systems work, and in this case, to understanding how even the most beneficial of nutrients might at times be too much of a good thing.

#### Link

- To learn more about the Clean Water Act, go to: [www.epa.gov/owow/watershed/wacademy/acad2000/cwa](http://www.epa.gov/owow/watershed/wacademy/acad2000/cwa)



## Model My Watershed:

### PREPARING STUDENTS FOR CAREERS IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH

After a hectic three weeks of traveling to and participating in meetings on both sides of the country, Dr. Susan Gill returned to Stroud™ Water Research Center a bit weary but overjoyed with the feedback she had received on a project that will change the way students learn about math and science, and especially their own watersheds. The first leg of her journey had taken her to the American Association for the Advancement of Science (AAAS) Meeting in Washington D.C. followed by the Innovative Technology Experiences for Students and Teachers (ITEST) Summit in Arlington, Va. She then headed to the Conference on Cyberlearning Tools for STEM Education (CyTSE)

in Berkeley, Ca., which showcased projects backed by big-league funders like the National Science Foundation (NSF), Microsoft, and Google, among others. Scientists, engineers, policymakers, and educators came together to explore cutting-edge discoveries in and opportunities to advance science, technology, engineering, and math — the STEM disciplines — as well as education in all four.

The whirlwind was well worth it, for the buzz circulating among those in attendance was filled with amazement and excitement over Gill's unveiling of the developments and future possibilities of the Model My Watershed project.

## A Bright Idea

Funded with a three-year grant from NSF, Model My Watershed will enable students to learn about their watershed and the impacts of land use and other changes on their environment and on the water quality of their streams using an open-source, interactive Web tool that displays real-life scenarios in a virtual environment. It also draws on the social media boom. Online social experiences — highly appealing to the videogame-playing, Facebook-messaging, app-for-that-seeking younger generations — enter the classroom, where students will interact with project scientists, software developers, and other environmental STEM professionals via webcasts, videos, and online chat through the project website, [www.wikiwatershed.org](http://www.wikiwatershed.org).

"The goal," says Gill, "is to engage and excite students about the diverse STEM careers that are necessary to study and address tomorrow's environmental issues."

That goal is the product of Stroud Water Research Center's mission to advance knowledge and stewardship of freshwater, and the Education Department channels efforts toward that end through its many programs such as the Leaf Pack Network®, Mountaintop to Tap, and now — Model My Watershed.

"Students know very little about where their water comes from and how land use impacts water quality," says Gill, who is the director of education and public programs at Stroud Water Research Center. Model My Watershed will change that. She adds, "Today's students are the future, so we need to give them the tools to make educated decisions about water quality, which is so important because it affects all of us."

Preparing the next generation of decision makers, problem solvers, and fact finders means getting students excited about STEM careers early, so the Center is working with 12 teachers — six math and six science — from six local schools in the Schuylkill River watershed to integrate the pilot project into customized curricula that appeal specifically to student interests and concerns.

What matters to students are the issues that affect them directly. "Research shows that place-based and problem-based education are highly effective in the classroom because you are

dealing with real problems that affect people in their own backyards," says Gill.

*"Today's students are the future, so we need to give them the tools to make educated decisions about water quality, which is so important because it affects all of us."*

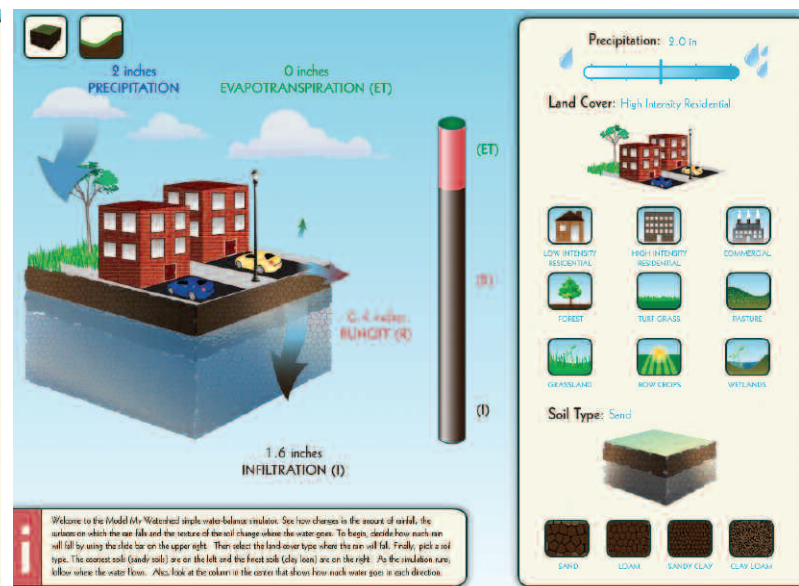
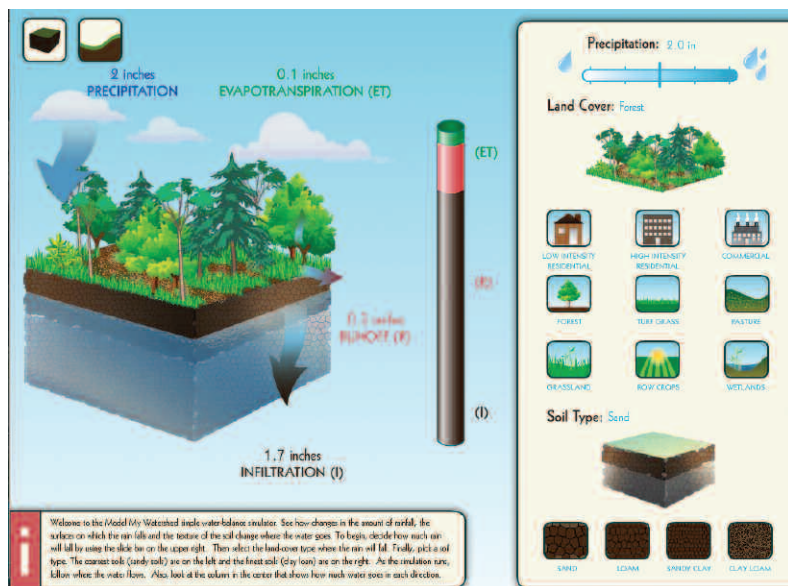
— DR. SUSAN GILL, DIRECTOR OF EDUCATION AND PUBLIC PROGRAMS

Model My Watershed is both place-based and problem-based. What's more is that it's designed to foster the collaborative skills necessary in STEM careers using media that appeal to students. They will be encouraged to communicate ideas and solutions on the Model My Watershed website and to invite other students to expand and possibly improve on them.

Azavea, Inc. is designing the sophisticated tool's interface and will use geographic information systems (GIS) technology with GoogleEarth, and hydrologic modeling algorithms developed by two LEED-certified civil engineers, Michele C. Adams and Steve Benz, in such a way as to capitalize on the allure of visually engaging and dynamic game-like graphics. However, instead of destroying aliens or zombies, students will examine how watershed alterations such as urban development or the implementation of best management practices (BMPs) like rain gardens and porous pavement reduce or improve water quality.

Gill expects that introducing students to the STEM disciplines in this way will allow them to tap into their creativity and collaborative problem-solving skills while promoting environmental stewardship and, at the same time, showcasing career opportunities they may not otherwise consider.

Female and minority students especially have much to gain. The American Association of University Women reports that only 15 percent of female college freshmen plan to major in any of the STEM disciplines, and the National Action Council for Minorities in Engineering (NACME) reported in 2008 that African Americans, Latinos, and Native Americans receive only about 12 percent of the degrees awarded in engineering even though they constitute about 30 percent of the overall undergraduate student population.



Left: This generic application models the connections among the land cover type, the rainfall amount, and the soil type to produce the water budget illustrated by the tube. Right: In this illustration of the simple model, the student has changed forest in the previous illustration to high-intensity residential, thus increasing runoff.

## Thinking Globally; Acting Locally

For now, the project is targeting schools in the Schuylkill River watershed, which provides drinking water for nearly 2.5 million people in the region, including over 200,000 middle- and high-school students. However, the project is unique in its applicability on both a local and national level. Gill explains this is rare. Not only is this project problem-based as well as place-based, she says, “but it can work anywhere because everyone has a watershed and faces issues that challenge water quality.” Plus, she adds, “We’ve designed the model and the tool to work in geographic regions throughout the country.”

It is for this reason, and in response to the positive response to the pilot, that Stroud Water Research Center will apply for funding to expand the project beyond southeastern Pennsylvania.

In the meantime, the Education Department is moving full steam ahead toward launching Model My Watershed in the 12 preselected classrooms. Participating teachers have been busy attending workshops at the Center to develop the curricula

that will utilize the tool in the 2011-2012 academic school year. Their students are getting a sneak peak at what the new semester will bring during the tool's testing phase. Their feedback will help shape the final version of Model My Watershed and possibly the future of science and math education.

## Links

- To learn more about Model My Watershed, visit the information portal: [www.wikiwatershed.org](http://www.wikiwatershed.org)
- Read what participating educators have to say about the Model My Watershed project in a past *Upstream Newsletter*: [www.stroudcenter.org/newsletters/2009Fall/my\\_watershed.html](http://www.stroudcenter.org/newsletters/2009Fall/my_watershed.html)
- To learn more about the American Association for the Advancement of Science (AAAS), go to: [www.aaas.org](http://www.aaas.org)
- To learn more about Innovative Technology Experiences for Students and Teachers (ITEST) projects, visit the ITEST Learning Resource Center website: [itestlrc.edc.org](http://itestlrc.edc.org)
- To learn more about Cyberlearning Tools for STEM Education (CytSE), go to: [www.cyberlearningstem.org](http://www.cyberlearningstem.org)

# Research Projects

## Consequences of erosion and deposition in the Fly River, Papua New Guinea on carbon cycling and climate change

**Funded by:** National Science Foundation

This three-year research project on the Fly River in Papua New Guinea, one of the more dynamic sediment delivery systems in the world, aims to determine whether the combined effects of mountain erosion and deposition in floodplains and estuaries have important local or global consequences for carbon cycling and climate. In 2010 researchers conducted a three-week field expedition and analyzed samples.

**Principal Investigator:** Anthony K. Aufdenkampe

**Collaborators:** Miguel Goni (Oregon State University), Rolf Aalto (University of Exeter, United Kingdom), Wes Lauer (Seattle University), and Bill Dietrich (University of California, Berkeley)

## Earthworm invasion: Investigating changes in soil chemistry and carbon sequestration

**Funded by:** U.S. Department of Agriculture

Human activities over the last 100 years have introduced exotic earthworms into many pristine northern forests. These earthworm invasions are moving north at 15-30 feet per year, bringing with them radical changes to forest ecology and soil chemistry. Our study is designed to examine whether earthworms increase or decrease carbon storage in forest soils, with consequences to greenhouse gases and climate change. In 2010 researchers analyzed hundreds of samples from 2009 fieldwork, and the Center hired two new graduate students at the University of Minnesota.

**Principal Investigator:** Anthony K. Aufdenkampe

**Collaborators:** Kyungsoo Yoo (University of Minnesota) and Cindy Hale (University of Minnesota, Duluth)

## The first assessment of Congo River organic matter chemistry and reactivity

**Funded by:** Stroud Water Research Center

The Congo River is the second largest river in the world, but little is known about it because regional conflict has made its study logistically difficult. In 2010 Center scientists prepared a second paper for publication.

**Principal Investigator:** Anthony K. Aufdenkampe

**Collaborators:** Rob Spencer, Peter Hernes, Johan Six (University of California, Davis), Aron Stubbins (Old Dominion University), and Robert Holmes (Woods Hole Research Center)

## Christina River Basin Critical Zone Observatory: Quantifying carbon sequestration resulting from human-induced erosion

**Funded by:** National Science Foundation EAR 0724971

In collaboration with the University of Delaware, Center scientists established one of six Critical Zone Observatories in the United States and began to establish the sensor and data infrastructures required to test a set of hypotheses about the connections between land use and climate change. The study aims to determine whether large-scale, human-induced soil erosion might transport, bury, and sequester carbon in floodplain and coastal sediments, modifying greenhouse gas emissions from the landscape. 2010 was an exceptionally active year: the Center hired three post-doctoral scientists, one new staff member (electrical engineer Steve Hicks) and five new graduate students (all via the University of Delaware), and began to test and install a wide variety of field sensors and infrastructure.

**Principal Investigators:** Anthony K. Aufdenkampe, Louis A. Kaplan (Stroud Water Research Center), and Donald L. Sparks (University of Delaware)

**Collaborators:** J. Denis Newbold, David B. Arscott, Charles L. Dow, Susan E. Gill (Stroud Water Research Center), Kyungsoo Yoo (University of Minnesota), Jim Pizzuto (University of Delaware), Rolf Aalto (University of Exeter, United Kingdom), and George Hornberger (Vanderbilt University)

## Easter Island: Reconstructing the failure of a civilization

**Funded by:** The Marsden Fund, New Zealand

The collapse of the once thriving human population on Easter Island has been largely attributed to environmental degradation, but questions still remain regarding the causative factors. This study will determine the sequence and timing of the collapse of humans, seabirds, forest trees, and soils by detailed dating and analysis of sediment cores from bogs for DNA, pollen, charcoal, soot, and fecal steroids. In 2010 post-doctoral scientist Cathy Tompson visited Stroud Water Research Center from New Zealand for hands-on training with the Center's fecal steroid methods over a six-week period.

**Principal Investigator:** Anthony K. Aufdenkampe

**Collaborators:** Troy Baisden (Institute for Geological and Nuclear Science, New Zealand), Mark Horrocks (Microfossil Research Ltd.), and John Flenley (Massey University, New Zealand)

## Testing a proxy of historical nutrient status using diatom-bound nitrogen isotopes

**Funded by:** The American Chemical Society, Petroleum Research Fund

Climate science relies on interpreting proxies of past environmental conditions in dated sediment and ice cores. This study will develop a rapid approach to analyzing the stable isotopes of proteins within the glass shells produced by diatom algae, which is likely to be an improved proxy for historical nutrient status because of its uniform biological source. Although the researchers will initially apply the results of their studies to studies of ocean sediments, the technique will be transferable to lakes, ponds, and rivers. In 2010 the Center hired a post-doctoral scientist, Rebecca Hays, to help develop new methods, analyze sediments from the oceans of Antarctica, and publish results.

**Principal Investigator:** Anthony K. Aufdenkampe

**Collaborator:** Katarina Billups (University of Delaware)

## Hydrologic regulation of dissolved organic matter biogeochemistry from forests through river networks

**Funded by:** National Science Foundation EAR 0450331

This collaborative proposal will generate the mathematical models that simulate stream flow in White Clay Creek and the movement of water carrying dissolved organic carbon from soils to the stream. Standing on the stream bank, scientists have been looking both upslope and downstream, focusing on the interactions of water movement and organic carbon supply and investigating processes within the hillslope soils, individual stream reaches, and the entire river network.

**Principal Investigator:** Louis A. Kaplan (Stroud Water Research Center)

**Collaborators:** J. Denis Newbold, Anthony K. Aufdenkampe (Stroud Water Research Center), and George M. Hornberger (Vanderbilt University)

### **The application of scaling rules to energy flow in stream ecosystems**

**Funded by:** National Science Foundation DEB 0516516

Scientists have grown young deciduous trees in an atmosphere enriched with the stable isotope of carbon so as to follow the fate of those organic molecules in small laboratory reactors, microcosms, and through whole stream releases of these molecules in first- through fifth-order streams. Investigations during the summer of 2010 involved working in the forested Neversink River watershed of New York.

**Principal Investigator:** Louis A. Kaplan (Stroud Water Research Center)

**Collaborators:** J. Denis Newbold, Anthony K. Aufdenkampe (Stroud Water Research Center), Robert H. Findlay (University of Alabama), and Peggy H. Ostrom (Michigan State University)

### **Water quality assessment in California using DNA barcoding**

**Funded by:** Southern California Coastal Water Research Project (SCCWRP)

This pilot study was designed to test how the use of a new technology called DNA barcoding can improve water quality assessment in California streams by enabling researchers to identify macroinvertebrate larvae collected from the field to species. SCCWRP will use the study results to decide if this new technology can and should be applied more widely in their monitoring program of both inland and coastal waters.

**Principal Investigators:** Bernard W. Sweeney and John K. Jackson (Stroud Water Research Center)

**Collaborator:** Paul Hebert (University of Guelph)

### **Fish inventories in the Christina River Basin**

**Funded by:** Stroud Water Research Center

In 2009 and 2010 scientists conducted surveys of fish in small streams in the Bucktoe Preserve in the Red Clay Creek watershed and the Stroud Preserve in the Brandywine Creek watershed to document species presence, abundance, and distribution. The data provides a description of the local fauna and can be used to evaluate the impact of removing a dam on the Stroud Preserve.

**Principal Investigator:** William H. Eldridge (Stroud Water Research Center)

### **The snail the dinosaurs saw or an introduced species? Using genetic data to untangle the history of a snail that is new to Pennsylvania**

**Funded by:** Stroud Water Research Center

The snail *Goniobasis proxima* has never been observed north of the James River in Virginia until discovered by Stroud Water Research Center biologists in three locations in southeastern Pennsylvania in 2010. Genetic data will be used to disentangle the history of the species in Pennsylvania and to evaluate a controversial hypothesis that some snails have not moved between watersheds for over 60 million years.

**Principal Investigator:** William H. Eldridge (Stroud Water Research Center)

### **Fish dispersal across a riparian habitat gradient**

**Funded by:** Stroud Water Research Center

Stream fish appear largely immune from physical, chemical, and biological changes between meadow and forested habitats. In 2010 a study in which fish were tagged and recaptured was initiated to measure fish dispersal along a two-kilometer stretch of the White Clay Creek spanning a meadow, recovering forest, and mature forest to evaluate the scale at which habitat modification would be expected to affect stream fish.

**Principal Investigators:** William H. Eldridge (Stroud Water Research Center) and Eli Gurarie (NOAA-Fisheries)

### **Review of a proposed pipeline construction project in Pennsylvania**

**Funded by:** Earth Justice

Stroud Water Research Center researchers reviewed a proposed pipeline project in central Pennsylvania and determined that natural gas exploration, extraction, and transport will impact aquatic habitats. However, additional baseline and long-term monitoring and precautions will be needed to evaluate and minimize those impacts. A comprehensive review of the cumulative impacts of natural gas extraction in the northeastern United States is essential.

**Principal Investigators:** David B. Arscott, Louis A. Kaplan, and William H. Eldridge (Stroud Water Research Center)

### **Review of Pennsylvania's proposed water quality criteria for chloride**

**Funded by:** University of Pittsburgh Environmental Law Clinic

Center researchers reviewed the Pennsylvania Department of Environmental Protection's proposed water quality criteria for chloride. The proposed criteria are not protective of aquatic communities and should be lowered as a precaution until adequate data are generated.

**Principal Investigators:** David B. Arscott, John K. Jackson, and William H. Eldridge (Stroud Water Research Center)

### **Development of an educational tool to better understand the physical, chemical, and biological connections between wetlands and downstream waters**

**Funded by:** U.S. Department of Justice, Environment and Natural Resources Division

The U.S. Department of Justice, Environment and Natural Resources Division contracted with Stroud Water Research Center for the creation of a set of educational materials that describe the function and structure of wetlands. These materials will focus on how the physical, chemical, and biological integrity of downstream waters are connected with wetlands and may be impacted by the removal of a particular wetland or collection of similarly situated wetlands.

**Principal Investigator:** David B. Arscott (Stroud Water Research Center)

### **AMD remediation and stream ecosystem function**

**Funded by:** Pennsylvania Department of Environmental Protection

This study was designed to determine the impact of abandoned mine drainage (AMD) on stream ecosystem functions, such as algal growth, nutrient spiraling, litter decay, and enzyme function, as well as on macroinvertebrate communities. It will also aid in the assessment of the effectiveness of AMD remediation efforts. This research broadens our understanding of the scope of concerns generated by AMD pollution, considered the most extensive pollution problem in terms of stream miles affected throughout Pennsylvania, and it has the potential to lead to greater support for remediation efforts.

**Principal Investigators:** Thomas L. Bott, Bernard W. Sweeney, J. Denis Newbold, and John K. Jackson (Stroud Water Research Center)

**Collaborators:** Matthew McTammy (Bucknell University) and Steven Rier (Bloomsburg University)

### **Long-Term Research in Environmental Biology (LTREB): Dynamics of stream ecosystem responses across gradients of reforestation and changing climate in a tropical dry forest**

**Funded by:** National Science Foundation DEB 0516516

Stroud Water Research Center has expanded on 20 years of research on tropical streams near the Maritza Biological Station in northwest Costa Rica, which provides the framework of this study, to include

sites near Santa Rosa and Rincón de la Vieja in an effort to study a wider range of environmental conditions. Scientists are examining stream responses to the large-scale reforestation of tropical dry forests, as well as to the natural moisture gradients (i.e., wet versus dry seasons and rain versus dry forest sites) that define much of the character of the Guanacaste Conservation Area.

**Principal Investigators:** John K. Jackson, Louis A. Kaplan, J. Denis Newbold, Thomas L. Bott, and Anthony K. Aufdenkampe (Stroud Water Research Center)

**Collaborator:** Julio Calvo (Escuela de Ingeniería Forestal del Instituto Tecnológico de Costa Rica)

### **Spatial and temporal variation in water quality among major tributaries of the Schuylkill River**

**Funded by:** William Penn Foundation

This research, education, and outreach project continues efforts with local watershed groups to monitor macroinvertebrates in streams throughout the Schuylkill River Basin, which is located in the Northern Piedmont and the Ridge and Valley ecoregions. Work during 2010 focused on long-term change and environmental variation among the 19 sites on the major tributaries of the Schuylkill River that were sampled annually between 1996 and 2010.

**Principal Investigator:** John K. Jackson (Stroud Water Research Center)

### **Parthenogenesis (virgin reproduction) and hybridization in mayflies**

**Funded by:** Pennswood No. 2 Research Endowment and Stroud Water Research Center

Stroud Water Research Center's multiyear focus on the mayfly *Centropilum triangulifer* has been expanded to include a number of related and unrelated mayfly species in White Clay Creek as well as in streams throughout eastern North America. This effort has increased our understanding of parthenogenesis (i.e., virgin reproduction) and hybridization in mayflies, confirmed the biological integrity of species that are morphologically cryptic (i.e., those that are genetically distinct but morphological keys currently give them the same name), and led to the development of valuable laboratory techniques for mating and rearing aquatic insects.

**Principal Investigators:** David H. Funk, Bernard W. Sweeney, and John K. Jackson (Stroud Water Research Center)

### **Macroinvertebrate monitoring at sites in White Clay Creek, Pa., Flint River, Ga., Mississippi River, Mo., Susquehanna River, Pa., and Delaware River, Pa.**

**Funded by:** Various public and private sources

These projects use aquatic macroinvertebrates such as mayflies, stoneflies, and caddisflies to provide assessments of current water quality in these streams and rivers. Where long-term data are available, the most recent conditions are interpreted with the invaluable perspective of conditions observed 5, 10, 20, or 30 years ago.

**Principal Investigators:** John K. Jackson and Bernard W. Sweeney (Stroud Water Research Center)

### **Effects of elevated and fluctuating temperature regimes on macroinvertebrates and fish in Pennsylvania's warm water streams and rivers**

**Funded by:** Pennsylvania Department of Environmental Protection

This laboratory project investigates macroinvertebrate and fish responses to artificial changes in water temperature. Thermal regimes are warmer than normal and approach or exceed physiological and regulatory limits. Daily temperature changes emulate patterns characteristic of plant operations that discharge warm effluents.

**Principal Investigators:** John K. Jackson, William H. Eldridge, and Bernard W. Sweeney (Stroud Water Research Center)

### **Algal and macroinvertebrate responses to elevated phosphorus concentrations in Pennsylvania streams**

**Funded by:** Pennsylvania Department of Environmental Protection

This project took advantage of the unique facilities of Stroud Water Research Center as a field station with first-rate laboratory facilities in an Exceptional Value Watershed and the experience of the research programs and personnel that allows for experimental manipulations impossible to conduct elsewhere. Phosphorus is a major pollutant of fresh waters, historically turning streams, rivers, lakes, and reservoirs green with excess algae. These experiments were designed to look at algal responses of elevated phosphorus and how macroinvertebrates responded to these changes in algae.

**Principal Investigators:** John K. Jackson, Thomas L. Bott, J. Denis Newbold, and Bernard W. Sweeney (Stroud Water Research Center)

**Collaborator:** Hunter J. Carrick (Penn State University)

### **Water quality monitoring in White Clay Creek watershed, 1991-2008.**

**Funded by:** White Clay Wild & Scenic Management Committee, White Clay Creek Watershed Association, Pennswood No. 2 Research Endowment, and Stroud Water Research Center

Scientists combined data collected by the White Clay Creek Stream Watch Program (Pennsylvania and Delaware) and Stroud Water Research Center to provide an assessment of current conditions across 18 locations throughout the watershed and an additional nine sites around Avondale, Pa. They also documented long-term changes and variations at sites with multiple years of data. Comparable data from sites in the Schuylkill River Basin provided an invaluable perspective.

**Principal Investigators:** John K. Jackson and Bernard W. Sweeney (Stroud Water Research Center)

### **Expert report on the relationship between land use and stream condition (as measured by water chemistry and aquatic macroinvertebrates) in the Delaware River Basin**

**Funded by:** Delaware River Basin Commission

Stroud Water Research Center researchers were asked to provide evidence of the relationship between changes in land use and changes in stream quality. The Center's data from hundreds of sites in the Schuylkill River, upper Delaware River, and Hudson River basins illustrated the decline in stream quality as land cover was converted from forest to agricultural, urban, and/or industrial uses. This relationship has direct implications for the potential for stream degradation resulting from future changes in Delaware River watersheds, including those associated with the local and regional development of natural gas reserves in Marcellus Shale.

**Principal Investigators:** John K. Jackson and Bernard W. Sweeney (Stroud Water Research Center)

### **Dynamics of organic particles in river ecosystems**

**Funded by:** National Science Foundation DEB 0543526

Suspended organic particles are important to river food webs and in the transfer of organic carbon from land to ocean. In an experiment conducted in the Stroud Water Research Center streamside flumes, researchers verified that biofilms — algae and microbes that coat streambed surfaces — continually trap and release organic particles, thereby controlling their rate of downstream migration. The results of this and other experiments from this project are being used to model the influence of headwater streams on the downstream river network.

**Principal Investigators:** J. Denis Newbold, Anthony K. Aufdenkampe, Louis A. Kaplan (Stroud Water Research Center), Aaron I. Packman (Northwestern University), and James N. McNair (Annis Water Research Institute)

# Education Projects

## Leaf Pack Network® goes to Peru

**Funded by:** National Geographic Society

In partnership with the Amazon Center for Environmental Education and Research (ACEER) based out of West Chester University, Stroud Water Research Center educators provided Leaf Pack workshops in the cities of Iquitos and Pucallpa, Peru. Through this funding, Stroud Center educators were also able to further edit and finalize the Spanish version of the Leaf Pack Network® Resource Manual. Other collaborators on this project were Wills Flowers, professor of entomology at Florida A&M University; Francisco “Paco” Ollervides, senior field coordinator for Waterkeeper Alliance; and Therany Gonzales-Ojeda, Peruvian Leaf Pack Ambassador.

**Collaborator:** Amazon Center for Environmental Education and Research (ACEER)

## Leaf Pack Network® goes to Costa Rica

**Funded by:** Stephen Stroud

This train-the-trainer Leaf Pack workshop consisted of employees and board members from Asociación de Amigos de la Naturaleza del Pacífico Central y Sur (ASANA), ecotourist guides, as well as other local educators. The purpose of this two-day workshop was to build upon the participants' capacity to train teachers, students, and community members, specifically within the Tapir Biological Corridor, on how to assess stream health using the Leaf Pack Experiment. Teaching this workshop were Stroud Water Research Center educators and Rafa Morales, manager and research technician of the tropical research projects in Costa Rica for Centro de Investigación de Agua Stroud, the Center's local, not-for-profit sister organization in Costa Rica.

## From Classroom to Creek

**Funded by:** Stormwater Programs for the City of Newark, Delaware

Stroud Water Research Center educators visited several elementary schools within the city of Newark to introduce them to the concepts of watersheds and how to minimize stormwater runoff in their communities. Students learned about where the water goes during a precipitation event, that storm drains are meant for water only, and how trees throughout a watershed not only help to filter water but also help minimize the amount of water traveling to storm drains.

## The Science of Water Through the World of Art

**Funded by:** Point Lookout Farmlife and Water Preserve Foundations

This program at Point Lookout Preserve gives students and teachers new ways of thinking about stream ecosystems and stewardship through the creative processes of art and science. High school and elementary school students from Delaware and Pennsylvania participated in programs that combined watershed science, artistic exercises, canoeing, and introductions to the art of the Brandywine Valley with a focus on the art of the Wyeth family.

## Consortium for Scientific Assistance to Watersheds (C-SAW)

**Funded by:** Pennsylvania Department of Environmental Protection, Growing Greener Stewardship Funds

Stroud Water Research Center educators provided technical assistance to county conservation districts, municipal environmental advisory committees, watershed associations, and citizen action groups as part of a partnership of nine organizations across Pennsylvania whose goal is to teach conservation groups how to conduct effective watershed assessments and restoration efforts.

## Integrating the carbon and water cycles within an ecosystem esthetic approach to landscapes

**Funded by:** National Science Foundation

Stroud Water Research Center educators and scientists developed and began implementation of Your Livable Landscape: Cultivating an Ecosystem Esthetic, a collaborative education program that builds on the landscape practices of Longwood Gardens and the science of the Stroud Water Research Center. The program teaches Longwood visitors the connections among landscape practices, stormwater runoff, and the mobilization and mineralization of carbon. Through the program, visitors to Longwood Gardens will learn about beautiful landscaping techniques that allow rainwater infiltration, reduce stormwater runoff, and sequester carbon.

**Principal Investigators:** Susan E. Gill, Louis A. Kaplan, Anthony K. Aufdenkampe, and J. Denis Newbold (Stroud Water Research Center)

**Collaborators:** Michelle Adams (Meliora Design), Muscoe Martin (M2 Architecture), and Rick Darke (Rick Darke LLC)

## Model My Watershed

**Funded by:** National Science Foundation

Stroud Water Research Center educators and scientists launched Model My Watershed, an innovative, three-year program to develop, test, and disseminate a watershed-modeling tool set for Philadelphia-area secondary schools. The goal of the program is to engage and excite students about the diverse science, technology, engineering, and math (STEM) careers needed to address environmental issues. Using an interactive, hydrologic modeling tool set, students make real-world decisions based on real scientific data and models and learn to predict how environmental changes in their watersheds affect the hydrologic cycle.

**Principal Investigators:** Susan E. Gill, Anthony K. Aufdenkampe, J. Denis Newbold (Stroud Water Research Center), Robert Cheetham (Azavea), Dana Tomlin (University of Pennsylvania), and Nanette Dietrich (Millersville University)

**Collaborators:** Michelle Adams (Meliora Design) and Steve Benz

## Critical Zone Geoscience Education

**Funded by:** National Science Foundation

Stroud Water Research Center educators and scientists are teaching the principles and processes of the earth's critical zone to teachers, informal educators, and academically at-risk youth. This program is based on the research of the Christina River Basin Critical Zone Observatory.

**Principal Investigators:** Susan E. Gill (Stroud Water Research Center) and Gary Coutu (West Chester University)

# Gifts and Contributions

2010

## Major Gifts

1675 Foundation	The Davenport Family Foundation	Mr. & Mrs. Frederick L. Meserve Jr.	Virginia Wellington Cabot Foundation, LLC
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Mr. Seth Bradford	Haverford College	Mr. David Patterson	Welfare Foundation
Mr. Martin S. Brown	Mr. Peter Kjellerup & Mrs. Amanda Cabot	Mr. & Mrs. William R. Peelle	Mr. George A. Weymouth
Mr. & Mrs. Gilbert Butler	The Laffey-McHugh Foundation	Mr. William R. Peelle III	Mr. & Mrs. William R. Wister Jr.
Coventry Health Care, Inc.	The Longwood Foundation	Mr. & Mrs. Richard E. Riegel Jr.	
Mrs. Kathleen Craven	The Marmot Foundation	Mr. & Mrs. Stephen M. Stroud	
The Crestlea Foundation		Mr. & Mrs. John H. Taylor Jr.	

## Gifts to Annual Fund

It is only by knowing how healthy streams and rivers work, and what happens when they become polluted, that we can determine how to protect this vital resource now and for generations to come. Your gift to the 2010 Annual Fund enabled us to continue the freshwater research and watershed education programs that are helping to protect, preserve, and restore fresh water everywhere. With loyal support from you, the Friends of the Stroud Water Research Center, our work will continue for many years to come.

### \$10,000 and up

Jessie M. Allred  
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John Lazarich Foundation  
Isabella P. S. Johnson  
Jane C. MacElree  
Mr. & Mrs. Rodman Moorhead III  
Mrs. Willard Speakman III  
Mr. & Mrs. Stephen M. Stroud  
The Willowdale Steeplechase  
Mr. & Mrs. William R. Wister Jr.

Mr. & Mrs. Charles P. Schutt Jr.  
Spurlino Family Fund  
Mr. & Mrs. Morris B. Stroud  
Holly McAllister Swett  
(Anonymous-1)

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Winky Foundation  
Mr. Charles H. Wolfinger  
(Anonymous-2)

### \$500 - \$999

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George & Dorthea Chidester  
Barbara O. David  
Mr. Alfred Gollatz & Mrs. Jill Garner  
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Mr. & Mrs. William Wylie Jr.

*Care has been taken to ensure the accuracy and completeness of this listing. We regret any omission and ask that you bring any corrections to our attention.*

## \$250 - \$499

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 John Bare  
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 Kay Dixon  
 Mr. & Mrs. Gerard Dorrian  
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 Mr. & Mrs. Lee F. Driscoll  
 Mr. & Mrs. William J. Duckett  
 Louise Duncan  
 Mr. Court E. Dunn  
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\* Matching Gift

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Kay & Bill Wells  
Dorothy P. West

Peter & Maria Weygandt  
Wynne & Sam Wharry  
Drs. Tracy Wiegner & Josh Pierce  
White Clay Fly Fishers Assoc.

Rosie & Hal Wilkinson  
Barb & Jim Yeatman  
Mr. Ross Zimmer  
Helen Zipperlen

Thomas & Kathy Zunino  
(Anonymous-3)

### Mayfly Club Memberships 2010

Thomas Allen  
Jamie Aller  
Annie Dahlie  
James Dunning

Murray Fisher  
Sarah & Christian LeSage  
Emily Neville  
William Ostrem

Billy Peelle  
Laela Perkins  
Christopher Pulling  
Dylan Sage

Marian Seherr-Thoss  
Caitlin Smith  
Steven Welzer

### In Memory of Ida Kerr Lofting

Patricia & Andrew Augustine  
Joan S. Blaine  
Tom Brightman & Tara Tracy  
Mr. & Mrs. Ford B. Draper Jr.  
Reeve Draper  
Bill & Helen Elkins

Katherine Evans  
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Mrs. John B. Hannum Sr.  
Jim & Terry Hayes  
Ann Jones  
Midge Leitch V.M.D.

Wendy Lofting  
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Mr. & Mrs. Edgar Scott Jr.  
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Eric Teder & Donna M. Merrill  
Turtledove Folk Club

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Dr. John Jackson  
Dr. & Mrs. Bernard Sweeney

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Patagonia

# Financials

2010

## Operating Statement for the year ended December 31, 2010

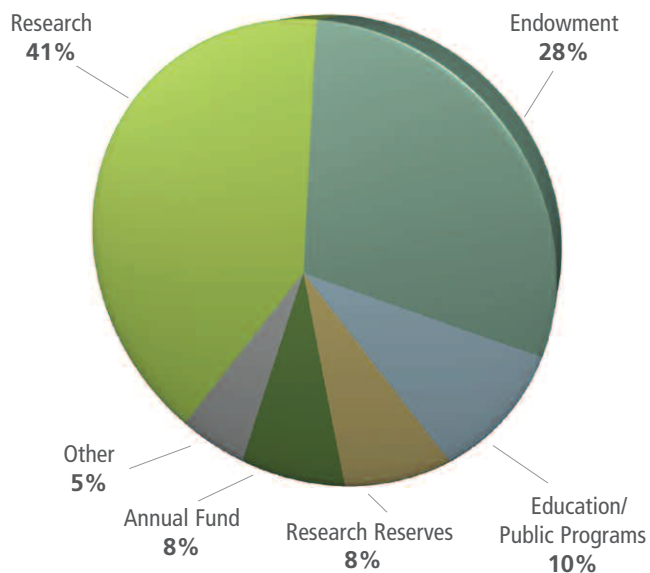
### Revenues & Support

Research Programs (Grants & Contracts)	\$ 1,761,678
Endowment	1,208,404
Education/Public Programs	435,511
Research Reserves	349,516
Annual Fund	342,586
Other Contributions & Income	220,086
<b>Total Revenues &amp; Support</b>	<b>4,317,781</b>

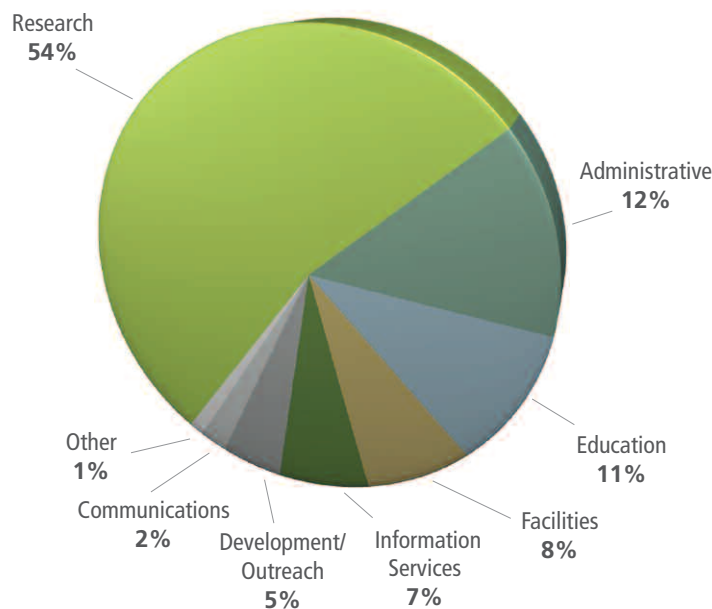
### Expenditures

Research	2,325,805
Administration	579,472
Education	454,441
Facilities	335,544
Information Services	291,773
Development/Outreach	195,462
Communications	87,818
Other	47,466
<b>Total Expenditures</b>	<b>4,317,781</b>

### 2010 Operating Revenues & Support



### 2010 Operating Expenditures



# Staff, Interns and Volunteers

2010

## Administration

Bernard W. Sweeney  
*President, Director &  
Senior Research Scientist*

David B. Arscott  
*Assistant Director  
& Research Scientist*

John D. Pepe  
*Controller & Treasurer*

### STAFF

Shelby J. vonTill  
*Executive Administrative Assistant*

## Biogeochemistry

Louis A. Kaplan  
*Senior Research Scientist*

### STAFF

Jessica Duffy  
*Intern*

Emily Gray  
*Intern*

Michael D. Gentile  
*Research Tech III*

Pat Hopkinson  
*Intern*

Cassie Ianni  
*Intern*

Christine McLaughlin  
*Ph.D. Student,  
University of Pennsylvania*

Yi Mei  
*Ph.D. Student,  
Vanderbilt University*

Jean Peirson  
*Laboratory Assistant*

Sherman L. Roberts  
*Research Tech III*

Sarah L. Smith  
*Research Tech II*

Yin-Phan Tsang  
*Post-Doctoral Associate*

Ponni Vel  
*Intern*

## Communications & Marketing

Liz Brooking  
*Director of Communications  
& Marketing*

## Development

Lynn Biddle  
*Director of Development  
& Secretary to the Board of Directors*

### STAFF

Kay Dixon  
*Associate Director of Development*

## VOLUNTEERS

Lauren & Mike Broomall

Eliot & Tish Dalton

Marie Dalton-Meyer

Evie Dutton

Libby Gregg

Julia Keane

Julia Loving

Christina Medved

Sarah Smith

Andrea Sweeney

Margot Taylor

## Ecosystems

J. Denis Newbold  
*Research Scientist*

### STAFF

William C. Anderson  
*Intern - RET*

Sara R. Geleskie  
*Research Tech III*

Chad T. Hudson  
*Intern*

Dillin McGinnis  
*Intern*

## Education

Susan E. Gill  
*Director of Education*

### STAFF

James G. Blaine  
*Research Associate*

Elizabeth S. Gregg  
*Education Assistant*

Christina Medved  
*Education Programs Manager*

Kristen S. Travers  
*Associate Director*

Vivian L. Williams  
*Education Programs Manager*

## Entomology

John K. Jackson  
*Senior Research Scientist*

### STAFF

Juliann M. Battle  
*Research Tech IV*

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*Research Tech II*

Travis C. Burt  
*Intern*

Hannah Devine  
*Intern*

David H. Funk  
*Research Tech V*

Molly K. Gabler

*Intern*

Kevin M. Gill

*Intern*

Stephanie L. Liguori

*Intern*

William L. Milliken, Jr.

*Field Assistant*

Carly S. Nagle

*Intern*

Sally Peirson

*Research Tech III*

Roberta M. Weber

*Research Tech III*

## Facilities

David H. Funk  
*Director of Facilities*

### STAFF

William L. Milliken Jr.  
*Maintenance Mechanic*

Tonya Prigg  
*Janitor*

Salomon Romero  
*Woodlot Tech*

Javier Tinoco  
*Woodlot Tech*

## Fish Molecular Ecology

William H. Eldridge  
*Assistant Research Scientist*

### STAFF

Laura Borecki  
*Research Tech III*

Gavin K. Ferris  
*Research Tech II*

## Information Services

Charles L. Dow  
*Director of Information Services  
& Research Scientist*

### STAFF

Melanie L. Arnold  
*Data Analyst*

Heather P. Brooks  
*Data Analyst & Web Designer*

Elizabeth S. Gregg  
*System Administrator*

## Maritza Station\* Costa Rica

Rafael A. Morales  
*Station Manager & Research Tech*

### STAFF

Cristian A. Collado  
*Research Tech*

## Microbiology

Thomas L. Bott  
*Senior Research Scientist  
& Vice President*

Jinjun Kan  
*Assistant Research Scientist*

### STAFF

David S. Montgomery  
*Research Tech III*

## Organic Geochemistry

Anthony K. Aufdenkampe  
*Assistant Research Scientist*

### STAFF

Bonnie Dickson  
*Research Tech*

Stephanie A. Dix  
*Research Tech III*

Rebecca Hays  
*Post-Doctoral Associate  
University of Delaware*

Steven Hicks  
*Research Tech III*

Diana Karwan  
*Post-Doctoral Associate*

Olesya Lazareva  
*Post-Doctoral Associate  
University of Delaware*

Emily Maung  
*Post-Doctoral Associate  
University of Delaware*

Alex Rittle  
*Intern*

Carl Rosier  
*Post-Doctoral Associate  
University of Delaware*

Catherine E. Thompson  
*Post-Doctoral Associate  
North Carolina State University*

## Research Support

### STAFF

Cristina Romero  
*Laboratory Assistant*

### VOLUNTEERS

Linda Carter  
*Research Assistant*

Frank Klein  
*Research Assistant*

\* The Maritza Station staff is employed by the Asociación Cento de Investigación Stroud, a non-governmental organization in Costa Rica which serves as the umbrella organization for all the Center's research and education activities in Central and South America.



970 Spencer Road  
Avondale, PA 19311-9514  
USA

(610) 268-2153 Telephone  
(610) 268-0490 Fax  
[www.stroudcenter.org](http://www.stroudcenter.org)

## OUR MISSION

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