STROUD
WATER RESEARCH CENTER

2013 Annual Report

A YEAR IN REVIEW

To the Streams We Go:

Pioneering Freshwater Science and Solutions

2013 AT A GLANCE

A. On Earth Day, Stroud Water Research Center announced that its Moorhead Environmental Complex achieved LEED® Platinum, the highest level of certification established by the U.S. Green Building Council for leadership in energy and environmental design. The Moorhead Environmental Complex combines some of the most innovative approaches to "getting the water right," including systems for managing stormwater and optimizing the use and treatment of water on site. Photo: Halkin Mason Photography

B. The Water's Edge paid special tribute to Ruth Patrick, who died in 2013 at age 105. She helped found the Stroud Center in 1967 and made incredible contributions in freshwater science and stewardship.

C. Stroud Center scientist Willy Eldridge is using funding from DuPont Clear into the Future to develop a technique to test for the presence of freshwater mussels simply by sampling stream water. The technique relies on detecting the DNA in free-floating cells that have sloughed off a mussel. Once the technique has been optimized, it will be used to locate other remnant populations and to determine if any of the other four mussels species that were here historically persist. Photo: Jan Battle

D. In partnership with the Brandywine Conservancy, Stroud Water Research Center Director Bern Sweeney led a tree-planting event along the headwaters of the East Branch of the White Clay Creek. The planting will not only improve the water quality in the small stream it surrounds, it also will serve as a scientific test of tree protection methods. Volunteers from Dansko, Inc., the Cheshire Hunt Conservancy, and Stroud Water Research Center planted 985 trees. Photo: Dave Arscott

E. Bern Sweeney was honored by the Alliance for the Chesapeake Bay and the U.S. Forest Service at the opening ceremonies of the 2013 Chesapeake Watershed Forum. The conference, attended by nearly 500 conservationists, scientists, and educators, celebrated 30 years of the Chesapeake Bay restoration effort. The award recognized Sweeney's efforts throughout his career to conserve, restore, and celebrate Chesapeake forests in order to improve the quality and health of the Chesapeake Bay. Photo: Alliance for the Chesapeake Bay

F. The Joan & Dick Stroud Memorial Lecture Series in 2013 featured *Chasing Ice*, an award-winning documentary about climate change that shows Earth's most beautiful icy landscapes rapidly melting away. Film Director and Producer Jeff Orlowski journeyed from Colorado to introduce the film event at Winterthur. He shared details about the making of the film and afterward spoke to attendees, including students from the Kids Leadership Academy. Group photo: Dave Arscott

G. Stroud Water Research Center partnered with National Wildlife Federation (NWF) to provide more classrooms with its powerful stream and water-testing tool. Developed by the Stroud Center, the Leaf Pack Experiment Stream Ecology Kit is a hands-on scientific stream-testing kit that measures the numbers and kinds of insects and other invertebrates in streams to determine overall water quality. It enables schoolchildren to explore nature as they learn about stream ecology and how to monitor their local freshwater sources.

H. Jane Lubchenco (right center), former Under Secretary of Commerce for the National Oceans and Atmosphere Administration (NOAA), and Kathryn Sullivan (left), Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator, received the 2013 Stroud Award for Freshwater Excellence for their commitment to stewardship of fresh water. Stroud Water Research Center presented the award at The Water's Edge, the Stroud Center's annual gala in October. Photos: (left) Kristine Lisi and (right) Yeda Arscott

Front cover: Kerry Mapes takes a kick sample for macroinvertebrates in the White Clay Creek. Photo: Dave Funk


Photo: Rafa Morales

To the Streams We Go: Pioneering Freshwater Science and Solutions

Message
FROM THE DIRECTOR

There are few organizations in the world that visit more streams and rivers during the year than Stroud Water Research Center. Dr. Ruth Patrick, my mentor and one of our founders, set the bar high from the get-go when, in the late 1960s, she and Founding Director Robin Vannote, responded to a call from the Army Corps of Engineers. The challenge: to review the effects of channelization on more than a hundred streams across the continent. No goal was out of reach because of her passion for using freshwater science for good. Ruth passed away last fall at the age of 105, but her legacy lives on in a big way. We follow in her footsteps, journeying to streams and rivers around the world to research how they function and to share our knowledge about ensuring water quality and availability.

We added another dimension to our work last year with the creation of our Watershed Restoration Group, now comprised of three full-time employees who are fully immersed in restoration activities. This year, we will likely add more talented individuals and extend our geographic reach. We want to continue delivering solutions to the many individuals, municipalities, and agencies that are clamoring for assistance.

What makes our freshwater solutions unique? It always comes back to the science. We flood restoration activities with cutting-edge theoretical and technological advances rooted in our research groups. They work collaboratively to pioneer science that delivers an intimate and well-rounded understanding of freshwater systems. We then carefully monitor the results of our restoration-focused research and share what we learn with the public. In all that we do — whether it be tracking fish, planting forest buffers, or helping schoolchildren study slimy packs of leaves — you'll find us along stream banks.

Following the lead of those like Ruth who came before us, to the streams we go in 2014, more than ever before. I hope you'll continue to join us on this journey.

People tend to think that if there are bugs in the water, the water must be dirty, but if you see a swarm of mayflies over a stream, that's a good sign.

Photos: Dave Funk

From Cradle to Grave:

HOW STUDYING MAYFLIES THROUGHOUT THEIR LIVES IS KEY TO UNDERSTANDING STREAM POLLUTION

Healthy Streams Are Living Streams

Those who have hiked along the banks of the White Clay Creek or other clean streams in spring or fall have likely witnessed swarms of tiny, delicate, winged creatures dancing in midair above the flowing water. They are mayflies. These short-lived aquatic insects are of special significance to Stroud Water Research Center, for they are one of the most reliable indicators that stream ecologists can look to in determining whether a waterway is healthy or unhealthy.

"Healthy streams support life," says John Jackson, a senior research scientist and head of the Entomology Group. "They have lots of insects and microbes and fish. Mayflies, in particular, are present in healthy streams. If we don't find mayflies living in a stream, that's a red flag."

Entomologist Dave Funk adds, "People tend to think that if there are bugs in the water, the water must be dirty, but if you see a swarm of mayflies over a stream, that's a good sign. They're very sensitive to pollution and other changes that alter how streams naturally function. If anything goes wrong in a stream, mayflies are often the first to go. They are basically the canary in the coal mine. You lose the mayflies and other bugs, you lose the fish."

For this reason, scientists at Stroud Water Research Center often use mayflies in bioassay work — experiments that test the affects of a potential stressor on a living organism. Some of the most groundbreaking studies conducted at the Stroud Center have featured the remarkable mayfly. Time and again, throughout four decades of research, they have revealed how safe or harmful a contaminant is to streams and rivers.

The Problem With Standard Bioassays

Despite their efficacy, mayfly studies are infrequently used for freshwater research in the bioassay world.

"To do any kind of bioassay," Jackson explains, "you need a lot of aquatic insects of the same age and species. Collecting enough of them for a study would be almost impossible, so that means you have to culture them, and traditionally it's been difficult to get mayflies to reproduce in the lab." Instead, most freshwater bioassays use aquatic species that are easy to culture in laboratories, such as daphnids (also called water fleas) and fathead minnows.

But there's a serious drawback to conducting freshwater bioassays with species such as daphnids: they're not found in streams — at least not in any significant number or for long. Funk says, "They can't really hold their own in flow. Yes, they are aquatic, but they're more representative of what you'd find in ponds and lakes — not streams."

"In the bioassay world, when mayflies are used, you'll find they're generally used to determine acute mayfly responses." The Stroud Center focuses on both acute and whole life cycle responses. "It's important to look at the whole life cycle response because mayflies in streams might be exposed to something for longer than a couple days. If that's the case, an acute test might not indicate that a particular contaminant is harmful to mayflies when, in fact, it might be if they are exposed to it for a longer period of time."

Raising the Bar, Raising Mayflies

While it's no easy task to study mayflies from cradle to grave, the Stroud Center has made it possible. Scientist and Director Bern Sweeney solved the problem of supply in the 1980s when he began culturing the mayfly species *Centroptilum triangulifer*. Because it's parthenogenic, meaning all offspring are clones of the mother, only a single female is needed to start the process.

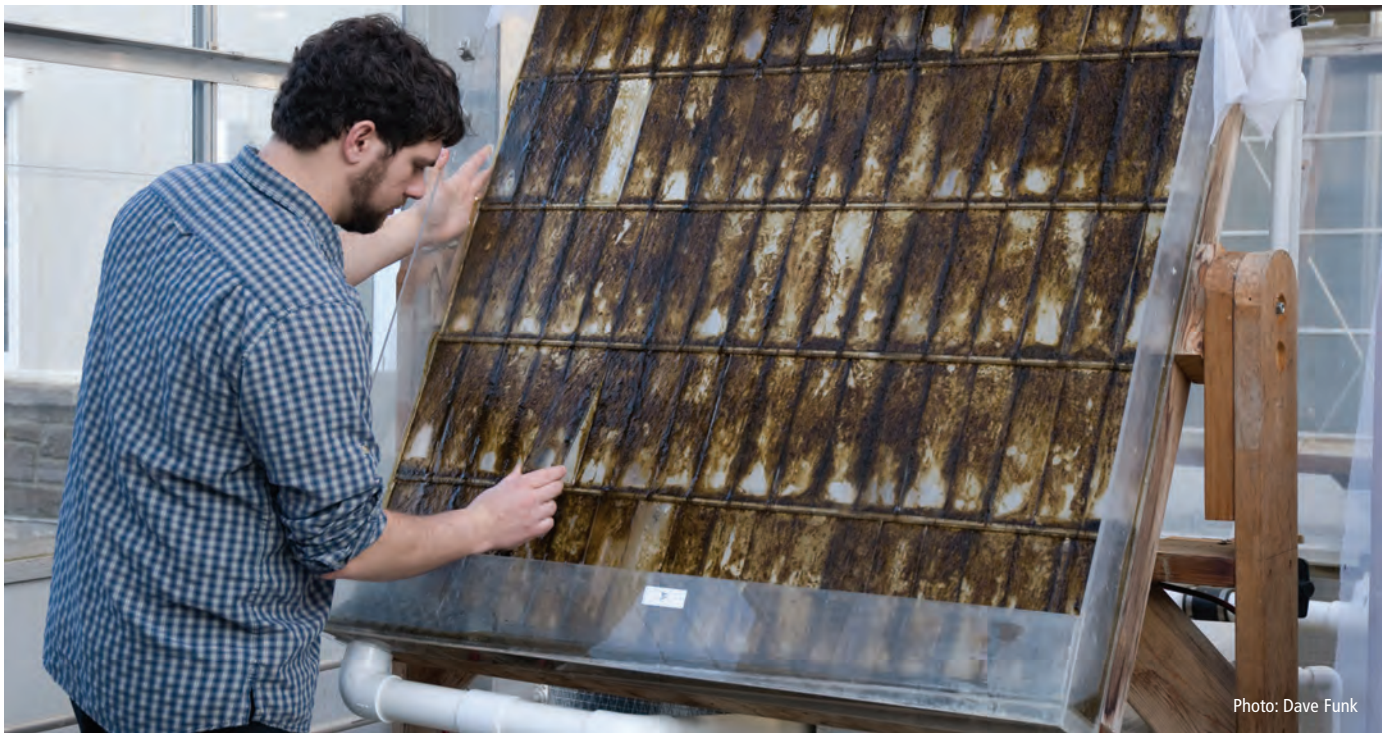


Photo: Dave Funk

Algae grows on a collection of plates washed in stream water. The Stroud Center's ability to grow algae as a food source for mayflies allows scientists to conduct studies with mayflies throughout their entire life cycle.

"Suddenly, we had more than enough stock," Jackson says, but that's still not sufficient for any kind of bioassay work because in order to sustain mayflies throughout their life cycle, researchers need to provide them with food and stream water.

The Stroud Center solved that problem too. The White Clay Creek sends a constant flow of stream water through the indoor wet lab. By using that water, scientists here can grow an abundance of mayfly food. "When we do any kind of study with mayflies, we're creating optimal conditions in every way except the variable that we're testing," says Funk. The water from the creek is markedly clean compared to most area streams thanks to decades of restoration activities.

"What we have here is pretty exceptional. To really understand how environmental changes affect the health of streams, we need to be looking at mayflies, and the Stroud Center has the unique ability to raise and study them through their entire life cycle."

Portrait of the Mayfly

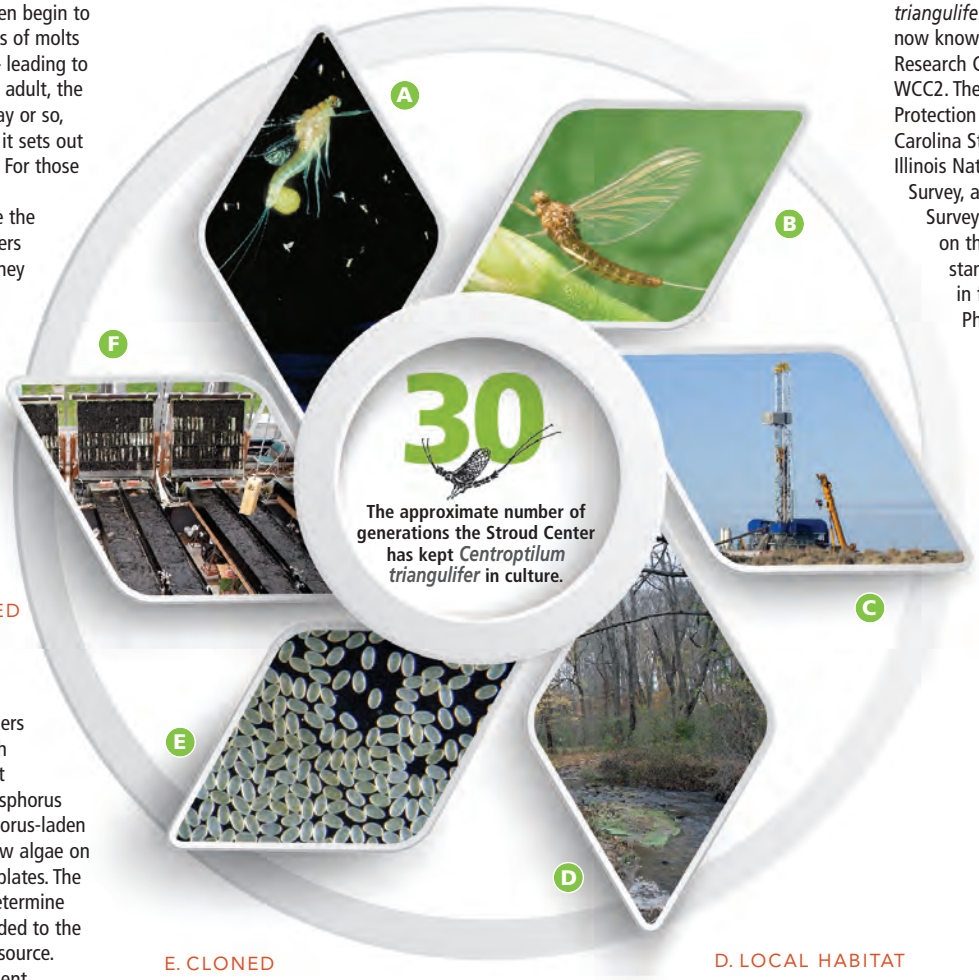
AT STROUD WATER RESEARCH CENTER

A. BRIEF ENCOUNTER

The mayfly life cycle is one of the most fleeting in nature. After adult females have laid their eggs in water, the eggs develop over a couple of weeks, hatch, and then begin to grow through a series of molts — as many as 50 — leading to adulthood. At last an adult, the mayfly only lives a day or so, and within that time it sets out to produce offspring. For those species that sexually reproduce, it is above the flowing waters of rivers and streams where they swarm and mate. Photo: Dave Funk

B. A NEW SPECIES

In 1984 Bern Sweeney and Robin Vannote published the Stroud Center's first paper featuring the parthenogenic mayfly species *Centroptilum triangulifer*. This species is now known as Stroud Water Research Center Clone WCC2. The Environmental Protection Agency, North Carolina State University, the Illinois National History Survey, and U.S. Geological Survey have all relied on this now standardized species in freshwater studies. Photo: Dave Funk



C. RED FLAGS

Many of the Stroud Center's most groundbreaking studies have looked at how mayflies respond to contaminants. In 2013 scientists discovered that produced water from fracking is toxic for mayflies even in concentrations as low as 1%.

F. STREAM TESTED

Setting up artificial stream channels in the Stroud Center's greenhouse, researchers in 2010 exposed each channel to a different concentration of phosphorus and used the phosphorus-laden stream waters to grow algae on corresponding glass plates. The algae was used to determine how mayflies responded to the resulting algae food source. Phosphorus is a nutrient commonly found in fertilizer that can enter streams via stormwater runoff. Photo: Gene Miller Photography

E. CLONED

Centroptilum triangulifer offspring are clones of the parent and thus can be cultured in the Stroud Center's laboratories using only a female parent. Photo: Dave Funk

D. LOCAL HABITAT

The Stroud Center's proximity to the White Clay Creek and its indoor wet laboratory make it possible for Entomologist Dave Funk to obtain stream water and grow the food necessary for raising mayflies. Photo: Kay Dixon

Photo: Kay Dixon

Our restoration work provides a bigger, better lab for our scientists.

Watershed Restoration Group to the Rescue

BORN JUST A YEAR AGO, THE TEAM IS SECURING SUBSTANTIAL GRANT FUNDS, EXPANDING ITS REACH, AND HAS RECENTLY ADDED A THIRD MEMBER.

A green, algae-choked stream meanders through a farmer's field in bucolic Lancaster County, Pennsylvania, weaving a sinuous path toward the Chesapeake Bay. Along its banks, some random tufts of weeds poke through the cracked earth. A herd of cows, seeking relief from the afternoon heat, wade into the stream. Their hooves part the mat of algae, and they drink from the tepid water beneath. Doing so, they ingest bacteria from the manure of livestock upstream, which they, in turn, will return to the livestock downstream.

During rainstorms, water — laced with nitrogen, phosphorus, and sediment — flows from our farms, parking lots, and housing developments into streams. This runoff feeds the thick carpet of green and brown algae that can choke the native plants and animals out of a stream. Most of us would keep a healthy distance from such water. But to the three members of the Watershed Restoration Group at Stroud Water Research Center, such a distressed stream is a call to action and returning it to good health, an exciting, fulfilling mission.

"It's very rewarding to know you are making a positive difference on a significant scale," said Watershed Restoration Manager David Wise, who joined the Stroud Center in January 2013, along with Matt Ehrhart, director of watershed

By installing fences to keep cows out of streams, this Lancaster County farm can continue to produce not only dairy milk but also cleaner water.

restoration. Together, the two men launched the Watershed Restoration Group, which effectively expanded the Stroud Center's mission by applying its research and education to the real world.

In January 2014 the team gained a third member, Lamonte Garber, as watershed restoration coordinator. Garber previously worked for the Chesapeake Bay Foundation, developing relationships with farmers to implement best management practices (BMPs).

"We're on the threshold of something remarkable and exciting," says Ehrhart, who guides the group's strategic vision and overall direction. "Our restoration work provides a bigger, better lab for our scientists. They, then, can take that knowledge and use it to develop better science that informs even better watershed restoration processes. It's a complete cycle."

Clean, healthy watersheds depend on an informed public making the right decisions. Therefore, the group will educate landowners and the general public about best management practices (BMPs) for conserving, restoring, and protecting watersheds, and they'll assist them in implementing those practices.

What is a Watershed?

A casual, and uncharacteristically unscientific (for the Stroud Center) man-on-the-street interview of passersby at a few nearby shopping centers yielded some interesting responses:

"A watershed is a tiny room in an old Victorian house where a toilet has a pull chain that releases water from an overhead storage tank to flush it," said one woman, apparently confusing a watershed with a water closet.

"It's another word for outhouse," three adult respondents ventured, without breaking their stride.

"It's a place where a farmer or gardener stores hoses and buckets and, maybe, fertilizer and stuff," said a teenager after hopping a curb on his skateboard.

None of the bystanders were able to accurately describe a watershed.

According to the U.S. Environmental Protection Agency (EPA), a watershed is the area of land where all of the water that is under it or drains off of it goes into the same place.

Garber poetically adds that a notable feature of watersheds is the forested areas along streams, called the riparian zone; it's "where the magic happens between trees and water."

Scientist geographer John Wesley Powell described a watershed as "that area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course and where, as humans settled, simple logic demanded that they become part of a community."

Unfortunately, our watersheds are stressed precisely because humans settled and established communities near waterways. Erosion, agricultural runoff, animal waste, and storm water laced with salts and petroleum compounds are just a few ways pollutants reach our streams and rivers.

During a recent presentation hosted by the Stroud Center, Ehrhart told a gathering of local equestrians that streams have suffered a 70 percent loss of species caused by human activities.

"Stream organisms are highly specialized and are adapted to forested ecosystems where the food web is very complex," he said. "They are specifically adapted to eat the food that has been in the environment for eons."

When a stream loses its forested cover, the organisms are forced to eat things that are not in their usual diet, Ehrhart explained. One of those things is filamentous algae, commonly referred to as nuisance algae. These multicellular algae form long, visible chains, or filaments, that intertwine, resembling matted, wet wool. Many aquatic invertebrates indicative of healthy forested streams, such as mayflies, are unable to eat these types of filamentous algae.

"Trees feed streams," said Ehrhart. "They produce litter in the form of branches, twigs, and leaves falling into streams, and they create a 'watershed tea' of dissolved organic compounds that make up about two-thirds of a stream's food supply." He adds that the forest shade keeps the stream cooler and wider, which is a big factor for cold-water fish.

"When you get too far below 70 percent forest cover, the stream loses its ability to support brook trout. So in a very real way, fish grow on trees," said Ehrhart.

Ehrhart believes that being able to cite Stroud Center research gives the Watershed Restoration Group added credibility when talking to landowners.

Among the BMPs the group will encourage landowners to implement will be the installation of fences to keep livestock out of streams as well as a series of level platforms designed to interrupt and slow down the gush of storm water that rushes toward a stream, giving it time to be absorbed into the soil.

Restoring Riparian Buffer Zones

The most significant of the group's projects will be organizing and overseeing the planting of thousands of acres of trees to restore hundreds of miles of riparian buffer zones — forested areas along streams. Biologists and conservationists have known for decades that trees are vital to streams because they filter many water contaminants and absorb and use excess nutrients before they get into the stream. However, during the past few years, Stroud Center researchers found clear evidence that mature streamside forests actually help the streams process and remove pollutants from the water more effectively than grass buffers do. This is in addition to the filtering effect of the riparian forests. Trees also provide direct benefits to the stream ecosystem. Branches in the water slow the flow of

Stroud Water Research Center is investigating low-cost methods for reforestation, including the propagation of trees, like this sycamore, and shrubs from live cuttings.

stream water, thus slowing the movement of sediment and nutrients downstream.

Stroud Center scientists have determined that the optimum riparian buffer is at least 100 feet wide on both sides of a stream.

"When there's an adequate riparian buffer, and healthy stream processes return, we can achieve so many important objectives at once," says Garber. "We see improved water quality, water temperature, carbon cycling, pollution filtering and removal, and a healthier stream community of animals and plants. There are so many processes that happen in this zone that I find intrinsically interesting. There is so much life and diversity."

Garber adds that restoring riparian buffers is also cost-effective.

"These projects take good planning and early maintenance, but once they're established, they are relatively self-sufficient. And these buffers only get better with age. Trees continue to grow and forests continue to get better over centuries. What other infrastructure improvement can we say gets better with age? Even wastewater pipes are installed with only a 100-year horizon. Many of our structural BMPs have only a 10-15 year lifespan. With forests we're working with a very resilient solution."

Grant-Funded Projects

The Watershed Restoration Group isn't funded with an endowment, and it relies heavily on grant funding for its work. The challenge is that while grants typically award two-year projects, some of the Stroud Center's best work — establishing riparian buffers — takes between 5 to 10 years to see the benefits. Ehrhart says another challenge is the "tendency among some funders to want what's new and sexy. But sometimes you just need to do more of the stuff that works really well."

Among the grants awarded to the group thus far are three from the National Fish and Wildlife Foundation:

- The Chesapeake Bay Stewardship Fund Implementation Grant: The group will work with farmers and absentee landowners to restore forest buffers on at least 15 farms.
- Low-Cost Methods for Forested Buffer Planting: The group earned a grant to develop and evaluate low-cost methods of forest buffer plantings, including natural regeneration, direct seeding, live staking and alternative protection, and herbicide treatments.
- Leveraging Ag BMPs and Nutrient Trading for Water and Habitat: The group will use a grant to help 27 farmers achieve full compliance with BMPs by providing technical assistance and helping them implement an affordable program.

Additionally, The Campbell Foundation awarded the group a $35,000 grant for a Nutrient Management Plan Verification and Agricultural Recognition Program for which they will develop criteria for a water quality recognition program for farms, with tracking systems that will validate results and gather long-term data on BMP performance.

The three-person team has an incredible amount of work ahead of them, but they are confident that they will be not only improving the watersheds they will be working in, but that their work will be regarded as a model to be widely adopted throughout the country and, ultimately, the world.

"Our funders know they are supporting restoration work that is as good as it can be. We are bringing the best science into the best restoration work," says Ehrhart. "We look for gaps in other programs and figure out how to get more bang for the buck. Then we communicate that to funding agencies and foundations to make sure their specifications reflect the best science."

He adds, as restored watersheds mature, their benefits continue to expand.

"They create habitat for birds, and landowners notice more density and diversity of other kinds of wildlife," he says. "And the forest creates a pleasant area for picnicking, hunting, and fishing. So there's a quality-of-life aspect that goes beyond the benefit to the stream."

Research Projects

Restoration of streamside forest for improving water quality

Funded by: White Clay Creek Wild & Scenic Rivers Management Committee Program

This project involved an experimental planting of trees as a best management practice for keeping pollutants out of a stream and improving its health as well as learning new insights as to how to increase seedling survivorship and growth. In collaboration with the Brandywine Conservancy and Dansko, Inc., the Stroud Center planted about 985 trees along a portion of the East Branch of the White Clay Creek, which is part of a Pennsylvania-designated Exceptional Value watershed, and installed more than 500 tree shelters on two acres of riparian land.

Principal Investigators: Bernard W. Sweeney and David Wise; Wes Horner (Brandywine Conservancy)

Restoration of streamside forest for improving water quality

Funded by: PA DCNR TreeVitalize Program in partnership with the Pennsylvania Horticultural Society

This project was a collaborative effort with the Brandywine Conservancy and involved planting trees at four different locations involving four local municipalities (East Bradford, East Brandywine, Franklin, and Pennsbury) as a best management practice for keeping pollutants out of local streams and improving their health. The projects involved about 3,600 trees planted by more than 630 volunteers.

Principal Investigators: Bernard W. Sweeney; Wes Horner (Brandywine Conservancy)

CZO research: The role of metals in nitrogen cycling of soils and streams

Funded by: National Science Foundation EAR 1024545

A collaboration with researchers at Princeton University will leverage the exceptional sensor and geochemistry data from our CZO project developed by Stroud Center scientists to explore the importance of a number of trace metals in the nitrogen fixation and denitrification transformations of nitrogen within our flood plain soils and sediments.

Principal Investigators: Anthony K. Aufdenkampe; Anne Kraepiel and Francois Morel (Princeton University)

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

Funded by: National Science Foundation

This 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 flood plains and estuaries have important local or global consequences for carbon cycling and climate.

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)

NEW IN 2013

Melinda Daniels, Ph.D.

In the spring of 2013, the Stroud Center welcomed **Melinda Daniels, Ph.D.**, as its newest associate research scientist.

Formerly a professor at Kansas State University, Daniels brings a wealth of expertise in how landscape-wide physical changes affect river systems. Daniels heads the new Fluvial Geomorphology Group, occupying the laboratory previously overseen by Denis Newbold, research scientist emeritus.

Since joining the Stroud Center's staff, Daniels has been appointed by Secretary of Defense Chuck Hagel to serve on the Environmental Advisory Board to the U.S. Army Corps of Engineers. Her term began in December 2013.

Moreover, she is the lead principle investigator on a new project funded by a grant from the National Science Foundation. For this project, she is investigating water sustainability in the Smoky Hill basin in the U.S. Central Great Plains.

NEW IN 2014

Beverly Payton, M.A., APR

Beverly Payton, M.A., APR, joined the Stroud Center in January as its communications director after a long and varied communications career.

She was a newspaper reporter and copyeditor at the *Bucks County Courier Times* and *The Daily Intelligencer* in Doylestown, Pa.

Later, she was a developmental editor at MediMedia, where she oversaw the creation of books for the American Red Cross and newsletters for hospital and managed-care organizations.

In 2008 Payton launched her own public relations consulting firm, Payton Communications, where she specialized in helping nonprofits get their message across.

Payton is excited to join the Stroud Center: "The mission is absolutely vital, nothing is more important to life on Earth than having access to clean, safe, fresh water."

Lamonte Garber

Lamonte Garber is the Watershed Restoration Group's latest hire. As of January 2014, Garber is serving as the watershed restoration coordinator, working with landowners and partnering agencies on restoration and conservation projects throughout Pennsylvania and beyond.

Hailing from the Chesapeake Bay Foundation (CBF), Garber has established himself as a friend of farmers and the environment.

He received his Bachelor of Science degree in agricultural economics and rural sociology from The Pennsylvania State University. Throughout his career — having a great appreciation of agriculture and environmental stewardship — Garber has worked with farmers to implement best management practices (BMPs). His talents in relationship building, marketing, fundraising, and project management will no doubt serve the Stroud Center well.

Daniels and Garber photos by Dave Arscott; Payton photo by Todd Trice

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.

Principal Investigator: Anthony K. Aufdenkampe

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

Photo: Kay Dixon

MRI: Acquisition of a high-sensitivity light stable isotope mass spectrometer for Critical Zone studies

Funded by: National Science Foundation 1126627

This grant supports the acquisition of a high-sensitivity stable isotope ratio mass spectrometer (IRMS) at Stroud Water Research Center, which will provide enhanced capabilities and greater sensitivity analyses than currently available at the Stroud Center. The new IRMS system will be put to use in several funded projects.

Principal Investigator: Anthony K. Aufdenkampe

Collaborators: J. Denis Newbold and Louis A. Kaplan

Developing a community information model and supporting software to extend interoperability of sensor- and sample-based Earth observations

Funded by: National Science Foundation EAR 1224638

This EAR Geoinformatics Program grant supports a two-year project to develop a community information model and related software to enable web based interoperability of Earth observations derived from sensors and samples that span now discrete data and informatics initiatives for multiple communities.

Principal Investigator: Anthony K. Aufdenkampe

Scientific software integration (SSI): The community-driven BiG CZ software system for integration and analysis of bio- and geoscience data in the Critical Zone

Funded by: National Science Foundation ACI 1332257

The overall goal of this project is to co-develop with the Critical Zone science and broader community, including natural resource managers and stakeholders, a web-based integration and visualization environment for joint analysis of cross-scale bio and geoscience processes in the critical zone (BiG CZ), spanning experimental and observational designs.

Principal Investigator: Anthony K. Aufdenkampe

EarthCube Domain End-User Workshop: Engaging the Critical Zone community to bridge long-tail science with big data

Funded by: National Science Foundation EAR 1252238

This workshop served two objectives: (1) to engage approximately 45 cyber-literate Critical Zone scientists in the EarthCube process and (2) to inform about 20 of EarthCube's cyberscientists of the diversity of needs of Critical Zone science. The overall goal of the workshop was to develop a set of unifying requirements for the integration of "long tail" data and "big data" and to develop an interactive community of domain scientists and cyberscientists to pursue solutions.

Principal Investigator: Anthony K. Aufdenkampe

Collaborators: Christopher Duffy (Penn State University) and Gregory Tucker (University of Colorado Boulder)

Integrated data management system for Critical Zone Observatories

Funded by: National Science Foundation EAR 1332257

The objective of the project is to develop a comprehensive, integrated data management system for the Critical Zone Observatory (CZO) program, called CZOData. The overall goal for CZOData is to support, empower, and broaden the impact of CZO science and maximize the return on investment of the CZO program by transforming capabilities to easily share, integrate, analyze, and preserve the wide range of multidisciplinary data generated within and across CZOs.

Principal Investigator: Anthony K. Aufdenkampe

Using DNA in water to test for the presence of freshwater mussels

Funded by: DuPont Clear Into the Future

Determining that a species is present in a stream has traditionally required collection surveys to visually observe one or more individuals of that species. However, collection surveys may harm rare or endangered species, are time consuming, and may miss well-camouflaged or hidden species. On the other hand, aquatic organisms are continuously releasing DNA into the environment that is either free floating or in small clusters of cells. We are developing a noninvasive survey technique to search for DNA sequences that are unique to freshwater mussels in a sample of water. We will apply this technique to search for freshwater mussels in the White Clay, Red Clay, and Brandywine creeks.

Principal Investigator: William H. Eldridge

Developing a Water Atlas for the ACOSA region of Costa Rica

Funded by: Blue Moon Fund

Stroud Water Research Center biologists are working with researchers and managers in the ACOSA region of southwest Costa Rica to collect and disseminate information on streams and rivers to a variety of user groups. The two-year project will involve education programs to teach school students, researchers, and other citizens about stream health and monitoring protocols; professional surveys conducted by Stroud Center biologists; and development of an online Water Atlas to store, visualize, and share data among government managers and scientists, nongovernmental organizations, and citizens.

Principal Investigator: William H. Eldridge

Collaborators: Bernard W. Sweeney and David B. Arscott

Threats and opportunities in the conservation of native pelagic spawning fishes in Kansas

Funded by: Kingsbury Family Foundation

This project is documenting the fragmentation of stream networks by small dams in the Central Great Plains region. Many fishes native to this region broadcast buoyant eggs into the water column where they float downstream while developing. Juveniles then migrate back upstream to breed as adults. Using geographic information science, we are documenting fragmentation points (dams) that capture downstream drifting eggs as well as block maturing fish from returning to upstream portions of the network.

Principal Investigator: Melinda D. Daniels

CNH: Coupled climate, cultivation, and culture in the Great Plains: Understanding water supply and water quality in a fragile landscape

Funded by: National Science Foundation

In this collaborative project, we develop a coupled human-landscape model that incorporates the linkages and feedbacks among atmospheric, terrestrial, aquatic, and social processes that can be used to predict the potential impact of climate variability, climate change, land use, and human activity on water resources at decadal to centennial scales in the Central Great Plains of North America. In the first three components, we develop and interactively couple mechanistic models of the three systems controlling water supply and water quality (the hydrosystem), the aquatic ecosystem, and the human system. In the fourth research component, these three system models are integrated in two ways. First, we use an agent-based decision model to evaluate whole-system (hydrosystem, aquatic ecosystem, human system) response to climate variation scenarios derived from historical data and downscaled climate projections. Second, we use policy optimization modeling to identify the most effective strategies to achieve sustainability.

Principal Investigator: Melinda D. Daniels

Collaborators: Marcellus Caldas, Jessica Heirr-Stamm, Jason Bergtold, Aleksy Sheshukov, Martha Mather, and David Haukos (Kansas State University)

Microbial population dynamics of periphyton biofilms in the White Clay Creek

Funded by: Stroud Water Research Center

Starting in the summer of 2011, Stroud Center scientists deployed glass slides (periphytometers) to enrich biofilms in three reaches of the White Clay Creek with distinct streamside land uses (mature forest, restored but immature forest, and meadow from upstream to downstream). Molecular DNA fingerprints of small subunit ribosomal RNA gene demonstrated spatial and temporal variations of biofilm population structures on both natural surface and glass slides. In-depth community structures have been characterized by using the 454 pyrosequencing platform at the University of Pennsylvania. The data analysis is ongoing.

Principal Investigator: Jinjun Kan

Sediment microbial fuel cells (MFCs)

Funded by: Space and Naval Warfare Systems Command (SPAWAR) and Stroud Water Research Center

Two streambed sediment microbial fuel cells have been deployed in the White Clay Creek, and a sweeping test has been done. The maximum voltage for the sediment fuel cells on streambed is about 1 volt. One demo unit has been installed in the in-house stream channel, and a Christmas tree is connected to demonstrate the power generation/application from the respiration of bacteria buried in the indoor stream sediments. Further data collection and analyses continue.

Principal Investigator: Jinjun Kan

Collaborator: Y. M. Arias-Thode (SPAWAR)

Christina River Basin Critical Zone Observatory (CRB-CZO): Quantifying carbon sequestration resulting from human-induced erosion

Funded by: National Science Foundation EAR 0724971 and 1331856

In collaboration with the University of Delaware, Stroud Center scientists established one of six Critical Zone Observatories in the U.S. 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 flood plain and coastal sediments, modifying greenhouse gas emissions from the landscape.

Principal Investigators: Anthony K. Aufdenkampe and Louis A. Kaplan; Donald L. Sparks (University of Delaware)

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

Photo: Kay Dixon

Long-Term Research in Environmental Biology (LTREB): Trajectory for the recovery of stream ecosystem structure and function during reforestation

Funded by: National Science Foundation DEB 1052716

Stream restoration in the U.S. is a multibillion-dollar industry, but long-term monitoring of it is virtually nonexistent. Stroud Center scientists initiated a study to follow restoration within the White Clay Creek that involves the reforestation of meadows or pastures with native deciduous trees and the removal of invasive plant species. As the planted forest matures, researchers will characterize the changes in the aquatic biological communities and their associated activity. Teachers will be trained in the use of long-term environmental data as a means to enhance teachers' and students' math skills, analytical abilities, and environmental knowledge.

Principal Investigator: Louis A. Kaplan

Collaborators: Anthony K. Aufdenkampe, John K. Jackson, Jinjun Kan, J. Denis Newbold, William H. Eldridge, David B. Arscott, Charles L. Dow, Susan E. Gill, and Bernard W. Sweeney

Scientific expert testimony for Department of Justice: Wetland connectivity related to jurisdictional determination in a Painesville, OH wetland complex. US v. Osborne, Sr. DJ#90-5-1-1-18628

Funded by: US Department of Justice

Principal Investigators: David B. Arscott and William H. Eldridge

Water quality impacts of the interoceanic highway in the eastern Andes Amazon headwaters region

Funded by: Blue Moon Fund

This collaborative project with the Amazon Center for Environmental Education and Research (ACEER) involves conducting a comprehensive assessment of water quality impacts for streams and rivers intersected by South America's first transcontinental highway, which bisects the Amazon basin from the Atlantic Ocean in Brazil to the Pacific Ocean in Peru. The assessment also includes testing the efficacy of Stroud Water Research Center's Leaf Pack Experiment Kit to evaluate water quality in tropical systems.

Principal Investigators: Bernard W. Sweeney, John K. Jackson, and David H. Funk

Collaborators: Roger W. Mustalish (ACEER) and Wills Flowers (Florida A&M University)

Photo: Kay Dixon

Water quality assessment in California using DNA barcoding

Funded by: Southern California Coastal Water Research Project (SCCWRP), Pennswood No. 2 Research Endowment and Stroud Water Research Center

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 various species of macroinvertebrate larvae collected from the field. 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

Collaborators: Peter Miller and Paul Hebert (University of Guelph), Eric Stein (SCCWRP), and Erik Pilgrim (USEPA)

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 *Centroptilum triangulifer* has been expanded to include a number of related and unrelated mayfly species in the 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

Ecotoxicity study for mayflies exposed to ambient stream water from the Upper Delaware Basin and to produced water from natural gas drilling

Funded by: Delaware River Basin Commission

The production of natural gas from the Marcellus shale in Pennsylvania results in water that travels up through the well bore. This water generally has high concentrations of various salts and other dissolved substances, as well as a variety of other compounds. This project measures lethal and nonlethal responses of mayflies exposed to produced water diluted with water from the White Clay Creek and another Exceptional Value stream in northeastern Pennsylvania. It builds on our experience in rearing the parthenogenetic mayfly *Centroptilum triangulifer* in the laboratory by comparing responses of *C. triangulifer* from the White Clay Creek with responses of two mayfly species that commonly co-occur with *C. triangulifer* in small streams of eastern North America.

Principal Investigators: John K. Jackson and Bernard W. Sweeney

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

Comparative life cycle and toxicity testing of multiple mayfly species across a gradient of total dissolved solids, with methods development for native species in the Central Appalachian coal fields

Funded by: United States Environmental Protection Agency

Many water quality standards for pollutants in streams are based on laboratory toxicity tests that rely on macroinvertebrate species that are easy to handle in the laboratory. Unfortunately, these standard test species generally do not live in streams, and their sensitivity relative to most native stream species is unknown. This project measures lethal and nonlethal responses of mayflies exposed to water from streams flowing out of valleys filled with mountaintop mining overburden in West Virginia and Kentucky. It builds on our experience in rearing the parthenogenetic mayfly *Centroptilum triangulifer* in the laboratory by comparing responses of *C. triangulifer* from the White Clay Creek with responses of five mayfly species collected from small streams in West Virginia.

Principal Investigators: John K. Jackson, David H. Funk, and Bernard W. Sweeney

Monitoring, evaluation, scientific support, and capacity building for watershed protection and restoration projects: Entomological collections

Funded by: Academy of Natural Sciences of Drexel University (ANSDU)

The goal of this project is to collect and interpret entomological data from 35 stream sites. These sites represent an initial baseline as part of ANSDU's comprehensive monitoring and technical support for projects funded by the William Penn Foundation to restore and protect water quality in the Delaware River basin.

Principal Investigator: John K. Jackson

Collaborators: Roland Wall, Stefanie A. Kroll, Richard J. Horwitz, Jerry V. Mead, Donald F. Charles, and David J. Velinsky (Academy of Natural Sciences of Drexel University)

Planning phase — Protecting and Restoring Places of Ecological Significance (Brandywine-Christina and Middle Schuylkill Clusters)

Funded by: William Penn Foundation

Stroud Center scientists participated with several collaborators in the development of restoration and protection implementation plans for targeted watersheds in the Brandywine-Christina and Middle Schuylkill clusters in the Delaware River basin. These implementation plans defined conservation priorities and goals, identified strategies needed to achieve those goals, and designed monitoring programs to measure short- and long-term progress toward those goals. The combination of priorities, goals, strategies, and monitoring provides important, multi-organizational structure to help focus conservation efforts funded by the William Penn Foundation.

Principal Investigators: John K. Jackson, Matthew J. Ehrhart, and Bernard W. Sweeney

Collaborators: Berks Conservancy, Brandywine Conservancy, Brandywine Valley Association, Natural Lands Trust, Partnership for the Delaware Estuary, The Nature Conservancy of Delaware, and University of Delaware

Evaluating potential impacts on groundwater of passive composting of spent mushroom substrate according to best practices guidelines.

Funded by: Stroud Water Research Center

Guidelines for passive composting of spent mushroom substrate (SMS) are contained in a Pennsylvania Department of Environmental Protection document entitled "Best Practices for Environmental Protection in the Mushroom Farm Community." This guidance document is designed to allow SMS to be handled in a way that prevents the pollution of the air, water, or other natural resources. When the guidance practices are followed, groundwater monitoring is not required. Research designed to test the tacit assumption that the guidelines protect groundwater includes the installation of monitoring wells for groundwater, soil water samplers, and probes to measure the conductivity in the soil and in the groundwater.

Principal Investigator: Louis A. Kaplan

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 rainy 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

Collaborators: Julio Calvo (Instituto Tecnológico de Costa Rica Escuela de Ingeniería Forestal, Costa Rica)

Metaecosystems and the upstream legacy: Influence of dissolved organic matter on the structure and function of streambed bacterial communities

Funded by: National Science Foundation DEB 1120717

Organic carbon, in the form of dissolved molecules transported in stream water, is processed for energy by microorganisms that live on the streambed. Looking out over a drainage network, investigators explore how the quality of the organic molecules changes with distance downstream and how those changes influence the composition of the communities of streambed microbes using that food resource. Research sites range in size from small streams to small rivers within temperate and tropical forests. The research goals include advancing knowledge of stream ecosystems across drainage networks and forging a broad model of stream ecosystems in the global carbon cycle.

Principal Investigator: Louis A. Kaplan

Collaborators: Jinjun Kan, Susan E. Gill, and Jennifer J. Mosher; Robert H. Findlay (University of Alabama) and David C. Richardson (SUNY New Paltz)


Photo: Dave Funk

A golden shiner swims in a tributary to the Brandywine Creek.

Watershed Restoration Projects

Demonstrating low-cost methods for reforestation

Funded by: National Fish and Wildlife Foundation

Four sites in New York, Pennsylvania, and Maryland will demonstrate options for improving the cost-effectiveness of reforestation methods including direct seeding, innovative fencing in lieu of tree shelters, live stakes, improved herbicide methods for managing herbivores/competition, and more.

Principal Investigator: Bernard W. Sweeney

Collaborators: Paul Salon (U.S. Dept. of Agriculture)

Demonstrating low-cost methods for reforestation

Funded by: National Fish and Wildlife Foundation and Pa. Dept. of Environmental Protection's Growing Greener Program

Stroud Water Research Center's Farm Stewardship Program provides technical and financial assistance to farmers and landowners to implement best management practices (BMPs) to protect water quality and improve stream health. This program encourages farmers and landowners to meet a higher standard of stewardship excellence, and it shows a wide variety of agencies and funders that farmers and landowners are willing to meet this higher standard through practices such as the restoration of streamside forest buffers as a condition of receiving funds for BMPs. In 2013 the Stroud Center secured landowner commitments for work on 15 farms to implement about 95 agricultural BMPs including about 75 acres of forested buffer on 15 miles of streambanks. Education and research elements are integral.

Project Leader: Matthew J. Ehrhart

Collaborators: Red Barn Consulting, Inc., TeamAg, Inc., Berks and Chester County Conservation Districts, multiple land trusts and conservancies, and others.

Education Projects

From Classroom to Creek

Funded by: Stormwater Programs for the City of Newark, Del.

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

Project Lead: Christina Medved

The Science of Water Through the World of Art

Funded by: Point Lookout Farmlife and Water Preserve Foundation

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. Elementary through high 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.

Project Lead: Vivian Williams


Photo: Kay Dixon

As part of a Department of State exchange program, international leaders involved in water management and associated fields visited the Stroud Center to learn more about freshwater research. Drs. Lou Kaplan and Dave Arscott led the group on a tour to showcase best management practices for managing water.

Consortium for Scientific Assistance to Watersheds (C-SAW)

Funded by: Consortium for Scientific Assistance to Watersheds

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.

Project Lead: Christina Medved

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 mathematics (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, and J. Denis Newbold; Robert Cheetham (Azavea), Dana Tomlin (University of Pennsylvania), and Nanette Dietrich (Millersville University)

Collaborators: Michele Adams (Meliora Design) and Steve Benz (OLIN)

Critical Zone geoscience education

Funded by: National Science Foundation

Stroud Water Research Center educators developed and delivered educational programs to students and teachers based on the science of the Christina River Basin Critical Zone Observatory project. The goal of the program was to introduce students and teachers to the study of soils, surface water and the effects of vegetation as well as how human activities can alter the environment. Participants worked with soil cores, sediment samples and sensors to investigate the characteristics of their local environment.

Principal Investigators: Susan E. Gill and Elizabeth Gregg

Stroud Seminar Series

Funded by: Cockayne Fund, Inc.

Stroud Water Research Center scientists presented their work through a series of evening lectures. These lectures covered topics such the Stroud Center's work with restoring riparian buffers on farmland and planting trees as the most effective way to increase stream health; harvesting electricity from microorganisms that live in sediment; and the genetics of fish and how their populations might be changing because of human-induced changes in the stream channel and landscape.

Stream school for New Jersey Department of Environmental Protection (NJ DEP)

Funded by: NJ DEP

For several years now, Stroud Center educators have provided two-day stream ecology trainings for Americorps New Jersey Watershed Ambassadors and citizen water quality monitoring volunteers. NJ DEP utilizes volunteer data, at the state level, for assessing the health of its water bodies.

Project Lead: Christina Medved

Note: All investigators, project leads, and collaborators are from Stroud Water Research Center unless otherwise noted.

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Gifts and Contributions

Gifts to the Annual Fund

Your contribution to the 2013 Annual Fund enabled us to continue our vital freshwater research, watershed restoration, and education programs. The generosity of the Friends of the Stroud Center, as well as 100% of our Board of Directors and Senior Staff, ensures our work will continue for many years to come. We are especially grateful for our staff, noted with an * mark, who donated in 2013.

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While we continue to raise funds for endowment of our education department and our Maritza Biological Station in Costa Rica, these generous supporters have made the dream of a new education and outreach building a reality and the endowment of the Assistant Director position possible.

Many thanks to everyone who supported our achievement of a green building for environmental education and public outreach that is LEED certified to the Platinum level!

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Mr. and Mrs. Stephen M. Stroud	Funds to support operations of the Maritza Station in Costa Rica and the education department

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Thanks to our volunteers of all ages!

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Many thanks to our 2013 interns!

The development department is so grateful to have wonderful volunteers, who generously gave their time to help the Stroud Center in 2013. Whether it's stuffing envelopes or invitations, serving as bartenders or greeters, or simply sharing creative talents or ideas, these magnificent volunteers are truly appreciated! Thank you Franny Abbott, Alyssa Arscott, Lewis Arscott, Jan Battle, Laura Borecki, Mike Broomall, Christine Chapman, Laurie de Grazia, Rebecca Duczkowski, Evie Dutton, Diane Huskinson, Donnan Sharp Jones, Kerry Mapes, Katharine Maroney, Allison Masci, Jennie Matkov, Christina Medved, Melanie Miller, Jen Mosher, Barbie Riegel, Winden Rowe, Trish Scott, Payton Shonk, Anabel Simpson, Andrea Spahr, Boo Stroud, Andrea Sweeney, Brenna Sweetman, and Shelby vonTill.

(We could always use more dedicated volunteers, so if you would like to join this distinguished group, please contact Kay or Kristine.)

Financials

Operating Statement
for the year ended December 31, 2013

Revenues & Support

Research Programs (Grants & Contracts)	$ 2,187,063
Endowment	1,566,862
Annual Fund	426,323
Other Contributions & Income	389,346
Watershed Restoration Group Programs	352,139
Reserves	309,811
Education/Public Programs	261,911
Total Revenues & Support	**5,493,455**

Expenditures

Research	$ 2,664,250
Facilities	857,628
Administrative	611,386
Information Services	342,704
Watershed Restoration Group	321,874
Development/Outreach	299,936
Education	259,759
Other	68,692
Communications	67,226
Total Expenditures	**5,493,455**

Financial Information

Stroud™ Water Research Center is a 501(c)(3) nonprofit organization registered with the Pennsylvania Bureau of Charitable Organizations.
Gifts to Stroud Water Research Center are tax deductible on a U.S. return as allowed by law.
The Stroud Water Research Center Employer Identification Number (EIN) is 52-2081073.
The fiscal year is January 1 to December 31.
The annual audit is performed by Gunnip & Company.
Investment assets are managed by New Providence Asset Management and Passive Capital Management. The Center is also the beneficiary of the Morris W. Stroud 3rd Pennswood No. 2 Trust managed by the Glenmede Trust Company.

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

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