STROUD
WATER RESEARCH CENTER

2014 Annual Report

A YEAR IN REVIEW

The Future of Fresh Water Starts Here.

AT A GLANCE

2014


A.

A. Partnering with Osa Conservation, we're working to protect the watersheds of Costa Rica's Osa Peninsula. Stroud Center scientist William Eldridge, Ph.D., and Education Programs Manager Tara Muenz trained citizens and Osa staff in chemical, physical and biological methods to monitor streams for long-term freshwater stewardship. Photo: Osa Conservation

B. Stroud Center hosted representatives from the U.S. Department of Agriculture, the Natural Resources Conservation Service and the Pennsylvania Department of Conservation and Natural Resources for a workshop about the latest research regarding forested buffers. Forested buffers transform the stream environment so that streams can be vibrant, robust and more functional. Photo: Tara Muenz


B.

C. Robert F. Kennedy Jr. (left), who received the 2014 Stroud Award for Freshwater Excellence, shares a moment with Tom Lovejoy, Ph.D., at The Water's Edge gala at Longwood Gardens in October. Photo:Yeda Arscott


C.

D. Research Engineer Steve Hicks (left) speaks to a group of international leaders involved in water management and associated fields. A total of 16 visitors toured Stroud Center as part of a Department of State exchange program. The goal of the program is to build understanding between professionals in the U.S. and other countries. Photo: Beverly Payton


D.

E. Anthony Aufdenkampe, Ph.D., and Sara Damiano measure discharge during an April storm in White Clay Creek. Photo: Steve Hicks


E.

F. Education Programs Manager Tara Muenz surveys for aquatic macroinvertebrates within a lake as part of the Upper Delaware BioBlitz. Photo: Kerry Mapes


F.

Cover photo: Todd Trice

MESSAGE FROM THE DIRECTOR

Photo: Todd Trice

Those famous words from scholar John Schaar ring true here at Stroud Water Research Center. We believe that the work we do today in research, education and restoration is creating a future of clean fresh water for everyone.

The threats to our freshwater streams and rivers are many: road salts, stormwater runoff, invasive species, deforestation, climate change — the list goes on. To understand how these threats impact our freshwater resources, and to provide solutions, we add to our existing knowledge of how streams work by continuously seeking answers to new questions.

We ask basic questions about fresh water and its ecosystems such as the one postdoctoral researcher Lindsey Albertson asked last summer: Will the silk nets spun by caddisflies in streambeds weaken during periods of drought and cause the streambed to break up, thus increasing the likelihood of erosion? The answers help us understand how the health of our waterways is interwoven into the health of the aquatic life they support. I invite you to learn more about Lindsey's research project on page 2.

We travel the world seeking the best places to answer our questions. Yet often the answers lie right in our own backyard, in White Clay Creek. Here we study how a watershed changes from one decade to the next. White Clay Creek is also host to education programs such as the National Science Foundation's Research Experience for Undergraduates and Teachers. In 2014, we introduced 11 undergraduates and four K-12 teachers to two of our nation's Critical Zone Observatories (CZO): the Christina River Basin and the Susquehanna Shale Hills CZOs. We led instruction on CZO science and gave participants a taste of what scientists do. They pulled on boots and explored how the White Clay Creek ecosystem works. By the end of the summer, each of the participants had completed his or her own CZO research project. Our education programs manager, Tara Muenz, tells us more about this innovative program on page 6.

Beyond the lab and classroom, we put our knowledge of streams and rivers to work through restoration projects, which you can learn more about on page 10. Since forming our Watershed Restoration Group, we've helped dozens of farmers get state and federal funds to adopt best management practices on their farms. We show them how to improve their businesses while protecting our waterways. And with our partners and volunteers, we've planted hundreds of miles of streamside forests. We're raising the bar, helping farmers do more for fresh water.

I hope you'll consider raising the bar too. With your continued support, we can make the future of fresh water a bright one.

Yours in freshwater stewardship,

RESEARCH

In a running stream, caddisfly silk binds plants, debris, rocks, gravel and sand together. This is important because it can prevent the streambed from breaking up and washing away during a flood.

Photo: Lindsey Albertson

Caddisflies, like this *Hydropsyche* larva, spin underwater silk nets in streams. *Photo: Dave Funk*

Aquatic Insects Affect Sediment Stability in Streams

By Beverly Payton, Director of Communications

Caddisflies: Underwater Architects

You might not think the aquatic larvae of a tiny mothlike insect could affect the stability of an entire streambed, but Lindsey Albertson, Ph.D., a postdoctoral researcher in the Fluvial Geomorphology Group at Stroud Center, knows otherwise. Her experiments in Stroud Center's stream flumes last summer examined how these small creatures influence sediment erosion in streams during storms.

One of her experiments involved caddisflies, a group of species that — like mayflies and stoneflies — plays an important role in the bioassessment surveys Stroud Center entomologists do when monitoring water quality.

"Caddisflies are cool because they spin silk webs, much like a spider does, but underwater," says Albertson. "Even though they are small — less than a centimeter long — there can be hundreds or thousands of webs built by hundreds or thousands of caddisflies in a very small area."

They use their silk webs, excreted from salivary glands near their mouths, to collect food and build protective cases to hide from predators. Under a microscope, the web lattice resembles a small, rectangular wire fence that's astonishingly symmetrical. In a running stream, caddisfly silk binds plants, debris, rocks, gravel and sand together. This is important because it can prevent the streambed from breaking up and washing away during a flood. Because many streams are experiencing changes in their flooding regimes due to land-use change, damming and other impacts, it is important to understand how these silk webs will respond.

"In summer, many small streams dry up, so we needed to find out how periods of drought affect caddisfly nets," says Albertson. Even when dry, stream channels are usually well-defined paths for storm flows, and it can be very destructive if the streambed breaks up during a storm, she explains.

"When there's a big rainstorm, and all this water is rushing down a creek, we need to understand both the physical and biological forces that govern the impact of floods and how much sediment is moved during those high waters. If the caddisfly silk is binding sediments together and reducing erosion, then it's important to understand how the silk itself responds to drought," says Albertson.

To test the resiliency of caddisfly nets, Albertson experimented using flumes in Stroud Center's stream house, a greenhouse equipped with 10 recirculating stream channels. Some flumes (the control group) flowed throughout the entire experiment, so the caddisfly silk nets stayed wet. Water in the other flumes was turned off for 14 days, allowing the flumes to dry out. The research team then compared the silk strength of the wet and dry flumes. When the experiment

concluded, Albertson and Melinda Daniels, Stroud Center's fluvial geomorphologist, were surprised by the resilience of the caddisfly nets.

"We thought the caddisfly nets in the dry beds would degrade in a few days because the silk would dry out and lose its elasticity," says Albertson. "But we found when we measured the tensile strength even two weeks later that they were just as strong."

This study suggests that biological processes, even in temporary streams, are an important part of a watershed's sediment dynamics. The findings also emphasize that biological structures such as silk webs may be resilient to various forms of human disturbance in stream ecosystems.

Studies related to Albertson's caddisfly research were recently published in PLoS ONE and the *Journal of Geophysical Research* with colleagues at the University of California, Santa Barbara, the University of Michigan and San Francisco State University.

For Crayfish, Size Does Matter

In another stream house experiment, Albertson, along with Daniels, studied the biological effects of native crayfish on streambed stability. They then compared results from those experiments to results from a field study on an invasive species of crayfish.

Photo: Lindsey Albertson

"We're seeing changes to biodiversity across the globe," she says. "We're losing native species and gaining invasive species. It's important to understand the impact those invasive species have on native populations."

The rusty crayfish — an invasive species here in Pennsylvania that has expanded its range from Indiana, Ohio and Kentucky — has been found living in Valley Creek and the Schuylkill River near King of Prussia, Pennsylvania. "Many people think that their range expansion is due to fishermen using them as bait, then releasing them into the environment, not realizing that they don't really belong here," says Albertson.

Albertson and Daniels, in collaboration with Amy Ruhe and Kate Jensen at Valley Forge National Historic Park, studied how the invasive rusty crayfish affected the habitat and aquatic insect community when compared to the native spiny cheek crayfish that is dominant in White Clay Creek near Stroud Center.

"The invasive crayfish are huge," says Albertson. "They have huge claws and huge appetites. They can kill the native crayfish species, but what's more significant is that they are potentially eating the native crayfish's food supply. They also have a thicker exoskeleton that is harder for trout to digest."

Albertson adds that crayfish also disturb the streambed: "That goes for all species of crayfish, but we are starting to monitor whether the rusty crayfish disturbs the streambed more than the spiny cheek crayfish due to its larger size. When crayfish search for food or shelter, they dig with their huge claws. This kicks fine silt and gravel up and loosens gravel. So, during a flood, the crayfish-scavenged sediments are more likely to move."

The results of their experiments in the stream house and at Valley Forge National Historic Park show that both spiny cheek and rusty crayfish move a significant amount of gravel to build pits where they can shelter. Through this activity, the movements of the rusty crayfish also stir up fine sediments and reduce settling of silt. Although the researchers expected the rusty's food source, aquatic insects, to be reduced, Albertson and Daniels found that these bugs were actually more abundant when crayfish were present.

Photo: Kay Dixon

Stroud Center's Stream House: Where Research Goes With the Flow

Visitors touring Stroud Center's facilities are always intrigued by the variety of experimental streams. These artificial streams can replicate aspects of a natural stream on a smaller scale so Stroud Center scientists can apply, test and calibrate results to quantitatively assess the structure and function of stream ecosystems.

The U-shaped stream channel in the basement of the research wing is thought to be the oldest and longest continuously flowing indoor stream used for research in the world. "When it was built, in 1968, it was the first of its kind," says Director Bern Sweeney, Ph.D. He adds that it's unique because it is essentially an indoor version of White Clay Creek, as it is fed with high-quality water from the East Branch of White Clay Creek, classified by the Commonwealth of Pennsylvania as an Exceptional Value Stream.

Just north of Stroud Center's building complex are four 100-foot-long streamside flumes built in 1994 — when Denis Newbold, Ph.D., studied how microscopic organic particles are carried by the stream, deposited in the streambed and then resuspended to continue downstream. Experiments in the streamside flumes have shown that algae and microbes on sediment surfaces also entrap and remove particles from stream water.

In late 2009, a 10-flume system of stream channels was built when Tom Bott, Ph.D., and John Jackson, Ph.D., studied the ecological effects of phosphorus. These 10 stream channels are located in the greenhouse, or stream house, that is situated between Stroud Center's research building and the new Moorhead Environmental Complex.

All of these stream systems facilitate experiments that require seminatural settings replicated in independent units, where the researcher needs control over certain environmental factors such as flow, temperature or water chemistry. "This enables our researchers to conduct more tightly controlled experiments that require reliable reference conditions and replication," says Assistant Director Dave Arscott, Ph.D.

SPOTLIGHT:

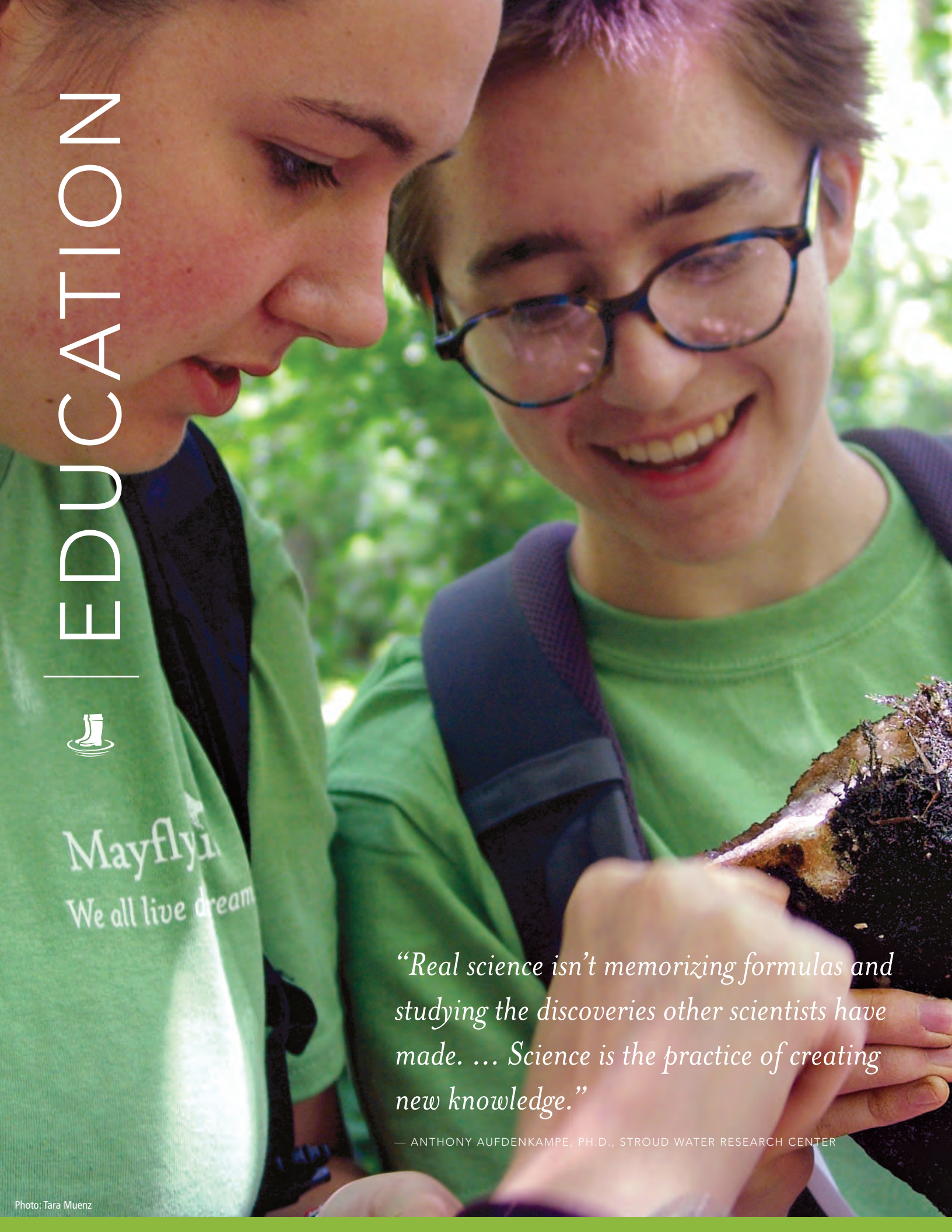
LINDSEY ALBERTSON COMPLETES POSTDOCTORAL STUDIES AT STROUD CENTER

Lindsey Albertson (also pictured above) earned her doctorate in ecology at the University of California, Santa Barbara, last year and has been doing postdoctoral research with Daniels at Stroud Center.

Albertson grew up in Deerfield, Massachusetts, and completed her undergraduate work at Brown University in Providence, Rhode Island. Photo: Kay Dixon

When she finishes her work at Stroud Center, Albertson says she will seek a faculty or research position.

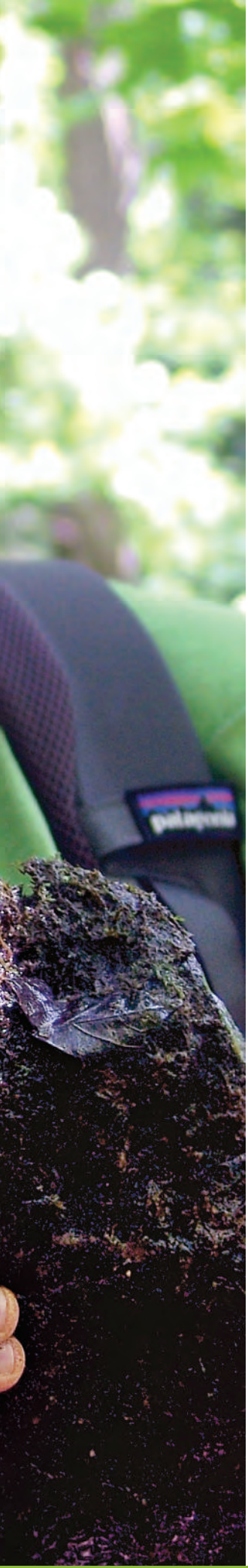
EDUCATION



"Real science isn't memorizing formulas and studying the discoveries other scientists have made. … Science is the practice of creating new knowledge."

— ANTHONY AUFDENKAMPE, PH.D., STROUD WATER RESEARCH CENTER

Photo: Tara Muenz



Scientists, Teachers and Undergrads Enter the Critical Zone

By Tara Muenz, Education Programs Manager

> "This experience sold me on graduate school and convinced me to focus on conservation."

> "Field skills! I learned how to conduct vegetation surveys in ways that I can integrate into my studies. I also learned a lot about field instruments and skills for discussing my research."

> "I loved it. Making discoveries and getting interesting results for my own research project is a great feeling. I'm now considering a career in research."

Those enthusiastic remarks were just a few among the many compliments we received from the 11 undergraduates and four K-12 teachers who, last summer, learned what it takes to conduct scientific research. They were part of the Critical Zone Observatory Research Experience for Undergraduates and Teachers (CZO REU/RET), part of the National Science Foundation's Critical Zone Observatories program.

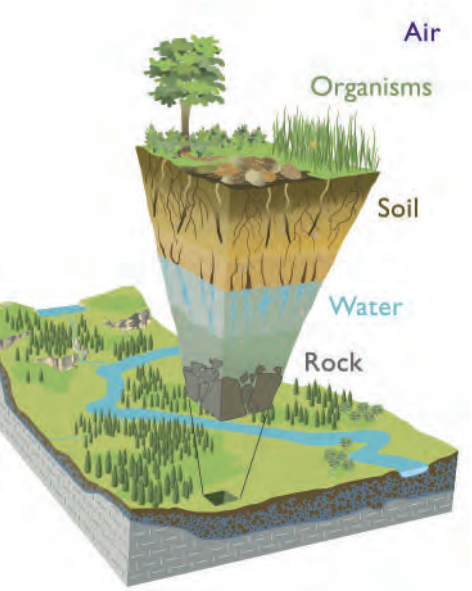
As participants lace up their boots, Anthony Aufdenkampe, Ph.D., of Stroud Water Research Center, warns, "First lesson: If you're a scientist conducting research in the field, you must be prepared for the elements. Today that means you'll need sun protection — so hats, sunblock, long-sleeve shirts if you have them." The group starts passing around a large bottle of sunblock and a stack of waterproof notebooks.

Soon, the group is tramping down a forest trail that follows the sinuous curve of a stream. Aufdenkampe leads the way while explaining the significance of the Critical Zone and how Stroud Center researchers are using wireless sensors to automatically collect data from White Clay Creek.

Where Rock Meets Life

The Critical Zone is the zone on the earth's surface that makes life possible — loosely described as "where rock meets life." In 2007, the National Science Foundation created the Critical Zone Observatories (CZO) program, spearheading a national effort in which interdisciplinary teams of scientists study the earth's outer skin. There are currently 10 CZOs, each located in a different region with its own distinct climate, rocks, soils and plants.

"Practically speaking, Critical Zone science can help us answer questions about how we as humans are affecting the Critical Zone, and it can show what that might mean in terms of, for example, climate change," says Aufdenkampe.



Water and atmospheric gases move through the porous Critical Zone, and living systems thrive in its surface and subsurface environments, shaped over time by biota, geology and climate.
Illustration: Modified from Chorover, J., R. Kretzschmar, F. Garcia-Pichel, and D. L. Sparks. 2007. Soil biogeochemical processes in the critical zone. Elements 3, 321-326. (Artwork by R. Kindlimann).

Earth's Critical Zone is as fascinating as it is important to sustaining life on Earth, so it's not surprising that the CZO REU/RET program attracted applicants from across the nation. Selected participants were assigned to either the Christina River Basin or Susquehanna Shale Hills CZO. Stroud Center, in partnership with the University of Delaware, established the Christina River Basin CZO in 2009. It extends from the streams of the Christina River in Pennsylvania to the tidal rivers in the Delaware Bay. The other CZO that some of the participants were assigned to, the Susquehanna Shale Hills CZO, consists of one headwater catchment in the Susquehanna River Basin called the Shale Hills (Pennsylvania).

Tim White, Ph.D., of Penn State University, and Aufdenkampe led the REU/RET experience, and both serve in larger leadership roles with the national program.

"Good science starts with asking the right questions," says Aufdenkampe. "What can we learn that will help us make influential choices to better steward the natural environment? That's what the CZO program is really all about."

A two-week orientation kicked off the summer program; participants spent one week at Stroud Center and one at Penn State. Scientists at Stroud Center, the University of Delaware and Penn State University led exercises in research design and taught participants how to take careful observations in the field, analyze data and communicate research findings.

Real-World Research

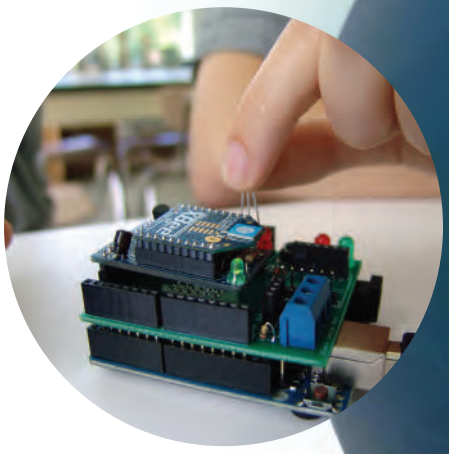
"We wanted the undergraduates to deeply connect with each other and to pursue interdisciplinary research in the Critical Zone," says Tim White. "Most of all, we wanted to make sure they understood the concept of the Critical Zone through this experience." His goal for teachers was to "help them develop a knowledge base and learning modules they can use in their classrooms and, ultimately, share with the greater community so that the general public will eventually become familiar with Critical Zone science."

Aufdenkampe adds, "Real science isn't memorizing formulas and studying the discoveries other scientists have made. It's not the body of knowledge that already exists. Science is the practice of creating new knowledge."

To guide the participants through the process of creating new knowledge, scientists led hands-on and critical thinking exercises spanning multiple science disciplines. Stroud Center scientists included Dave Arscott, Lou Kaplan, Willy Eldridge, Melinda Daniels and Anthony Aufdenkampe. Holly Michael and Jim Pizzuto from the University of Delaware also worked directly with the participants.

Eel River
CA

Southern Sierra
CA



> "My summer RET program exceeded my expectations! The program allowed me to learn the latest research techniques, and I was able to transfer what I learned to my classroom."
>
> —MELISSA HESS, RET, CONESTOGA VALLEY MIDDLE SCHOOL, LANCASTER, PENNSYLVANIA

Photos: Tara Muenz

Other Stroud Center staff assisted and coordinated field experiences. Among them was Steve Hicks, our research engineer, who showed them how to build their own data sensors and share their data with the broader CZO community online.

After completing the orientation, participants tackled summerlong research projects with help from the scientists.

Sharing Their Science

The REU and RET experience emphasized sharing data and learning how to communicate scientific concepts and findings effectively. To conclude the program, students and teachers gave poster presentations at the biennial meeting of the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) in Shepherdstown, West Virginia, in early August.

Participants participated in a three-hour poster session, answering questions and discussing their research with other CUAHSI attendees and poster judges. This is much like what professional scientists do to share new knowledge. The teachers took their research findings one step further, using it to develop curricula for their own classrooms.

"I think few people know what scientists actually do," says Aufdenkampe. "This program helps to demystify what scientific research is all about. It requires an innate curiosity, a strong commitment to answering tough questions, collaborative work with other scientists and creativity. Oh, and sun protection."

To learn more about the CZO program and to view the participants' posters, go to: http://czo.stroudcenter.org/reu/completed-research/

"I have an opportunity to help others foster an appreciation for and connection with Earth's waterways, which is a big first step toward conservation." — TARA MUENZ

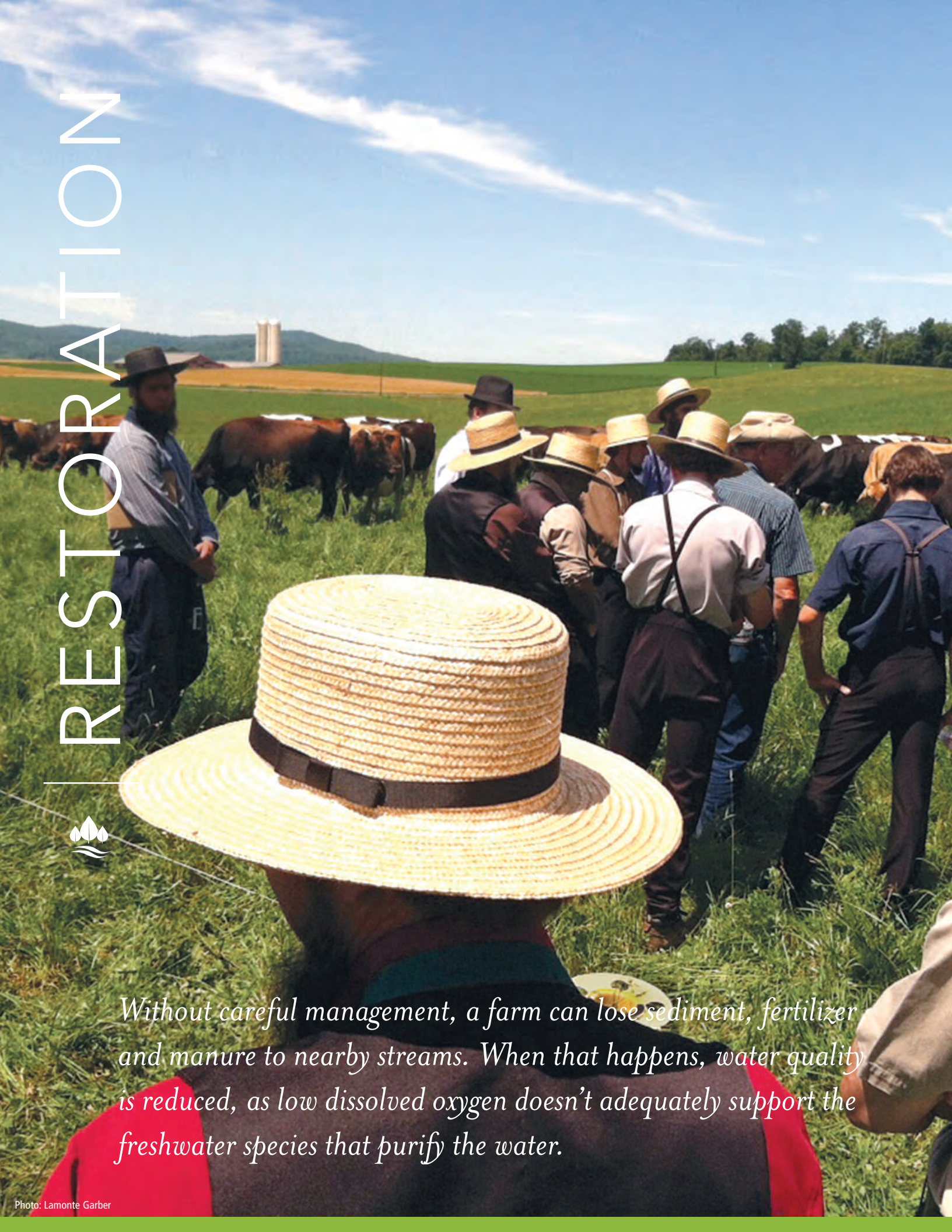
SPOTLIGHT:

TARA MUENZ JOINS STROUD CENTER FAMILY

Tara Muenz, an aquatic biologist with 10 years experience as an environmental educator, joined Stroud Water Research Center as education programs manager in April 2014. In her first year, she developed new partnerships and taught throughout several states and Costa Rica. She also expanded the capacity of Stroud Center classrooms and curriculum, helped implement the Critical Zone Observatory REU/RET and Trout Grow on Trees programs and developed the watershed monitoring program for the Osa Peninsula in Costa Rica.

Muenz earned her B.A. in zoology from Miami University in Oxford, Ohio, and her M.S. in conservation ecology and sustainable development from the University of Georgia. Prior to joining Stroud Center, she was employed by Georgia's Department of Natural Resources Environmental Protection Division as the state coordinator for a volunteer program to monitor water quality.

RESTORATION



Without careful management, a farm can lose sediment, fertilizer and manure to nearby streams. When that happens, water quality is reduced, as low dissolved oxygen doesn't adequately support the freshwater species that purify the water.

Photo: Lamonte Garber

Watershed Team Raises the Bar for Healthier Streams

THEY AIM TO MAKE FARMERS, COWS AND FISH HAPPY

By Lamonte Garber, Watershed Restoration Coordinator

The "Luxury" of Stewardship

Every morning, Jonas Stoltzfus* rises before dawn, splashes cold water on his face and makes his way to the barn.

Jonas, an Amish dairy farmer in Lancaster County, Pennsylvania, is one of several landowners the Watershed Restoration Group at Stroud Water Research Center is connecting with to protect the stream that runs through his property.

By midday, Lamonte Garber, Stroud Center's watershed restoration coordinator, arrives at the farm and greets Jonas in the barn. The summer heat intensifies the pungent smell of hay and manure. After exchanging pleasantries, Jonas wastes no time returning to his chores. Cows moo in anticipation of the feed about to be tossed in front of their stalls. Today's conversation is one of several Garber will have with Jonas about Stroud Center's Farm Stewardship Program.

"There's field work, a baler to repair, and the vet and the feed man are coming later today," he tells Garber. "There's no time to plant trees, even if I wanted to."

Trying to persuade family farmers to implement best management practices (BMPs) is a huge challenge for Garber and the rest of the Watershed Restoration Group. Maintaining farmland can routinely cost in excess of $20,000 per acre. So budgeting for environmental stewardship might seem like a luxury for farmers like Jonas. Despite the many opportunities for clean water projects on the Stoltzfus farm, Jonas' milk check does not include a bonus for ensuring only clean water flows off his farm, and commodities markets do not reward farmers who are good stewards. Moreover, due to political and budgetary constraints, regulatory enforcement is unlikely to drive change on its own.

But, as Garber explains, "Farm BMPs are very important if we want to have healthy streams and clean water."

In farming regions like Lancaster County, surface runoff from the land threatens many of our streams, rivers, lakes and estuaries and causes a variety of ills. And stormwater runoff from developed areas makes matters worse.

Without careful management, a farm can lose — through runoff and leaching — a massive amount of sediment, fertilizer and manure to nearby streams. When that happens, water quality is reduced, as low dissolved oxygen doesn't adequately support the freshwater species that purify the water.

Matt Ehrhart, Stroud Center's director of watershed restoration, says that in farming regions such as southeastern Pennsylvania, the Delmarva Peninsula and the Shenandoah Valley,

**A composite character based on several individuals.*

> Every farmer who chooses to work with us is taking action to better steward his farm for his children and grandchildren and for all of us who need clean fresh water."
>
> — MATTHEW EHRHART,
> DIRECTOR OF WATERSHED RESTORATION,
> STROUD WATER RESEARCH CENTER

On an Amish dairy farm (left) there was an area near the barn where stormwater mixed with animal waste would pollute a nearby stream. Stroud Center and Team Ag partnered on this project, and (center) a concrete bed was poured to create an impervious surface that directs stormwater into the manure storage pit for later field application. The improvement (right) not only protects the stream but also keeps the animals healthier and creates cleaner working conditions for the farmer. *Photos: Team Ag, Inc.*

"We want to have our meat and eat it too. We want clean water without having to sacrifice agriculture's major economic power." No problem, he adds. "With the right management, farms can be a stream-friendly alternative to hardscaped development."

And by working with Stroud Center's Farm Stewardship program, farmers receive technical and financial assistance to adopt BMPs that keep our rivers and streams healthy.

With such help, farmers can address runoff problems and prevent soil erosion, as well as write soil and manure management plans that are required of all farms in Pennsylvania. Cooperating farmers plant and maintain a forested stream buffer, at least 35 feet wide on each side, along all streams on their property. Decades of research at Stroud Center clearly shows that such forested buffers are essential for healthy stream habitats because they provide shade, leaf litter, roots that reduce erosion and more.

It's for farmers like Jonas that the Watershed Restoration Group designed its raise-the-bar approach to farm and stream stewardship.

Jonas heard about the program from a fellow Amish farmer who now receives a rental income for his acres of streamside farmland that are now lined with young trees. Word of mouth drives many farmers, like Jonas, to inquire about the program. Jonas is interested but skeptical.

"It takes time to build trust and relationships with Plain sect farmers," who include Amish and Mennonite. "The idea of giving up valuable farmland to plant trees is a hard sell, and sometimes it's a couple of years before a stewardship project comes to fruition," Ehrhart says.

Jonas' son, who looks about seven or eight, silently trails behind his father, shuffling from stall to stall, while Garber explains how the program works: "Stroud Center and its

partners will provide the dollars and necessary technical guidance," he explains. "This will help you update your facilities, protect and build your soil, and bring back natural habitat on your farm."

"Some parts of my barn are more than 100 years old and in need of repairs," Jonas protests.

"Stroud Center can help address those repairs for you and at the same time see that BMPs are implemented to keep manure and surface runoff from your barnyard out of the stream," Garber counters.

A Good Deal Where Everyone Wins

When shown the financial and operational benefits of going beyond minimum standards to achieve a higher level of environmental performance, many farmers, like Jonas, commit to the process, and most even contribute their own funds to help cover project costs.

"Once cooperating farmers understand the benefits, it's almost a no-brainer," Ehrhart says. "They're getting modernized, more efficient farming equipment and facilities. They qualify for generous rental income from the U.S. Department of Agriculture for every acre of forested buffer installed on their farms. And they are getting the peace of mind that comes from knowing that government regulators will more likely look elsewhere and scrutinize other farms that are not adequately controlling polluted runoff."

Taxpayers win too. Future costs are avoided by completing most or all of a farm's needed BMPs all at once instead of over a longer timeframe. Funding and scarce staff time can flow to new farms where they're needed most.

Stroud Center's raise-the-bar approach is gaining traction with policymakers and funders as well. The stewardship program has received millions of dollars over the past three years from the USDA's Natural Resources Conservation Service, the National Fish and Wildlife Foundation, the Pennsylvania Department of Environmental Protection, the William Penn Foundation and others.

"These donors and agencies are looking for value," Ehrhart says, "and the resources our program has received show it's worth the investment.

"This approach holds tremendous potential for stream restoration and farm profitability throughout the mid-Atlantic region and beyond. Every farmer who chooses to work with us is taking action to better steward his farm for his children and grandchildren and for all of us who need clean fresh water."

Stroud Center Volunteers Help Plant Nearly 10,000 Trees in 2014

With help from dozens of volunteers and contractors, we planted nearly 10,000 trees in 2014. Stroud Center has long advocated for streamside forests, publishing studies observing their benefits in the 1970s and initiating experimental tree plantings as early as 1982. In 2014, we published a study reporting our findings that streamside forests can keep, on average, 43 percent of sediment and 27 percent of nutrients, such as nitrogen, from entering a stream.

Research Projects

Note: Stroud Water Research Center scientists and staff are indicated in bold.

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 10 Critical Zone Observatories in the U.S. and began to establish the sampling, 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**; Jim Pizzuto and Holly Michael (University of Delaware); Kyungsoo Yoo (University of Minnesota)

Collaborators: Jinjun Kan, **Melinda Daniels**, **David B. Arscott**, **Charles L. Dow** and **Susan E. Gill**; Rolf Aalto (University of Exeter, United Kingdom); Lee Slater (Rutgers University); Rodrigo Vargas, Clara Chan and Donald L. Sparks (University of Delaware)

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

This collaborative project develops a model to predict the potential impact of climate variability, climate change, land use and human activity on water resources across decades and centuries in the Central Great Plains of North America. First, the researchers develop and interactively couple models of the three systems controlling water supply and water quality (the hydrosystem), the aquatic ecosystem and the human system. Next, these three system models are used to evaluate the whole-system (hydrosystem, aquatic ecosystem, human system) response to climate variation scenarios derived from historical data and downscaled climate projections. Finally, 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)

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); Bill Dietrich (University of California, Berkeley)

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 leverages the exceptional sensor and geochemistry data from a Critical Zone Observatory project developed by Stroud Center scientists to explore the importance of trace metals in the transformation of nitrogen compounds in flood plain soils and sediments.

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

Collaborator: Jinjun Kan

Delaware River Watershed Initiative — Monitoring, Evaluation, Scientific Support and Capacity Building for Watershed Protection and Restoration Projects — Entomological and Fish Collections

Funded by: Academy of Natural Sciences of Drexel University (ANSDU), William Penn Foundation

This project collected and interpreted data on macroinvertebrate specimens from 38 stream sites and on fish from 14 stream sites to provide a baseline for restoration projects funded by the William Penn Foundation in its efforts to restore and protect water quality in the Delaware River Basin.

Principal Investigator: John K. Jackson

Collaborators: William Eldridge; 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)

Delaware River Watershed Initiative — Protecting and Restoring Places of Ecological Significance (Brandywine Christina and Middle Schuylkill Clusters)

Funded by: William Penn Foundation

This project develops and implements restoration and protection plans for targeted watersheds in the Brandywine-Christina and Middle Schuylkill clusters in the Delaware River Basin. Professional and volunteer monitoring of the restoration and protection efforts represents an invaluable (and often neglected) scientific and program tool to help evaluate short- and long-term progress toward conservation priorities and goals.

Principal Investigators: John K. Jackson, **Matthew J. Ehrhart**, **Bernard W. Sweeney** and **Susan E. Gill**

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

Delaware River Watershed Initiative — Protecting and Restoring Places of Ecological Significance (Schuylkill Highlands Cluster)

Funded by: Green Valleys Watershed Association, William Penn Foundation

In collaboration with our cluster partners, this project monitored macroinvertebrates to establish a water-quality baseline at 10 selected sites associated with protection and restoration efforts for targeted watersheds in the Schuylkill Highlands cluster (i.e., French, Pickering, Hay Creeks and Pigeon Run) in the Delaware River Basin.

Principal Investigator: John K. Jackson

Collaborators: Green Valleys Watershed Association, Natural Land Trust, French and Pickering Creeks Conservation Trust, Partnership for the Delaware and Pennsylvania Audubon

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 supported a two-year project to develop the Observations Data Model version 2 (https://github.com/UCHIC/ODM2) and related software to enable Web-based interoperability of Earth observations derived from sensors and samples that span discrete data and informatics initiatives for multiple communities.

Principal Investigator: Jeffrey Horsburgh (Utah State University)

Collaborators: Anthony K. Aufdenkampe; Ilya Zaslavsky (University of

California, San Diego), Kerstin Lehnert (Columbia University) and Emilio Mayorga (University of Washington)

Developing a Water Atlas for the ACOSA Region of Costa Rica

Funded by: Blue Moon Fund

Stroud 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 community stakeholders. The two-year project, which started in 2013, 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, David B. Arscott and **Tara Muenz**

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)

Ecotoxicity Study for Mayflies Exposed to Elevated Concentrations of Chloride

Funded by: Pennsylvania Department of Environmental Protection

Chloride naturally occurs in all freshwater systems. However, recent data analyses reveal that chloride concentrations in surface waters have been increasing over the last several decades at multiple locations throughout the United States. Elevated chloride concentrations have been observed in effluents from wastewater treatment plants; in wastewaters from some agricultural, industrial and oil and gas production activities; and in road runoff following applications of deicing products. At times, it appears that ambient chloride concentrations now reach levels that may have a negative effect on aquatic organisms. This project measures lethal and nonlethal responses of six mayfly species exposed to elevated chloride concentrations in water from three Exceptional Value streams in Pennsylvania as well as in White Clay Creek at Stroud Center. It builds on our experience in rearing the parthenogenetic mayfly *Neocloeon* (formerly *Centroptilum*) *triangulifer* in the laboratory by comparing responses of *N. triangulifer* from White Clay Creek with responses of five mayfly species that commonly co-occur with *N. triangulifer* in small streams of eastern North America, and with previously published responses for invertebrate species that are standard laboratory test species but are not native to the eastern North America streams.

Principal Investigators: John K. Jackson and **David H. Funk**

Evaluating Potential Impacts on Groundwater of Passive Composting of Spent Mushroom Substrate According to Best Practices Guidelines

Funded by: Stroud Water Research Center and American Mushroom Institute

Guidelines for passive composting of spent mushroom substrate (SMS) are contained in a Pennsylvania Department of Environmental Protection's "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

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. There are two main goals for CZOData. One is to support, empower and broaden the impact of CZO science. The second is to 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

Collaborators: Ilya Zaslavsky (University of California, San Diego); Kerstin Lehnert (Columbia University); Jeffrey Horsburgh (Utah State University); and Emilio Mayorga (University of Washington)

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 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

Co-Principal Investigators: Anthony K. Aufdenkampe, John K. Jackson, Jinjun Kan and **William H. Eldridge**

Collaborators: J. Denis Newbold, David B. Arscott, Charles L. Dow, Susan E. Gill and **Bernard W. Sweeney**

Ben Ireland, a grad student at the University of Pennsylvania, worked under John Jackson, Ph.D., in the Entomology Group. *Photo: Kay Dixon*

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**

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

Co-Principal Investigators: Jinjun Kan, **Susan E. Gill** and **Jennifer J. Mosher**; Robert H. Findlay (University of Alabama)

Collaborator: David C. Richardson (SUNY New Paltz)

Microbial Population Dynamics of Periphyton Biofilms in 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 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 genes 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. Comparing the results from other projects (LTREB and Metaecosystems), we found that the surfaces on which microorganisms grow may be one of the most important environmental drivers for the microorganisms' growth.

Principal Investigator: Jinjun Kan

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 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**

Parthenogenesis (Virgin Reproduction), Hybridization and Life History Plasticity in Mayflies

Funded by: Stroud Water Research Center Endowment Funds

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 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**

Restoring Flood Attenuation and Ecological Resiliency in the Mid-Atlantic Piedmont

Funded by: National Fish and Wildlife Foundation

Scientists and watershed restoration professionals at Stroud Water Research Center will restore Sharitz Run, a tributary to Doe Run in the headwaters of the Brandywine Creek near Coatesville and Unionville, Pennsylvania. The project goal is to reduce flooding to downstream communities and improve the stream ecology so that it will once again support a breeding population of native brook trout and other coldwater fish species. The restoration work will include 14,000 feet of infiltration berm to intercept and infiltrate surface runoff from fields, 15 acres of floodplain wetland creation and nearly 80 acres of riparian forest buffer to reduce flooding and improve stream temperature and water quality..

Principal Investigator: Melinda D. Daniels

Collaborators: Bernard W. Sweeney, **David B. Arscott**, **Matthew J. Ehrhart**, **William H. Eldridge**, **John K. Jackson** and **Susan E. Gill**

Scientific Expert Testimony for Department of Justice: Wetland Connectivity Related to Jurisdictional Determination in a Painesville, Ohio, Wetland Complex US v. Osborne, Sr. DJ#90-5-1-1-18628

Funded by: U.S. Department of Justice

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

Collaborator: John K. Jackson

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 communities, 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

Collaborators: Ilya Zaslavsky (University of California, San Diego); Kerstin Lehnert (Columbia University); Jeffrey Horsburgh (Utah State University); and Emilio Mayorga (University of Washington)

Sediment Microbial Fuel Cells (MFCs)

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

For this study, we set out to determine the feasibility of using microbes to generate clean energy on a large scale. We deployed two streambed sediment microbial fuel cells in White Clay Creek and completed a sweeping test. The maximum voltage for the sediment fuel cells on streambed is about one volt. We installed a demo unit in the indoor Stream House, and connected a Christmas tree to demonstrate the power generation/application from the respiration of bacteria buried in the indoor stream sediments. We continue data collection and sample analyses, and testing on biocathode performance. Also, we are working on potential future funding/collaboration opportunities.

Principal Investigator: Jinjun Kan

Collaborators: Y. M. Arias-Thode and Lewis Hsu (SPAWAR)

Threats and Opportunities in the Conservation of Native Pelagic Spawning Fishes in Kansas

Funded by: Kingsbury Family Foundation

This project documents how small dams have fragmented stream networks 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

Searching for DNA in Water to Test for the Presence of Freshwater Mussels

Funded by: National Science Foundation CZO REU

Determining that a species is present in a stream has traditionally required collecting individuals of that species during surveys using active or passive sampling gear. These traditional surveys may harm rare or endangered species. They are time consuming, and they 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 White Clay, Red Clay and Brandywine creeks.

Principal Investigator: William H. Eldridge

Water Quality Impacts of the Interoceanic Highway in the Eastern Andes Amazon Headwaters Region

Funded by: Blue Moon Fund

This collaborative involved 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 Center's Leaf Pack Experiment Kit to evaluate water quality along an elevational gradient.

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

Collaborators: Roger W. Mustalish (Amazon Center for Environmental Education and Research) and Wills Flowers (Florida A&M University)

Education Projects

Comprehensive Aquatic Learning Project

Funded by: 3M

This collaborative partnership with Tyler Arboretum initiates teacher training programs in watershed research and education. We engaged teachers in our Leaf Pack Network, conducting a one-day intensive training in methods, macroinvertebrate identification and freshwater ecology.

Project Leader: Tara Muenz

Consortium for Scientific Assistance to Watersheds (C-SAW)

Funded by: Consortium for Scientific Assistance to Watersheds

Stroud Center educators and scientists 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 Leaders: Dave Arscott and **Tara Muenz**

Model My Watershed — Delaware River Basin

Funded by: The William Penn Foundation

This project will expand the Model My Watershed application to the entire Delaware River Basin. This effort is in support of restoration efforts being funded by WPF. This application will provide higher-resolution modeling applications that will assist in developing effective restoration plans in targeted watersheds. The models that are integrated into this application include stormwater runoff, water quality modeling (nutrients, pathogens and sediments) and terrain analysis.

Project Leaders: Anthony Aufdenkampe and **Susan Gill**

Collaborators: Robert Cheetham (Azavea, Inc.), Emilio Mayorga (University of Washington) and David Tarbotan (Utah State)

A student participating in the Brandywine Trek looks for aquatic macroinvertebrates. *Photo: Beverly Payton*

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

Funded by: NJ DEP

Stroud Center continues to provide expertise in two sets of 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 Leader: Tara Muenz

Stroud Stream Programs for Public Schools

Funded by: The Education Improvement Tax Credit Program (EITC)

Stroud Center educators conduct a four-hour boots-in-the-water stream program for students in fourth through 12th grade. It is funded by approved business within the EITC program. Students visit Stroud Center, where we engage them in the many decades of research we do here. We cover aquatic insect collection and identification as well as instruction on the importance of trees for stream health. The program helps students better understand their impact on our waterways and how they can protect and improve this vital resource for all life.

Project Leader: Tara Muenz

Teaching Environmental Sustainability — Model My Watershed

Funded by: National Science Foundation, Discovery Research K-12

Stroud Center educators and scientists are enhancing the Model My Watershed application by integrating water quality and terrain analysis models. This work is being completed in partnership with the Concord Consortium, who will lead the curriculum development and Millersville University of Pennsylvania, who will conduct research on learning. The geographic extent of this expansion will be for the contiguous 48 states. However, teacher professional development will take place in California, Iowa, Kansas, Pennsylvania and Virginia.

Principal Investigators: Susan E. Gill and **Anthony K. Aufdenkampe**

Collaborators: Carolyn Staudt (Concord Consortium); Nanette Marcum-Dietrich (Millersville University of Pennsylvania); Emilio Mayorga (University of Washington); and Robert Cheetham (Azavea, Inc.)

Trout Grow on Trees

Funded by: DuPont Clear Into the Future

This project produces written curriculum materials and pilot tests a beta version of the new environmental education program Trout Grow On Trees in elementary schools in the Christina River watershed. It also shares the curriculum materials with teachers, school administrators and the general public through academic, news and social media outlets.

Principal Investigators: Bernard W. Sweeney and **Tara Muenz**

Water SCIENCE

Funded by: National Science Foundation, Innovative Technology Experience for Students and Teachers

Stroud Center's education department is collaborating with the Concord Consortium on a project to introduce middle school students to engineering practices for water resources. This project targets schools in Boston, Kennett Square, Pennsylvania, and Phoenix/Tempe, Arizona. Millersville University of Pennsylvania is also involved.

Principal Investigator: Carolyn Staudt (Concord Consortium)

Collaborators: Susan E. Gill and Nanette Marcum-Dietrich (Millersville University of Pennsylvania)

Pocopson Elementary School students look at juvenile trout swimming in jars. Stroud Center Director Bern Sweeney, Ph.D., taught students how "fish grow on trees." *Photo: Beverly Payton*

Watershed Restoration Projects

Ag Best Management Practices Planning and Implementation for Berks County

Funded by: PA Dept. of Environmental Protection and National Fish and Wildlife Foundation

This project will continue the Farm Stewardship Program in Berks County, assisting farmers to implement whole-farm conservation while leveraging USDA funding for work including forested buffers.

Project Leader: Matthew J. Ehrhart

Collaborators: Red Barn Consulting, Inc., TeamAg, Inc., Berks County Conservation District, Berks Conservancy, Partnership for the Delaware Estuary and others.

Ag BMP Planning and Implementation for Chester County

Funded by: PA Dept. of Environmental Protection

This project will continue the Farm Stewardship Program in Berks County, assisting farmers to implement whole-farm conservation while leveraging USDA funding for much work, including forested buffers.

Project Leader: Matthew J. Ehrhart

Collaborators: Red Barn Consulting, Inc., TeamAg, Inc., Chester County Conservation District, Brandywine Conservancy, Brandywine Valley Association and others

Delaware River Watershed Initiative Circuit Rider for Technical Assistance to Grantees

Funded by: William Penn Foundation and National Fish and Wildlife Foundation

This project will provide technical assistance to grantees of the William Penn Foundation and the National Fish and Wildlife Foundation in support of grants to develop and implement watershed restoration efforts and grants to monitor the impact of projects implemented in the Delaware River Watershed Initiative (DRWI). Stroud Center's efforts with the DRWI partners will lead to better proposals and projects as well as improved assessment of the project outcomes.

Project Leader: Matthew J. Ehrhart

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 methods for managing herbivore 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 Pennsylvania Department of Environmental Protection's Growing Greener Program

Stroud 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 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

Nutrient Management Plan Verification and Agricultural Recognition Program

Funded by: The Campbell Foundation and The Foundation for Pennsylvania Watersheds

Farmers and watershed managers don't yet have the tools to track and verify actual (versus planned) agronomic, conservation and nutrient management operations as well as the water quality impacts of these activities on specific farming operations. Stroud Center will demonstrate the feasibility and implementation of in-field monitoring equipment for manure applications and field-specific water quality impacts of farming practices. The project will also develop an operating structure and a set of evaluation criteria for an agricultural clean water recognition program.

Project Leader: Matthew J. Ehrhart

Streamside Forest Restoration to Improve Water Quality

Funded by: PA DCNR TreeVitalize Program in Partnership With the Pennsylvania Horticultural Society

This project involved an experimental planting of 925 trees on 4.1 acres of riparian land for keeping pollutants out of two headwater tributaries of Crum Creek and learning new insights into how to properly install the bird netting, associated with protective shelters, placed on all seedlings to increase their survival and growth.

Principal Investigator: Bernard W. Sweeney

Collaborators: Willistown Conservation Trust and the Chester Ridley Crum Watershed Association

Streamside Forest Restoration to Improve Water Quality

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

This project involved an experimental planting of 500 trees on 1.5 acres of riparian land as a best management practice for keeping pollutants out of a headwater tributary of Red Clay Creek as well as creating a research site for testing the effects of herbicide use on the survival and growth of seedlings.

Principal Investigator: Bernard W. Sweeney

Collaborator: Dansko Co.

Streamside Forest Restoration to Improve Water Quality

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

This project involved planting 400 trees along Craigs Mill Run (1.8 acres) and 600 trees along the East Branch of Brandywine Creek (1.8 acres) in Pennsbury and East Brandywine townships, respectively, as a best management practice for keeping pollutants out of local streams and improving their health.

Principal Investigator: Bernard W. Sweeney

Collaborator: Brandywine Conservancy

Whole Farm Conservation Including Forested Buffers

Funded by: National Fish and Wildlife Foundation

This project expands the Farm Stewardship Program in Lancaster and Franklin Counties — the top two dairy counties in Pennsylvania. We implement whole-farm conservation plus forested buffers, leveraging USDA funding. We also promote advanced conservation methods including precision agriculture that reduces environmental impacts from farming.

Project Leader: Matthew J. Ehrhart

Collaborators: Red Barn Consulting, Inc., TeamAg, Inc. and others

Stroud Center board members from left, Peter Kjellerup, Dixon Stroud, Donnan Sharp and Franny Abbott planted trees with other volunteers to help restore a stream on the Sharp-Jones Farm. *Photo: Kristine Lisi*

Gifts and Contributions

We gratefully acknowledge the following 356 donors who generously contributed $452,809 to our annual fund. This is a new record in dollars and donors! Our annual fund covers operational expenses, not supported by grants, and it allows us to continue our work in freshwater research, education and restoration. Thank you!

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The Sage and Hayward families gathered to celebrate the Sandy Sage lobby dedication. *Photo: Beverly Payton*

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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.

Douglas Myers and Kimberlee Brosnan-Myers
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**Stroud Center staff. We are pleased to report that once again 100 percent of our board of directors supported the 2014 annual fund, as did 100 percent of our senior staff. In fact, 71 percent of our entire staff, and many of their family members, gave to the 2014 annual fund. Thank you!*

Gifts to the Capital Campaign *"Getting The Water Right"* 2007-2014

Thanks to these generous supporters, Stroud Center now has endowments for the assistant director position, the education department and the Maritza Biological Station in Costa Rica, in addition to the Moorhead Environmental Complex, our LEED Platinum certified environmental outreach and education building. Words cannot express the significance of what this means to us. Collectively, the following donors gave more than $12 million to makes these dreams a reality, and we wish there was a more substantial way to express our profound gratitude. We are truly in your debt.

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Funds to support operations at the Maritza Biological Station in Costa Rica

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Four framed prints by R. C. Kray

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Peter Kjellerup and many Dansko employees
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To learn how you can get involved, please go to www.stroudcenter.org/volunteer.

Financials

Operating Statement
for the year ended December 31, 2014

Revenues & Support

Research Programs (Grants & Contracts)	$ 2,310,744
Endowment	2,075,87
Watershed Restoration Group Programs	685,990
Annual Fund	452,809
Reserves	411,177
Education/Public Programs	303,426
Other Contributions & Income	264,683
Total Revenues & Support	**6,504,700**

Expenditures

Research	$ 2,972,401
Facilities	1,104,259
Administrative	629,782
Watershed Restoration Group	625,312
Information Services	362,160
Education	310,138
Development/Outreach	299,118
Communications	147,832
Other	53,698
Total Expenditures	**6,504,700**

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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Stroud Water Research Center donor records are not sold, bartered, leased, exchanged, or otherwise provided to any outside organizations.

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Your continued generosity through annual, endowed, and planned gifts is vital to our research and education programs. Below is a brief list of ways you can make a tax-deductible gift:

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Visit www.stroudcenter.org/donate

CASH OR CHECK
Please mail donations to:
Stroud Water Research Center, 970 Spencer Road, Avondale, PA 19311

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Remember a friend, neighbor, or loved one with a gift in his/her name. All tributes will be listed in the annual report, and, when an address is provided, a letter will be sent on your behalf.

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Kay D. Dixon, Associate Director of Donor Relations, kdixon@stroudcenter.org, 610-268-2153, ext. 303

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In late February, Stroud Center staff gather to celebrate Founders Day in memory of W.B. Dixon Stroud. *Photo: Tara Muenz*

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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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2014

Stroud Center gratefully acknowledges the service of Aldo Morell and Paul Sniegowski, who retired from the board in 2014 after many years of service.

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Every effort has been made to produce this report in a responsible manner. This piece is printed on process chlorine-free Mohawk Options, 100 percent PC, which is made with 100 percent post-consumer recycled fiber. Mohawk Fine Papers purchases enough Green-e certified renewable energy certificates (RECs) to match 100 percent of the electricity used in their operations. This paper is also certified by Green Seal. All inks are soy- and vegetable-based. Paper-based environmental savings are as follows:

17 trees preserved for the future
49 lbs. water borne waste not created
7,177 gallons wastewater flow saved
794 lbs. solid waste not generated
1,564 lbs. net greenhouse gases prevented
11,968,000 BTUs energy not consumed