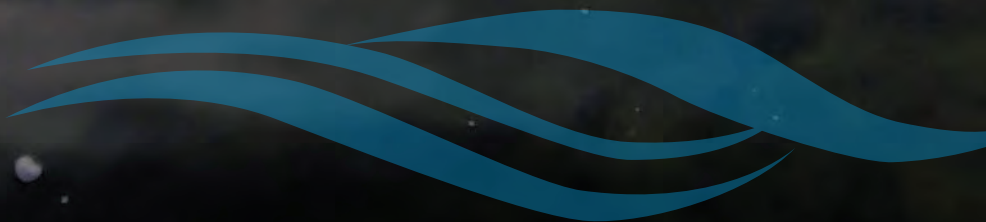




2021 Annual Report

A YEAR IN REVIEW

The Journey Toward Hope



For more than 50 years, Stroud™ Water Research Center has focused on one thing: clean fresh water. Through scientific research, environmental education, and watershed restoration, the Stroud Center is advancing knowledge and stewardship of freshwater systems in your community and around the world. Learn more and make a difference today at stroudcenter.org.

A | RESEARCH

David Funk, Bern Sweeney, Ph.D., and John Jackson, Ph.D., revealed new research showing that the increased demand for oxygen that mayflies face in warmer waters was not the cause of their poorer outcomes. The scientists' work was published in the internationally acclaimed *Journal of Experimental Biology* and provides insight into the consequences of climate change and thermal pollution.

B | EDUCATION

Stroud Center scientist Diana Oviedo-Vargas, Ph.D., who is a native Spanish speaker from Costa Rica, collaborated with the Education Department to engage migrant farming families in water chemistry and aquatic insect activities. The program was part of ongoing watershed education outreach for English language learners.

C | RESTORATION

The Stroud Center's Robin L. Vannote Watershed Restoration Program launched LandownerHelp.com in 2021. The website provides free educational resources and planning tools for landowners like Bud and Marilyn Miller, who lease their land to farmers, to create better landowner-tenant relationships that incentivize long-term environmental improvements for the land they love.

D | THE WATER'S EDGE

The 2021 Stroud Award for Freshwater Excellence was awarded to Melissa D. Ho, Ph.D., on November 4 at The Stone Barn in Kennett Square, Pa., during The Water's Edge, an annual gala presented by Wilmington Trust. As senior vice president for fresh water and food at World Wildlife Fund, Ho drives landscape and transformational initiatives that support the conservation of freshwater ecosystems and the sustainability of agricultural systems.

E | COMMUNITY SCIENCE

Community science volunteers installed the 100th EnviroDIY™ Monitoring Station in the Delaware River watershed in June. The milestone came as part of a Stroud Center-led effort to monitor water quality for the more than 15 million people living in the watershed.

AT A GLANCE

2021



478 active research sites visited



17 annual peer-reviewed

ARTICLES, BOOKS, AND SCIENTIFIC REPORTS PUBLISHED



173 best management practices

ENABLED BY OUR WATERSHED RESTORATION PROGRAM



5,435 people

BENEFITED FROM WATERSHED RESTORATION WORKSHOPS, TRAININGS, AND OUTREACH



110 acres

OF FORESTED STREAMSIDE BUFFERS ESTABLISHED



14,000 people

IMPACTED BY OUR EDUCATION DEPARTMENT'S PROGRAMS AND TRAININGS



A1.



A2.



B.



C.



D.



E.

MESSAGE

FROM THE EXECUTIVE DIRECTOR



*“He who plants a tree,
plants a hope.”*

— LUCY LARCOM, AMERICAN POET,
TEACHER, ABOLITIONIST

what you
can do

To learn about our latest work and to share it with others, sign up for our newsletter at stroudcenter.org/subscribe and follow us on social media.

Dave Arscott stands next to a portrait of Ruth Patrick, who is holding her trademark field hat, a vista of the Susquehanna River behind her. Painting by Eleanor McCargar, 1977. Photo: Howard Sundwall

Looking back, 2021 was in many ways a repeat of 2020. Much of what brought fear, uncertainty, and anger continued throughout the year. Although we now have several vaccines, the United States had more COVID-19 deaths in 2021 than in 2020. Misinformation and distrust continued to spread. Climate change contributed to the deadliest tornado outbreak on record in the United States. And while awareness of discrimination and injustices has grown, we are far from reaching equity and justice. And yet, we continue to hope.

Hope is more than a feeling. It is an act of courage. In the face of existential challenges, we choose to put one foot in front of the other, moving toward something better — a more sustainable future.

It was hope that inspired our founding scientist, Ruth Patrick, Ph.D., to set up our first laboratory in partnership with Joan and Dick Stroud. Ruth knew that in order to restore polluted streams, scientists needed to understand healthy ones. A trailblazer, she was motivated to use science for good more than she was deterred by sexism in her field.

It was hope that led Bern Sweeney — in response to concerns about the decline in students interested in science — to launch our Education Department 30 years ago and use our cutting-edge research as a springboard for educating the public about freshwater science and stewardship.

It was hope that inspired us to study better ways of restoring watersheds and to show landowners, policymakers, and an engaged public science-based solutions to climate change, health and educational inequities, and environmental harms that affect the availability of clean fresh water for all.

As we celebrate major milestones in the Stroud Center's history and the impact we made in 2021, we recognize that our work is unfinished. To protect clean fresh water — a basic human right — and ensure its availability for generations to come, we rely on the support of our partners, donors, volunteers, and funders. I hope you will continue to join us on the journey toward hope.

Executive Director, President, and Research Scientist

A photograph of a researcher in a stream. The researcher is wearing a light blue baseball cap, a red jacket, green rubber gloves, and grey waders with black knee pads. They are holding a black bucket with a wooden handle and are pouring a yellowish liquid into the stream. The stream is surrounded by lush green vegetation and fallen logs. Another person in a blue jacket is visible in the background, also working in the stream.

RESEARCH

“Whether it’s in White Clay or the Chesapeake, whether it’s something we started more than 20 years ago or last year, all our research is tied in various ways to the idea that we need to know where and why streams are good and where and why streams are bad.”

— JOHN JACKSON, PH.D., SENIOR RESEARCH SCIENTIST, ENTOMOLOGY GROUP, STROUD WATER RESEARCH CENTER



Below: *Earthrise*, taken on December 24, 1968, by Apollo 8 astronaut William Anders.



Breaking the Fall

HOW THE CLEAN WATER ACT CHANGED THE TRAJECTORY OF AMERICA'S WATERWAYS AND BECAME A BEACON FOR FRESHWATER SCIENCE

By Diane Huskinson

The Tipping Point

When U.S. legislators passed the Clean Water Act (CWA) in 1972, it was an overwhelming bipartisan response to a national outcry. Less than a year after the Cuyahoga River fire was featured in *TIME* in 1969, only months after the Santa Barbara oil spill, activists took to the streets for the first Earth Day. The consequences of degraded and desecrated natural spaces stood in contrast to the isolated beauty of a blue Earth rising amid the void in the now famous photograph taken on Apollo 8. Our nation had sent men to the moon for the first time, looking for meaning beyond our planet, only to stare in awe at the sanctity, rarity, and fragility of our home.

The movement that followed led to growing public awareness of environmental threats, multinational commitments to reduce them, and sweeping U.S. federal protections of land, water, and species.

Freshwater science, too, was advancing. A few years after Rachel Carson wrote *Silent Spring*, igniting public discourse around clean water and setting the stage for the CWA, Ruth Patrick, Ph.D., had an idea. A freshwater scientist at the then Academy of Natural Sciences of Philadelphia, Patrick, years earlier, had begun researching how all forms of life interact in a stream.

When, in the 1960s, Patrick met Dick and Joan Stroud, she had been looking for a healthy stream she could use to compare with the polluted ones she was researching and aiming to restore. The east branch of White Clay Creek, which snaked through the Strouds' farm in Chester County, Pennsylvania, fit the bill. The Strouds agreed to let Patrick set up a laboratory on their farm, and they in turn challenged her to make freshwater science accessible, understandable, and useful to all people, not just scientists. Since then, Stroud™ Water Research Center has focused on one thing — fresh water.

Left: Jan Battle and Lindsey Colgan, Stroud Center entomologists, collect freshwater insects in a tributary to French Creek on the Thomas P. Bentley Nature Preserve in Chester County, Pa., for a project that examines the impact of streamside restoration on water quality. Photo courtesy of Bill Gladden of French & Pickering Creeks Conservation Trust, a partner on the project.

The same year the CWA became law, a determined and inexhaustible team of scientists, led by then Director Robin Vannote, Ph.D., formulated the River Continuum Concept, which redefined a river as an interconnected physical, chemical, and biological system that is influenced by adjacent riparian, upstream, and upland conditions. The novel hypothesis positioned the Stroud Center to answer the call of the CWA to protect and restore the health of the nation's waters. To this day, its 1980 publication in the *Canadian Journal of Fisheries and Aquatic Sciences* is the most highly cited article in scientific literature on streams and rivers.

By investigating what makes streams and rivers healthy, the Stroud Center — without allegiance to political parties, shareholders, or special interests — shares its unbiased knowledge of how to ultimately protect fresh water. This science has informed policymakers, such as through expert testimony on wetland protection provided to the U.S. Department of Justice, and has helped guide farm management, such as through the U.S. Department of Agriculture's recommended reforestation methods.

Within a decade of Patrick establishing the Stroud Center, Robin Vannote teamed up with Bern Sweeney, Ph.D., to drop a second groundbreaking hypothesis, again shattering traditional thinking about freshwater ecosystems. The Thermal Equilibrium Concept explained how warmer temperatures threaten freshwater species gradually over time and generations rather than in a single catastrophic event, setting the stage for future research on how to best restore watersheds. (Hint: Reforestation, particularly within the riparian zone, is a key part of the equation.)

The Schuylkill River, which cuts through Philadelphia, is an impaired waterway, according to the Pa. Department of Environmental Protection.

Our impact:

THE STROUD CENTER IS HELPING
TO MONITOR WATER QUALITY FOR

15 million+ people

ACROSS

4 states

IN THE DELAWARE
RIVER WATERSHED



Time — The Great Healer and Revealer

The relevance of these two concepts today cannot be overstated as scientists seek to understand and remediate the effects of climate change and human activities on our freshwater resources. Stroud Center scientists have studied water quality in streams before and since the passage of the CWA, shedding a light on its force against the demands of a growing population. What they have found is that when conditions that support a healthy freshwater ecosystem are restored, time will heal many, though perhaps not all, wounds.

The White Clay Creek watershed, for example, has long been an agrarian landscape. When the Stroud Center was founded in 1967, cattle grazing and farming practices posed a threat to some portions of White Clay Creek. That changed in 1989 when the Stroud Center began a long-term restoration science project by planting trees along the streambanks. With funding from the National Science Foundation, and subsequent Experimental Ecological Reserve and Long-Term Research in Environmental Biology site designations, Stroud Center scientists began monitoring the stream's forested, reforested, and meadow sections.

More than 30 years after reforestation, the long-term success of the project is coming into focus. The reforested sections are becoming wider, which could lower nitrate concentrations and provide better habitat for the bugs and other critters living in the stream. And although the biology of the reforested section still isn't the same as that of the forested section, the improvement is unquestionably significant.

"Whether it's in White Clay or the Chesapeake, whether it's something we started more than 20 years ago or last year, all our research is tied in various ways to the idea that we need to know where and why streams are good and where and why streams are bad," says John Jackson, Ph.D., who leads the Stroud Center's Entomology Group.

The CWA, which Patrick helped draft, requires states to conduct water quality assessments and identify "bad" streams on a blacklist of impaired waterways, the 303(d) list. Fifty years later, more than half of U.S. rivers and streams still do not meet water quality standards for fishing, swimming, or drinking, according to the EPA. In Pennsylvania, where efforts to reduce water pollution have been aimed at the leading source — agriculture — the number of impaired waterways is lower: 30%.

However, Jackson points out that the freshwater landscape isn't so black and white, that these numbers do not reflect the continuum of degradation: "A stream could be labeled as unimpaired and yet be very close to the line, meaning still significantly degraded. Every bad stream was at one time a fair stream, and every fair stream was at one time a good stream. It's like falling down a hill. The first step is to stop the fall. The next step is to start climbing back up. Anti-degradation is generally about stopping or preventing the fall. Restoration is about climbing back up."

Restoration Science

On July 21, 2021, two Conestoga Valley High School teachers met up with the Stroud Center's David Bressler and Rachel Johnson. Bressler, the community science program facilitator, and Johnson, a research engineer technician, helped the teachers install two EnviroDIY™ Monitoring Stations on Stauffer Run at the Lancaster County Country Club to capture water quality data in real-time. Jim Hovan and Kerri Snavelly, both science teachers, are incorporating the monitoring tool along with Monitor My Watershed®, an online data visualization tool, into their lesson plans on watershed science.

Stauffer Run is one of 18 streams that Lancaster Clean Water Partners is targeting to restore and ultimately remove from Pennsylvania's list of impaired streams, a process called delisting. The Stroud Center is leading this effort for three of the 18 streams.

"Delisting a stream isn't going to happen overnight. It could take us 10 years or longer, depending on stream conditions," says Lamonte Garber, the watershed restoration coordinator. "Being delisted is symbolic but also practical. It means these waters would be safer for children to play in. It means wild trout would gain a foothold. And it would be a success story that encourages action on other streams." Restoration of these streams will be ushered through the Stroud Center's Farm Stewardship Program, which connects farmers with financial incentives to implement farming practices that are better for stream health.

Three years ago, Stroud Center scientists began collecting baseline data on another of the targeted streams. Four landowners with farms along the stream have agreed to participate in the Farm Stewardship Program. A series of best



Kerri Snavelly and Jim Hovan, Conestoga Valley High School science teachers, install an EnviroDIY™ Monitoring Station on Stauffer Run at the Lancaster County Country Club.

practices, including streamside forests and fencing to keep cows out of the stream, are being staggered so that their immediate effects can be isolated. Over the span of years, decades even, scientists will monitor their cumulative impact on water quality.

Diana Oviedo-Vargas, Ph.D., who leads the Biogeochemistry Group, says, "Right now, the stream is in bad shape. It's biologically impaired, but we're hoping to change that." The four farms in this headwater stream occupy over 80% of its watershed, providing a unique research opportunity. "Many times, it's hard to evaluate the effectiveness of restoration activities because landowner participation accounts for a small fraction of the watershed, and any potential improvement becomes too diluted. In this case, we will have a better chance to quantify change and start to understand the impact when you target not just a stream, but a watershed," says Oviedo-Vargas.

And that, says Jackson, would be the ultimate success story of the CWA. As one of dozens of organizations working to monitor, protect, and restore the Delaware River watershed, the Stroud Center is helping to understand the impact of watershed restoration on freshwater resources for more than 15 million people across four states.

"What we're trying to do is balance the need for food with the need for clean water," says Jackson. "In White Clay Creek, that balance has been achieved. The next goal is to replicate that at a much larger scale."

get
involved

Interested in monitoring water quality in your local area? [Email us at communitysci@stroudcenter.org](mailto:communitysci@stroudcenter.org) to become a community scientist today.

EDUCATION



“Stroud Water Research Center is a place where education can literally grow! As the K-12 science curriculum specialist for a public school in South Central Pa., when I had a need for high quality, professional, and not to mention fun, water science educational opportunities for my teachers and their students, the Stroud Center delivered!”

— DANIEL G. DANEKER, Ed.D., ASSISTANT PRINCIPAL, GERALD G. HUESKEN MIDDLE SCHOOL, LANCASTER, PENNSYLVANIA



The Stroud Center has a history of teaching people about the freshwater sources that supply their communities with drinking water and outdoor recreation. Left: New York Harbor School students in 2006 embarked on a three-week trek, called Mountaintop to Tap, tracing the path of New York City's drinking water from the Catskill Mountains to the city's five boroughs. Right: Last October, migrant families enjoyed a day on the water canoeing at Marsh Creek State Park, many of them for the first time, and on land learning about watershed science during a program tailored for English language learners.



Rooted in Science

30 YEARS AND COUNTING, THE STROUD CENTER'S EDUCATION DEPARTMENT MAKES CUTTING-EDGE FRESHWATER SCIENCE FUN

By Diane Huskinson and Steve Kerlin, Ph.D.

Bern Sweeney, Ph.D., still remembers the day more than 30 years ago when he put on a suit, packed up his slides and projector, and drove to Wilmington, Delaware, to convince Endsley Fairman of the Longwood Foundation to give him \$50,000.

Sweeney, then director of Stroud™ Water Research Center, had read an article in the journal *Science* about students who were losing interest in science by the time they reached college and how this was shifting their career choices away from scientific disciplines. It was a worrying trend.

"Science had always been fun and interesting in grade school, but somehow we were losing students in middle school and high school. I realized we needed to intervene," says Sweeney.

But the Stroud Center hadn't done this before. In the first two decades after its founding in 1967, the primary focus of the small team of freshwater scientists was the pursuit of new knowledge about streams and rivers. Groundbreaking discoveries were being made and shared mostly among the broader scientific

community, post-secondary academia, and by the 1980s, with public and private partners to implement science-based solutions to environmental problems.

Necessity, it's said, is the mother of invention, and as Sweeney explains, "I saw a need for outdoor environmental education programs targeting this age group, so I decided the Stroud Center was going to step up."

Sweeney walked into Fairman's office, pulled out his slide presentation, and began to tell the story of a day he spent with his daughter's science class. The students pictured were outside, working with their hands, smiling, having fun. They were conducting an experiment using bags of leaves to monitor water quality in a stream. Scientists had been using the same method as a research tool (and still do), but Sweeney saw its potential as an educational tool. He wanted to bring the leaf pack projects, along with other watershed education experiences, to classrooms — first locally, and eventually, throughout Pennsylvania and beyond.

Fairman was so impressed he wrote and handed Sweeney a check on the spot. With that seed money, he hired the Stroud Center's first full-time educator and began piloting education programs with school and conservation groups, organizing tree-planting events, and hosting public lectures and workshops. By 1992, the Stroud Center had a busy and successful Education Department.

Today, the department provides more programs and connects with more individuals and diverse audiences than ever before. As it has grown and adapted, one thing has remained the same: the Stroud Center's education efforts are rooted in its cutting-edge science.

The Stroud Center supports the United Nations Sustainable Development Goals (SDGs).

For more information, visit sdgs.un.org/goals

Connecting Learners to the Latest Research

SDG 4:
Quality
Education

Education Director Steve Kerlin, Ph.D., says the Stroud Center's research into watershed restoration has yielded discoveries about how wide a streamside forest should be and how to increase the survivorship of newly planted trees. "The Education Department shares this knowledge through activities like real-life habitat assessments and tree monitoring, and we help learners explore the value of trees in protecting fresh water through tools like Macroinvertebrates.org and resources like our field notebooks."

The Education Department conducts its own research that is then used to inform Stroud Center education programs, as well as curriculum development for and recommendations to schools, teachers, and the authors of academic standards. In one case study last year, Kerlin and Adjunct Education Researcher Nanette Marcum-Dietrich, Ph.D., investigated the effects of outdoor learning on students and teachers during the coronavirus pandemic. They found that students and teachers responded favorably, reporting greater enjoyment, creativity, and collaboration, as well as better behavior and mood. In turn, the researchers were able to make recommendations for permanently established outdoor classrooms, well-defined expectations, and professional development to connect STEM learning to the outdoors.



A participant in a professional development training explores PocketMacros. Launched in 2021, the app transports Macroinvertebrates.org — the vibrant, interactive, and accessible insect identification tool — directly to one's pocket.

Discovering Joy and Lessons From Nature

SDG 3:
Good Health
and Well-Being



Teachers experience lessons from nature by searching for insects that, like humans, require clean water to survive.

Bringing people outdoors and into streams and rivers has been a cornerstone of the Stroud Center's education programs since the first leaf pack projects, which can be used to assess the health of a stream based on the bugs living there. Interactive, immersive, sensory experiences that require real-world critical thinking — what educators like to call hands-on, minds-on learning — include the Stroud Center's boots-in-the-water stream studies and on-the-water trips like canoeing and fishing. Newer ones include stream-to-screen virtual programs, which integrate digital and outdoor learning.

"We want learners to have fun while gaining a better understanding of their local watersheds. And if it's fun and meaningful, they are more likely to show interest in STEM careers," Kerlin says.

Bridging Barriers to Equitable Education

SDG 5:
Gender Equality
&
SDG 10:
Reduced
Inequities

The Education Department is turning challenges — the creation of distance and separation to mitigate COVID-19, as well as unequal access to meaningful environmental education in underserved communities — into opportunities for action. “We meet learners where they are,” says Kerlin. The underserved include marginalized communities of color; socioeconomically disadvantaged populations; women and girls; English language learners; and other communities disproportionately harmed by environmental injustice.

That means helping people learn about the health of their local watersheds in their own homes through virtual learning programs, at their own schools through on-site programs, and in their own communities via community science and the Stroud Center’s new Watershed Education Mobile Lab.

It also means adopting educational best practices and accessibility standards that meet the needs of learners and help them to understand the value of freshwater science and stewardship in their own lives.



Newly outfitted with instructional materials like microscopes, water chemistry kits, and bilingual field guides, the Watershed Education Mobile Lab will act as a watershed on wheels to deliver environmental education directly to local communities. We are grateful to the many donors who made this possible. See the Watershed Education Mobile Lab project description on page 20 for the full list.

Inspiring Today’s Learners to Become Tomorrow’s Leaders

SDG 6:
Clean Water
and Sanitation
&
SDG 13:
Climate Action



“The Stroud Center taught me that even though I am still a young student, I can be an advocate for our streams and make a huge beneficial difference in my community,” says Maggie Auman, who worked with Assistant Director of Education Tara Muenz, Watershed Education Specialist Mandy Nix, and Watershed Restoration Coordinator Lamonte Garber on a leaf pack project. For the project, Auman placed packs of dried leaves in streams to collect aquatic insects that she then used to assess stream health. Her project won first place in her local science fair. What Auman and others like her learn through the educational opportunities at the Stroud Center provides the knowledge and motivation to take action on some of today’s most pressing issues, including climate change and threats to clean water and its availability for all.

During experiments with homemade leaf packs, Auman harnessed her local waterways as living laboratories to study aquatic insects and water quality.

Last year, despite ongoing challenges posed by the coronavirus pandemic, the current staff of 18 full- and part-time educators taught more than 14,000 people throughout the world about freshwater science and stewardship, made possible in part by stream-to-screen virtual programs. Learners included students in kindergarten through graduate school, Scouts, families, community groups, school administrators, teachers, and nonformal educators. And when looking at the Stroud Center’s online educational resources and other connections, the indirect impacts total more than 153,000 in 2021.

Looking to the future, Kerlin says, “We are seeing education changing to a blended-learning approach, which combines online use of educational technology resources such as videos and digital field notebooks with in-person school and field-based hands-on learning activities. By embracing this approach, the Education Department is already creating deeper understandings of watershed science and expanding our reach to new audiences.”

get
involved

On-site and off-site school and Scout programs for youth, professional development workshops for adults, and family programs in virtual, remote, and in-person settings are just some of our available education options. Visit stroudcenter.org/education for more information.

Our impact:

IN 2021,

18 educators
TAUGHT MORE THAN
14,000 people

THROUGHOUT THE WORLD ABOUT
FRESHWATER SCIENCE AND
STEWARDSHIP, AND WE HAD
153,000+ indirect
impacts



WATERSHED RESTORATION



Nearly 10 years ago, the Stroud Center launched what would later be named the Robin L. Vannote Watershed Restoration Program. The team recognized they needed to address the entirety of a farm operation's environmental impacts — a whole-farm approach. This focus has guided efforts in work with farms to combine funding from government, grants, tax credits, and state funds into packages individually designed to meet the needs of each farm.



OF WATERSHED RESTORATION

A journey toward hope.

Left: Farmers like father-and-daughter team Linford and Deanne Weber, are key partners in planting forests for clean water. Right: The watershed restoration and education teams brought together students within the Plain community, who come from farming families, to learn about freshwater stewardship.



On the Road to Restoration

HOW FAR WE'VE COME AND WHERE WE'RE GOING TO HELP FARMS ADOPT SCIENCE-BASED SOLUTIONS THAT RESTORE HEALTHY WATERS

By Matt Ehrhart and Diane Huskinson

Ten years ago, Bern Sweeney, Ph.D., former executive director of Stroud™ Water Research Center, had an idea. A big idea. What if the Stroud Center added watershed restoration as a third action — in addition to scientific research and environmental education — in its mission to advance knowledge and stewardship of fresh water? An initiative within the Stroud Center, focused not only on implementing the best possible watershed restoration but also on integrating that work into the science and education activities, would enable the kind of symbiotic collaboration that creates real change. While this is the same fundamental concept underpinning the nation's land-grant universities, implementing it on a focused issue within a research institution that does not have the same silos and bureaucracies of a large university creates more freedom of opportunity.

Sweeney, Senior Research Scientist John Jackson, Ph.D., and others at the Stroud Center were no strangers to watershed restoration and collaborating with others on the science behind it. The Stroud Center's work to reforest a reach of White Clay Creek at its campus in Avondale, Pennsylvania, was one of the first riparian forest buffer plantings in the mid-Atlantic region, if not the nation. The use of tree shelters on the second generation of those plantings was the first documented use of tree shelters in the United States. Sweeney and Jackson collaborated with the Chesapeake Bay Foundation to monitor several streams in Lancaster County, Pennsylvania, that were being targeted in the 1990s to improve management practices on farms that affect water quality, including the planting of streamside forests. Additionally, as many of the first tree plantings



Initial planting



Four years later

Four years after planting trees, the forest on this farm is flourishing thanks to science-based techniques pioneered by the Stroud Center.



Thanks to our partners. We couldn't do it without you.

Alliance for the Chesapeake Bay
Berks County Conservation District
Berks Nature
Brandywine Conservancy
Brandywine Red Clay Alliance
Chesapeake Bay Foundation
Chesapeake Conservancy
Chester County Conservation District
Cover Crop Coaching, LLC
Hemp-Alternative

i2Capital
James River Association
Lancaster Clean Water Partners
Lancaster County Conservation District
Lancaster Farmland Trust
Meadow Springs Farm, Hicks Brothers, LLC
Mowery Environmental, LLC
National Fish and Wildlife Foundation
Octoraro Native Plant Nursery
Partnership for the Delaware Estuary
PennAg Industries, Inc.
Penn State Ag and Environment Center
Penn State Cooperative Extension
Pennsylvania Dept. of Environmental Protection
Pennsylvania Dept. of Conservation and Natural Resources

Pennsylvania No-Till Alliance
Propagate Ventures
Red Barn Consulting, Inc.
Rosetree Consulting, LLC
TeamAg, Inc.
The Nature Conservancy
Trout Unlimited
Trust in Food
University of Montana
Upper Susquehanna Coalition
USDA Farm Service Agency
USDA Natural Resource Conservation Service
William Penn Foundation
Plus the many farmers and landowners who partner with us!

were failing to survive, the Stroud Center began studying how to best care for young forests, quickly becoming a national leader in the discussion on how to successfully plant trees and keep them alive.

Nearly 10 years ago, the Stroud Center launched what would later be named the Robin L. Vannote Watershed Restoration Program, hiring Matt Ehrhart as director of watershed restoration and David Wise as watershed restoration manager. An initial grant from the National Fish and Wildlife Foundation kicked off restoration efforts in the farming communities of the Chesapeake Bay watershed. Building on lessons learned from the prior collaboration with the Chesapeake Bay Foundation, the team recognized that to be most successful, they needed to address the entirety of a farm operation's environmental impacts — a whole-farm approach. This focus has guided efforts in work with farms to combine funding from federal and state governments, private and foundation grants, tax credits, and state revolving loan funds into packages individually designed to meet the management, implementation, and financial needs of each farm.

As the watershed restoration team's grant funding grew and their reach expanded, Ehrhart and Wise continued discussions with Stroud Center scientists on how to integrate their work more effectively. In 2014, the William Penn Foundation launched the Delaware River Watershed Initiative (DRWI). The DRWI was developed with eight target geographies, known as clusters, where grant partners primarily focused on aggregating either land protection efforts in headwater forests

or watershed restoration in agricultural watersheds. This focus, and the support from the William Penn Foundation, enabled the Stroud Center and the DRWI partners to aggregate whole-farm watershed restoration efforts in small watersheds and to model, monitor, and evaluate the impact of that work in an unprecedented effort. This funded opportunity for collaboration, not only between the science and research teams, but also with partners from across the Delaware River watershed, accelerated the integration for our work. This critical effort is enabling the Stroud Center to delve into long-standing questions about why, historically, watershed restoration work hasn't led to the ecological outcomes we've hoped for. The search for a better understanding of the scope and scale required to make a bigger impact, as well as the lag time and other factors affecting restoration efforts, positions the Stroud Center as a leader in developing and disseminating this crucial information.

The Stroud Center's work on issues surrounding soil health provides another window into the growing collaboration between the scientific research groups and the watershed restoration team.

Roger Rohrer, a farmer in Strasburg, Pa., and a long-time ally of the Stroud Center, peels a tree tube from a healthy, three-year-old tree along Little Beaver Creek. Photo: Will Parson/Chesapeake Bay Program



Recognizing how healthy farm soils improve climate resiliency, water quality, and farm profitability, the watershed restoration team has partnered with the Pennsylvania No-Till Alliance, an organization led by and consisting of active farmers. With the Stroud Center's support, the alliance provides outreach and education, training, mentoring, and financial support to members. Simultaneously, Stroud Center scientists have been working to better understand the mechanisms and functions of how no-till agriculture, cover crops, and the microbial communities of our soils lead to improved soil structure, drought resistance, and improved infiltration, as well as the management and decision-making necessary to achieve these improvements. This work was initiated with a Conservation Innovation Grant from the U.S. Department of Agriculture and continues with a long-term research collaboration with Rodale Institute, funded by the William Penn Foundation. The combination of efforts on the science, education, and implementation of soil health practices led to the Stroud Center being selected to lead the newly formed Pennsylvania Soil Health Coalition. Soil Health Coordinator Lisa Blazure and Watershed Restoration Coordinator Lamonte Garber spearhead this effort.

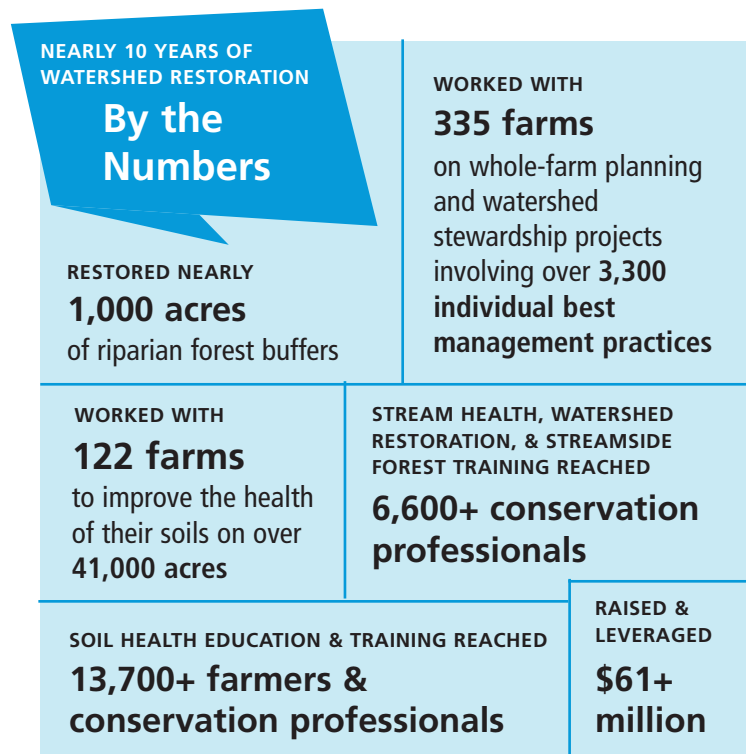
As the Watershed Restoration Program continued to grow in scope and scale, the list of external collaborators has grown. The program enjoys the rich contributions from private-sector partners, academic partners from across the country, nongovernmental organizations from the region and across the country, and federal, state, and local government entities.

While the Watershed Restoration Program has enjoyed great success in developing a broad funding base from private and government grant-making organizations, the contributions of individual donors have provided the program with the flexibility and nimbleness to grow and respond to new opportunities. In 2019 the team was humbled by the support of founding Executive Director Robin L. Vannote, Ph.D., and the program was formally named in his honor.

To date, the Watershed Restoration Program has restored nearly 1,000 acres of riparian forest buffers, worked with 335 farms on whole-farm planning and watershed stewardship projects involving over 3,300 individual best management practices, and worked with 122 farms to improve the health of their soils on over 41,000 acres. The Stroud Center raised and leveraged over

\$61 million to implement the work. Additionally, we've trained over 6,600 conservation professionals on issues of stream health, watershed restoration, and riparian forest buffers. Our soil health education and training events have reached over 13,700 farmers and conservation professionals.

As the watershed restoration team considers the opportunities and challenges ahead, we look forward to the growing internal collaboration with Stroud Center scientists and educators on issues such as the deposition of per- and polyfluoroalkyl substances, also known as forever chemicals, onto the agricultural landscape. Even now, we are improving our understanding of how stormwater volumes and water quality from adjacent agricultural lands affect the resiliency of local communities, and we are improving approaches to watershed restoration in the region. The team also has ongoing external collaborations with the University of Montana, Penn State University, and the University of Maryland that focus more on the human dimensions of this work and will provide insights into how best to work with farmers and nearby towns. The first decade of the Watershed Restoration Program has proved the value in Bern Sweeney's big idea, and we look forward to the insights, collaboration, and dissemination of ideas in the years to come that will assist our communities in protecting clean fresh water.



For better success in planting and maintaining streamside forests, check out our helpful fact sheets and guides. Visit stroudcenter.org/restoration/resources to download.



During a Soil Health and Water Quality Field Day at the Stroud Preserve, scientist Jinjun Kan, Ph.D., tells farmers about techniques the Stroud Center and Rodale Institute are studying to benefit not only healthy soils but also freshwater streams and rivers. Photo: Jack Dempsey

Research Projects

Note: Research, education, and watershed restoration projects listed were active in 2021. Stroud Water Research Center scientists and staff are indicated in bold.

Assessment of Environmental Conditions in Bennett's Run at Kendal-Crosslands

Funded by: Phoebe A. Driscoll and the Phoebe Internship Fund

Bennett's Run is a small tributary to Brandywine Creek in southern Chester County, Pa., where a watershed conservation plan is being developed. To inform this plan, this study is measuring water chemistry, temperature, aquatic macroinvertebrates, and fish to quantify the condition of Bennett's Run between Longwood Gardens and Kendal-Crosslands Communities, and again downstream from Kendal-Crosslands.

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

Assessment of Environmental Conditions in Streams of the Runnymede Sanctuary

Funded by: Runnymede Sanctuary

The 1,670-acre Runnymede Sanctuary preserves historic and scenic resources including forests, shrublands, meadows, and hayfields that offer important habitat for local and migratory wildlife and ensure replenishment of groundwater that feeds tributaries of Doe Run. This study measures water chemistry and aquatic macroinvertebrates of Doe Run and its tributaries as they enter and exit the sanctuary and at other streams in the region.

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

Collaborators: Melinda D. Daniels; Valérie Ouellet (Northeast Fisheries Science Center)

Biological Nitrogen Removal in Sediment Plumes: A Critical but Missing Component of Watershed Models

Funded by: U.S. Department of Agriculture

Nutrient export from rivers is closely tied to sediment plumes that form during storms. By using experiments and methods to peer inside these sediment plumes, this project will discover how biological processes change nutrients while sediment plumes move downstream. The results will lead to more accurate watershed management models and better decisions on where best management practices can be most effective in agricultural watersheds.

Principal Investigators: Marc Peipoch and Jinjun Kan

Collaborator: Shreeram Inamdar (University of Delaware)

Brandywine Stream Stewards: Community Action in Support of Healthy Waters

Funded by: William Penn Foundation

The Stream Stewards Program engages adults and youth from Wilmington, Del., to monitor water resources in the 1,100 acres of open space in the First State National Historical Park. This educational program and community science effort galvanizes people around watershed protection and leads to conservation and improved management of land and water resources

Principal Investigators: The Nature Conservancy – Delaware Chapter; John K. Jackson and Matthew J. Ehrhart

Collaborators: Jinjun Kan, Melinda D. Daniels, and David B. Arscott

DRWI Phase II Monitoring, Evaluation, Scientific Support, and Capacity Building for Watershed Protection and Restoration Projects

Funded by: William Penn Foundation

This project, part of the Delaware River Watershed Initiative, collects and interprets data on macroinvertebrate specimens from stream sites to provide a baseline to evaluate goals for restoration and protection projects.

Principal Investigator: John K. Jackson

Collaborators: Matthew J. Ehrhart and David B. Arscott; Roland Wall, Stefanie A. Kroll, Richard J. Horwitz, Marie J. Kurz, David Keller, Lin Perez, and David J. Velinsky (Academy of Natural Sciences of Drexel University)

DRWI Phase II Monitoring, Evaluation, and Scientific Support for Protecting and Restoring Places of Ecological Significance (Brandywine-Christina, Middle Schuylkill, Schuylkill Highlands Clusters)

Funded by: William Penn Foundation

Professional and volunteer monitoring of chemistry, macroinvertebrates, and fish to support restoration and protection efforts represent an invaluable (and often neglected) tool to evaluate short- and long-term progress toward conservation priorities and goals. This project, part of the Delaware River Watershed Initiative, develops and implements monitoring and evaluation efforts as part of restoration and protection plans for targeted watersheds in the Brandywine-Christina, Middle Schuylkill, and Schuylkill Highlands clusters.

Principal Investigators: John K. Jackson and Matthew J. Ehrhart

Collaborators: Audubon Pennsylvania; Berks Nature; Brandywine Conservancy; Brandywine Red Clay Alliance; French and Pickering Creeks

Conservation Trust; Green Valleys Watershed Association; Natural Lands; Partnership for the Delaware Estuary; The Nature Conservancy of Delaware; University of Delaware

DRWI Pollution Assessment: Stage 1

Funded by: William Penn Foundation

The Delaware River Watershed Initiative pollution assessment will estimate progress to protect and restore water quality in targeted geographies. In this study, researchers utilize water quality modeling tools to estimate the impact of strategies to reduce water pollution and provide forest protection and then relate these outcomes to broader estimates of total water pollution in the watershed.

Principal Investigators: David B. Arscott

Collaborators: Anthony Aufdenkampe (LimnoTech); Lin Perez, Barry Evans, and Michael Campagna (Academy of Natural Sciences of Drexel University)

Ecotoxicity Study for Mayflies Exposed to Elevated Concentrations of Chloride at Different Temperatures

Funded by: Pa. Department of Environmental Protection and Stroud Water Research Center

Chloride concentrations in surface waters have been increasing over the last several decades across the United States and at times may reach levels that threaten aquatic organisms. To test this, laboratory experiments are performed with four mayfly species exposed to elevated chloride concentrations and temperatures ranging from 5–25 degrees Celsius.

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

Evaluating How Conventional, Conservation, and Organic Farming Management Practices Enhance Soil Health and Improve Water Quality

Funded by: William Penn Foundation

This project investigates how different agricultural management practices influence water quality and soil health. Using Rodale Institute's 37-year-old Farming Systems Trial and a recent transition to organic farming at the Stroud Preserve, it examines the effect of farming techniques on water infiltration, runoff, and nutrient, contaminant, and sediment export. Results will inform practices that can reduce contamination and flooding in the Delaware River watershed.

Principal Investigators: Jinjun Kan, Melinda D. Daniels, Diana Oviedo-Vargas, Marc Peipoch, David B. Arscott, Matthew J. Ehrhart, and Bernard W. Sweeney

Collaborators: Jeff Moyer, Andrew Smith, Gladis Zinati, Yichao Rui, and Kirsten Pearsons (Rodale Institute); Raven Bier (Savannah River Ecology Lab, University of Georgia); Kurt Williamson (William & Mary)

Evaluating NCRN Data Quality, Revising and Updating Protocols, and Analyzing Long-Term Data

Funded by: National Park Service

The National Park Service National Capital Region Inventory and Monitoring Network (NCRN) has monitored stream water quality and quantity for more than 15 years in shallow streams located in 10 national parks in and around Washington, D.C. The main goal of this project is to analyze this complex dataset to document spatiotemporal trends and assess watershed health in NCRN streams.

Principal Investigators: Diana Oviedo-Vargas, Marc Peipoch, Melinda D. Daniels, Jinjun Kan, and Scott H. Ensign

Evaluating the Effects of Watershed-Scale Agricultural Best Management Practices on Water Quality

Funded by: Stroud Water Research Center

In early 2020, streambank fencing, forested buffers, and barnyard improvements were installed on Amish farms in Lancaster County, Pa. This project is monitoring stream nutrient and sediment loads and macroinvertebrates before, during, and after the implementation of the best management practices to detect changes in water quality due to these efforts.

Principal Investigators: Jinjun Kan, Diana Oviedo-Vargas, Marc Peipoch, and John K. Jackson

Collaborator: Lamonte Garber

Evaluating the Risk for PFAS Contamination of Surface and Groundwater Through Application of Biosolids in Agroecosystems

Funded by: Foundation for Food and Agricultural Research

Per- and polyfluoroalkyl substances (PFASs) are a group of thousands of chemicals that are used in a wide range of industrial applications and represent a risk to human health. They can end up on farm fields through the application of contaminated biosolids. This occurs when biosolids are sourced from a wastewater treatment facility that receives water contaminated with PFASs. Scientists are investigating whether biosolid application on Pennsylvania farms represents a significant source of PFASs in soils and water.

Principal Investigators: Diana Oviedo-Vargas and Matthew J. Ehrhart

Collaborators: Seetha Coleman-Kammula and Charles Powley (STRIDE)

Exploring the Link Between Soil and Human Health: Protein, Protein Quality, and the Nutraceutical Amino Acid Ergothioneine

Funded by: Foundation for Food and Agriculture Research

Ergothioneine, an amino acid that has scientifically proven benefits to human health, is exclusively biosynthesized by fungi and certain bacteria in soils. With coupled field testing and lab incubation experiments, this project is investigating how soil microbes synthesize and transform ergothioneine from soil to products under different farming practices.

Principal Investigator: Jinjun Kan

Collaborators: Andrew Smith (Rodale Institute); Harsh Bais (University of Delaware); Wade Heller (USDA)

Impact of Land Management on Winter Squash Yield and Post-Harvest Nutrient Density

Funded by: Pa. Department of Agriculture

By examining the bacteria, Archaea, and fungi living in soils, this project will provide insights on how farming practices and land management affect the microbes that make soils healthy. This information will help improve guidelines for growing squash and managing nutrients on farm fields.

Principal Investigator: Jinjun Kan

Collaborators: Gladis Zinati (Rodale Institute); Lavanya Reddivari (Purdue University)

Land Protection Impact Assessment in Support of the DRWI

Funded by: Open Space Institute

This project, part of the Delaware River Watershed Initiative, evaluates the hypothesis that protection or maintenance of natural land maintains ecological stream quality by limiting, preventing, or redirecting changes to land cover and use away from headwaters, stream buffers, and wetlands.

Principal Investigators: John K. Jackson and Charles L. Dow

Collaborators: Stefanie A. Kroll, Marie J. Kurz, David Keller, and Lin Perez (Academy of Natural Sciences of Drexel University)

Land Protection Impact Assessment in Support of Delaware River Watershed Initiative

Funded by: Open Space Institute

This project evaluates the hypothesis that protection and/or maintenance of natural land maintains ecological stream quality by limiting, preventing, or redirecting changes to land cover and use away from headwaters, stream buffers, and wetlands. The project will be conducted in two steps — looking first at available chemical, macroinvertebrate, and fish data, and then collecting additional data specifically focused on the relationship between protecting forests and stream quality.

Principal Investigators: John K. Jackson and Charles L. Dow

Collaborators: Stefanie A. Kroll, Marie J. Kurz, David Keller, and Lin Perez (Academy of Natural Sciences of Drexel University)



Elrod Owusu-Asumeng and Laura Zgleszewski prepare mixtures of water and particles from different parts of the Choptank River before incubating the samples to track how the microbial communities change over time.

Long-Term Research in Environmental Biology: River Ecosystem Responses to Floodplain Restoration

Funded by: National Science Foundation

After 25 years of litigation, a massive ecological restoration is under way in the Upper Clark Fork River, Mont. Metal-laden floodplain soils are being removed, floodplains are being reconnected with river floods, and over 70 kilometers of floodplains are being restored. This project uses long-term monitoring data to discover how river ecosystem structure and function respond to changing nutrient concentrations and large-scale floodplain restoration. By testing fundamental theories and frameworks of ecology, these discoveries will guide future river restorations.

Principal Investigator: Marc Peipoch

Collaborators: Maurice Valett and Michael DeGrandpre (University of Montana); Rob Payn and Juliana D'Andrilli (Montana State University)

Long-Term Research in Environmental Biology: Trajectory for the Recovery of Stream Ecosystem Structure and Function During Reforestation

Funded by: National Science Foundation

Stream restoration in the United States is a multibillion-dollar industry, yet long-term monitoring of its effectiveness is virtually nonexistent. To fill this gap, the Stroud Center restored a portion of White Clay Creek by reforesting meadows and pastures with native deciduous trees and removing invasive plant species. Decadal changes in the aquatic biological communities and how they function are being monitored as this forest matures. This project is producing discoveries and insights that will guide future restoration techniques and train teachers to use long-term environmental data to enhance math skills, analytical abilities, and environmental knowledge of students and teachers.

Principal Investigators: John K. Jackson, Jinjun Kan, Melinda D. Daniels, Diana Oviedo-Vargas, and Marc Peipoch

Collaborators: J. Denis Newbold, David B. Arscott, Charles L. Dow, Steven C. Kerlin, Tara K. Muenz, Louis A. Kaplan, and Bernard W. Sweeney

Low-Head Milldams as Hotspots for Denitrification and Nitrogen Consumption: Hydrologic and Biogeochemical Controls

Funded by: National Science Foundation

As dam removal has increased in recent years in an effort to improve fish habitat and reduce financial liability, few studies have addressed the consequences of these removals for water quality and regulatory compliance. This project investigates the role of low-head milldams on nitrogen and sediment transport in stream ecosystems.

Principal Investigator: Marc Peipoch

Collaborators: Shreeram Inamdar (University of Delaware); Art Gold (University of Rhode Island)

Macroinvertebrate Monitoring at Sites in White Clay Creek, Pa., Flint River, Ga., 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 compared to historical conditions.

Principal Investigator: John K. Jackson

Microbial Population Dynamics of Periphyton Biofilms in White Clay Creek

Funded by: Stroud Water Research Center

Using glass microscope slides as tiny gardens to grow microbial biofilms, this project explored differences in microorganisms between three reaches of White Clay Creek with different streamside vegetation. Molecular DNA fingerprints of biofilms on glass slides differed in the three reaches, as did the biofilms on natural underwater surfaces. This revealed how subtle differences in surfaces and surroundings affect microbial communities and their distribution.

Principal Investigator: Jinjun Kan

Mitigating Agricultural Pollution of Fresh Water and Combating Climate Change by Restoring Soil Health

Funded by: Prince Albert II of Monaco Foundation

Plowing, disking, synthetic fertilizers, and pesticides have damaged the health of agricultural soils, resulting in reduced rainfall infiltration and storage, increased stormwater and pollutant runoff, degraded streams, and contaminated groundwater. This project measures how no-till seeding, multi-species cover cropping, and elimination of synthetic fertilizers and pesticides (in particular, neonicotinoids) can rejuvenate agricultural soils and protect water quality.

Principal Investigators: Melinda D. Daniels, Jinjun Kan, Diana Oviedo-Vargas, and Marc Peipoch

Model My Watershed

Funded by: Stroud Water Research Center, William Penn Foundation, Pa. Department of Environmental Protection

The Stroud Water Research Center continues to maintain and update the Model My Watershed® web application. Updates for 2021–2022 include adding historic and more current layers of land use data and a higher resolution stream network map for the contiguous 48 states and updating the underlying software version to ensure future functionality.

Principal Investigators: David B. Arscott and Steven C. Kerlin

Collaborators: Anthony Aufdenkampe (LimnoTech); Lin Perez, Barry Evans, and Michael Campagna (Academy of Natural Sciences of Drexel); Robert Cheetham (Azavea, Inc.).

Molecular Ecology of Archaea in Aquatic and Terrestrial Environments

Funded by: Southern University of Science and Technology (SUSTech), China

Less is known about Archaea than the other two domains of life on Earth (Bacteria and Eukarya), particularly the role they play in ecosystem functions and nutrient cycling (e.g., ammonia oxidation). Applying cutting-edge molecular approaches, this project is characterizing community composition and spatiotemporal distribution of Archaea in White Clay Creek, Costa Rica, Chesapeake Bay, and terrestrial environments.

Principal Investigator: Jinjun Kan

Collaborators: Chuanlun Zhang (SUSTech)

Monitoring Fish Populations and Stream Habitat Quality for the National Park Service

Funded by: National Park Service

This project monitors biological conditions, water quality, habitat integrity, and fish at 37 sites in 10 national parks in the National Capital Region

Network around Washington, D.C. The findings of this project are used by the National Park Service to make conservation and management decisions.

Principal Investigators: Marc Peipoch, Melinda D. Daniels, Diana Oviedo-Vargas, John K. Jackson, Jinjun Kan, and Scott H. Ensign

North American Macroinvertebrate Taxonomic Certification Program

Funded by: Society for Freshwater Science

This program coordinates and executes the taxonomic certification program for the Society for Freshwater Science, conducting family- and genus-level tests throughout the year.

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

Collaborator: Michael C. Broomall

Phytoplankton Dynamics at the Brandywine River

Funded by: Stroud Water Research Center

High-frequency temperature, oxygen, and chlorophyll sensors, canoe float trips, and nutrient monitoring are the tools being used to study how much and how fast algae grow while they travel down the Brandywine River. By understanding how suspended algae respond to storms and how dams affect patterns in algae, this project will improve predictions of future changes in the river if dams are removed.

Principal Investigators: Marc Peipoch, Scott H. Ensign, and Diana Oviedo-Vargas

Recovery of Nutrient Processes and Microbial Communities in Relict Hydric Soils Following Restoration

Funded by: U.S. Department of Agriculture

This research explores how microbes and biogeochemical processes in buried relict soils evolve after restoration and how these organisms and processes can be harnessed to remove nitrogen before it pollutes streams. This will help practitioners design restoration projects with conditions that fast-track microbial recovery and nitrogen processing.

Principal Investigators: Jinjun Kan and Marc Peipoch

Collaborator: Shreeram Inamdar (University of Delaware)

Restoration Project Impact Assessment in Support of the DRWI

Funded by: National Fish and Wildlife Foundation

This project quantifies the positive impacts of restoration projects on water quality and soil health associated with the Delaware River Watershed Initiative.

Principal Investigators: John K. Jackson, Diana Oviedo-Vargas, Matthew J. Ehrhart, Melinda D. Daniels, Jinjun Kan, and Marc Peipoch

Collaborators: Stefanie A. Kroll, Marie J. Kurz, David Keller, and Lin Perez (Academy of Natural Sciences of Drexel University); Green Valleys Watershed Association; French and Pickering Creeks Conservation Trust; Berks Nature; Musconetcong Watershed Association; The Nature Conservancy – New Jersey; North Jersey Resource Conservation & Development Council; Trout Unlimited; South Jersey Land and Water Conservancy; Rutgers University; New Jersey Audubon

Source Tracking and Spatial/Temporal Dynamics of Bacterial Contaminants in Red Clay Creek

Funded by: Starrett Foundation

Scientists monitored fecal indicator bacteria and water chemistry on a monthly basis in the east and west branches of the Red Clay Creek watershed.

Principal Investigators: Jinjun Kan, Jacob Price, and David B. Arscott

Stroud EnviroDIY™ Monitoring Stations in Red Clay Creek

Funded by: Cabot-Kjellerup Foundation

This project built and deployed two water monitoring sensor stations in tributaries of Red Clay Creek and provided maintenance support and educational/technical assistance for staff at The Land Conservancy for Southern Chester County.

Principal Investigator: David B. Arscott

Tidal Rivers Biofingerprinting Sediment: Resolving Sediment Connectivity Between Rivers and Estuaries by Tracking Particles With Their Microbial Genetic Signature

Funded by: National Science Foundation

Sediment flowing from rivers to estuaries is a double-edged sword: too much sediment can harm oyster beds but not enough sediment can starve tidal marshes. Measuring whether a river is providing too much or not enough sediment requires knowing exactly where that sediment comes from and when. This project uses molecular characterization of attached microbes on sediment particles to detect where sediment comes from during different periods of river flow.

Principal Investigators: Scott H. Ensign and Jinjun Kan

Collaborator: Steven C. Kerlin

Understanding Thermal Limitation in Aquatic Insects: Implications for Freshwater Biodiversity in a Warming World

Funded by: National Science Foundation

This project tests the hypothesis that temperature limits the distributions of aquatic insects through its effect on resource allocation, and that warming decreases reproduction by shunting energy away from egg production to other metabolic processes.

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

Collaborators: David B. Buchwalter (North Carolina State University); Charles P. Hawkins (Utah State University); Goggy Davidowitz (University of Arizona)

Using Microbial Source Tracking to Identify Potential Bacterial Sources in White Clay Creek

Funded by: White Clay Watershed Association and White Clay Creek Wild and Scenic River Program

Scientists monitored fecal indicator bacteria in White Clay Creek during summer and identified potential bacterial contamination by molecular microbial source tracking with the goal of targeting best management practices and implementation strategies.

Principal Investigators: Jinjun Kan and Jacob Price

Collaborator: Shane Morgan (White Clay Creek Wild and Scenic River Program)

Water Quality Modeling to Support Source Water and Aquatic Life Protection in Octoraro Creek Watershed

Funded by: Environmental Protection Agency

This project supports water quality monitoring and development of a water quality model to guide an alternative restoration plan for the Octoraro Creek watershed. The data, model, and plan will guide the Pa. Department of Environmental Protection in implementing nutrient reduction strategies that restore designated uses of Octoraro Creek.

Principal Investigator: Marc Peipoch



Rachel Johnson and Shannon Hicks install an EnviroDIY™ Monitoring Station in the Pocomoke River in Maryland to track sediment pollution.



A budding angler at Camp Quiet Thunder proudly holds the catch of the day, while other fourth-to-sixth-grade campers launch canoes into Chambers Lake. Funded by the Pa. Department of Environmental Protection, this annual partnership between the Education Department and Coatesville Youth Initiative immerses young leaders in discovery-based, skill-building activities like fishing, paddling, and water quality monitoring.

Education Projects

Advancing Education and Community Outreach — Oxford Area

Funded by: Oxford Area Foundation

Continued support enables the expansion of education and outreach in southeastern Pennsylvania, including K–12 school programs, out-of-school youth programs, educator professional development trainings, and community science projects.

Project Lead: Steven C. Kerlin

Collaborators: Tara K. Muenz, Mandy Nix, and David Kline

Boy Scouts of America (BSA) Programs

Funded by: Donna Queeney and Nick Kerlin

Educators engage and empower K–12 youth involved in BSA in environmental badges, awards, service projects, and other advancements.

Project Leads: Steven C. Kerlin, Mandy Nix, and Tara K. Muenz

Collaborator: Chester County Council, BSA

Building District Capacity for Environmental Literacy and MWEEs in Delaware

Funded by: Del. Sea Grant and NOAA

This project strengthens state and school district capacity to integrate environmental literacy (E-LIT) and Meaningful Watershed Educational Experiences (MWEEs) into learning for Delaware students. Collaborators will create a Delaware MWEE Facilitator Guide and work directly with Caesar Rodney and Appoquinimink school districts and Sussex Montessori Charter School in Delaware to expand environmental education and develop E-LIT plans that serve as models for other districts.

Project Lead: David Christopher (Del. Sea Grant)

Collaborators: Steven C. Kerlin; Tonyea Mead (Del. Department of Education); David Pragoff (Del. Nature Society); Ashley Melvin (Del. Association for Environmental Education)

Bringing the Amazon Rainforest Home

Funded by: The Longwood Foundation

Fifteen teachers from New Castle, Sussex, and Kent counties in Delaware worked with partners to develop curricula that not only meets the robust Next Generation Science Standards of the U.S. Educational System but also fosters mutual understanding between cultures and allows schools to engage directly with a network of professionals in the Amazon rainforest.

Project Lead: Amazon Center for Environmental Education Research Foundation

Collaborator: Tara K. Muenz

Capacity-Building for Girls-in-STEM Watershed Education

Funded by: Pa. Department of Environmental Protection (DEP)

This project expanded meaningful and inclusive education in water-focused environmental STEM for regional K–12 girl audiences, including pilot programs for high-needs and marginalized youth in DEP environmental justice areas. Girl audiences may include cis and trans girls, nonbinary youth, gender-nonconforming youth, and/or youth who identify with the experience of girlhood as part of their unique journeys.

Project Leads: Mandy Nix and Steven C. Kerlin

Collaborator: Tara K. Muenz

Consortium for Scientific Assistance to Watersheds

Funded by: Pa. Department of Environmental Protection's Growing Greener Program

Education, research, and watershed restoration staff provided technical assistance to statewide conservation groups in effective watershed assessment, monitoring, and restoration.

Project Leads: Scott H. Ensign, David B. Arscott, and Tara K. Muenz

Collaborators: Alliance for Aquatic Resource Monitoring at Dickinson College; Conemaugh Valley Conservancy; Del. Riverkeeper Network; Pa. Lake Management Society; U.S. Geological Survey; Pocono Northeast Resource Conservation and Development Council

Delivering Meaningful, Safe, and Accessible Watershed Education

Funded by: Pa. Department of Environmental Protection

This project expands meaningful and inclusive environmental STEM programs, including online stream study lessons for fourth-grade and middle school students and a Watershed Education Mobile Lab for outreach to environmental justice communities.

Project Lead: Tara K. Muenz

Collaborators: Steven C. Kerlin and Mandy Nix

Equity and Environmental Education (EE) in the Time of COVID-19 to Support EE Providers

Funded by: Chesapeake Bay Trust and Pa. Department of Education (PDE)

Educators modified existing and piloted new programming for virtual and in-person watershed education during the pandemic. Additional funding from PDE supported initial planning of a website to further support EE providers like classroom teachers, nonformal educators, and guardians/caregivers.

Project Leads: Steven C. Kerlin and Tara K. Muenz

Collaborators: Mandy Nix and Heather P. Brooks; Tamara Pepper (Pa. Department of Education); Chesapeake Bay Program

Expanding Environmental Literacy and Meaningful Watershed Educational Experience (MWEE) Implementation Capacity Across Pennsylvania

Funded by: National Oceanic and Atmospheric Administration

This 2020–2022 statewide project builds capacity for environmental literacy and stewardship of the Chesapeake Bay and other watersheds in Pennsylvania by expanding the inclusion and implementation of environmental education, particularly MWEEs, in schools.

Project Leads: Steven C. Kerlin; Tamara Pepper (Pa. Department of Education)

Collaborators: Mandy Nix; Bert Myers and Allison Acevedo (Pa. Department of Environmental Protection); Jessica Kester (Pa. Association of Environmental Educators); Carissa Longo (Pa. Bureau of State Parks); Nanette Marcum-Dietrich (Millersville University); Jenn Fetter (Penn State Extension); Paul Joyce (West Chester Area School District)

GIS-Based Professional Development: Helping K–12 Teachers Overcome Obstacles Due to COVID-19

Funded by: Pa. Sea Grant and National Oceanic and Atmospheric Administration

This project builds capacity and advances environmental literacy efforts that integrate geospatial technology use among educators in the Lake Erie, Susquehanna River, and Delaware Estuary watersheds. Partners are developing, implementing, and researching a professional development module that encourages the use of GIS to support watershed-based inquiry practices in times of physical distancing and limited mobility.

Project Leads: Tamara Pepper (Pa. Department of Education); Steven C. Kerlin

Collaborators: Michelle Niedermeier (Pa. Sea Grant); David Kline

Growing Diversity and Inclusion in On-the-Water Education

Funded by: Pa. Fish and Boat Commission

This project supports expanding and sustaining inclusive on-the-water education through fishing and canoeing programs that prioritize female, marginalized, and economically disadvantaged populations in southeastern Pennsylvania and the Delaware River basin.

Project Leads: Tara K. Muenz and Mandy Nix

Collaborators: Steven C. Kerlin, David Kline, and Steve Mohapp

Habitat Restoration and Outdoor Education in the Caesar Rodney School District

Funded by: National Fish and Wildlife Foundation

This project restores underutilized space on 10 public school campuses within the Caesar Rodney School District in Delaware, providing benefits to wildlife and water quality, as well as meaningful outdoor learning opportunities for teachers and their pre-K–12 and special needs students.

Project Lead: Caesar Rodney School District

Collaborators: Steven C. Kerlin, Tara K. Muenz, and David Kline; Del. Nature Society; U.S. Fish and Wildlife Service

Hidden Gems of the Delaware and Susquehanna River Basins: Increasing Accessibility to On-the-Water Education

Funded by: Pa. Fish and Boat Commission

This project serves Scout, school, and public audiences with on-the-water education through fishing and canoeing programs to improve equitable access to safe outdoor aquatic recreation, raise awareness of related careers, and foster environmental awareness throughout these watersheds.

Project Leads: Tara K. Muenz and Mandy Nix

Collaborators: Steven C. Kerlin, David Kline, and Steve Mohapp

Increasing Accessibility to Watershed-Based Climate Change Education in the White Clay Creek Watershed

Funded by: National Park Trust

With a theme of climate change literacy within the White Clay Creek watershed, this project delivers a series of canoeing, angling, and Watershed

Education Mobile Lab programs to engage marginalized youth, their families, and educators in recreation and stewardship in watershed STEM.

Project Leads: Steven C. Kerlin and Tara K. Muenz

Collaborator: Shane Morgan (White Clay Creek Wild and Scenic River Program)

Independent K–12 Student Research Projects

Funded by: Auman Family

The establishment of this fund makes staff support available to assist K–12 students interested in conducting independent scientific research in freshwater ecology.

Project Lead: Tara K. Muenz

Lancaster Area Outdoor Learning Network Initiative

Funded by: Chesapeake Bay Trust

Educators planned and delivered teacher professional development in watershed education content and skills for Conestoga Valley, Ephrata, and Columbia school districts in Pennsylvania.

Project Lead: Dan Daneke (Conestoga Valley School District)

Collaborators: Steven C. Kerlin and Tara K. Muenz; Nanette Marcum-Dietrich (Millersville University); Chesapeake Bay Foundation; Lancaster County Conservation District

Lawrenceville School Partnership for Student Water Quality Monitoring of Shipetaukin Creek

Funded by: Fair Play Foundation

Educators are partnering with The Lawrenceville School to create and implement opportunities for students to study water quality impacts on the school campus using EnviroDIY™ Monitoring Stations.

Project Leads: Steven C. Kerlin and Tara K. Muenz; Stephen Laubach (The Lawrenceville School)

Collaborator: David Bressler

Leaf Pack Kit and International Community

Funded by: Stroud Center Education Product Development and Anonymous

This international program, which is bilingual in English and Spanish, engages students, teachers, families, and the public in water quality monitoring through the lens of aquatic macroinvertebrates.

Project Lead: Tara K. Muenz

Collaborator: Steven C. Kerlin

Learning to See, Seeing to Learn

Funded by: National Science Foundation

This project continued to enhance the Macroinvertebrates.org site in addition to creating aquatic macroinvertebrate identification resources for learners, teachers, and trainers.

Project Lead: Marti Louw (Carnegie Mellon University)

Collaborators: Tara K. Muenz, Mandy Nix, Steven C. Kerlin, John K. Jackson, and Michael C. Broomall; John Morse (Clemson University); John Wenzel (Carnegie Museum of Natural History)

Pa. Gateway to Green Website Development

Funded by: Pa. Department of Education (PDE)

Stroud Center education and information services staff collaborated with state partners and PDE's environment and ecology advisor to create, launch, and maintain a new website to improve educators' ease of access to environmental literacy resources in Pennsylvania.

Project Leads: Tamara Pepper (Pa. Department of Education); Steven C. Kerlin

Collaborators: Heather P. Brooks and Mandy Nix



In 2021, generous grant funding from the Pa. Fish and Boat Commission and the Bass Pro Shops and Cabela's Outdoor Fund significantly expanded the Education Department's on-the-water education equipment. Education staff Steve Kerlin, Ph.D., David Kline, Mandy Nix, Tara Muenz, and Steve Mohapp pose proudly with new fishing and canoeing supplies.

Pa. Healthy Learning Environments Advisory Council to the Pa. Department of Health's COVID-19 Initiative

Funded by: U.S. Center for Disease Control

Educators provided feedback on technical plans, guidance, and resources for a cohesive system of professional development and classroom materials to create healthy schools and childcare environments that prevent the spread of COVID-19.

Project Leads: Pa. Department of Health; Drexel University; Pa. Department of Education

Collaborators: Steven C. Kerlin and Tara K. Muenz

School Study on the Effects of Outdoor Learning

Funded by: Anonymous

This school-case-study research project surveyed and interviewed middle school students and teachers to determine if and how outdoor learning experiences are impacting students.

Project Leads: Steven C. Kerlin; Nanette Marcum-Dietrich (Millersville University)

Scouts BSA Fish and Wildlife Merit Badge in Times of COVID-19

Funded by: Pa. Department of Environmental Protection

Educators develop and implement new hybrid merit badge programming with online and in-person portions, including an online learning portal for remote education to limit face-to-face contact and reduce virus transmission.

Project Leads: Steven C. Kerlin, David Kline, and Tara K. Muenz

Collaborators: Department of Conservation and Natural Resources; Pa. Fish and Boat Commission

Scout Watershed STEM Education, Recreation, and Stewardship Programs and Educator Professional Development

Funded by: National Park Trust

Educators engage Boy Scouts of America, Girl Scouts USA, and adult educators in a series of watershed STEM experiences, including canoeing, recreation, and stewardship programs.

Project Leads: Steven C. Kerlin and Tara K. Muenz

Collaborators: Lorin Felter, Cinda Waldbuesser, and Samantha Baranski (First State National Historical Park)

Stream Study Programs for Pa. Public Schools

Funded by: Brown Brothers Harriman, First Citizens Community Bank, First Resource Bank, M&T Bank, PECO, PPL Corporation, and Truist

Educators provided boots-in-the-water stream study education and stream-to-screen virtual education programs for K-12 students, who learned

about their impact on waterways and how they can protect and improve this vital resource for all life.

Project Leads: Steven C. Kerlin, Tara K. Muenz, and Jessica M. Provinski

Collaborators: Mandy Nix, David Kline, and Nicole Wickenhauser

Underserved-in-STEM Education Programs

Funded by: Blue Yak Foundation, Anonymous, and Donna Queeney and Nick Kerlin

This fund supports ongoing education with underserved populations in environmental STEM. Audiences include marginalized communities of color; socioeconomically disadvantaged populations; women and girls; English language learners; and other communities disproportionately harmed by environmental injustice. An integral partner in this project, the Harambee Institute of Science and Technology Charter School in Philadelphia, offers community-driven education focused on the origins, status, and future of the African world.

Project Leads: Mandy Nix, Tara K. Muenz, and Steven C. Kerlin

Collaborator: David Kline

Watershed Awareness Using Technology and Environmental Research for Sustainability (WATERS)

Funded by: National Science Foundation

Educators developed and piloted a new national curriculum and extensive learning resources using principles of universal design for learning in California, Pennsylvania, and Virginia, with special attention to students who are English language learners.

Project Leads: Steven C. Kerlin; Nanette Marcum-Dietrich (Millersville University); Carolyn Staudt (Concord Consortium)

Collaborators: Melinda D. Daniels, Diana Oviedo-Vargas, David Kline, Tara K. Muenz, and Mandy Nix

Watershed Education Mobile Lab

Funded by: E. Kneale Dockstader Foundation, Pa. American Water, Pa. Department of Environmental Protection, CCRES Educational and Behavioral Services, Pa. Fish and Boat Commission, National Park Trust, Burkholder Manufacturing, Pengara Design and Production, Full Throttle Wraps and Graphics, and Bass Pro Shops and Cabela's Outdoor Fund

The new lab is a fully outfitted 14-foot box trailer ready to travel to and deliver education programs to underserved schools and communities unable to visit the Stroud Center. It also expands public engagement at parks and festivals.

Project Leads: Tara K. Muenz and Steven C. Kerlin

Collaborators: Mandy Nix and David Kline

Watershed Education Programs While Canoeing

Funded by: Education Program fees, National Park Trust, and Pa. Educational Improvement Tax Credit Program

Stroud Center educators provided watershed education experiences while canoeing on local streams, lakes, and reservoirs for schools, Scouts, community groups, and audiences of all ages.

Project Leads: Steven C. Kerlin and Tara K. Muenz

Collaborators: Mandy Nix and David Kline

Watershed STEM Meaningful Watershed Educational Experience (MWEE) After-School Programming

Funded by: North American Association for Environmental Education, National Oceanic and Atmospheric Administration

Thanks to a generous eeBLUE grant program, educators engaged high-needs students from four 21st Century Community Learning Center (CCLC) sites in MWEEs and watershed-focused STEM.

Project Lead: David Kline

Collaborators: Mandy Nix, Steven C. Kerlin, and Tara K. Muenz; 21st CCLC sites in Coatesville Area, Oxford Area, and Avon Grove school districts

Water Quality App

Funded by: Stroud Center Education Product Development and National Science Foundation

The Water Quality App for Apple and Android mobile devices received updates to its macroinvertebrate digital field guide, pollution tolerance index, and water chemistry parameters.

Project Leads: Steven C. Kerlin and Tara K. Muenz

Collaborators: Heather Mayfield (Foundation for Ohio River Education); and Miriam Steinitz-Kannan (Northern Kentucky University)

West Chester Area School District (WCASD) Water Quality Education Center

Funded by: Pa. Department of Environmental Protection

Educators and restoration staff helped establish and enrich teacher professional development, watershed education curricula, watershed restoration projects, and three outdoor learning stations with interpretive signs at elementary and middle school properties of WCASD in Pennsylvania.

Project Lead: Paul Joyce (WCASD)

Collaborators: Steven C. Kerlin, Tara K. Muenz, Calen Wiley, and Mandy Nix

Virtual Learning Resources

Funded by: Connelly Foundation, Oxford Area Foundation, and Longwood Rotary Foundation

In response to COVID-19 emergency learning conditions, educators created and delivered new and modified watershed education resources for use in nearby nature and stream-to-screen virtual education settings, both during the pandemic and beyond.

Project Lead: Mandy Nix

Collaborators: Tara K. Muenz, David Kline, and Steven C. Kerlin

Watershed Restoration Projects

Agricultural Best Management Practices and Forested Buffers for Chester County Focus Areas

Funded by: Pa. Department of Environmental Protection

This project implements agricultural conservation practices on three Plain community farms in the Honey Brook, Pa., area.

Project Lead: Matthew J. Ehrhart

Collaborators: Brandywine Conservancy; Brandywine Red Clay Alliance; Mowery Environmental, LLC

Agricultural Best Management Practices and Forested Buffers for Lancaster Focus Areas

Funded by: Pa. Department of Environmental Protection

This project implements whole-farm conservation on all four farms in the catchment of a very small unnamed tributary to Pequea Creek in Lancaster County, Pa. The farmers are undertaking comprehensive conservation planning and implementation to address major water quality issues from their dairy operations. Coordination with Stroud Center science staff is underway to document response to restoration efforts.

Project Lead: Matthew J. Ehrhart

Collaborators: TeamAg, Inc.

Agricultural Best Management Practices and Buffers for Middle Schuylkill Focus Area

Funded by: National Fish and Wildlife Foundation

Farmers receive assistance to plan and implement at least 80 agricultural best management practices (BMPs) on the condition that they also install forested buffers on their streams.

Project Lead: Matthew J. Ehrhart

Collaborators: Berks County Conservation District; Cover Crop Coaching, LLC (Steve Groff); Pa. No-Till Alliance; Red Barn Consulting, Inc.; TeamAg, Inc.

Delaware River Watershed Initiative Circuit Rider for Technical Assistance to Grantees

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

The Stroud Center provides technical assistance to grantees of the William Penn Foundation and the National Fish and Wildlife Foundation to develop and implement watershed restoration efforts and grants to monitor the impact of projects implemented in the Delaware River Watershed Initiative clusters.

Project Leads: Matthew J. Ehrhart, John K. Jackson, and David B. Arscott

Collaborators: Bernard W. Sweeney, Jinjun Kan, and Melinda D. Daniels

Delaware River Watershed Initiative Community Science II

Funded by: William Penn Foundation

This project engages watershed residents to be active participants in efforts to document conditions across the focus areas of the Delaware

River Watershed Initiative. Work includes efforts to support monitoring, communication, technical support via a circuit rider, work with farmers of the Pa. Association for Sustainable Agriculture, and technical report details.

Project Leads: Matthew J. Ehrhart, John K. Jackson, and David B. Arscott

Collaborators: David Bressler, Jinjun Kan, Melinda D. Daniels, and Steven C. Kerlin

Delaware River Watershed Initiative Phase II Work in Focus Areas

Funded by: William Penn Foundation

This funding supports the Stroud Center's Robin L. Vannote Watershed Restoration Program to participate in the Delaware River Watershed Initiative's focus areas within the Brandywine-Christina, Middle Schuylkill, and Schuylkill Highlands focus areas where restoration efforts are underway in highly targeted locations.

Project Leads: Matthew J. Ehrhart and John K. Jackson

Delaware River Watershed Initiative Rodale-Stroud Center Collaboration

Funded by: William Penn Foundation

This project enables a collaboration with Rodale Institute to advance knowledge on soil health and impacts on water quality, including a comparison of till, no-till, and organic-based cropping systems. Related efforts will engage farmers and service providers in strategies for soil health and regenerative agriculture.

Project Lead: Matthew J. Ehrhart

Forested Buffers for Farms in the Chesapeake Bay Watershed

Funded by: Pa. Department of Conservation and Natural Resources



Keynote speaker Rick Bieber addresses farmers at the 2021 Pennsylvania No-Till Alliance Summer Field Days. The Stroud Center's Lisa Blazure, who is an associate director on the alliance's board and led planning of the event, also gave a presentation on farming for soil health and water quality. Photo: Steve Groff

This project provides funding for five farms in Lancaster and Chester counties in Pennsylvania to install forested buffers and any needed infrastructure to protect streams from livestock.

Project Lead: Matthew J. Ehrhart

Collaborators: Alliance for the Chesapeake Bay; Mowery Environmental, LLC; Salisbury Township; TeamAg, Inc.

Forest Buffer Tree Seedling Care Initiative 2020

Funded by: Marshall Reynolds Foundation

This project includes site visits to check the status of recently planted buffers, replanting of any mortality, and providing feedback to landowners on status and success of their buffer plantings.

Project Lead: Matthew J. Ehrhart

“Healthy Soils, Healthy Streams” Training and Technical Assistance

Funded by: Pa. Department of Environmental Protection and National Fish and Wildlife Foundation

This project will conduct trainings on soil health and stream health for nearly 6,000 farmers, conservation professionals, and others. The Pa. No-Till Alliance will offer technical assistance on cover crops and no-till farming to at least 24 farmers. The potential for synergy between the alliance and the Stroud Center is promising. The same biological principles — nurturing microbes and other organisms that do the real work — apply to achieving both healthy soils and healthy streams.

Project Lead: Matthew J. Ehrhart

Collaborators: Pa. No-Till Alliance; Cover Crop Coaching, LLC

Improving Success and Cutting Costs on Riparian Buffers

Funded by: Chesapeake Bay Foundation

Chesapeake Bay Foundation’s Keystone 10 Million Trees Partnership contracts with the Stroud Center to test tree planting and maintenance-related materials. The goal is to demonstrate methods that maintain high levels of forested buffer success while reducing herbicide use and total costs. This work is occurring in the west branch of Red Clay Creek.

Project Lead: Matthew J. Ehrhart

Modeling Land Protection Impact Assessment for the Open Space Institute

Funded by: Open Space Institute and William Penn Foundation

This project uses Model My Watershed to communicate the value of forest protection by estimating its impact on water quality.

Project Lead: David B. Arscott

Collaborators: Barry Evans, Lin Perez, and Ali Shokoufandeh (Academy of Natural Sciences of Drexel University); Claire Jantz (Center for Land Use and Sustainability, Shippensburg University)



Farmer Travis Martin and the Lancaster Conservancy’s Fritz Schroeder join Stroud Center staff and other conservation professionals for Lancaster Water Week to engage local families and individuals in education, recreation, and stewardship activities in and around waterways.

Outreach and Installation of Agricultural Best Management Practices in Brandywine-Christina

Funded by: National Fish and Wildlife Foundation

This project installs conservation practices on farms to improve watershed health. It provides outreach, technical assistance, and financial assistance to farmers to plan and implement whole-farm conservation.

Project Lead: Matthew J. Ehrhart

Collaborators: Brandywine Conservancy; Brandywine Red Clay Alliance; Chester County Conservation District; Mowery Environmental, Inc.; Red Barn Consulting, Inc.; TeamAg, Inc.

Partnering for Accelerated Agricultural Best Management Practices in South Central Pa.

Funded by: National Fish and Wildlife Foundation

This project supports the Stroud Center’s continuing efforts on soil health, particularly for outreach and education on cover crops and no-till farming. It also installs conservation practices on farms to improve watershed health.

Project Lead: Matthew J. Ehrhart

Collaborators: Cover Crop Coaching, LLC (Steve Groff); Pa. No-Till Alliance; Red Barn Consulting, Inc.; TeamAg, Inc.

Soil Health and Stream Health for Red and White Clay Creeks

Funded by: National Fish and Wildlife Foundation

This project engages two farmers to implement more than 1,000 acres of cover crops, conduct trials of eight or more innovative methods to advance cover crop and no-till techniques, and create infrastructure that lessens soil compaction and nutrient losses from fields. More than 20 acres of forested buffers will be restored in these watersheds.

Project Lead: Matthew J. Ehrhart

Collaborators: Brandywine Conservancy; Brandywine Red Clay Alliance; Chester County Conservation District; Cover Crop Coaching, LLC (Steve Groff); Mowery Environmental, LLC; Red Barn Consulting, Inc.; TeamAg, Inc.

South Central Pa. Conservation Partnerships

Funded by: National Fish and Wildlife Foundation

This project helps about two dozen farms in Lancaster and Chester counties to install nearly 200 agricultural best management practices, including nine miles of forested buffers and nearly 21,000 acres of cover crops. It also provides outreach and training to more than 11,000 farmers and conservation professionals.

Project Lead: Matthew J. Ehrhart

Collaborators: Alliance for the Chesapeake Bay; Chesapeake Bay Foundation; Chester County Conservation District; Crow and Berry Land Management; Lancaster County Conservation District; Mowery Environmental, LLC; Penn State Agriculture and Environment Center; Red Barn Consulting, Inc.; TeamAg, Inc.

Stroud Center–Alliance for Chesapeake Bay Partnership

Funded by: Alliance for the Chesapeake Bay

This project supports installation and care of about 25 acres of forested buffers after they are planted in the west branch of Red Clay Creek.

Project Lead: Matthew J. Ehrhart

Stroud Center–Pa. Department of Conservation and Natural Resources Buffer Collaborative

Funded by: Pa. Department of Conservation and Natural Resources

This project installs nearly 80 acres of forested buffers and demonstrates the income potential from buffers for fruits, nuts, and salable horticultural materials.

Project Lead: Matthew J. Ehrhart

Collaborators: Brandywine Conservancy; Berks County Conservation District; Chester County Conservation District; Crow and Berry Land Management; Mowery Environmental, LLC; Red Barn Consulting, Inc.; TeamAg, Inc.

Stroud Center–Pa. Department of Conservation and Natural Resources Forested Buffer Partnership 2020

Funded by: Pa. Department of Conservation and Natural Resources

This project restores 30 acres of forested buffer in the west branch of Red Clay Creek and includes care after planting. The buffers are part of whole-farm work on a former dairy farm in the headwaters of the watershed.

Project Lead: Matthew J. Ehrhart

Collaborator: Hicks Brothers, LLC

Support for a Coalition on Soil Health in Pennsylvania

Funded by: National Fish and Wildlife Foundation

This project establishes the Pennsylvania Soil Health Coalition to improve communication and coordination among numerous organizations involved with soil health education, implementation, and research. Coalition member organizations will conduct educational programming on soil health, collect soil health samples for analysis, and implement no-till, cover crops, or rotational grazing on 12,600 acres.

Project Lead: Matthew J. Ehrhart

Collaborators: Pa. No-Till Alliance; Pasa Sustainable Agriculture, Capital RC&D, The Nature Conservancy

Targeted Agricultural Best Management Practices and Forested Buffers for Lancaster County Focus Areas

Funded by: National Fish and Wildlife Foundation

In targeted portions of the Chesapeake Bay watershed in Lancaster and Chester counties, Pa., the project implements whole-farm systems of best management practices on about two dozen farms, restores about 50 acres of forested buffers, and prepares Comprehensive Nutrient Management Plans.

Project Lead: Matthew J. Ehrhart

Collaborator: TeamAg, Inc.

Targeted Agricultural Best Management Practices and Forested Buffers for Chester County Focus Areas

Funded by: National Fish and Wildlife Foundation

This project implements agricultural best management practices and forested buffers on farms, which includes stormwater-runoff controls for barnyards and mushroom compost processing areas, new and seasonally earlier cover crops, improved no-till practices, riparian forest buffers and related infrastructure, and more.

Project Lead: Matthew J. Ehrhart

Collaborators: Hicks Brothers, LLC; Mowery Environmental, LLC

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2021

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Two members of the 2020 U.S. Olympic Equestrian Team, Boyd Martin and Phillip Dutton, enjoy an evening with Stroud Center board members Bob Johnston and Michael Bucklin at The Water's Edge. Photo: Elizabeth Hedley

Gifts and Contributions



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We gratefully acknowledge the many donors who generously contributed more than \$483,000 to the 2021 Annual Fund. These vital funds cover expenses across the Stroud Center's work. On behalf of our research scientists, environmental educators, the watershed restoration team, and all of us, **thank you** for strengthening our work.

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A young Earth Day volunteer takes a break from tree maintenance near Buck Run Creek in Chester County, Pa. Photo: Jana Bannan Photography

“In all the years I’ve been involved with Stroud Water Research Center, either on the board or as a volunteer, I’ve never had a moment that I haven’t been totally inspired, impressed, or educated! The international staff is so dedicated to preserving fresh water and teaching the rest of the world how it can be done. I selfishly stay involved as I’ve learned so much about our environment and how to be a better steward.”

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Nita Greer, John Spence, and Vicki King are all smiles during The Water’s Edge.
Photo: Elizabeth Hedley

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Tim Sheppard and Victoria Downing at Chukkas, Caddisflies, and Chapeaus.
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Hard-working members of The Water's Edge Committee Katherine Bucklin, Brooke Moorhead, Evie Dutton, and Amy Borun enjoy the evening.
Photo: Elizabeth Hedley

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*“ My husband and I
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1 | RESEARCH

Empower renowned scientists to further their work and recommend ways to deliver fresh, healthy water around the world for generations to come.

2 | EDUCATION

Enable educators to utilize technology to enhance and expand education beyond the classroom.

3 | RESTORATION

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(A) Paddle Push participants enjoy a hike by Snow Lake in Washington. (B) Brandywine Polo pro Martin Estrada shares his knowledge of polo with attendees at Chukkas, Caddisflies, and Chapeaus (photo: Jana Bannan Photography). (C) Rikki Saunders and Dale Frankel at The Water's Edge (photo: Elizabeth Hedley). (D) The Fries family enjoys time on a lake in Ohio during the Clean Water Paddle Push.

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Financials

OPERATING STATEMENT

for the year ended December 31, 2021

REVENUES & SUPPORT

Watershed Restoration Group Programs	\$ 2,647,299
Research Programs (Grants and Contracts)	2,192,462
Endowment	1,938,806
Annual Fund	483,245
Education/Public Programs	472,986
Other Contributions and Income	459,737
Total Revenues & Support	\$8,194,535

EXPENDITURES

Research	\$ 2,492,503
Watershed Restoration Group	2,381,468
Facilities	1,229,766
Finance and Administrative	725,381
Education	476,994
Information Services	444,414
Development/Outreach	388,341
Communications	48,434
Other	7,234

Total Expenditures **\$8,194,535**

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 Belfint, Lyons & Shuman. Investment assets are managed by New Providence Asset Management, Passive Capital Management, and Brown Advisory. The Stroud 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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Visit www.stroudcenter.org/donate



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Please visit our website: www.stroudcenter.org or contact the Development Department at 610-268-2153 or development@stroudcenter.org to learn about special giving opportunities.





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To learn how you can get involved,
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“The Stroud Center’s efforts are as nearby as next door, yet also span the globe — they are often able to help well beyond our borders. Their research, restoration projects, and often free educational programs are invaluable, helping to ensure clean water presently and for generations to come!”

— ELLE KUEHNER

Volunteers from Resolution Life help plant trees for healthy streams.

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We gratefully acknowledge and appreciate all of our sponsors and volunteers, as well as our staff members who volunteer on top of their other responsibilities. By generously donating time, talents, or treasures, this dedicated group directly benefits our research, education, and watershed restoration programs. *Thank you!*

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attendees who make this event
so successful.*



USI Insurance help collect data on trees that were planted in 2017. The collected data is analyzed to determine the survivability and growth rate of tree species in varying shelter arrangements.



**join
us!**

We hope you'll join us for fabulous events, either virtually or in person, this year. Go to www.stroudcenter.org/events to learn more.

At our Chukkas, Caddisflies, and Chapeaus event at Brandywine Polo Fields, (A) Joseph and Allyson Debes enjoy the day, (B) the Debes grandchildren are all smiles, and (C) a beautiful arrangement of cookies donated by The Lucky Cupcake Company took center stage (photos: Jana Bannan Photography). (D) Horses clear one of the fences at the Willowdale Steeplechase. (E) Kids explore the water through fishing and boating at Marsh Creek State Park during the Clean Water Paddle Push. At the Fore Fresh Water Golf Invitational, (F) Ryan McMahon, Fritz Stueber, Mark Trani, and Chris Smith smile with volunteers from Resolution Life, and (G) Golf Outing Committee member Bob Johnston presents an award to Nick Demourtzidis. (H) Roz McPherson, Yeda Arscott, and Lee Clark, as well as (I) Ed and Diane Herr and Dixon Stroud, enjoy an evening at The Water's Edge (photos: Elizabeth Hedley).

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(A) Stroud Center scientists score big on an electrofishing trip near French Creek, finding seven species of fish. (B) Jinjun Kan brings his son, Calvin, to work to show him how scientists (literally) make it rain. (C) Jake Price winds through a maze of maize to set up scientific equipment at the Stroud Preserve. (D) Daredevil Mike Gentile climbs an old tree to grab data in White Clay Creek State Park. (E) It's a divine day for Dave Arscott out in the field. (F) Diana Oviedo-Vargas is ready to simulate rainfall at the Stroud Preserve. (G) Kay Dixon (retired) and Sherman Roberts greet the newest and youngest member of the Stroud Center staff family, son of Marc Peipoch. (H) Stephanie Bernasconi doesn't let a bit of ice stop her. (I) Courtland Hess brings the office to the outdoors. (J) Rebecca Duczowski, Scott Ensign, and Jess Provinski are ready for an evening of environmental films at the Wild & Scenic Film Festival hosted by Trail Creek Outfitters.

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The Stroud Center gratefully acknowledges the service of Barbara C. Riegel, emeritus, who retired on December 23, 2020 after decades of service.

**The Stroud Center gratefully acknowledges the service of William LaFond who retired on May 18, 2021.*

***At the September 2021 board of directors meeting, the board acknowledged the many years of dedicated service of Frederick L. Meserve Jr., and he was granted emeritus status.*



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Stroud™ Water Research Center seeks to advance knowledge and stewardship of freshwater systems through global research, education, and watershed restoration.

