

2011

Pulse of the Heartland Annual Report

Presented by the

SRHCES



**Susquehanna
River
Heartland
Coalition for
Environmental
Studies**



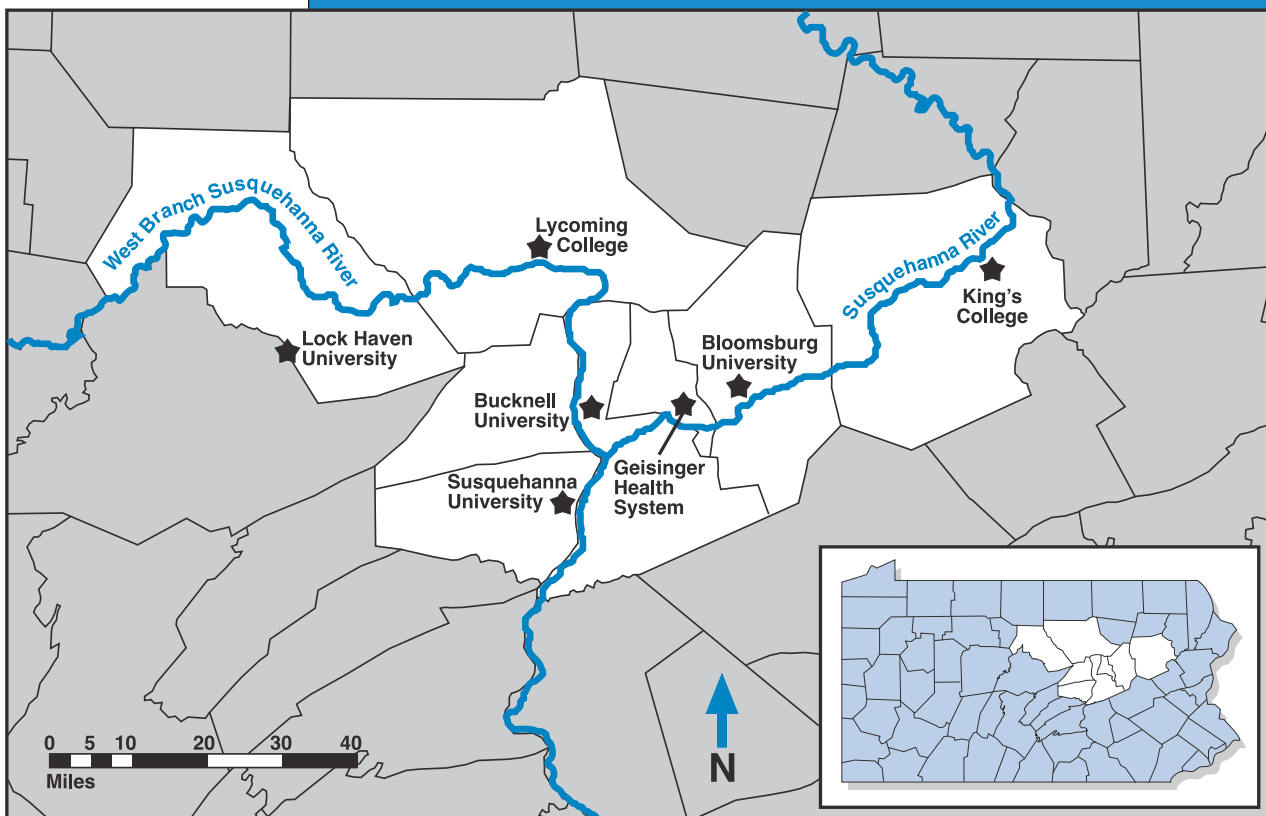


Susquehanna River Heartland Coalition for Environmental Studies

The Susquehanna River, and the watershed it encompasses, are arguably this region's most important assets in defining the quality of life for all who live, work and play within its boundaries. Because the Susquehanna River provides half of the fresh water that reaches the Chesapeake Bay, its influence extends beyond Pennsylvania to the lives of many within the Chesapeake Bay area.

In recognition of this tremendous asset, six regional colleges and universities joined other partners, including Geisinger Health System, Trout Unlimited, Northcentral Pennsylvania Conservancy, the Forum for Pennsylvania's Heartland and SEDA-COG, to work with state agencies and Chesapeake Bay affiliates to form the Susquehanna River Heartland Coalition for Environmental Studies (SRHCES). Through the Coalition, the faculty and staff's impressive talents are engaged to address environmental issues within the watershed. Additional promotion and support for this effort have come from sponsors such as WVIA (Northeastern Pennsylvania's public broadcasting station), Sunbury Broadcasting Co., The Daily Item, the Foundation for Pennsylvania Watersheds and the Degenstein Foundation.

Included in this report, you will find summaries of the projects and activities within the various fields in which SRHCES has become involved. Additionally, you will find updates on our partner the Nature and Human Communities Initiative, the efforts of Sunbury Broadcasting, and information regarding the Marcellus shale drilling that has become prevalent in the region.



Map provided courtesy of Jeff Brunskill, Department of Geography & Geosciences, Bloomsburg University

For more information about SRHCES, please visit www.SRHCES.org.

Monitoring the Susquehanna

Dr. Matt McTammany
Bucknell University



Dr. Matt McTammany, professor of Biology and Environmental Studies at Bucknell University, worked on several projects this summer. Currently, he is studying a site on the West Branch Susquehanna River at Milton, and two sites on the Susquehanna River at Danville, and Shady Nook. Among these three sites, there are ten sampling locations.

Dr. McTammany is looking at how types of macroinvertebrates vary based on different habitats. To study this he and his students are testing the velocity, depth, temperature, pH, oxygen, and alkalinity of the water, as well as differences in the vegetation and algal communities at the sites. He is especially interested in how the conditions in the river are affected by internal biological processes, including photosynthesis and respiration, versus the human influences on the river.

Sites in Danville and Milton are also being used to get basic water quality measurements. Data loggers placed in the West Branch Susquehanna River and the north branch of the Susquehanna River collect information on the turbidity, oxygen levels, and other water quality measurements every fifteen minutes, and these results are posted on the internet every hour so that the public has access to the river's water quality at all times. This information also helps Dr. McTammany to track the daily, seasonal, and annual dynamics of water quality and how the river changes over time. For more information on the dataloggers and their installation see the 2009 Pulse of the Heartland report.

Additionally, the Department of Conservation and Natural Resources (DCNR) is providing Bucknell access to the south branch of Roaring Creek, a protected water supply watershed. With DCNR's permission Dr. McTammany and his students are studying the physical, chemical, and biological patterns of the largest of the reservoirs in Roaring Creek and watershed-scale biogeochemical processes.



Dr. McTammany taking notes

Dr. McTammany was also one of three professors who taught "Bucknell on the Susquehanna," a semester-long course that connected various classes regarding the Susquehanna River in terms of biology, geology, natural history, land use impacts, and human impacts on water quality. The students who were a part of this program spent their semester in the field almost every day, traveling to different parts of the watershed as they studied various aspects of the river. This program will take a different form in future years, but is expected to continue.



The Susquehanna River Heartland Coalition for Environmental Studies (SRHCES) is a unique collaboration of professors and students working together to:

- Research and study the ecological conditions and processes in the watershed of the Susquehanna River and the West Branch Susquehanna.
- Create educational opportunities to promote student interest and involvement in the natural resources of the Susquehanna River watershed.
- Create a partnership that connects post secondary students attending institutions in the Susquehanna heartland region with local communities and environmental organizations.

The focus of the majority of the coalition members is to gather data to assess various parameters of the Susquehanna River. This section of the Pulse provides summaries on a variety of research that SRHCES members are conducting. This is by no means a full description of the projects, research, and activities the members have undertaken.

The group's website, www.srhces.org, is being re-built. Please keep checking back for updates and progress on these projects, and information on new projects as they develop.



McTammany and his students also spent time this summer working with Sean Reese, the Susquehanna River research technician at Bucknell's Environmental Center. Reese coordinated an effort to study the mussel populations near the sondes at Milton and Danville. This would allow the water quality data from the sondes to be reviewed as part of the mussel survey results.

This baseline study provides information on the types of mussels present and their density. Reese hopes that this qualitative study can be followed up later with a more quantitative study. The Susquehanna's mussels are relatively unstudied compared to other large water systems like the Mississippi River and Ohio River. The higher than normal water flows this year prevented the crew from getting to both sites. While Milton was completed, Reese and the team did not get to Danville. He hopes to continue the work in 2012 and get the Danville site complete.

Dr. Carl Kirby *Bucknell University*



Dr. Kirby is a Professor of Geology at Bucknell and the director of the Marcellus Shale Initiative of Bucknell's Environmental Center. He is currently working on several projects involving Marcellus shale. Dr. Kirby is writing up his research on the inorganic geochemistry of Marcellus shale flowback waters. (see the Marcellus Shale section of this report for more information on the drilling process) As part of the drilling process "fracking" occurs. Fracking involves a high-pressure injection of water, sand, and chemicals, into the well bore to release the gas. These flowback waters may have picked up additional components from the rocks and geology they are exposed to underground. Dr. Kirby is studying how the water chemically changes from injection to flowback. Barium and strontium, as well as indicators of radiation have been found in this water. He also studies how the flowback water chemistry varies between drilling sites. This process of tracking the changes in water is referred to as geochemical modeling.

On another project Dr. Kirby is collaborating with researchers from the University of Pittsburgh and the University of Binghamton. The researchers are "fingerprinting" the Marcellus Shale flowback waters, or determining the various chemicals that indicate differences between Marcellus waters and mine drainage or road salt runoff, all of which are salty, resulting in high conductivity. In order to establish a unique fingerprint, these researchers will examine many other parameters, including major and minor elements and light stable isotope ratios, which will likely prove different in different potentially contaminated waters.



Frack equipment

Finally, Professor Kirby is supervising the growth of the Marcellus Shale Publications Database (for more info go to www.bucknell.edu/MarcellusShaleDatabase). This website is designed to provide scientists, regulators, and citizens access to the research being done on Marcellus shale development, other similar non-conventional shale resources, and fracking and provides the general public with information on how to find publications that are usually only readily available to those with access to university libraries. The database does not evaluate news reports, and it offers information about how to find the most reliable sources for information, such as peer-reviewed journals. Plans are to continue to add to the database to provide the public with as much information as possible.

Dr. Md. Khalequzzaman *Lock Haven University of Pennsylvania*



Dr. Md. Khalequzzaman (Dr. K), Professor of Geology at Lock Haven University of Pennsylvania, is currently assessing water quality in three areas of Clinton and Centre counties. Assisting in this effort are three student interns and retired professor, Dr. John H. Way.

Two of these projects are taking place in the Beech Creek watershed. Along with members of the Centre County Senior Environmental Corps, Dr. K's teams have been collecting water samples from 12 locations to assess baseline water quality before drilling for Marcellus shale natural gas occurs. They are testing both upstream and downstream from the permitted drilling sites with the intention of assessing any changes in the water quality during or after drilling. The teams collect water temperature, alkalinity, total dissolved solids, conductivity, dissolved oxygen, oxidation-reduction potential, and stream-flow data in the field. Subsequently, water samples are taken to the laboratory where they are further analyzed.





Dr. K and student surveying water ways



In addition, Dr. K is working on research related to acid-mine drainage. In 2006, the Department of Environmental

Protection's (DEP) Bureau of Abandoned Mine Reclamation (BAMR) completed a passive acid-mine drainage treatment facility in the Middle Branch subwatershed of the Beech Creek watershed. The acid mine drainage is the legacy of the coal mining done in the area. Since it went online, Dr. K and his students have been collecting data and assessing the treatment facility's operation in terms of improving the region's water quality.

The newest project the Lock Haven professors are working on involves the Hall Run watershed, a small watershed which serves as South Renovo Borough's water supply. This watershed provides drinking water for over 500 people. Concerned that the water quality could potentially be affected by Marcellus shale natural gas drilling activity in adjacent watersheds, Dr. K and his team are collecting water-quality data from this watershed to establish a baseline dataset. Looking ahead, they are hoping to partner with fish biologists and macrobiologists to perform additional assessments.

Dr. Jack Holt

Susquehanna University



Susquehanna University

Dr. Holt, a professor at Susquehanna University, studies algal communities in his various projects. For the Susquehanna River Assessment, he is looking at the different species of algae currently growing on rocks in the Susquehanna River. In order to discern the different algal communities present, Dr. Holt is using biofilm, which is generally made up of multiple types of algae, some films containing up to 25 different species. The biofilms are removed from their hosts and transferred to test tubes where they are treated with concentrated acids. The chemical reaction caused by the acids helps allow scientists to differentiate between various species and identify the algae present.

Another way this can be done is by putting artificial substrates straight into the river. These contain glass slides that the biofilm can develop on. This is more accurate because the biofilm doesn't have to be scraped off of the rocks, which can often cause certain components of the biofilm to shatter.

The algal communities are identified by design, complexity, and other factors. Dr. Holt is looking at the similarities and differences between various species. Last year, when there were high levels of water, the algal communities were 80-100% similar. However, during a dry year, communities have been as low as 20% similar. Because communities of algae take about three weeks to stabilize, the presence of specific algal communities can tell researchers a lot about the water.



Rock baskets on bank of Susquehanna ready for submersion

Dr. Holt is also looking at benthic macroinvertebrates in certain areas where he studying algal communities. These areas include Mahantango Creek and Middle Creek, located in Snyder and Juniata Counties. Both creeks are tributaries to the Susquehanna River below the confluence with the West Branch Susquehanna River.

On another project, Dr. Holt is working with Bucknell's Professor McTammany to look at plankton in area waterways. The presence of plankton in rivers is usually rare because river systems are typically flushed out by the constant flow of water. The fact that there is plankton present in the Susquehanna River means that the plankton must be coming consistently from a source outside of the river or the plankton are reproducing as quickly as they are being flushed out. In this study, Dr. Holt is looking at these questions on a smaller scale in hopes of answering them.

Dr. Jonathan Niles

Susquehanna University



Susquehanna University

Dr. Jonathan Niles, a professor at Susquehanna University, is one of three Susquehanna River Heartland Coalition for Environmental Studies working with the Pennsylvania Fish and Boat Commission on the Unassessed Waters Initiative. Working with his students, Dr. Niles completed surveys on 80 streams this summer. Of those 80 streams, 64 had trout. The data has been forwarded to the Pennsylvania Fish and Boat Commission for review and processing.

While sampling for fish, Dr. Niles and his students also conducted benthic macroinvertebrate surveys, algal sampling, and standard water quality testing. The algal communities is something Dr. Niles works on with his colleague at Susquehanna University, Dr. Holt.

Dr. Niles is also doing work on the west and north branches of Mahantango Creek, along the border of Snyder and Juniata Counties. He is sampling the fish, macroinvertebrate, and algal communities in this area. These studies allow for Dr. Niles to assess the stream's health and water quality. In this project he is also working alongside Dr. Holt, who is measuring both water quality and the algal communities in the same area.



Susquehanna University students of Dr. Niles surveying a stream

Dr. Peter Petokas

Lycoming College

Dr. Petokas, a professor at Lycoming College, continues his long-term monitoring of Eastern Hellbender populations on the West Branch Susquehanna River. The project is now in its sixth year and over one thousand hellbenders have received implanted microchips. Strictly a North American species, the hellbender has been declining throughout its entire geographic range and is now under review for possible federal listing as threatened or endangered.



Lycoming College Students of Dr. Petokas monitoring stream for the Eastern Hellbender.

The two locations where the hellbender seems to be doing best are in the West Branch Susquehanna River sub-basin and in northern Georgia. Current results indicate that most existing West Branch populations are stable and self-sustaining, but at least one major population has declined precipitously in the past six years. Possible causes of the declines are diseases such as amphibian chytrid fungus, chemical pollution including endocrine disruptors, and invasive species such as the rusty crayfish. Habitat degradation has also limited where hellbenders can survive in Pennsylvania waterways.

As Dr. Petokas and his team of students continue their monitoring efforts, they are also developing plans for enhancing stream habitat through placement of large, flat rocks which serve as cover for hellbenders, constructing and placing artificial nesting chambers in areas where there are few suitable nest rocks, and head-starting larval hellbenders for release in areas where populations have declined or where populations have disappeared completely. This year the team is also assisting the Hellbender Recovery Team in New York where the species has all but disappeared in the North Branch of the Susquehanna River.

Another project that Dr. Petokas and his students have been conducting is a study of vernal pool ecology. They have been monitoring seasonal water chemistry of the pools, physical and hydrological conditions, and use of the pools by plants and animals. They are currently using drift fences to monitor migration by amphibians to and from the pools. Future efforts include vernal pool construction in areas where pools once occurred, but were destroyed by forestry practices, agriculture, or other human development activities.



Dr. Petokas and his students provide education and outreach to local schools, environmental groups, and the general public. If you would like to report a Hellbender sighting, request information on the Eastern Hellbender or vernal pool ecology, or schedule a presentation for a group, Dr. Petokas can be reached via email at petokas@lycoming.edu.



Dr. Petokas and his students completed an inventory of the plants and animals at Camp Victory near Millville, PA, in 2010. The inventory results and educational materials that were created were intended for use at a proposed camp nature center. With funding for construction now available, Dr. Petokas is assisting the advisory committee and the architect with the design of the new nature center.

Dr. Mel Zimmerman

Lycoming College



Dr. Zimmerman, professor of Biology at Lycoming College, has continued his work with the Pennsylvania Fish and Boat Commission on the Unassessed Waters Project this year. His focus is on the Pine Creek Watershed, where there are over 300 unassessed streams. He and his students completed 96 streams this year. Over half were found to have trout. This year, Dr. Zimmerman was a recipient of the Pennsylvania Wilds Award for conservation efforts related to his unassessed waters work.

Another of Dr. Zimmerman's projects is being done on the West Branch Susquehanna River. The focus is on 12 different sites between Lock Haven and Sunbury. He and his students are monitoring these sites by placing rock baskets in the river to sample for algae. They are also collecting macroinvertebrates and fish using a shoreline sein. They collect monthly samples of water all year round to test for nitrogen, phosphorus, conductivity, and total dissolved solids. This is the third year Dr. Zimmerman is monitoring these sites.

Finally, Dr. Zimmerman is working with Lycoming County Conservation District. He is providing base-line water quality data so that the conservation group can work with the farmers of White Deer Creek Watershed to support best management practices (BMPs). It is hoped that the BMPs will reduce the nutrients being put into the Chesapeake Bay as part of the Chesapeake Bay Initiative.



Lycoming College students of Dr. Zimmerman assess a waterway.

Dr. Christopher Hallen and Dr. Cynthia Venn

Bloomsburg University of Pennsylvania



Dr. Christopher Hallen, professor of Chemistry, and Dr. Cynthia Venn, professor of Geography and Geosciences, have been working together to analyze the chemical content of the water in the Susquehanna River and the West Branch Susquehanna River. They currently have sampling sites in Danville, Milton, Shady Nook, and Watsontown. The two professors are studying the same areas as the biologists involved, but with the goal of providing information on the chemistry of the water that could potentially affect the biology.



Bloomsburg students analyzing the West Branch of Fishing Creek

After taking water samples from multiple sites on the river, they analyze the raw sample on site for turbidity and preserve triplicate samples to analyze later for metals. They then filter the remainder of the water samples and test for alkalinity and acidity.

Back at the lab, they test the water for negative ions, including chloride, fluoride, bromide, nitrate, nitrite, phosphate, and sulfate, as well as positive ions, including calcium, magnesium, potassium, and strontium. Analysis for various metals is performed in the lab using atomic absorption spectroscopy.

Last year, high levels of lead were found in the water at some sites near Shady Nook, whereas this year, high levels of sulfate have been found at several sites. This year's metal analyses are still pending, awaiting new instrumentation. Dr. Hallen and Dr. Venn are looking at a variety of possible explanations for these levels.

Dr. Hallen and Dr. Venn are working with their students to study the water quality of Hunters Lake northeast of Hughesville. The lake is within the Fishing Creek watershed. Fishing Creek is the source of Bloomsburg's drinking water. By testing the chemistry of the water before Marcellus Shale drilling occurs, they hope to be able to gather baseline chemical data that will enable them to detect any changes in water chemistry that might result from the drilling operations.





Dr. Rier's interns sampling a stream

Dr. Steven Rier

*Bloomsburg University
of Pennsylvania*



Dr. Steven Rier, associate professor of Biology and Ecology at Bloomsburg University, has been studying the effects of phosphorus on stream microbial communities in 26 different streams in the area. He and his student interns have been studying how algae and bacteria growing on the bottoms of streams use brief pulses of phosphorus that are associated with storm runoff. Because many types of algae and other microorganisms are capable of storing phosphorus for a "non-rainy day" and most phosphorus disappears from the stream water during periods of low flow, it is possible that phosphorus pulses during storm runoff are an important source of this essential nutrient for these ecosystems. Understanding phosphorus pulse dynamics has a number of practical applications including reducing nuisance algal blooms in streams and reducing nutrient export to the Susquehanna River and ultimately the Chesapeake Bay.

This project includes measuring phosphorus concentrations in the water both at high and low flow, determining how much phosphorus is being stored by the microorganisms and measuring a number of metabolic processes associated with nutrient availability including photosynthesis, respiration, extracellular enzyme activities and nitrogen and phosphorus uptake rates.

Dr. Rier and his students are also working on a project to build artificial streams on campus. This would provide them with an environment where they can manipulate phosphorus in a more controlled setting and begin to develop empirical models describing phosphorus pulse dynamics in streams.

Dr. Ahmed Lachhab

Susquehanna University



**Susquehanna
University**

Dr. Ahmed Lachhab, assistant professor of Earth and Environmental Sciences at Susquehanna University, is continuing to focus on water quality around the Shady Nook area. He is studying the mixing dynamics of water from the West Branch Susquehanna River and the north branch of the Susquehanna River. The study includes measurements ranging from nutrient load to chemical and physical properties in order to assess the condition of this segment of the river.

This summer, Dr. Lachhab has selected 11 sites along the entire length of Middle Creek to study the impact of farming activities as well as the effect of Walker and Faylor Lakes, located near the headwaters. The investigation of Middle Creek is important, as it is one of the tributaries of Susquehanna River. Dr. Lachhab believes that problems being faced within Susquehanna River and the Chesapeake Bay can be solved upstream at the level of small streams such as Middle Creek. The research involves the analysis of stream water nutrients, chemistry, physical properties, and hydrology. To monitor the water, he is looking for trends in all these parameters. He is also integrating his work with biological findings in a group effort with aquatic ecologists.



Dr. Lachhab of Susquehanna University

Another project of interest to Dr. Lachhab involves geophysical hydrology. He is tracking groundwater using geophysical techniques such as seismic refraction. He has recently developed two facilities at the Center for Environmental Education and Research (CEER) at Susquehanna University for this purpose.

Dr. Carlos Iudica

Susquehanna University



**Susquehanna
University**

Dr. Carlos Iudica, associate professor of Biology at Susquehanna University, takes a different approach to research than many of his colleagues in the Susquehanna River Heartland Coalition for Environmental Studies. Instead of studying water quality or animals in the River, he is focusing on the animals that live along the River, including birds, reptiles, and mammals.



A skull used in Dr. Ludica's studies

One of his main projects is studying the feeding ecology of minks in the area. This study, is using about 150 minks and focuses on the minks' diets. This allows Dr. Ludica to obtain information about the roles different prey play on the survivorship of these important small riverine carnivores. He is also looking at the levels of mercury found in the minks' fat tissue, which could possibly be a link to mercury levels in the water.

Dr. Ludica is also wrapping up a study on gray and red foxes in the Susquehanna Basin. After completing four years of this research, he is currently writing a paper to submit for publication. This research revolves around the question of how two similar carnivores, gray foxes and red foxes, are able to live in the same area and still thrive, with neither species forcing the other one out. Ecological questions such as how the two species avoid competition, especially regarding diet have been the main focus of Dr. Ludica's work.

He is working on a paleoecological study of cave sediments. The cave acts as a time capsule, holding materials as they accumulate over time. This allows Dr. Ludica and his students to study the layers of the soil in order to determine which species were present during which periods of time. He identifies bones found in these soil samples to determine the different species. This study helps to show not only what is happening in the area now, but also what animals inhabited the area in the past.

Dr. Ludica is writing a book on bats. Similar to his other projects, this relates to the River because bats rely on the waterways for food. He will be looking at the ecology of 11 species of bats as well as a new epidemic, known as "white nose syndrome." The syndrome is the result of a fungus that has recently begun to kill bats in huge numbers during the time that they hibernate. This research is important because bats are extremely important for pest control in terms of insects that destroy crops. He hopes to have completed the first draft of this book by next summer.

Dr. Ludica has also been invited to write a chapter in a book being written by Dr. Howard Whidden,

a professor of Biology at East Stroudsburg University. Dr. Ludica will use his research on the ecophysiology of bats to write about a local maternity colony of little brown bats, currently affected by white nose syndrome.

Dr. Brian Mangan *King's College*



A professor of Environmental Science and Biology at King's College, Dr. Mangan is studying mercury contamination in the Susquehanna River. Consumption advisories for Susquehanna River fishes have been issued for many years because of contaminants such as mercury and PCBs. Dr. Mangan is attempting to discover how mercury is entering the fish by looking at small fish and the organisms on the bottom of the river. His focus last year was on crayfish, and he showed that their mercury burden depended on where they were in the river. He found that the concentration of mercury in the crayfish decreased from upstream to downstream locations.

From this year's information, Dr. Mangan hopes to uncover the major food pathways for mercury through the aquatic food chain. In addition, he is investigating if mercury can travel from the river to nearby forests through the bodies of aquatic insects. To do this, he is studying a common insect predator living in riparian forests, a spider known as the Spined Micrathena (*Micrathena gracilis*). He has already shown that mercury is present in these spiders and is now comparing mercury burdens between spiders from riparian forests and upland forests.



The web of a Spined Micrathena

Additionally, Dr. Mangan is studying invasive species in the Susquehanna River, including Asian Clams, Zebra Mussels, and the Rusty Crayfish. The Rusty Crayfish, a native of the Ohio River Drainage, has invaded Pennsylvania largely from bait-bucket introductions. Dr. Mangan has found that Rusty Crayfish are now established at a number of his sampling locations in the Susquehanna between the New York boarder and Harrisburg. Where Rusties occur in the river, the native Allegheny Crayfish is no longer present.



Marcellus Shale Natural Gas

Marcellus Shale and Its Development

Marcellus shale is a formation of fine-grained, black rock that contains natural gas. The formation covers the entire northern and western parts of Pennsylvania and extends into portions of New York, West Virginia, and Ohio. The result of the solidification of ordinary mud, the shale is approximately 390 million years old and was originally deposited at the bottom of an inland basin. The basin was akin to an inland ocean. The water did not have any oxygen in it, which the organic material (such as plants and insects) needed to survive. Without oxygen, the organic material died and fell through the water to the bottom of the ocean floor, where the organic material was eventually buried over millions of years. Under thousands of feet of rock, the organic material became pressurized and cooked into natural gas. Now, the natural gas is locked in the shale formation itself.

Gas exploration and development companies from across the country are now working in Pennsylvania to drill into this formation and extract the natural gas, which is a relatively cleaner fossil fuel than coal. The drilling is having a profound effect throughout the Appalachian plateau of Pennsylvania. Development of the deep wells and the well sites — including construction of the entire supporting infrastructure: roads, compressor stations, pipelines, etc. — is just beginning to ramp up.



Well pad being constructed

The process of developing a well begins with constructing a wellpad for the drilling and production processes. Typically, a level area between three and five acres in size is created and stabilized with stone along with an access road to allow the rig, other equipment and materials to reach the site.

The drill rig and associated equipment is brought on the wellpad and assembled. The drilling process begins with a vertical well being drilled. Various fluids are used to keep the drill bit cooled and lubricated. Casing and cementing occur at various stages during the process to prevent the drilling from contaminating ground water.



Drilling rig

Developing a well for extraction of natural gas from the Marcellus shale is the same process used to extract gas from a variety of other geologic formations through the drilling of the vertical bore. The differences begin to emerge in the next phase.



Drill bit

Once the desired vertical depth is reached, the drill bit is turned and begins drilling a horizontal leg. Because of Marcellus's structure, the wellbore needs to expose as much surface area within the shale layer as possible. The drilling equipment is then removed, and hydraulic fracturing begins.

Hydraulic fracturing has been used in Pennsylvania since the 1960s. This small scale fracking was done to stimulate wells and to create or expand storage fields for natural gas.

Small holes are created along the well bore. Water, sand, and various chemicals are then pressurized and sent down the bore and through these holes. The sand particles prop open the fissures created in the formation, allowing the gas to escape. This process is known as hydrofracking and requires millions of gallons of water. While most companies are re-using their water, there are still concerns about adequate treatment of the waste water when it can no longer be used.

The drilling and extraction process have raised many questions about how this development could impact water quality, air quality, habitat

Tankers
like this
are used
for hauling
water for
the
fracking
process



fragmentation, and the spread of invasive species. The Susquehanna River Heartland Coalition for Environmental Studies (SRHCES) is well-positioned to launch a nonbiased, information, and research initiative to address important questions relating to the impact of shale gas activities in Pennsylvania.

The SRHCES's members have the experience and the technical knowledge to monitor and analyze flowback water, ground water, and surface water. Several of the SRHCES researchers have spent time studying and analyzing streams and other water systems. The group has members who have studied habitat changes and the impacts faced by animals from these changes. SRHCES is also building competency in understanding social-ecological system interactions and how these, in turn, influence long term community well-being throughout the Susquehanna River basin.



Completed well pad

Why Science is Needed

Marcellus shale natural gas (MSNG) has been a major topic of conversation across many areas of study as well as among people living in areas affected by the drilling. Because Marcellus shale natural gas drilling has just recently expanded, the impacts of this drilling are not yet known, but a lot of research is underway in order to find out.

Marcellus Shale lies under portions of Maryland, New York, Ohio, Pennsylvania, and West Virginia.

Due to the high demand for natural gas, drilling has increased. The third largest natural gas reserve in the world, some estimates show that the Marcellus shale formation could provide the United States with a 100-year supply of natural gas.



Once drilling is complete, a "Christmas tree" is placed at the surface

Marcellus shale natural gas drilling is regulated at federal, state, and local levels in different degrees. Permits are necessary for a plethora of different situations — for well drilling; water management; erosion, sediment, and storm water control; water quality management; solid waste transportation (the material brought up during drilling); water withdrawal (water removed from streams and surface water sources for use in the fracking process); dam safety (if water impoundments are created to store clean or used fracking water); construction and operation of pipelines; and highway occupancy (to allow access roads onto state and township roads), among other things (Marcellus Shale Citizens' Guide pages 4-6). More information about what these permits include as well as what exactly they are needed for can be found at: http://www.mde.state.md.us/programs/Land/mining/marcellus/Documents/marcellus_citizens_guide.pdf, a citizens' guide created by the National Sea Grant Law Center and Pennsylvania Sea Grant.

Despite permits and regulations put on Marcellus shale natural gas drilling, there are many unanswered questions. There are researchers working hard to answer some of these questions. The Susquehanna River Heartland Coalition has put a large focus on Marcellus Shale impacts this year, both in their research as well as through a project where they have developed questions they feel pertain to the land and the people of Pennsylvania. (see sidebar on "Critical Questions", page 13) The group spent several months discussing what they could and should do. They decided since they are both researchers and educators they should begin by cataloging their questions.

Many of the professors working with the Susquehanna River Heartland Coalition for Environmental Studies (SRHCES), who have been mentioned earlier in this year's report, have specific questions of their own as well. As a group, the coalition finds these questions to be of importance, and much of their research is



directed towards answering them and understanding the impacts of the Marcellus Shale. These surface, sub-surface, and water impacts all raise different questions, and at the moment the majority of those involved in the Susquehanna River Heartland Coalition are focusing on water, including but not limited to the Susquehanna River and the West Branch Susquehanna River. However, many researchers, both in and out of the coalition, are discussing questions unrelated to water, including social and economic questions.

According to Jason Weigle a SRHCES member, community and social impacts, although not studied as much as water impacts, are still very relevant. Researchers are looking not only at how the direct impacts of Marcellus Shale drilling will affect the community, but also at how people in the area view Marcellus Shale drilling and how this causes them to act. People's perceptions of the drilling are not always fact-based because of the number of questions that remain unanswered, so it often happens that blame is placed on Marcellus Shale drilling when issues in the area are actually being caused by factors unrelated to the drilling. Because of this, in order for progress to be made within communities, it is important that people are informed about what is known regarding the drilling and what remains unknown or has already been proven to be unrelated. With more and more questions arising, funding for research regarding this issue has increased, so researchers are hopeful that they will be able to expand their studies.

Community Impacts Being Studied

Development of natural gas from Marcellus Shale is having a profound effect on communities in Pennsylvania. The emergence of natural gas development is ushering in an era of unheralded wealth among portions of the general public from leasing and royalties, higher incomes from stable and high paying jobs, increased jobs throughout the economy, higher philanthropic giving, and entrepreneurial opportunities in corners of the

state largely left behind by modern patterns of economic development. These windfalls aren't without their price though, as many communities are experiencing the pains of rapid (and in some respects, urban) growth: increased traffic, growing populations, increased demands for housing, displaced low and moderate income residents, conflict between residents and newcomers, increased demand for government services and support, and decreasing satisfaction with the community.

These changes, both good and bad, are actively altering the very structure of communities throughout the shale region. Unfortunately, there is a lot we do not know regarding these changes, and this uncertainty makes it difficult to make informed decisions about how to deal with many of the problems communities are experiencing. How local decision makers choose to act – or not to act – will in large part determine the overall effects of change on Pennsylvania's communities in the years to come.

Boom/Bust Cycles in Extraction Economies

Economies based primarily on the extraction of non-renewable resources tend to follow a cycle of explosive growth followed by a period of decline. A key feature of development of

natural resources such as the Marcellus Shale is it attracts large numbers of people into an area in a short amount of time. These 'booms' in both people and economic activity bring with them rapid social and economic changes. The towns and cities where this type of development occurs are known as 'boomtowns'.

SRHCES members have colleagues across the Commonwealth who are also looking at the impacts from development of shale gas. Some of the topics include:

- How are the forests and forest resources in the area affected
- How are agricultural and residential development changing due to drilling
- What are the economic impacts of the Marcellus Shale, both on communities and on other forms of energy
- What are citizens' perceptions of the economic and social aspect of development
- How are the physical, chemical, and hydrological properties of the soil around drilling sites changing
- What are the impacts on the water supply



“Critical Questions” Being Asked by the SRHCES

The Susquehanna Heartland Coalition for Environmental Studies (SRHCES) and the Bucknell University Marcellus Shale Initiative (MSI) are developing a set of “Critical Questions” relating to Marcellus Shale natural gas (MSNG) development and hydraulic fracturing. Categories of questions include:

- 1) Overarching (large-scale),
- 2) Biological/Ecological,
- 3) Chemical,
- 4) Geological,
- 5) Hydrogeological,
- 6) Social/Economic/Landowner,
- 7) Public Health,
- 8) Law, Public Policy, and Regulations.

The premise is that there are large numbers of questions that physical and social scientists would like answers to minimize negative environmental, human health, and socioeconomic impacts due to MSNG development. The SRHCES and MSI hope that such questions can be answered through their own efforts and through the efforts of others quickly.

MSNG development in Pennsylvania and nearby states is occurring at an unprecedented pace and scale in a region that is struggling to keep up with the shifting socioeconomic, legal, political, regulatory, public health, and environmental landscape.

The developing set of Critical Questions currently numbers more than 175, underscoring the need for a much greater understanding of the Marcellus play and its positive and negative impacts on the region. The Critical Questions are under review by an ad hoc committee of the SRHCES; its members are editing and prioritizing the questions before releasing them. Three examples of the large-scale, overarching questions and one example of a more specific question are listed below to illustrate the nature of some of the questions.

OVERARCHING QUESTION EXAMPLES

- What should be on a list of critical chemicals that should be monitored in surface and ground water? What concentrations are acceptable? Where and when should monitoring take place? How should data be evaluated and disseminated?
- How do exploration, drilling, hydraulic fracturing, and well completion affect the nearby ecosystems/wildlife?
- How well do we, or can we determine the causes of spills and accidents that have occurred related to Marcellus Shale operations?

MORE SPECIFIC QUESTION EXAMPLE

- How much terrestrial habitat will be fragmented and degraded due to the building of well pads, compressor stations, gas pipelines, and associated roads? How will the impact vary between species?

Boomtowns often have a rapid increase in population followed and supported by an increase in services, infrastructure, and housing. These places also tend to see population-driven increases in things like crime, drug and alcohol abuse, traffic, and other social ‘ills’. Residents and newcomers might experience increases in social conflict, a loss of community adhesion, and a loss in sense of place.

When the resource is depleted or a replacement is found the intensity of development decreases, economic drivers disappear, and suddenly a community faces what is known as the ‘bust’. Busts might be rapid or might occur over a long period of time. During bust periods, communities might find themselves struggling to maintain the quality of life in their area, and, in some cases, communities might cease to exist altogether, resulting in what are familiarly known as ‘ghost towns’.

Growth, Change, and Social Adaptation

From a social perspective, there are typically four attitude stages that a community will go through during the development cycle (see Gilmore 1976 and Freudenburg 1981 for more information). At first, people tend to be enthusiastic and open to development. The future is seen in terms of income and possibilities and the potential negative impacts are often overlooked. This stage can typically be found in the exploration and early development phase of natural gas development.

As the development continues to grow, a period of uncertainty emerges as the community begins to change and the negative impacts of – in this case Marcellus Shale development – start to become evident. At this point, communities are often divided into supporters of the development and those who oppose it.

As development continues to grow, a community might enter a state of near-panic as the development (and impacts from it) grows faster than expected. Long-term residents may become confused or angry and conflicts may arise among community divisions. Media bias and other misinformation become prevalent in aiding in this confusion and divergent views lead to increased conflict over what is wrong or right for a particular community or place.

Finally, these conflicts lead to adaptation. During the adaptation process, core problems are identified and planning and mitigation strategies are developed. The level of separation between interests created during the periods of uncertainty and near-panic will in large part determine the fate of the community when the adaptation phase is reached. The point where production decreases and starts to decline is a critical juncture for communities to ensure that they have made adequate decisions to carry their communities into the future. Conflict and social disruption emerging from growth and change can prevent sustainable decisions from being made toward a community's future.

When Will Boom Become Bust in the Marcellus? Or will there be a Bust?

What we do know, as noted previously, is that the development phase will be the period where the largest amount of change will occur and where the most people will be required for production. It is during this period that the foundation for a community's future will be laid. As we are still in the early production phase of Marcellus Shale development (and indeed some areas of the region are still in the exploration phase), we still have time to answer and address many of the issues facing local communities.

The biggest challenge facing us, then, is working through the social, economic, environmental, and political factioning and panic that is occurring within the state. That is perhaps the largest hurdle, and the source of the largest questions, that we have to face.

REFERENCES:

Freudenburg, W.R. 1981. Women and men in an energy boomtowns: Adjustment, alienation, adaptation. *Rural Sociology* 46(2):220-244.

Gilmore, J.S. 1976. Boom towns may hinder energy resource development. *Science* 191 (February 13): 535-540.

Overarching Question Examples

- How can we use MSNG development as a catalyst to help educate the public about issues that are common in all types of land use and development (i.e. storm water management, wastewater and drinking water management, waste management, land use and land development, infrastructure, habitat degradation etc.) and illustrate how proper planning and regulation can be used to address them?
- How can we use MSNG development as a catalyst to educate local municipal officials, especially those in rural areas of the state, about the importance of planning and zoning to control impacts, the importance of keeping these tools up to date, and the importance of enforcing them adequately? How can we ensure that there is adequate funding to support local municipalities in their efforts?
- How can we use Marcellus Shale Natural Gas (MSNG) development as a catalyst to develop adaptive capacity and resilience within social and economic systems at and across local, township and borough, county, state, and national levels of government? How can we ensure the social, economic, and political structures, functions, and processes are in place to prevent 'busts' from occurring in communities within the play?

Specific Question Examples

- What are the long term effects of the injection of income and wealth into the formerly poor and low income areas of Pennsylvania?
- How can we use MSNG development as a catalyst to update and revise outdated regulations within the state?
- What proportion of shale-gas profits will remain in municipalities or states?
- How can we use the revenue from natural gas development as a catalyst to foster other new economic drivers (i.e., activities that do not rely on natural resource extraction)?

Marcellus and the Public's Health

GEISINGER ENVIRONMENTAL HEALTH INSTITUTE (EHI)

The EHI continues its ongoing studies in environmental epidemiology in the region. These include the following studies:

- (1) The relation of the land use, physical activity, and social environments in communities to childhood body mass index among almost 50,000 children with a Geisinger primary care provider (a peer-reviewed manuscript was just published in the *American Journal of Preventive Medicine*).
- (2) Ann Liu, a doctoral student at the Johns Hopkins Bloomberg School of Public Health, just completed her thesis research on 28,000 Geisinger diabetic patients and the relation of hemoglobin A1c levels, a biomarker of diabetes severity and control, with the burden of abandoned coal mine lands in communities. Ann previously showed that the greater the burden of abandoned coal mine lands in communities, the higher the community socioeconomic deprivation.
- (3) Evaluation of the relationship between risk of methicillin-resistant *Staphylococcus aureus*

(MRSA) and animal feeding operations given the common use of human-relevant antibiotics in animal feeds. We have identified over 4,000 Geisinger patients with MRSA over the past decade, with prominent increases in the community-associated cases over this time.

The EHI's most recent efforts involve the Marcellus shale. We are particularly interested in air pollution from shale gas extraction, given data on criteria air pollutants, including ozone, fine particulate matter, and oxides of nitrogen from Wyoming, Texas, Colorado, and Louisiana shale extraction activities. Such shale-associated air pollution can exceed that from such important sources as airports and motor vehicles, and these levels have been associated in other studies with poor asthma outcomes in adults and children. Asthma is a very important health concern because of its prevalence and severity; it is affected by air pollution in the short-term; and when people with asthma have an exacerbation they seek medical care. Geisinger has 30,000 patients with asthma and its electronic health record has information over the past 10 years, the same time frame of aggressive Marcellus shale development in the state. We are working to obtain funding for a proposed study of Marcellus shale and a variety of asthma outcomes, with a recent application to the US National Institutes of Health.

The Susquehanna Colloquium

Focusing on the humanities and social sciences in relation to environmental studies on the Susquehanna River

Dr. Katie Faull *Bucknell University*

Katie Faull, Professor of German and Humanities at Bucknell University, has recently been working extensively with native populations of Pennsylvania. She was involved in last year's river symposium at Bucknell, which centered around protecting our vital resources. The Haudensaunee Indians were invited to the symposium to discuss the possible extension of the John Smith Trail deeper into Pennsylvania. Plans for the 2011 symposium include having the Delaware and Iroquois Indians in attendance, which will be the first time the two groups have met in 250 years.



In April of this year, Chief Oren Lyons, the faith keeper of the Iroquois, gave a speech to students and faculty at Bucknell. He spoke about environmental issues and how they affect the native people of Pennsylvania. He acknowledged and focused on the importance of Bucknell's efforts with both the River and the area's native people, which Faull has played a key role in.

Another project involving native populations was an eel release in Buffalo Creek. Working with the Pennsylvania Fish and Boat Commission young eels were released in the Creek. The eels will migrate to the Atlantic Ocean, and eventually return to Buffalo Creek. Traditionally native people fished for eels in streams throughout the region. It is



hoped that eventually the historic aspect of fishing for eels can resume.

Faull has also been doing work on the north branch of the Susquehanna River with the Susquehanna Greenway North Branch division, focusing on Friedenshütten, a Native American site in Wyalusing, Pennsylvania. Interpretive panels have been able to show a rendering of how the village appeared in the 1800s, and now Faull, along with others, is helping to establish a historic water trail from Wyalusing to the Wyoming Valley. This water trail is based on a 1768 map discovered in Germany that includes not only pathways up the Susquehanna River, but also medicinal botany along the trail.

Faull has also created a tourist brochure for the Susquehanna Visitors Bureau this summer. The brochure includes native pathways along the Susquehanna along with notable landmarks for those who wish to learn about and explore the area.

Faull is also teaching a new course at Bucknell, "Nature and the Enlightenment." It combines European concepts of the Susquehanna River in the 18th century with Native American concepts of the Susquehanna River in the 18th century. Focusing on the two groups' concepts of nature, the class will visit sites on the River for an interactive experience.

Alfred K. Siewers

Bucknell University



Alf received a Scadden Research Fellowship from Bucknell for a research project on the development of American views of nature along the Susquehanna River during the early 18th century, including those of James Fenimore Cooper, Susan Fenimore Cooper, Joseph Priestley, and Samuel Coleridge. He has been teaching a related course this semester entitled "Visions of the Susquehanna," examining the relation between regional narratives and environmental conservation. Several students have been working with him on related research projects, including development of a GIS map of the Coopers' writings in relation to the headwaters of the Susquehanna River.



Eel release in Buffalo Creek

He has helped coordinate the academic year component of the Bucknell on the Susquehanna program this year, including a trip by about 40 students and faculty to the headquarters of the Haudenosaunee (Iroquois) Confederacy and the SUNY Oneonta Biological Field Station on Lake Otsego, following his involvement in a similar trip last year with Matt McTammany, Craig Kochel and Peter Wilshusen. In that effort and in work on organizing an historic gathering of American Indian leaders at Bucknell, Sid Jamieson of Bucknell has been of invaluable help.

Sid's work has extended to help with gaining key support from the Haudenosaunee (Iroquois) Confederacy for designation of the Susquehanna River as a national historic connector trail to the Capt. John Smith Chesapeake National Historic Trail. The designation process has been moving forward within the National Park Service and would help create a framework for historic interpretation and conservation along the river, in an approach more integrated with such efforts on the Chesapeake Bay. With help from SRCHES' Skip Wieder and others, the designation process also garnered important support from the governors of New York and Pennsylvania during the past year. Faculty and students from Bucknell and Bloomsburg, together with SUNY Buffalo, developed research supporting the designation.

Alf also co-directed the Susquehanna Valley Summer Writers Institute with Amanda Wooden on Marcellus Shale in 2010, which this spring produced a website of student journalism and analysis which you can find at <http://susquehannawritersinstitute.blogs.bucknell.edu/>.

Alf is also co-editor with his colleague Katie Faull (who also is involved in the Bucknell on the Susquehanna and historic trail projects) of the *Stories of the Susquehanna Valley*, which is producing a series of publicly accessible yet scholarly peer-reviewed books on the region's environment, in cooperation with the Bucknell Press. Volumes now in the works include one by David Minderhout of Bloomsburg (emeritus) on Native Americans in the valley, and another by Katie Faull on early Moravian-Indian cultural exchanges on the river. Duane Griffin of Bucknell's Geography program has also been involved in helping to coordinate a team of scholars (including a co-editor from SUNY Binghamton) who are developing a natural history volume for the series. Other ideas are welcome!

Alf also continues to be involved with the Susquehanna Colloquium, SRCHES' branch group focusing on humanities and social science approaches to the environment, which hopefully will hold a series of new meetings later this academic year under the new coordination of Brandh

Green at Bucknell's Environmental Center together with Ben Marsh, who now holds the rotating position of Nature and Human Communities faculty coordinator at Bucknell (NHCI is Bucknell's liaison program with the Colloquium). One key continuing project of Colloquium member Jerry Wemple of Bloomsburg's English Department is the annual Watershed journal of writings on and about the Susquehanna River.

Jerry Wemple

Bloomsburg University of
Pennsylvania



The third issue of *Watershed*:

The Journal of the Susquehanna, will be published in early fall 2011. Its editor is Jerry Wemple, a professor of English at Bloomsburg University. The managing editor for the issue was Hannah K. Jones, a Creative Writing and History dual major who graduated Bloomsburg University in May 2011.

Watershed is an interdisciplinary journal. The upcoming issue features an article about the oral history of regional Native Americans by anthropologists David Minderhout and Jessica Dowsett, poetry by Le Hinton and Marjorie Maddox, and essays about groundhog hunting and hiking in The Black Forest Trail, and well as photography.

"The goal of the journal is to capture the spirit of this broad and changing region," Wemple says.

"Regardless of the genre, or medium, the pieces in *Watershed* should be evocative, speaking the reading about some aspect of this place." The journal looks for a variety of voices. In the 2011 features a poem by Emma Ginader, who was still in high school when she wrote her poem included in *Watershed*. By contrast, the issue also has a poem by Philip Miller, a distinguished poet and editor living in retirement Uniontown, Pennsylvania, when he passed away earlier this year.

Wemple says it is important for the journal to reflect the diversity of the Susquehanna River watershed, which encompasses 27,500 square miles in New York state, Pennsylvania, and Maryland. There are cities, mining towns, mill towns, farms, and vast forests in the region, Wemple says. There are people whose roots go back generations, and those who have only recently moved here. Yet, we can all appreciate the beauty and resources of this place, and *Watershed* is a vehicle that allows us to hear some of the voices and stories of the region.

The journal launched the following website in early 2011: <http://orgs.bloomu.edu/watershed/index.html>. The website includes some work from past issues, as well as exclusive web-only content. In addition, information about obtaining copies of journal can be found on the website.

Brandn Green



Brandn Green, a new employee of Bucknell University, recently earned a PhD in Rural Sociology and Human Dimensions of Natural Resources and the Environment from Penn State University. He is now working in the Environmental Center as the Director of the Nature and Human Communities Initiative. Green will be looking at how the resources at Bucknell can be used to help the local communities of Pennsylvania. Green hopes to help nonprofits specifically and to help link environmental groups together so that their resources can be shared for the benefits of everyone involved. The main focus of this initiative is the communities in the Susquehanna River Valley.

Green is also involved in getting Bucknell's *Stories of the Susquehanna* published. This is a printed collection of writings from both faculty and students at Bucknell that highlight the stories of the community, people, and environment.

Awareness & Education

WKOK

Newsradio
1070WKOK

Sunbury Broadcasting's Newsradio 1070 WKOK has successfully concluded the award-winning *Boroughs to the Bay* coverage and continues to report on the activities and initiatives of the Susquehanna River Heartland Coalition for Environmental Studies.

In the past year, through WKOK, www.wkok.com, and five radio stations, WKOK has provided

balanced and extensive coverage of the Marcellus Shale industry, the Gulf of Mexico oil spill, and local projects along the Susquehanna River in and near Sunbury. Additionally, they have reported on the efforts of the Chesapeake Bay Foundation and the work of local grassroots environmental organizations, including the Susquehanna River Trail Association, the Responsible Drilling Alliance, and the Friends of the Shikellamy State Park.





Mark Lawrence (third from left) interviews some guests at WKOK's studio

WKOK has also provided an open mic for individuals interested in the rich cultural and historic aspects of the Susquehanna River. They have interviewed Bucknell University Professor Katie Faull on several occasions and continue to monitor her work. They have also aired the music of Van Wagner, a Danville activist, author, and educator, and interviewed him about his environmental interests and concerns.

As *Boroughs to the Bay* came to a close and its successor, *Boroughs to the Bay and Beyond*, began, they sealed a four-year series of reports, which has garnered several awards from the Associated Press and Pennsylvania Association of Broadcasting. Reporters on the series included Mark Lawrence, Sara Bartlett and Katie Kirchner.

The series included visits in Baltimore, Harrisburg and several of the campuses of coalition members. Interviews and links were aired and posted on our website. Topics ranged from sojourns, to mercury, to local water well projects and intersexes.

The series concluded in Summer 2010 with an interview, recorded on the campus of Bloomsburg University, which provided an update on the still spewing Gulf oil spill. The Roundtable included interviews with three oceanographers. The guests were Bloomsburg University Professors Cynthia Venn and Thomas Klinger, along with Julie Ambler of Millersville University.

During the interview, the scale of the Gulf oil spill and the catastrophic and subtle impacts—as well as the unintended consequences of the efforts to reduce the impact of the spill were discussed. Long-term remediation efforts were also looked at. The Roundtable, produced by Selinsgrove Area High School intern Katie Kirchner, also won an AP Public Affairs award in a statewide competition.

WKOK continues to air stories regarding the environmental impacts, as well as the social

implications of Marcellus Shale drilling. Geisinger psychiatrist Dr. Susan Paolucci revealed on WKOK that several patients have woven Marcellus Shale drilling fears into their psychosis. WKOK interviewed advisors of the Marcellus Shale Coalition, including former Pennsylvania Governor Tom Ridge and former Pennsylvania Secretary of Agriculture Dennis Wolff. They attended numerous citizen group meetings, provided coverage of the RDA and began the coverage of the SHRCES's work by following the SHRCES's mercury research, the re-design of the Shikellamy State Park Marina building, and other projects of the coalition. The first in 2006 to report on the intersexes of fish, they have since monitored invasive clams and the release of eels. The eels are intended to bolster the mussel populations in the river.

WKOK also provided local coverage of the Shikellamy 'Friends' group and their many gatherings and kayak trips. They reported on the design and delays involving the fish ladder at the fabridam and the Sunbury amphitheatre riverfront project. Newsradio 1070 WKOK continues to include several environmental focuses, including the threats the river faces, the scientific and citizen coalitions working to identify those threats, and the SHRCES coordinated work to find solutions. The history, cultural richness and recreational opportunities of the river are still the primary focus of WKOK.

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**Susquehanna River Heartland Coalition
for Environmental Studies**

www.SRHCES.org