

## **Marcellus Shale Multi-State Academic Research Conference**

Blair County Convention Center, Altoona, Pa.

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### **Submitted Abstracts**

#### Economic Implications

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- Marcellus Shale and property rights: An institutional economic analysis. Theodore Alter, Timothy Kelsey, Theodore Alter, Penn State
- How should we think about the economic consequences of shale gas drilling. Susan Christopherson, Cornell University
- Fiscal impacts of gas development on local governments in Pennsylvania. Michael Jacobson, Penn State
- Local business impacts of Marcellus Shale development: the experience in Bradford and Washington counties. Melissa Ward, Timothy Kelsey, Penn State
- Pennsylvanians' Attitudes and Experiences with Leasing in Bradford and Tioga Counties, 2010: Melissa M. Ward, Timothy Kelsey, Penn State
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- Characterization of organics in Marcellus frac-back waters. Robert Wolford, Hyunchul Kim, Brian Dempsey, Penn State
- Significance of uncertainty in the approval of water withdrawals for hydraulic fracturing in the Marcellus Shale. Austin Mitchell, Carnegie Mellon

### Local Government/Public Policy/Health

- Multi-state water management commissions in the Northeast: What do we know about these institutions and how they are influencing Marcellus Shale development. Charles Abdalla, John Becker, Joy Drohan, Penn State
- Natural Gas Landowner Coalitions in New York state: Emerging benefits of collective natural resource management. Jeffrey Jacquet, Rich Stedman, Cornell University
- Using local legislation to mitigate negative impacts of gas shale development. Beth Kinne, Hobart and William Smith Colleges
- Perceptions of the natural environment and health among residents in Marcellus and non-Marcellus communities. Martin Sliwinski, Brian Orland, Kelly D. Davis, Mallika Bose, Mark Sciegaj, C. Andrew Cole, C. Paola Ferreri, Elizabeth Munoz, Penn State
- Spatial drivers and water policies as determinants of the location of Marcellus Shale gas development in Pennsylvania. Allen Klaiber, Charles Abdalla, Penn State

### Social Implications

- Risk perceptions of natural gas development in the Marcellus Shale. Kathryn Brasier, Matt Filteau, Diane McLaughlin, Fern K. Willits, Penn State; Rich Stedman, Cornell
- Investigating the role of identities and opinion leadership on risk information seeking and sharing about proposed natural gas drilling in New York's Marcellus Shale. Chris Clarke, Cornell
- Pennsylvania and New York residents' views of natural gas development in the Marcellus Shale region. Rich Stedman, Jeffrey Jacquet, Rod Howe, Cornell; Kathryn Brasier, Fern Willits, Matt Filteau, Diane McLaughlin, Penn State
- The effects of Marcellus Shale development on families with children: An exploratory study. Diane McLaughlin, Kelly D. Davis, Kathryn Brasier, Molly Martin, April Gunsallus, Khai Le. Penn State

- Public perceptions of Marcellus Shale knowledge gaps: Preliminary findings and new questions. Abby Kinchy, Rensselaer Polytechnic Institute; Gene Theodori, Sam Houston State University; Leanne Avery, SUNY Oneonta
- Marcellus Shale gas development in Pennsylvania and perceptions of opportunities and challenge among Pennsylvania educators. Kai Schafft, Leland Glenna, Jim Ladlee, penn State; Jeanette Carter, Penn College of Technology

**Abstract title:** Impact of Marcellus Shale Development in Pennsylvania on Downtowns and Downtown Businesses

- Eleanor Andrews (Masters candidate), Geography, Penn State University, University Park, Pa.; [esa5044@psu.edu](mailto:esa5044@psu.edu); 917-902-2682
- Timothy Kelsey, State Program Leader, Economy & Community Development, Agricultural Economics, Penn State University, University Park, Pa.; [tkelsey@psu.edu](mailto:tkelsey@psu.edu); 814-865-9542
- Theodore R. Alter, Agricultural, Environmental and Regional Economics, Penn State University, University Park, Pa.; [talter@psu.edu](mailto:talter@psu.edu); 814-863-8640
- Robert J. Rodino, Rodino Associates, 614 Berkshire Drive, State College, Pa., 16803; [bobrodino@aol.com](mailto:bobrodino@aol.com); 814-238-1004

The natural gas industry continues to bring both immediate and long-term economic, employment, and social impacts to the Commonwealth of Pennsylvania. An understanding of the impacts on Pennsylvania's downtown business communities will help these communities and others plan effectively, an important step in ensuring responsible development of the Commonwealth's natural gas. This research study is an analysis of the impact of Marcellus Shale development on downtown areas across Pennsylvania. While earlier studies of businesses sought to understand the economic consequences at the individual business level, this work examines business communities themselves, and takes into account not only the economic impacts of Marcellus activities -- retail space and storefronts, employee retention, sales and other business activity -- but also a wider range of concerns to business owners and association managers, such as strategies in adapting to the Marcellus development, and training or grants that may help business associations better respond.

Surveys were sent to the managers of downtown business associations, Main Street projects, and Chambers of Commerce with local oversight in municipalities with a census population of over 1000 and located in counties with extensive Marcellus Shale activity (over 100 wells by the end of 2010). Survey responses were merged with municipal data on revenues and expenditures to provide a context for the findings. Early observations indicate that many municipalities do not have downtown business associations, or chambers of commerce that help oversee the direction of development, which may make coordinated responses to the development of natural gas more difficult.

**Abstract title:** Marcellus Shale and Property Rights: An Institutional Economic Analysis

- Theodore R. Alter, Agricultural, Environmental and Regional Economics, Penn State University, University Park, Pa.; [talter@psu.edu](mailto:talter@psu.edu); 814-863-8640
- Timothy Kelsey, State Program Leader, Economy & Community Development, Agricultural Economics, Penn State University, University Park, Pa.; [tkelsey@psu.edu](mailto:tkelsey@psu.edu); 814-865-9542

Marcellus Shale is creating policy challenges for state and local governments and citizens in Pennsylvania due to some of the unique aspects of natural gas development. This study is using Schimid's 'Situation, Structure, Performance' institutional and behavioral economics concepts to examine interdependencies and conflicts involved with natural gas development, and how property rights and policy choices will affect the level and pace of development and the distribution of benefits and costs across people, places, and generations. This approach provides clear and penetrating insights into the policy issues and choices involved, and how such choices or decisions will affect how Marcellus development unfolds across the Commonwealth.

**Abstract title:** How Should We Think About the Economic Consequences of Shale Gas Drilling?

- Susan Christopherson, Cornell University, Ithaca, N.Y.; [smc23@cornell.edu](mailto:smc23@cornell.edu); 607-255-8772

The idea that dramatic and widespread economic benefits will accompany shale gas drilling emerged from a set of economic impact studies that, while providing some useful information, are constructed around assumptions that need to be closely examined.

The objective of this research is to go beyond the narrow models that have been used to predict the economic impact of shale gas drilling to look at three issues:

1. How will the pace and scale of shale gas drilling affect the short-term and long-term economic consequences for counties in the Marcellus shale gas play? What are the implications for job creation, in the short-term and in the long term?
2. What costs do communities face in conjunction with shale gas drilling? What are likely cumulative effects of shale gas drilling and production, not only from the drilling process itself but from the industrial infrastructure required to transport, and store the gas and service the wells. How will these costs be affected by the pace and scale of drilling?
3. What evidence is there to tell us about longer-term consequences of developing economies dependent on natural resource extraction, and particularly natural gas extraction? What will happen after the boom-bust cycle of drilling ends? How will other key industries be affected?

**Abstract title:** Fiscal impacts of gas development on local governments in Pennsylvania

- Michael Jacobson, Forest Resources, University Park, Pa., [mj2@psu.edu](mailto:mj2@psu.edu); 814-865-3994

Gas activities can bring enormous changes and unintended consequences for local governments and communities. In the short run there are fiscal costs such as upgrading roads, and providing additional social services such as police, fire, health, and housing. In addition there are numerous environmental costs or intangible costs that might not be immediately evident. On the other hand there are potential revenue sources from various charges, taxes and permit fees. The goal of the project is to examine the fiscal impacts from Marcellus shale gas production on local governments and communities. We selected two geographically and culturally different counties currently experiencing extensive Marcellus shale development activities in Pennsylvania: Susquehanna and Washington. We analyzed secondary fiscal data on relevant revenues and expenditures for each of the municipalities. Based on this information we selected townships to further analyze fiscal impacts. These included interviews with township and county officials and industry representatives. Results will be discussed as will issues in design of public policies such as severance taxes, impacts fees and revenue sharing to affected local government and communities.

**Abstract title:** Local business impacts of Marcellus Shale development: The experience in Bradford and Washington counties, 2010

- Timothy Kelsey, State Program Leader, Economy & Community Development, Agricultural Economics, Penn State University, University Park, Pa.; [tkelsey@psu.edu](mailto:tkelsey@psu.edu); 814-865-9542
- Melissa M. Ward (M.S. candidate), Rural Sociology and Human Dimensions of Natural Resources & the Environment, Penn State University, University Park, Pa.; [mmw23@psu.edu](mailto:mmw23@psu.edu)

There has been much speculation about how development of Marcellus Shale is affecting local economies and businesses in Pennsylvania communities. Some recent data from the Commonwealth indicates that such counties typically are experiencing faster employment growth and lower unemployment rates, but there has not been objective information about the direct impacts on businesses themselves.

This study uses results from a Fall 2010, survey of 2,000 local businesses in Bradford and Washington counties to examine how local businesses are being affected by Marcellus Shale development. The survey results provide insights into what occurred in two of Pennsylvania's most active Marcellus Shale counties during 2010, and potentially what other counties will experience as drilling activity increases there. Impacts were greater in Bradford than in Washington county, due in differences in population size and intensity of drilling activity.

The results suggest that activity related to Marcellus Shale overall is having positive impacts on many businesses within the counties where drilling is occurring, including increased sales, new customers, and higher employment. At the same time, some businesses are reporting more difficulties in retaining their workforce, and finding new employees. Although the number of responses was relatively small, the data also suggests that tourism-destination businesses so far are not suffering negative effects from Marcellus Shale development.



**Abstract title:** Pennsylvanians' Attitudes and Experiences with Leasing in Bradford and Tioga Counties, 2010

- Melissa M. Ward (M.S. candidate), Rural Sociology and Human Dimensions of Natural Resources & the Environment, Penn State University, University Park, Pa.; [mmw23@psu.edu](mailto:mmw23@psu.edu)
- Timothy Kelsey, State Program Leader, Economy & Community Development, Agricultural Economics, Penn State University, University Park, Pa.; [tkelsey@psu.edu](mailto:tkelsey@psu.edu); 814-865-9542

As the natural gas industry continues to spread throughout the Marcellus Shale, little is understood about the people leasing their mineral rights. Many assumptions have been made regarding how landowners view the booming industry, but few objective studies have been completed that look at landowners' experiences, perceptions, and attitudes of the leasing process.

As part of a larger study focusing on the economic impacts of Marcellus Shale development, a household survey was sent to 1,000 landowners in Pennsylvania's Bradford and Tioga counties in the Fall of 2010. Survey recipients were selected if they owned land within a 1,000-foot radius of producing Marcellus wells. Responses were received from 501 landowners (50.1 percent). This presentation will focus on the respondents actions prior to signing a lease with a natural gas company, such as talking with an attorney, attending educational workshops, or speaking with more than one company, and whether such actions seem to affect the terms of their lease and their satisfaction with it. It will also examine their perceptions of the good and bad changes occurring to their land and community as a result of gas development, and their attitudes about these impacts.

**Abstract title:** Economic Impact of Marcellus Shale Development in Pennsylvania

- Timothy W. Kelsey, Agricultural Economics, Penn State University; [tkelsey@psu.edu](mailto:tkelsey@psu.edu); 814-865-9542
- Tracy Brundage, Penn College of Technology
- Jim Ladlee, Penn State
- Jeff Lorson, Penn College of Technology
- Larry L. Michael, Penn College of Technology
- Tom Murphy, Penn State
- Melissa M. Ward, Penn State
- Martin Shields, Colorado State University

*Please direct correspondence to:* Timothy Kelsey, 105 Armsby, University Park, Pa. 16802

Prior studies of the economic impacts of Marcellus Shale have had to make substantial assumptions due to the scarcity of information about local spending and workforce, which materially affect their results. This study attempts to fine tune economic impact analysis by using data from three community-level surveys, GIS analysis, and face-to-face interviews with gas companies to adjust a standard economic impact model to avoid such assumptions, and to more accurately estimate the impacts of Marcellus Shale development in Pennsylvania. The surveys included a questionnaire to 1,000 landowners within 1,000 feet of active wells in Bradford and Tioga counties, focused on the percentage of leasing and royalty dollars they spent in the year they received the money; a survey of 2,000 businesses in Bradford and Washington counties, focused on how their level of business activity is changing, and the opportunities and challenges they face; and a survey of 500 municipal governments across the entire Marcellus region, focused on local government expenditure and revenue impacts. GIS land ownership data was used to identify the percentage of leasing and royalty income going to local residents, to non-residents living elsewhere in Pennsylvania, to non-resident owners living in other states, and to the Commonwealth. The survey results and GIS data were used to estimate how much gas company spending goes to the communities where drilling is occurring, rather than immediately leaving to non-resident property owners, out-of-state workers, and government, and how much was recirculated within the community.

**Abstract title:** Landscape change associated with Marcellus Shale exploration and development  
– Research and outreach efforts

- Margaret Brittingham, School of Forest Resources, Penn State University, University Park, Pa.; [mx21@psu.edu](mailto:mx21@psu.edu); 814-863-8442
- Patrick Drohan, Crop and Soil Sciences, Penn State University, University Park, Pa.; [pjd7@psu.edu](mailto:pjd7@psu.edu); 814-863-4246
- Joe Bishop, Riparia, Penn State University, University Park, Pa.; [jab190@psu.edu](mailto:jab190@psu.edu); 814-863-3530

Exploration and development of the Marcellus shale region is occurring at a rapid rate with number of permits and wells drilled increasing exponentially. We conducted a preliminary pre and post GIS analysis of disturbance associated with Marcellus well pads and present results that identify patterns of landscape fragmentation and habitat loss associated with Marcellus Shale development. Well pads are going in both areas that have previously been fragmented by other land uses and those that have not been previously fragmented. The largest concern will be in areas where fragmentation levels were previously low. We also conducted on the ground surveys of well pads sites. Well pad size averaged  $1.8 \pm 0.3$  ha (4.4 acres), range 1.1 – 6.4 ha (2.6-15.5 acres), n=17 with > 30% having more than 6 wells planned per pad. Restoration efforts were rare and focused primarily on establishing grassy cover. We are establishing an online field guide to provide up to date information on effects of Marcellus shale exploration and development on natural ecosystems and wildlife and to obtain information on landowner experiences and restoration attempts. This summer we are initiating a field research project to quantify local and landscape effects of Marcellus on terrestrial ecosystems

**Abstract title:** Prediction of spatial variability of Marcellus Formation geochemical and geomechanical parameters through improved understanding of sedimentological variability and stratigraphic architecture in central New York State

- Teresa E. Jordan, Earth & Atmospheric Sciences, Cornell University, N.Y.;  
tej1@cornell.edu
- Ceren Karaca, Earth & Atmospheric Sciences, Cornell University, N.Y.;  
ck465@cornell.edu

Exploitation of shale-gas requires not only a natural gas source and reservoir stimulation, but also requires planning to mitigate risks and treat waste water. The ability to predict the natural gas abundance, the ease of fracture of the host shale, and the nature and abundance of toxic metals that will be transferred from the rock to the introduced water (e.g. Ba, Sr, Br, Mg, Mn, Ra) is sought by the gas industry, landowners, community planners, and regulatory agencies, among others. Predictions will be improved if details of the properties of the shale, and their variability, are well understood.

Our overall approach is: to relate the variations of parameters of interest to stakeholders to the sedimentological variability of the Marcellus shale for quarry exposures; to develop a depositional system hypothesis for the spatial variability of sedimentological factors as well as statistical descriptions of the variability; to relate the facies variability vertically and laterally to stratigraphic sequence architecture; and to use well logs to extend the sequence stratigraphic framework regionally, and in turn to predict the regional spatial variability of the parameters of interest.

We have begun by characterizing the Marcellus in the Seneca Stone Quarry (Seneca County, NY), where variability can be measured over distances of 10s to 100s meters (10s to 1000s feet). Data now being assembled include mineralogy, sedimentary structures, textures and fabrics of grains, degree of bioturbation, general classes of body and trace fossils, and Total Organic Carbon. We plan to obtain a suite of geochemical data, including several metals of particular importance to wastewater planning and risk assessment. Even one quarry-based detailed section can be the basis for regional extrapolation to estimate spatial variability using published sequence stratigraphic frameworks. Yet we intend to incrementally add detailed studies from other quarries, to refine the accuracy of the prediction of parameters of importance to the stakeholders.

**Abstract title:** The Pennsylvania State Seismic Network

- Andrew Nyblade, Department of Geosciences, Penn State University, University Park, Pa.; [nyblade@psu.edu](mailto:nyblade@psu.edu); (814) 863-8341

Over the past three years, a state-of-the art broadband seismic network comprised of ten stations has been constructed with support from the Pennsylvania Bureau of Topographic and Geological Survey (BTGS), which is part of the Pennsylvania Department of Conservation and Natural Resources. The ten stations are distributed across the Commonwealth for the purpose of monitoring both naturally occurring and drilling/reservoir induced seismicity. The data from the stations are streamed in real time via the Internet to the Incorporated Research Institutions for Seismology (IRIS) data management center, where they are archived and openly distributed. Information about the stations can be found at: <http://www.iris.edu/mda/PENN>. The stations are located at several university campuses, the office of the BTGS in Middletown, and in several state parks. The data are also made available to the USGS to locate seismic events and determine magnitudes.

Abstract title: A laboratory experiment on the fate of pollutants in brines applied to roads

- Wenjing Sang, Biological and Environmental Engineering, Cornell University, N.Y.; [tss1@cornell.edu](mailto:tss1@cornell.edu); 607-255-2489
- Steve Pacenka, S. Steenhuis, Christopher Guerrero, Cornell University

*Please direct correspondence to:* Wenjing Sang, 206 Riley Robb Hall, Cornell University, Ithaca, NY 14850

Soil colloids can carry pollutants such as heavy metals to ground water. Recent studies have shown that colloid deposition/release is related to ionic strength. An interesting question, therefore, is how road salt affects the transport of colloids. Road salts when originating from spills of natural gas fracturing flowback water or production brine can contain high concentrations of heavy metals. Simple metal leaching experiments were conducted in 30cm columns filled with sand. 0.4 mL of brine or hydrofracturing return flow was added, followed by a slower 40 mL of 0.001mM NaCl solution. Metal concentrations were measured in the effluent. As expected, most applied metals leached through the sand.

Then colloid deposition/release experiments were performed with similar 20 cm sand columns. Polystyrene latex colloids (easy to track in a bright field microscope) were added in 25 mL of water with 50mM NaCl, or hydrofracturing flowback water. This was followed by colloid free solutions of the same water, then DI water. Colloid concentrations were measured in the effluent.

Previous research showed that increasing ionic strength resulted in increased colloid retention. Our results from hydrofracturing water differ. For the reference 50 mM NaCl solution, 80% of applied colloids were retained, until most were released by DI water. Microscope observations showed the only colloids remaining after the DI flush were either in stagnant water zones or associated with the primary minimum moisture. But for hydrofracturing water, only half as many colloids were retained initially and very few were released by final DI water.

These results give insights into metal behaviors to consider in planned experiments to apply flowback water or brine to more complex soils.

**Abstract title:** Fracture sidewall cementation and vein carbonate: Tracking vertical migration and oxidation of natural gas in the Marcellus Formation, Central New York

- Bruce W. Selleck, Department of Geology, Colgate University, 13 Oak Drive, Hamilton, NY 13346 [bselleck@colgate.edu](mailto:bselleck@colgate.edu) 315-228-7949

Exposures of the upper Marcellus Formation in Madison County, central New York host joints with cm-scale bands of calcite-cemented siltstone and shale symmetrically arranged parallel to vertical fracture midlines. The thickness of cemented fracture sidewall bands decreases upward from fracture bifurcations, suggesting that the fluids responsible for cementation migrated upward along fractures.. Fractures with sidewall cementation occasionally host thin (to 5 mm thick) low-magnesium calcite veins. The calcite forms 0.2-1.0 mm long blocky to prismatic crystals with random orientations relative to the vein walls; finer, scaly low-magnesium calcite microspar is also present in veins. Stable isotope signatures of calcite vein fill and sidewall cemented shale ( $\delta^{18}\text{O} = -7$  to  $-8$  PDB;  $\delta^{13}\text{C} = -8$  to  $-11$  PDB) are distinct from carbonate vein material in nearby structurally disturbed basal Marcellus ( $\delta^{18}\text{O} = -8$  to  $-11$ ;  $\delta^{13}\text{C} = +1$  to  $+4$ ). The strongly negative carbon isotope signatures of the calcite from veins and sidewall cementation bands are most consistent with methane oxidation as a source of carbonate. The negative oxygen values are consistent with precipitation from local meteoric groundwater.

The stratigraphic units containing fracture sidewall cementation features overly the gas-rich basal Marcellus, and natural methane seeps exist within one kilometer of outcrop exposures with these features. Water wells tapping fractured shale aquifers in the area south (down dip) of the outcrop exposures often yield water with dissolved natural gas sufficient to be flared at the faucet. Such wells are miles from the nearest natural gas production, and many such water wells were in existence prior to gas development in the region. Fracture sidewall cementation documents natural up-migration of methane from the basal Marcellus. These features should be present in geologically similar settings, and may be used to establish natural gas migration pathways in bedrock aquifer systems.

**Abstract title:** Décollement Zones in the Basal Marcellus Shale, Central New York State: A Potential Marcellus Reservoir Opportunity without Hydraulic Fracturing?

- Bruce W. Selleck, Department of Geology, Colgate University, 13 Oak Drive, Hamilton, NY 13346 [bselleck@colgate.edu](mailto:bselleck@colgate.edu) 315-228-7949

Exposures in a 180 km along-strike zone in the basal Marcellus Formation outcrop belt in New York document north-directed overthrusting in areas lacking subsurface Silurian salt (Cherry Valley, (Bosworth, 1984), and Oriskany Falls, NY, and to the west where salt is present (northern Cayuga Lake Valley). Detachment is localized within the 25-60' thick Union Springs Member, and in bentonite horizons in the underlying Onondaga Formation. Horizontal motion in the Union Springs was accommodated within carbonaceous shale, with striated and polished surfaces developed on stiffer, bounding carbonate units. Carbonate beds are cut by ramp faults with cm to m-scale displacement. Shale layers are thickened to form imbricate, cleaved and polished shale 'wads'. Black shales of the overlying Oatka Creek Member above the décollement show intensified vertical jointing and may provide enhanced permeability.

Veins in the detachments document two episodes of mineralization; early calcite and quartz crystal growth occurred during evolution of fluid hydrocarbons; a second phase of calcite/dolomite mineralization was accompanied by emplacement of high-reflectance bitumen in vein pore space. Veins preserve significant vuggy porosity. Fluid inclusion and stable isotope data indicate temperatures of mineralization range from 145-160°C in the eastern site (Cherry Valley) to 120-135°C in the western (Cayuga Lake) site. Hydrocarbon-rich fluid inclusions in quartz are common. Carbonate stable isotopes ( $\delta^{13}\text{C}$  range +0.5 to +4.2 PDB;  $\delta^{18}\text{O}$  range -7.8 to -10.4 PDB) are consistent with mineral precipitation from an aqueous phase in equilibrium with the carbonate units of the Union Springs Formation with minor contribution of carbonate from hydrocarbon decarboxylation.

Based on outcrop observations, these detachment faults should form zones of enhanced porosity and permeability within the Marcellus hydrocarbon system, and are accessible targets for horizontal development that may not require hydrofracturing.



**Abstract title:** Water Resource Impacts of Shale Gas Drilling

- Susan J. Riha, NYS Water Resources Institute, Cornell University, N.Y.; [sj4@cornell.edu](mailto:sj4@cornell.edu); 607-255-1729
- Brian G. Rahm, NYS Water Resources Institute, Cornell University, N.Y.
- William L. Fisher, U.S. Geological Survey, Department of Natural Resources, Cornell University, N.Y.
- Motoko Mukai, NYS Veterinary Diagnostic Laboratory, Cornell University, N.Y.
- Michael T. Walter, Biological & Environmental Engineering, Cornell University, N.Y.

*Please direct correspondence to:* Susan J. Riha, 1110 Bradfield Hall, Cornell University, Ithaca, NY 14850

Activities associated with shale gas drilling have a number of possible impacts on water resources. We have developed a relatively simple framework for identifying and organizing these important impacts. This framework distinguishes between above and below ground activities and between planned and unplanned events, and also acknowledges the role of cumulative impacts that occur as a function of the pace and scale of drilling operations in an area. We propose to use this framework as a basis for research and monitoring efforts toward the creation of a more comprehensive pre-drilling baseline with respect to ground and surface water quality and quantity. Data will be collected from a variety of natural and engineered systems, including private water wells, flowback/produced water impoundments, wastewater treatment facilities, and streams and rivers within the Upper Susquehanna basin. More specifically, we will analyze these samples for a variety of water quality parameters, including endocrine disruptors and organic compounds such as methane and other organics that may be of particular ecological concern, and which may be linked to gas drilling activities. This monitoring campaign will complement hydraulic modeling work within the basin explicitly aimed at developing surface water withdrawal criteria that account for impacts on valued fish habitats. Finally, we propose to use our framework in conjunction with various geospatial data sets in order to begin a comparative evaluation of water resource issues across different shale plays in the US that exist within different geological, social, and resource-availability contexts. This approach could be useful to industry and policy makers, as well as other researchers, in on-going efforts to evaluate the costs and benefits of certain energy choices.

**Abstract title:** Impact of Marcellus Gas Drilling on Rural Drinking Water Supplies

- Bryan Swistock, School of Forest Resources, Penn State University, University Park, Pa.; [brs@psu.edu](mailto:brs@psu.edu), 814-863-0194
- Elizabeth Boyer, Penn State
- Dana Rizzo, Penn State Cooperative Extension, Westmoreland County
- James Clark, Penn State Cooperative Extension, McKean County
- Mark Madden, Penn State Cooperative Extension, Sullivan County

*Please direct correspondence to:* Bryan Swistock, 308 Forest Resources Building, University Park, Pa. 16802

Historic data and anecdotal information from Pennsylvania suggest impacts from traditional shallow gas drilling and early Marcellus gas drilling in Pennsylvania have occurred sporadically. With funding from the Center for Rural Pennsylvania and the Pennsylvania Water Resources Research Center, Penn State is conducting a study to determine possible changes in groundwater quality near Marcellus gas drilling sites, study the factors that are related to changes (if it occurs), and survey water supply owners to document their experiences with gas drilling and water issues. Phase I of the project involves intensive pre and post drilling testing of several dozen private water wells located within 2,000 feet of an active Marcellus drilling site in comparison to several control sites. The second phase of the project involves post-drilling testing of about 200 private water wells located within 5,000 feet of a completed Marcellus gas well site in comparison to control sites. In this phase, water supply owners provide pre-drilling water testing data for comparison to post-drilling results. Participants in both phases of the project complete a survey about their experiences with nearby gas well drilling. Study results will be used to create educational materials for private water supply owners and to recommend potential policy considerations to protect private water wells near Marcellus drilling activity.

**Abstract title:** Water-Quality Monitoring in the Marcellus Gas-Drilling Area in the Beech Creek Watershed

- Md. Khalequzzaman, John Way, Christopher Darwin, Steve Cornia, Matt Keele, Lindsay Repman, Lock Haven University of Pennsylvania
- Kent Addis, Frank Bianco, Dan Delotto, Kathryn Farrigno, Ken Johnson, Stan Lembeck, Larry Lukens, Steve Lupis, Pennsylvania Senior Environmental Corps
- Ann Donovan, Centre County Conservation District

*Please direct correspondence to:* Md. Khalequzzaman, Dept. of Geology & Physics, Lock Haven University, Lock Haven, Pa. 17745; [mkhalequ@lhup.edu](mailto:mkhalequ@lhup.edu); 570-484-2075

Extracting natural gas from the Marcellus Formation requires large volumes of water and significant quantities of chemical additives to stimulate production from this tight, Middle Devonian shale unit. Accidents or the mismanagement of any fluids involved in the drilling, hydrofracing, and production processes have the potential to threaten surface and ground-water quality in those portions of the Susquehanna River basin impacted by exploitation of this resource.

Early in 2010, representatives from Lock Haven University's Geology program, the Centre County Chapter of Pennsylvania Senior Environmental Corps, the Centre County Conservation District, and the Beech Creek Watershed Association forged a partnership to establish a baseline water-quality-monitoring program in the Beech Creek watershed (BCW) in Centre and Clinton counties, PA. Using GIS techniques to identify potentially impacted sub-watersheds within the BCW, the partners selected 12 sampling sites that lie upstream and downstream of gas-well drilling locations.

Along with assessing visual conditions of the streams and their watersheds, the volunteers collected field data including: temperature, pH, total dissolved solids, conductance, oxidation-reduction potential, dissolved oxygen, and flow rate. Laboratory testing yielded total suspended solids, barium, total iron, manganese, aluminum, calcium, magnesium, copper, arsenic, chloride, and sulfate data. This study ran from May 2010 to November 2010.

Preliminary results indicate no apparent adverse impact on water quality in sampled streams. Although this was a modest attempt to assess water quality throughout a portion of the basin, it is the intention of the partners to seek additional funding in order to continue this monitoring project and add more sample sites and parameters to this project.

**Abstract title:** Characterization of Organics in Marcellus Frac-back Waters

- Robert Wolford (M.S., Environmental Engineering), Dept. of Civil & Environmental Engineering, Penn State University, University Park, Pa.; [rwolford84@gmail.com](mailto:rwolford84@gmail.com); 724-331-7053
- Hyunchul Kim (Postdoctoral Scholar, Environmental Engineering)
- Brian Dempsey, Environmental Engineering, Department of Civil & Environmental Engineering, Penn State University, University Park, Pa.; [bad5@psu.edu](mailto:bad5@psu.edu) 814-865-1226

Organic chemicals in flowback waters after hydrofracking the Marcellus shale have caused some concern but only a limited number of characterization studies have been performed. The purpose of this work was to identify organic matter in flowback waters within the first 30 days after hydrofracking (hydrofrac flowback) and also later than 30 days (production water). Flowback waters are high in sodium, chloride, bromide, alkaline earth metals, radioactivity, and the reported chemical oxygen demand (COD) values have ranged from 2,000 to 20,000 mg/L or about 5 to 50 times as concentrated as in municipal sewage. Paradoxically the reported total organic carbon (TOC) in flowback samples is much lower, resulting in reported COD/TOC ratios much less than theoretically possible for organic matter. Reported concentrations of specific volatile and semi-volatile chemicals are typically very low or non-detect. These observations motivated our study. We analyzed hydrofrac flowback and production waters for COD and TOC, used GLC for glycols, FTIR for functional moieties, and a fractionation strategy to identify generic organic groupings. Very large positive interferences were discovered in the COD procedure used by all reporting laboratories. Correction resulted in a decreasing average observed COD from >15,000 mg/L using standard procedures to ~500 mg/L using a procedure that eliminated interferences. Organic composition in hydrofrac flowback waters reflected some characteristics of the organic matter in the hydrofrac solutions. Production waters contained natural humic material. Organic acids contributed more than half of TOC, even in hydrofrac flowback. Work continues trying to characterize specific organic matter in the flowback but results to-date show that the concentration of organic matter in Marcellus flowback water is much lower than previously reported and that some analytical procedures have produced incorrect data.

**Abstract title:** Significance of Uncertainty in the Approval of Water Withdrawals for Hydraulic Fracturing in the Marcellus Shale

- Austin Mitchell (PhD student), Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, Pa.; [austinmi@andrew.cmu.edu](mailto:austinmi@andrew.cmu.edu); 419-283-9858

The burgeoning unconventional natural gas industry in Pennsylvania consumes large volumes of water, a majority of which is withdrawn from surface waters. In order to get a drilling permit, the operators must submit plans to the Pennsylvania Department of Environmental Protection (PaDEP) demonstrating that the proposed water withdrawals will minimize negative environmental impacts. The PaDEP uses two stream statistics to regulate allowable withdrawals – pass-by flow and 10% of the 7-day, 10 year low-flow (Q7-10). These measures are used deterministically, even though they are based on noisy data, flow records from U.S. Geological Survey (USGS) hydrometric gauging stations. Bayesian methods are employed to characterize the uncertainty in discharge estimated from the rating curve. The issues with monitoring compliance for pass-by flow are summarized when only provisional discharge data are available. Bootstrap re-sampling is used to calculate the uncertainty of Q7-10 estimated from the log-Pearson type III distribution. The 95% confidence intervals are provided for 63 gauging stations used by the USGS in their regional low-flow regressions. With these analyses, the potential consequences of ignoring the uncertainty in stream flow statistics are evaluated at a number of permitted withdrawal sites. At gauged streams, this research shows uncertainty in pass-by flow is small, but provisional data used for compliance may not protect streams with a probability of around 15%. It is demonstrated that the deterministic representation of Q7-10 hides considerable uncertainty of this estimate, especially at gauging stations with short records. Finally, this research shows that extrapolation of ADF to un-gauged streams may cause pass-by flow violations and the extrapolation of Q7-10 to un-gauged streams is so error-prone that this practice should be discontinued.

**Abstract title:** Multi-state Water Management Commissions in the Northeast: What Do We Know about These Institutions and How They are Influencing Marcellus Shale Development

- Charles Abdalla, Agricultural Economics & Rural Sociology, Penn State University, University Park, Pa. ; [cabdalla@psu.edu](mailto:cabdalla@psu.edu); 814-865-2562
- John Becker, Agricultural Economics & Rural Sociology, Penn State University, University Park, Pa.; [jcb1@psu.edu](mailto:jcb1@psu.edu); 814-863-0575
- Joy Drohan, Writer, Eco-Write

Extracting gas from the Marcellus shale through hydraulic-fracturing presents major economic opportunities and challenges to the Northeastern U.S. This projected very large natural gas reserve is located near major northeastern population centers with significant energy needs. Water is a critical input into and output (wastewaters) from hydraulic-fracturing. Large freshwater supplies are available in the Ohio, Susquehanna, Delaware, and Potomac Rivers and Great Lakes basins. Other important water uses are electricity production, industrial/commercial, residential and recreation. Three water-related concerns related to Marcellus development are: water supply adequacy, spills from transporting fluids/supplies, and wastewater treatment/disposal. Also, concerns exist about methane migration and the potential for contamination of drinking water supplies.

Recently, Marcellus shale gas drilling has accelerated in Pennsylvania and West Virginia and may begin in nearby states. State environmental agencies, which have responsibility for overseeing hydro-fracking and many aspects of water management, were largely unprepared for shale gas drilling. Because of hydrological inter-connections, decisions made in one state or watershed affect others. While water management is fragmented across jurisdictions, seven multi-state institutions with various powers exist in the Northeast. The two with the most authority are the Susquehanna River Basin Commission and Delaware River Basin Commission. Given the rapid increase in Marcellus exploration and the adverse water quantity/quality impacts experienced in some areas, the multi-state water management institutions have played a key role in managing water and thereby influencing shale development timing and patterns. This presentation will: communicate the results of a comparative analysis of the authorities of seven multi-state water management entities in the Marcellus region; describe how these institutions have responded thus far to the water quantity and/or water quality impacts from shale development; and identify public policy challenges facing multi-state and state agencies' and potential institutional innovations to overcome them. A paper will be available at the conference.

**Abstract title:** Natural Gas Landowner Coalitions in New York State: Emerging Benefits of Collective Natural Resource Management

- Jeffrey Jacquet, Cornell Department of Natural Resources, 312F Fernow Hall, Cornell University, Ithaca, N.Y. 14850; [bj47@cornell.edu](mailto:bj47@cornell.edu); 607-351-9886
- Rich Stedman, Cornell Department of Natural Resources, Cornell University, Ithaca, N.Y. 14850

Thousands of rural landowners in New York State have joined together to form grassroots organizations aimed at collectively bargaining with natural gas companies. The leverage afforded by acting collectively allows these landowner coalitions to potentially influence the economic, environmental, and community impacts of gas development across hundreds of thousands of acres. In-depth interviews with coalition leaders performed for this article reveal the scope, motivations, and benefits of membership of these groups. Our work examines these elements using multiple frameworks for understanding collective natural resource management. The coalitions are found to be primarily concerned with the advancement of private member benefits, while public benefits of the collective action are poised to accrue indirectly. Group leaders are also contemplating how to use their leverage to secure direct benefits for the wider community – actions that may provide communities a modicum of local control over gas development.

**Abstract title:** Using Local Legislation to Mitigate Negative Impacts of Gas Shale Development

- Beth Kinne, Environmental Studies Program, Hobart and William Smith Colleges, 300 Pulteney Street, Geneva, NY 14456; [Kinne@hws.edu](mailto:Kinne@hws.edu); 315-759-3913

Substantial economic benefits of oil and gas development often accrue to states and corporations, while negative environmental and social impacts often accrue at the local level in communities in close proximity to the gas resources. Tax revenue, corporate profits and high quality jobs accrue where oil and gas companies are headquartered, while wear and tear on infrastructure, the costs of pollution – both planned and accidental - and the social and economic impacts of hosting a largely temporary workforce fall on local municipalities. While the majority of regulation of drilling for natural gas occurs at the state level, as a home rule state, local governments in New York have the right to pass regulations governing road usage and maintenance, the levy and administration of local taxes, and the protection and enhancement of the local environment. This research will seek to address the following questions with respect to development of the Marcellus Shale in New York State, given the current state regulatory regime: (1) What approaches are local governments in New York taking to assess and mitigate the negative environmental, economic and social impacts of gas shale development? (2) To what extent are governments taking or defending these steps under the home rule provisions or other legal authority? (3) What are the greatest challenges faced by local governments in their endeavors to prepare for increased activity by the oil and gas industry? And, (4) to what extent are local governments drawing on experiences from other jurisdictions in their legislative development processes?



**Abstract title:** Perceptions of the Natural Environment and Health among Residents in Marcellus and Non-Marcellus Communities

- Martin Sliwinski, Brian Orland, Kelly D. Davis, Mallika Bose, Mark Sciegaj, C. Andrew Cole, C. Paola Ferreri, & Elizabeth Munoz, Penn State University, University Park, Pa.

*Please direct correspondence to:* Martin Sliwinski, Human Development and Family Studies, Director, Center for Healthy Aging, 118 Henderson Building, University Park, PA 16802; [mjs56@psu.edu](mailto:mjs56@psu.edu); 814-863-9980

This study examines associations between human health and the environmental and social changes resulting from the development of Marcellus shale gas deposits. The Marcellus energy extraction initiative may promote differential exposure to psychosocial stress, changing environmental conditions, and uneven access to community resources. We propose that emotional, cognitive, and biological responses to stress may represent a common pathway that links environmental and social conditions with health and disease. We hypothesize that psychosocial stress, and its cognitive and affective correlates, mediate the effects of social and environmental conditions on adverse health outcomes. We are collecting baseline data on environmental, social, psychological, and biological processes over time that are linked to health changes. The goal is to improve understanding of the mechanisms underlying observed relations between natural, built, and social influences and physical and mental health of residents. We have established a research infrastructure in communities that are immediately affected by Marcellus shale extraction efforts and others not yet affected. We are obtaining baseline measurements of the environment at the watershed and community level. Measures include biodiversity, habitat fragmentation and water quality measures; spatial, perceived environmental quality and design quality measures. With a projected sample of 250 adults aged 21-65 from watersheds in the immediately affected counties and an equal number from the counties not yet affected, we are obtaining baseline measurements of stressor exposure, health, and how important the environment is for overall quality of life via mailed surveys. The goal is to develop an understanding of environment-health relationships that can guide effective approaches to both land-use planning and community health strategies that promote individual well-being and disease prevention.

**Abstract title:** Spatial Drivers and Water Policies as Determinants of the Location of Marcellus Shale Gas Development in Pennsylvania

Allen Klaiber, Agricultural Economics & Rural Sociology, Penn State University, University Park, Pa.; [aklaiber@psu.edu](mailto:aklaiber@psu.edu); 814-865-0469

Charles Abdalla, Agricultural Economics & Rural Sociology, Penn State University, University Park, Pa.; [cabdalla@psu.edu](mailto:cabdalla@psu.edu); 814-865-2562

The positive and negative impacts of Marcellus shale development arise first in communities proximate to where gas well drilling occurs. To prepare for and manage impacts, decision-makers need knowledge about the most likely locations of future development as well as improved understanding of the drivers of existing development. During early exploration in Pennsylvania, shale characteristics (location, depth, thickness) and proximity to water were identified as primary drivers influencing drilling location. Recently, additional factors have been identified as drivers of the location of development, including: mineral rights associated with land; workforce availability; distance to wastewater treatment and disposal facilities; transportation infrastructure; population density; states' and multi-state river basin commissions' water access rules; and municipal regulations.

This study used information on existing development to examine the relative importance of water policies and other drivers in explaining the observed development patterns of the Marcellus shale. Preliminary results confirm much of our intuition and suggest that differences in water policies across river basin commission boundaries were a key determinant of the location of shale exploration activity. In addition to these preliminary results, we continue to collect and analyze secondary data about shale development (# permits issued and where, # wells drilled and where) and locations impacted which will be used to further our understanding of the drivers of Marcellus shale development. Additional information we are collecting includes data on natural gas firm characteristics, business climate in targeted areas, and more detailed information on water sources and wastewater disposal.

Results will help community decision makers better prepare for and manage impacts, and provide greater clarity in assessing these impacts. Since Pennsylvania shares hydrologic, economic, infrastructure, and institutional linkages with neighboring states, results may assist communities in states where gas exploration is at an earlier development stage.

**Abstract title:** Risk Perceptions of Natural Gas Development in the Marcellus Shale

- Kathryn J. Brasier, Agricultural Economics and Rural Sociology, Penn State University, University Park, Pa.; [kbraiser@psu.edu](mailto:kbraiser@psu.edu); 814-865-7321
- Matthew R. Filteau, Penn State University
- Diane McLaughlin, Penn State University
- Richard C. Stedman, Department of Natural Resources, Cornell University, N.Y.
- Fern K. Willits, Penn State University

*Please direct correspondence to:* Kathryn J. Brasier

The Marcellus Shale geologic formation contains vast quantities of natural gas, and lies beneath 5 Northeastern states—Pennsylvania, New York, Ohio, West Virginia, and Maryland. Significant development of Pennsylvania’s Marcellus Shale began in 2007; by comparison, New York placed a moratorium on all Marcellus drilling pending an environmental review. Development of this industry in Pennsylvania is creating considerable social change, including increases to population and diversity, increased income for property-holders who leased their land, financial pressures on those not benefiting directly from development of the Marcellus, and community conflict over the social and the environmental consequences caused by development. At the heart of the conflicting discourses lie differing perceptions of the risks associated with development of the natural gas. Risks are related to impacts on the natural environment, especially water resources, as well as community change and economic gain. This paper uses data from a household survey (N=1917) conducted in 29 Pennsylvania and New York counties from October 2009 through April 2010 to describe risk perceptions related to development of the natural gas industry. A scale to capture multiple dimensions (predictability, controllability, distribution of benefits, etc.) of risk is described. A model predicting levels of risk perception indicates the importance of institutional trust, level of development, sources of information, state, and demographic variables (gender, education). Implications of these findings are discussed, particularly related to improving local discourse surrounding Marcellus Shale development and efforts by educators and others to highlight the multiple dimensions of risk.

**Abstract title:** Investigating the Role of Identities and Opinion Leadership on Risk Information Seeking and Sharing about Proposed Natural Gas Drilling in New York’s Marcellus Shale

- Chris Clarke, Communication, Cornell University, Ithaca, N.Y.; [cec54@cornell.edu](mailto:cec54@cornell.edu); 732-407-8061

Potential development of Marcellus Shale in New York State provides opportunities for gathering and exchanging information about perceived impacts. This project investigates the role that identities, specifically opinion leadership, play in motivating risk information seeking and sharing about this issue. We address two goals. First, we explore how people negotiate a complex information environment – one that consists of myriad messages about potential social, economic, and environmental impacts. Second, we focus not just on seeking in the context of personal goals and benefits (such as gaining knowledge) but also the important role of information sharing (i.e., interpersonal discussion and informing/persuading others). We argue that an opinion leader identity and the contexts in which it emerges (i.e., group membership, individual traits, and social roles) guides the types of messages people look for and share about this issue.

We conducted 36 in-depth interviews with opinion leaders in three upstate New York counties. Interviewees perceived and sought and exchanged information about potential environmental, economic, infrastructure, and social impacts. Interviewees also reported a variety of meanings associated with this label (including staying informed about particular impacts) and reasons for seeing themselves/being seen in this light (i.e., belonging to organizations such as local Legislatures and occupying particular positions, such as an elected official). For some interviewees, these contexts shaped the types of information about which they felt social or personal pressure to remain informed and/or sought and shared. We discuss theoretical and practical implications of this research, including (1) measuring how people look for and exchange information about controversial, polarizing risk issues and (2) harnessing the power of opinion leaders to encourage communication behavior about contentious natural resource management issues as part of public participatory processes.

**Abstract title:** Pennsylvania and New York Residents' Views of Natural Gas Development in the Marcellus Shale Region

- Rich Stedman, Cornell Department of Natural Resources, Cornell University, Ithaca, N.Y. 14850
- Fern Willits, Agricultural Economics and Rural Sociology, Penn State
- Kathryn Brasier, Agricultural Economics and Rural Sociology, Penn State
- Matthew Filteau, Agricultural Economics and Rural Sociology, Penn State
- Diane McLaughlin, Agricultural Economics and Rural Sociology, Penn State
- Jeffrey Jacquet, Department of Natural Resources, Cornell University
- Rod Howe, Community and Regional Development Institute (CaRDI), Cornell University

The risks and benefits of extracting natural gas in the Marcellus Shale region (in the northeast United States) are rapidly evolving. Managerial responses of New York and Pennsylvania differ dramatically. In Pennsylvania, drilling permits have been issued, and extraction is proceeding; New York has prohibited permitting pending environmental review. Are these contrasts reflected in the views of residents? Questionnaires were sent to a random sample of 6,000 households in the Marcellus Shale area of New York and Pennsylvania. Our research focused on knowledge, participation, trust, and expected impacts.

Most respondents perceived low knowledge about the impacts of natural gas drilling: most expressed “no or very little knowledge” about issues related to jobs, regulations, government, legal implications, and drilling procedures. These figures did not differ across states, despite the history of gas drilling in Pennsylvania. New York respondents demonstrated higher levels of participation, including signing petitions, participating in groups, or contacting the media or government officials. Differences in trust were also observed: most respondents reported some trust in scientists and researchers. Pennsylvanians were more likely to trust the natural gas industry, and less likely than New York residents to trust environmental groups.

Finally, although most respondents seemed uncertain about impacts, more believed conditions would get worse than better vis-à-vis overall quality of life, affordable housing, roads, crime, environmental quality, drinking water, recreation, and overall cost of living. New York respondents were more likely to anticipate negative outcomes, and more likely to oppose gas development overall.

**Abstract title:** The Effects of Marcellus Shale Development on Families with Children:  
An Exploratory Study

- Diane K. McLaughlin, Rural Sociology, Penn State, University, Park, Pa.; [dkk@psu.edu](mailto:dkk@psu.edu); 814-863-8626
- Kelly D. Davis, Penn State
- Kathy Brasier, Penn State
- Molly A. Martin, Penn State
- April Gunsallus, Penn State
- Khai Le, Penn State

*Please direct correspondence to:* Diane K. McLaughlin, 110C Armsby Building, University Park, Pa., 16802

The Marcellus Shale Family study will provide preliminary information to refine a conceptual model of the effects of Marcellus Shale development on well-being of families with children. The model focuses on three domains by which Marcellus Shale development influences family and child well-being – community, natural environment, and family. Four counties in the Marcellus were selected for inclusion in the study. Two of these had active exploration and drilling whereas two had low or no drilling activity. Each active county is matched to a less active county based on geographic location and demographic characteristics. There are two phases of the study. The first involves interviewing roughly ten key informants from each county, where individuals were identified based on their expertise in one of six broad areas: community, natural environment, families and health, work and economic development and education. The interviews contained open-ended questions about what makes the community a good place to raise a family, the levels of trust and interaction in the community, the importance of the natural environment to residents and whether/how these have or are expected to change with development of Marcellus Shale. These interviews will provide insights into the different ways in which Marcellus Shale development factors may be associated with family well-being. The second phase involves interviewing parents in families with children (up to 80 families) using questions similar to those for the key informants, but also asking specifically about family relationships, children's health, activities, parent's friends and social support and direct experiences with Marcellus Shale. We will also administer a survey instrument to test questions for inclusion in subsequent research projects. The research is exploratory in that the purpose was to identify expected and unexpected ways in which Marcellus Shale development affects families with children through perceived changes in their communities, natural environments and family experiences. It will form the basis for future research to gather more detailed information from a larger sample of families across many counties. The results will be shared with those interviewed and made publicly available on appropriate websites in the form of fact sheets to those in communities affected by or likely to be affected by Marcellus Shale. This research does not provide an indication of the prevalence of these changes experienced, but it does provide insight into the range of possible effects and how different types of families are affected.

**Abstract title:** Public Perceptions of Marcellus Shale Knowledge Gaps: Preliminary Findings and New Questions

- Abby Kinchy, Rensselaer Polytechnic Institute, [kincha@rpi.edu](mailto:kincha@rpi.edu), 518-276-6980
- Gene Theodori, Sam Houston State University
- Leanne Avery, SUNY Oneonta

*Please direct correspondence to:* Abby Kinchy, Science and Studies, Rensselaer Polytechnic Institute, Sage Lab Building, 5403; 110 8th Street, Troy, NY 12180-3590

This presentation discusses public perceptions of the availability and credibility of information about the impacts of Marcellus Shale gas drilling. The public is dependent on regulatory agencies—and to a lesser extent, academic researchers—to document environmental contamination resulting from natural gas drilling and to provide pertinent risk information. However, public agencies and academic institutions often fail to produce knowledge that satisfies public demands. Preliminary results from ongoing focus group research in the Twin Tiers region of New York and Pennsylvania indicate that there is widespread discontent with the type and amount of information provided by public authorities, industry, and academia about the impacts of gas drilling. Many focus group participants expressed distrust in multiple sources of information about the topic of gas drilling, and felt frustrated that they were unable to find answers to their questions about environmental safety. These rural community residents described their ambivalence and uncertainty about the impacts of gas drilling.

Our research suggests a need for further investigation into reasons for the “knowledge gaps” that are perceived as problematic by members of communities affected by Marcellus Shale gas drilling. A central theme in the debate about hydraulic fracturing has been information disclosure. Public awareness that information is lacking can create fear, distrust, and anger at public agencies and research institutions. Furthermore, community groups that seek remedies for environmental problems associated with gas drilling are likely to find that they have little leverage without credible scientific data to support their position. Therefore, there is a clear need to examine, from a sociological perspective, the social forces that structure what is known and not known about the impacts of unconventional gas drilling. The presentation will outline possibilities for advancing this line of investigation, in addition to reporting the findings from four focus groups.

**Abstract title:** Marcellus Shale Gas Development in Pennsylvania and the Perceptions of Opportunities and Challenge Among Pennsylvania Educators

- Kai Schafft, Education Policy Studies, Penn State University; [kas45@psu.edu](mailto:kas45@psu.edu); 814-863-2031
- Leland Glenna, Agricultural Economics and Rural Sociology, Penn State University
- Jim Ladlee, Director, Clinton County Extension Penn State Extension
- Jeannette Carter, Director of Outreach for K-12 Penn College of Technology

*Please direct correspondence to:* Kai Schafft, 310B Rackley Building, University Park, Pa., 16802

The Marcellus Shale natural gas play, the second largest natural gas-bearing shale formation in the world, extends from New York's Southern Tier, through about two thirds of Pennsylvania and into parts of Ohio and West Virginia. Recent advances in drilling technology have led to dramatic boomtown development in many areas that have endured extended periods of economic decline. Gas drilling proponents frame Marcellus development almost exclusively in terms of its economic potential. However, for schools within areas of rapid natural gas development within the Marcellus Shale Play, changing economies and community conditions connected to gas drilling represent sets of both opportunities and challenges. This presentation presents preliminary results from a survey to educators and educational administrators across Pennsylvania's Marcellus region. We discuss the opportunities, contradictions and dilemmas facing many rural schools and communities in Pennsylvania as educators evaluate what gas development-based community change means for the role of secondary schools and Career and Technology Centers in workforce and economic development and for broader trends affecting community development and well-being.