



Possible Environmental Impacts

By Kate Cleary

Topic Discussion

Hydraulic fracturing of the Marcellus shale gas presents the opportunity for not only an energy source, but also for serious, negative environmental impacts. From air pollution to land degradation, these impacts must be looked at and considered to better understand what fracking is. Environmental impacts are important to the fracking situation at hand because when any unnatural extraction of a natural material occurs, it will inherently impact the environment. When the process is as intense as hydraulic fracturing, the potential of a serious threat increases, and the integrity of the environment must be looked after and protected.

Additionally, the environmental impacts of fracking are important to the controversy of fracking because if industries wish to explore the benefits of fracking and use this process for several decades, all negative aspects must be considered as well. The environmental impacts fracking could have would potentially be catastrophic, and understanding of these must exist to make informed decisions. While many argue that the extraction of natural gas will give the United States energy independence and economic benefits, the uncertainty of these impacts and potential loss of environmental services are far too important to ignore.

The controversy of fracking, including the environmental issues associated with it, is part of a larger energy issue that affects all communities and people. Understanding how fracking will impact the environment, and therefore all aspects of life in these natural areas, will allow people to form opinions on fracking. These opinions can be part of a greater decision on which direction our energy use and industries should head – in a sustainable or unsustainable direction.

There are a great many environmental concerns raised by the process of hydraulic fracturing including the creation of air, noise, and visual pollution, the potential for chemical

spills, radioactivity associated with fracking processes, impacts on and disturbance of natural lands, and impacts on biodiversity. Studies of these impacts are relatively limited, due to the newness of this type of intense hydraulic fracturing, and there is some level of uncertainty in these issues. The impacts that have been investigated, however, do show a strong correlation with the presence of fracking in the area.

Air pollution created by fracking activities is the greatest threat to the environment. Air pollution leads to decreased air quality for all life in the area and can even contribute to climate change. The most threatening component of air pollution that fracking creates is methane, a major component of greenhouse gas pollution (Marcellus Shale Advisory Commission, 2011). Methane is released into the atmosphere as a fugitive emission, or an emission of a gas from pressurized equipment due to leaks or irregular releases of gases. This can occur through leaks in processing equipment and pneumatic devices. A pneumatic device is one that is operated by air or by the pressure or exhaustion of air.

Methane presents a serious problem to the environment because as methane is vented into the atmosphere, global warming is amplified, which contributes to an already concerning problem. While some may argue that burning natural gas for energy is a cleaner solution to burning other materials, the amount of methane gas leaking during production negates the cleaner-burning advantages and can be 20% more harmful to the environment than coal (Lovejoy, 2012). In a 100-year period, methane is 21 times more harmful to the atmosphere than carbon dioxide. Recent studies have shown a strong correlation between natural gas industry-produced methane and atmospheric methane levels; as shale gas production has increased tenfold since 2005, the atmospheric methane levels have also been rising since 2006 (Lavelle, 2012).

To address this problem, the Environmental Protection Agency has established a new regulation that states all gas companies must begin capturing air emissions, including methane, by 2015 (Eilperin and Mufson, 2012). In the meantime, companies will be required to flare their emissions. While the EPA believes this is a wasteful action, as methane could have other useful applications, it will eliminate 90% of volatile organic compounds and break down the methane into water and carbon dioxide.

Other air pollutants created by fracking that are of concern include nitrogen oxides; volatile organic compounds (VOCs); benzene, toluene, ethyl benzene, and xylenes (BTEX); carbon monoxide; sulfur dioxide; particulate matter (PM); ground level ozone, created by the combination of VOCs and nitrous oxides; and hydrogen sulfide (League of Women Voters, 2009). Many of these compounds are created during transportation and production of shale gas, but can occur during any phase of production, and can be highly toxic and harmful. Overall, air emissions contribute to 2.4% of the overall environmental impact of fracking (Elcock, 2007).

Noise pollution, while not the greatest pollution threat, does create problems in the environment. The noise created by the all phases, from construction to deconstruction, can last between 800 and 2,500 days (Broomfield, 2012). This can disturb the natural habitats of many animals by deterring them from being in these areas. Many animals may use these sites as their everyday habitats, areas to migrate through, and even areas to find mates in.

Visual impacts poses many of the same threats and are especially damaging during the four-week construction period (Broomfield, 2012). The visual impact can be in the form of light pollution or the visible presence of fracking machinery. Light pollution occurs in these areas because fracking activities persist though all hours of the night. Since there is no relief from the

strong lights at the well pads, animals that are nocturnal are faced with disruptions in their daily life activities. Even animals that are not nocturnal can have disturbed sleeping patterns from these intense lights. Additionally, the presence of these large machines can affect migratory patterns and scare away organisms from their niche. A niche is the area that a specific organism does especially well in and is specialized to live in.

All of these impacts were documented in a study on the environmental impacts of hydraulic fracturing in Europe (Broomfield, 2012). Air pollution presented high cumulative risks during four of the six different stages of fracking and overall was presented as a high risk (Table 1). Noise and visual impacts varied across different stages of fracking, and cumulatively noise impacts were a high risk and visual impacts were a moderate risk (Table 1).

Chemical spills are of great concern to the public and the environment due to the great, unknown risks associated with these events. When chemical spills occur, the chemicals can leach into the soils and persist there for an extended period of time. This can lead to the death of plants and even agricultural crops in the area. Once the chemicals are incorporated into the topsoil, it is extremely difficult to remove them. In Bradford County, Pa., on July 4, 2012, 4,700 gallons of hydrochloric acid spilled at a well pad operated by Chief Oil and Gas. (Detrow, 2012). The Department of Environmental Protection conducted an investigation and blamed valve failure for the accident. While 4,000 gallons were successfully captured in a containment pond, 700 gallons still moved past the well pad site and made their way into the soil as well as a nearby creek. In this creek, a small fish kill occurred shortly after the contaminants reached the waterway, making it obvious the potential harm these chemicals could cause in the environment if released.

While radioactive materials occur naturally within soils in the ground, the type and amount of radiation that fracking of the Marcellus shale is contributing is of great concern. Fracking brings to the surface radioactive materials that could contaminate nearby lands for thousands of years (Grassroots Environmental Education, 2012). Radium-226, a radioactive material, is the main radioactive element found in the Marcellus shale, and it has a half-life of 1,600 years. This means that in 1,600 years, only half of the material that exists will have decayed and no longer be harmful. When these materials enter the soil, they can cause the death of plants in the area as well as agricultural lands and crops.

The disturbance of natural lands is another environmental impact highly correlated to fracking activities. This disturbance can come in the form of forest fragmentation, the creation of roads and increase in traffic, and even edge effect.

Forest fragmentation occurs when forested areas are split by the presence of machines and vehicles, changing contiguous forests into smaller, more isolated areas. Fracking often creates forest fragmentation, which can lead to the loss of soil integrity, the death of native species of plants and animals, the creation of the edge effect, and disturbance to all organisms in the area. Some estimates have said that Pennsylvania could lose between 38,000 and 90,000 acres of forest cover by 2030 from fracking (Marcellus Shale Advisory Commission, 2011), which would severely fragment the forests of these areas. On average, companies clear between three and four acres of land per well pad.

There are both direct and indirect impacts that affect the land around a well pad. Direct impacts include the direct clearing of land for the pad site, as well as land cleared for infrastructures such as the roads (Johnson, 2011). This can account for approximately 8.8 acres

of land lost (Table 2). Indirect impacts include land lost adjacent to the site, which can extend about 300 feet, and this is due to forest fragmentation, the creation of new forest edges, and changes in habitat conditions. These total to about 21.2 acres lost, giving a total of about 30 acres of land being lost to one site (Johnson, N., 2011) (Table 2).

State parks face a particularly unique challenge with fracking. In Pennsylvania, the state does not own rights to the minerals that underlie nearly 80% of all parks (Lavelle, 2010). The private owners can sell the rights to the minerals, which means that fracking companies can easily buy these rights and exploit the lands. Many fear what would happen in such a situation, and there is reason to have these fears. In 2008, the U.S. Forest Service conducted a study in the Fernow Experimental Forest in the Monongahela Nation Forest in West Virginia after fracking fluids from a nearby well pad were sprayed on trees, killing them (Kusnetz, 2011). This application of fracking fluids was intentional and a method of disposal called land-application. Immediately after application, there was an apparent impact, as massive foliage losses occurred and trees began to shed their barks (Figure 1). Initially, the project killed approximately 1,000 trees and caused damage to the ground cover as well. A year later, in 2009, the number of trees affected had increased, and dead foliage was still prevalent (Figure 2).

Much of the land disturbance is caused by the presence of trucks and traffic that normally does not exist in these areas. Since the companies cut into the forests, fragmenting the area, the roads are not always well constructed or planned. Some sites will see trucks moving between 7,000 and 11,000 times for a single ten-well pad and on average 250 truck trips are made daily to an individual site (Broomfield, 2012), all of which create significant road damage. In addition to this, these massive trucks and heavy equipment can lead to soil compaction. Soil compaction can occur as topsoil compaction, which is caused by tire pressure and can severely reduce plant

productivity in the short term, and subsoil compaction, which is caused by axle loads and reduces productivity for decades (League of Women Voters, 2009). Cumulatively, the impact is decreased soil percolation and increased runoff of water, leading ultimately to less growth of vegetation and more soil erosion.

Loss of biodiversity is a great threat to Pennsylvania, because out of the 329 species in the Marcellus drilling regions, 132 species, or 40%, are globally rare and critically endangered in Pennsylvania. These species include the green salamander and the snow trillium. In addition to these rare species, Pennsylvania may see a decrease in populations of the Northern Flying Squirrel, the Northern Goshawk, the Scarlet Tanager, and the Black-Throated Blue Warbler. Scarlet Tanager populations could decrease by 23% and the Black-Throated Blue Warbler could see decreases between 10% and 40% (Johnson, 2011).

Decreases in these populations would be seen mainly due to the increase in edge effect. The edge effect occurs when an area is fragmented, creating more edges in an area. Some edges can increase as much as 1,500 feet, leading to a significant change in the landscape. This can push out species native to these areas and make way for new, invasive species. Many predators thrive along edges and forage for resources and other animals, creating an uninhabitable area for many species (Blankenship, 2011). Additionally, construction can create ditches, making it harder for amphibians to move around, and can create changes in canopy cover, increasing the amount of light in a forest and changing growth rates of plants (League of Women Voters, 2009).

The impacts of hydraulic fracturing on the environment raise concern as to whether this is a process that should be continued in the future. With the economic gains and the claims by some that natural gas is a cleaner alternative to other fuels, it is easy to support fracking activities.

However, when the whole picture is considered, fracking tells a much different story, one that could destroy our air, our lands, and the life that exists there.

As citizens, I believe it is most important to focus on the most threatening aspect of environmental impacts: air pollution. The best way to address this problem is to first talk to local agencies and industries and find out who is polluting, who is not within regulations, and what is being done about it. If the proper actions are not being taken to control pollution by fracking industries, then actions should be taken and citizens can make recommendations for these actions. Some recommendations could include: using lower toxicity of fracking chemicals to minimize the quantities of the chemicals needed; burn the emitted gases to capture any other air pollutants that may be escaping during production; use low bleed pneumatic devices to reduce methane emissions up to 90%; and use electric motors instead of combustion engines. Citizen involvement and action is the most efficient way to begin to protect our environment and reduce the harmful effects of fracking.

Figures and Tables:

Table 1. Summary of preliminary risk assessment

AEA Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe

Table ES1: Summary of preliminary risk assessment

Environmental aspect	Project phase							Overall risk across all phases
	Site identification and preparation	Well design, drilling, casing, cementing	Fracturing	Well completion	Production	Well abandonment and post-abandonment		
Individual site								
Groundwater contamination	Not applicable	Low	Moderate-High	High	Moderate-High	Not classifiable	High	
Surface water contamination	Low	Moderate	Moderate-High	High	Low	Not applicable	High	
Water resources	Not applicable	Not applicable	Moderate	Not applicable	Moderate	Not applicable	Moderate	
Release to air	Low	Moderate	Moderate	Moderate	Moderate	Low	Moderate	
Land take	Moderate	Not applicable	Not applicable	Not applicable	Moderate	Not classifiable	Moderate	
Risk to biodiversity	Not classifiable	Low	Low	Low	Moderate	Not classifiable	Moderate	
Noise impacts	Low	Moderate	Moderate	Not classifiable	Low	Not applicable	Moderate-High	
Visual impact	Low	Low	Low	Not applicable	Low	Low-moderate	Low-Moderate	
Solmisticity	Not applicable	Not applicable	Low	Low	Not applicable	Not applicable	Low	
Traffic	Low	Low	Moderate	Low	Low	Not applicable	Moderate	
Cumulative								
Groundwater contamination	Not applicable	Low	Moderate-High	High	High	Not classifiable	High	
Surface water contamination	Moderate	Moderate	Moderate-High	High	Moderate	Not applicable	High	
Water resources	Not applicable	Not applicable	High	Not applicable	High	Not applicable	High	
Release to air	Low	High	High	High	High	Low	High	
Land take	Very high	Not applicable	Not applicable	Not applicable	High	Not classifiable	High	
Risk to biodiversity	Not classifiable	Low	Moderate	Moderate	High	Not classifiable	High	
Noise impacts	Low	High	Moderate	Not classifiable	Low	Not applicable	High	
Visual impact	Moderate	Moderate	Moderate	Not applicable	Low	Low-moderate	Moderate	
Solmisticity	Not applicable	Not applicable	Low	Low	Not applicable	Not applicable	Low	
Traffic	High	High	High	Moderate	Low	Not applicable	High	

Not applicable: Impact not relevant to this stage of development
 Not classifiable: Insufficient information available for the significance of this impact to be assessed

Ref: AEA/ED57201/Issue Number 17 vi

Source: Broomfield, 2012. AEA European Commission

Table 2. Forest Habitat Impacts – Marcellus Gas

Forest Habitat Impacts – Marcellus Gas		
Average Spatial Disturbance for Marcellus Shale Well Pads in Forested Context (acres)		
Forest cleared for Marcellus Shale well pad	3.1	8.8
Forest cleared for associated infrastructure (roads, pipelines, containment pits, etc.)	5.7	
Indirect forest impact from new edges	21.2	
TOTAL DIRECT AND INDIRECT IMPACTS	30	

Source: Johnson, 2011.

Figure 1. Apparent damage caused by land-application of fracking fluid in the Fernow Experimental



Figure 9.—Fluid application site 1, with non-treated forest in background, Fernow Experimental Forest. Photo taken May 17, 2009. Photo by U.S. Forest Service.



Figure 10.—Bark sloughing by American beech trees, fluid application site 1, Fernow Experimental Forest. Photo taken April 22, 2009. Photo by U.S. Forest Service.

Source: U.S. Forest Service

Figure 2. Leaves affected by land-application of fracking fluid in the Fernow Experimental Forest



Figure 6.—Foliage injury of Fraser magnolia on fluid application site 1, Fernow Experimental Forest. Note damaged red maple foliage in background (upper left). Photo taken June 19, 2008. Photo by U.S. Forest Service.



Figure 7.—Fluid application site 1, Fernow Experimental Forest, showing dead and damaged understory vegetation, and freshly fallen green leaves. Red flagging indicates trees showing symptoms. Photo taken July 9, 2008. Photo by U.S. Forest Service.



Figure 8.—Damaged greenbrier vines on fluid application site 1, Fernow Experimental Forest. Photo taken June 19, 2008. Photo by U.S. Forest Service.

Source: U.S. Forest Service

Stakeholder Interview

Roxann Steelman is a master's student at Lehigh University in the Environmental Policy Design program. Through her extensive work and research, she has become well versed on the impacts of fracking on the environment. Her master's research is on the effects of Marcellus Shale natural gas development on hunting, fishing, and other recreational activities throughout Pennsylvania. Her views are anti-fracking, due to the detrimental effects on many aspects of the environment and the lack of research on the subject.

Q: What is the most serious environmental impact caused by fracking that you have come across? Why should we be concerned about this?

A: In my opinion all of the environmental impacts are serious; it's hard to just pick one. There is the potential for so many different species to be negatively affected. Just losing one species could cause rippling effects through the food chain. Some examples: amphibians are already in decline around the world, water pollution caused by fracking fluids could spiral their decline in PA even faster; ruffed grouse are considered specialist game birds and cannot quickly adapt to habitat changes; forest fragmentation changes the light, temperature, and humidity levels around forest edge causing interior forest species such as migratory songbirds and vegetation to be negatively affected.

Q: *Do you think we should be more concerned about impacts on land and biodiversity or impacts on air quality?*

A: We need to be very concerned with both of these. If I had to pick one I would say land and biodiversity only because impacts to them may not be repairable once they are affected. Air quality can improve once the polluting source is removed. Biodiversity – once a species is wiped out it is gone!

Q: *Have there been any proven impacts on specific animal species associated with fracking activities? Are we seeing some species become threatened or even on the verge of extinction?*

A: Not in Pennsylvania, but in places like Wyoming. Mule deer are having their winter feeding grounds degraded causing them to bunch up and feed on marginal grounds. This causes malnutrition, disease transfer, and lower survival rates. I have not come across any specific species becoming threatened or close to extinction.

Q: *What aspect of air pollution related to fracking concerns you the most? Why?*

A: The toxic plumes that can be associated with well blowouts or flaring. Plumes can travel through the air for miles and particulate matter settles out as it goes. This could lead to other areas not currently being drilled to become polluted.

Q: *Are ecosystem services threatened by fracking activities? For example, wetlands provide wonderful services by taking toxins out of the environment. Could this be threatened if fracking occurred near a wetland?*

A: Absolutely! The recommendation for the gas companies is to have a setback of 300 feet from any wetland. In my opinion that is still too close. Wetlands serve as opportune breeding grounds for many species and insects, stopovers for migratory birds and water fowl, as well as what you mentioned above.

Q: *What solutions would you suggest to the environmental problems posed by fracking? (i.e. ban fracking, impose more strict regulations, etc.)*

A: I would suggest a moratorium on fracking to become effective immediately. According to the PA Chapter of The Wildlife Society, the “best practices” that the Pennsylvania Department of Conservation and Natural Resources (DCNR) has recommended to the gas companies have not been researched to determine if they are even effective environmental protection measures.

Profiles of Key Individuals and Groups

1. The Sierra Club

The Sierra Club is one of the largest and most influential grassroots environmental organizations, whose motto is to “explore, enjoy, and protect the planet”. It provides an

environmental perspective to fracking and is against the practice because of the belief that “natural gas drillers exploit government loopholes, ignore decade-old environmental protections, and disregard the health of entire communities.” With its vast amount of resources and large reach, the Sierra Club has enough funding to make sure that its information is well supported and research can be conducted by trusted specialists. It also provides information that is pertinent to members of the world and can reach a large audience.

The Sierra Club focuses on four aspects of drilling: closing industry loopholes, cleaning up drilling, protecting parks, and stopping exports. All of these topics include valuable information on how fracking influences the environment from the impacts of air pollution to the value of natural areas that would be impacted. To find this information, go to content.sierraclub.org/naturalgas/content/beyond-natural-gas. The Sierra Club can be contacted in a variety of ways, including: contacting their national headquarters, their legislative office, and even specific email addresses pertaining to specific inquiries and topics. To find this information, follow the website link, and click the tab “Contact Us.”

2. PennEnvironment

PennEnvironment is statewide, citizen-based environmental advocacy organization in Pennsylvania that seeks to protect the natural areas in Pennsylvania while advancing its environmental values. One of the main issues it focuses on is the effects of Marcellus Shale gas drilling on Pennsylvania’s environment. This group takes an anti-fracking stance and calls for an end to gas drilling. Topics the group covers include pollution created by fracking activities and risks fracking poses to the health of the environment. The group also provides news releases on the site about the most up-to-date fracking information.

It has a sister organization, PennEnvironment Research and Policy Center, that is dedicated to researching and investigating issues that affect the air, water, and open spaces. This organization also helps to give citizens voices in politics and make the issues known. This site can provide valuable research studies on the environmental impacts of fracking, as well as other impacts. To contact either of these organizations, the website is <http://www.pennenvironment.org>. On this site, under the “Contact Us” tab, information on how to contact both their Philadelphia and Pittsburgh offices is available. There is also the option to directly send an email to the organization from this page.

3. The Pennsylvania Department of Conservation and Natural Resources (DCNR) and the Bureau of Forestry

The Department of Conservation and Natural Resources is a state agency with several branches. It is part of the government of Pennsylvania. Part of this department is the Bureau of Forestry, which specializes in various important environmental issues, including natural gas exploration on state forest lands. The DCNR has overseen controlled natural gas extraction while protecting habitats for plants and animals for over 60 years. The DCNR Bureau of Forestry was the first to issue an oil and gas lease in 1947 and has continued to participate in similar activities while promoting environmental conservation. It believes that state forests should be used as models of conservation as well as to provide timber, recreation, and even natural gas. The Bureau has taken a pro-fracking stance, as long as activities are properly conducted and the integrity of the environment is respected and maintained. Its website provides a wealth of information on natural gas drilling and the impacts this has on our natural lands. Specifically, this group has looked into how fracking will affect state forests that it protects, attempting to find

a balance between protecting forests while using natural gas drilling for energy and economic benefits.

To access this group and its resources, the website is <http://www.dcnr.state.pa.us/forestry/naturalgasexploration/index.htm>. To contact individuals, the site provides a link to the central office directory in Harrisburg, which contains a list of all employees, their job titles, and their phone numbers. There is also a link to the directory for the Bureau of Forestry, which provides a list of all 20 forest district offices with their address, telephone numbers, and email addresses.

4. The U.S. Environmental Protection Agency

The Environmental Protection Agency is a federal government agency that seeks to protect human health and the environment through enforcement of regulations, studying environmental issues, teaching people about the environment, and passing legislation. The EPA has taken a pro-fracking stance with the condition that fracking practices are not at the expense of public health or the environment. The agency does a great deal of research on various issues of fracking, especially regarding the pollution created by fracking and the effects of this on the environment. It focuses on providing oversight, guidance, and rulemaking to achieve the best possible protection for the environment, which includes the air, water, and lands that may be affected. As the main enforcers of laws on fracking, the EPA is one of the best authorities on fracking from which people can obtain useful information on the issues.

To learn more about the EPA's fracking authority, visit their website: <http://www2.epa.gov/hydraulicfracturing>. The site provides a long list of ways to get in touch with the agency under the tab "Contact Us". Under this list, one can find the mailing addresses of

the EPA headquarters, regional offices, and laboratories, as well as the directory containing all EPA employees by calling (202) 272-0167. Additionally, for people that wish to report an emergency event, a spill, or releases, they can call 1(800) 424-8802 or fill out a reporting form found on the website.

Web Resources for Additional Information

1. The National Resources Defense Council (NRDC): www.nrdc.org/health/drilling/

The National Resources Defense Council provides information on the impacts of fracking and how to avoid disastrous outcomes. It provides information on health effects, laws, pollution, and environmental impacts and what citizens can do about fracking in their areas. The website is easy to navigate, has a wealth of information, and is well balanced on all aspects of fracking. The site also contains many links to other useful sites and organizations that provide information on fracking, including a section on the different resources and sites available within each state.

2. State Impact (NPR association)- the Department of Conservation and Natural Resources: <http://stateimpact.npr.org/pennsylvania/tag/department-of-conservation-and-natural-resources/>

This State Impact site is a “Guide to DCNR: The Agency Balancing Drilling and Conservation Interests.” It discusses the role of the DCNR in fracking and its impacts on state parks and forests. There is a great deal of information and details on the environmental impacts of fracking for people to access, mainly in the form of posts and news reports on fracking related to the DCNR. The site provides information almost exclusively on the actions of the DCNR related to fracking and is very easy to navigate. The site also provides a few links to other sites, with most of them being parts of the DCNR’s main website.

3. FracTracker: <http://www.fractracker.org/>

FracTracker is a non-profit organization that is dedicated to providing information to the public about the impacts of the shale gas industry by collecting, interpreting, and sharing data through its aggregator website. The site provides a variety of opinions and types of information, with a great deal of information on the environmental impacts of fracking. The site is very easy to navigate and provides a few outside links to other groups and information on fracking.

4. National Wildlife Federation: <http://www.nwf.org/What-We-Do/Energy-and-Climate/Drilling-and-Mining/Natural-Gas-Fracking.aspx>

The National Wildlife Federation's site on fracking and its impacts seeks to ensure that fracking companies are held responsible for living up to the keystone conservation laws, such as the Clean Air Act, and that key habitats are protected from fracking. The site focuses on the impacts to water and air quality and to wildlife. The website itself does not have a great depth of information, but there is additional, detailed information available in a pdf provided by the site of the NWF's report exposing the hazards of fracking. Seven related resources links can be accessed at the site for more information, as well as links to blogs and news on fracking.

5. Susquehanna River Basin Commission:

<http://www.srbc.net/programs/projreviewnaturalgas.htm>

The Susquehanna River Basin Commission's website on natural gas shales and well development is very easy to use and has a good balance in the information it presents. The information is presented as links to various resources, all of which are related to the environmental impacts of fracking. These links vary from press releases to Susquehanna River Basin Commission resources to regulatory information.

6. Delaware River Basin Commission: <http://www.state.nj.us/drbc/programs/natural/>

The Delaware River Basin Commission site provides a natural gas drilling index page that is easy to navigate and provides useful information for any curious or concerned citizen. There are five main tabs on the site to access that give information on a wide range of fracking topics and concerns. All of these topics have links to other resources to access more information on fracking and its impacts. There is even a map of the Delaware River Basin special protection waters, the special protection waters drainage areas, and the location of the Marcellus shale formation.

For More Information

1. The United States Geologic Survey (USGS):
<http://www.usgs.gov/science/science.php?term=770>
2. The Society of Environmental Journalists (SEJ): <http://www.sej.org/search/node/fracking>
3. The Pennsylvania Department of Environmental Protection:
http://www.portal.state.pa.us/portal/server.pt/community/marcellus_shale/20296
4. Earth Justice: http://earthjustice.org/our_work/campaigns/fracking-gone-wrong-finding-a-better-way
5. Earth Works:
http://www.earthworksaction.org/issues/detail/hydraulic_fracturing_101#.UMAdt6X3BT4
6. Berks Gas Truth: <http://www.gastruth.org>

Works Cited

- Blankenship, K. (2011, December 1). Marcellus Shale drilling may take huge chunks out of PA forests. *Bay Journal*. Retrieved from [http://www.bayjournal.com/article/marcellus_shale_drilling_may_take_huge_chunks_out_of_p a_forests](http://www.bayjournal.com/article/marcellus_shale_drilling_may_take_huge_chunks_out_of_p_a_forests)
- Broomfield, M. (2012, October 8). Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe. AEA Technology plc. Retrieved from <http://ec.europa.eu/environment/integration/energy/pdf/fracking%20study.pdf>
- Detrow, S. (2012, July 5). 4,700 Gallons of Acid Spill at Bradford County Drilling Site. *NPR State Impact*. Retrieved from <http://stateimpact.npr.org/pennsylvania/2012/07/05/4700-gallons-of-acid-spill-at-bradford-county-drilling-site/>
- Eilperin, J., & Mufson, S. (2012, April 18). EPA gives oil companies more time to capture emissions from wells. *The Washington Post*. Retrieved from http://articles.washingtonpost.com/2012-04-18/national/35453115_1_shale-gas-natural-gas-oil-and-gas
- Elcock, D. (2007, September). Life-Cycle Thinking for the Oil and Gas Exploration and Production Industry. Environmental Science Division of the Argonne National Laboratory. Retrieved from http://www.evs.anl.gov/pub/dsp_detail.cfm?PubID=2154

- Marcellus Shale Advisory Commission. (2011, March). Pennsylvania Department of Environmental Protection. Retrieved from http://www.portal.state.pa.us/portal/server.pt/community/marcellus_shale_advisory_commission/20074
- Grassroots Environmental Education. *Radioactive Fracking Waste Fact Sheet*. Retrieved from <http://www.grassrootsinfo.org/pdf/radioactivewaste.pdf>
- Johnson, N. (2011, April 1). *Marcellus Gas Development and Habitat Impacts* [PowerPoint slides]. Retrieved from http://www.mde.state.md.us/programs/Land/mining/marcellus/Documents/Johnson_TNC_MarcellusScienceMeeting.pdf
- Lavelle, M. (2010, October 17). Parks, Forests Eyed for the Fuel Beneath. *National Geographic*. Retrieved from <http://news.nationalgeographic.com/news/2010/10/101022-energy-marcellus-shale-gas-parks-forests/>
- Lavelle, M. (2012, December). Good Gas, Bad Gas. *National Geographic*. Retrieved from <http://ngm.nationalgeographic.com/2012/12/methane/lavelle-text>
- League of Women Voters of Pennsylvania. (2009). Marcellus Shale Natural Gas: Environmental Impact. Retrieved from http://www.palwv.org/files/224_MarcellusShaleStudyGuideII.pdf
- Kusnetz, N. (2011, February 4). Anatomy of a Gas Well: What Happened When a Well Was Drilled in a National Forest. *ProPublica*. Retrieved from <http://www.propublica.org/article/anatomy-of-a-gas-well-what-happened-when-a-well-was-drilled-in-a-national-f>

U.S. Forest Service. Retrieved from <http://www.nrs.fs.fed.us/ef/locations/wv/fernow/>