Environmental Effects of Hydraulic Fracturing Across Pennsylvania Counties

Kayla Yuditsky & Halie Staub
Millersville University
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Introduction

Since 2003 when Pennsylvania began utilizing hydraulic fracturing on a massive scale, there's been increasing controversy over the practice's environmental impact. Hydraulic fracturing, or "fracking," is a stimulation process used to extract natural gas from deep reserves far below the earth's surface. Deep holes (wells) are established by pumping massive amounts of water, chemicals, and sand at a high pressure into the earth's surface, which fractures the surrounding rock and opens up otherwise inaccessible passages. The induced underground pressure forces the natural gas to move upward to the oil extraction sites. Tapping into our local reserve of natural gas is valuable in the sense that it decreases our foreign dependency on a limited resource, but the current fracturing practices have proven to be more damaging to the environment than initially expected. Pennsylvania is the third most prevalent 'fracking' state in the country, following only Texas and Colorado in terms of gas production. These regions are of particular interest to oil companies because of their bedrock geology. Certain types of shale have high concentrations of organic material that can be converted to energy. PA itself is unique because it falls almost completely on top of a region composed of Marcellus shale. This specific bedrock is a black shale that was formed by the oxygen-deprived compression of a rich marine environment around 390 million years ago. This Marcellus formation (which spans across much of the Appalachian basin) is estimated to hold 1,925 billion cubic feet of recoverable gas. There are significant environmental and health concerns associated with this extraction, ranging from deforestation to depletion and contamination of natural water reserves to toxic air emissions (and many more). The purpose of this project was to investigate which counties in PA have been most dramatically affected by the increased implementation of fracking. Figure 1 depicts our results by ranking the counties based on an environmental index which incorporates the combined effects of fracking on air pollution, water usage, and state forest land cover.

Methods

We began the process by investigating relevant information about our topic such as chemicals and emissions, water usage and pollution, land use, facility types, and environmental regulations. From here, we needed to determine the most effective way to quantify the information in order to establish an environmental index for displaying our results. The numerical data were obtained from various sources, like PASDA and the EPA, and checked extensively against each other to ensure accuracy. Once we compiled all of our data, we performed calculations to quantify each element on a per well basis.

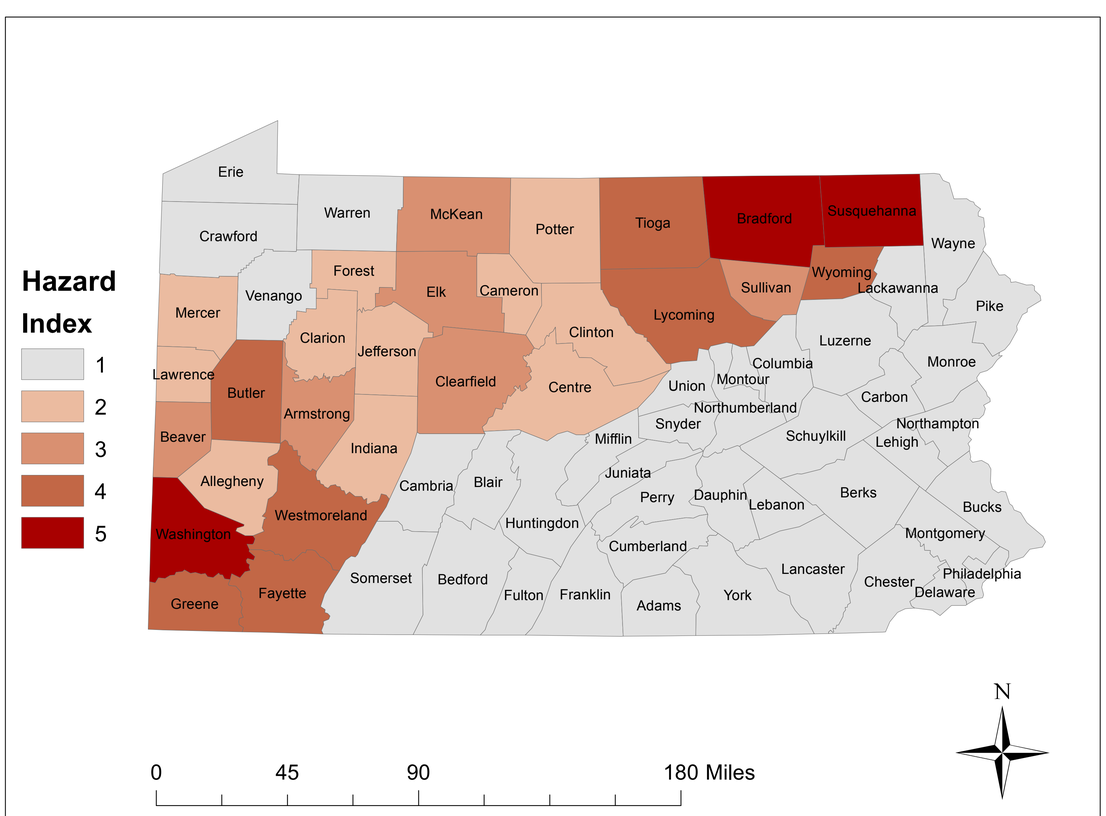

Figure 1. This map displays the potential environmental hazards of each county rated according to an environmental index. Counties with a higher ranking are more likely to suffer negative consequences of fracking. See methods for exact values used.

Methods (cont.)

We started with the Pennsylvania oil and gas wells layer, and queries were used to isolate only the active, unconventional wells. We projected a PA counties layer and a summarized join was used to display the average number of wells per county. In the new join table, we added three new fields to represent air, water, and land. We used the field calculator to apply our calculated environmental constants to the number of wells for each county. We quantified these elements based on a well's lifetime with average CO_2 equivalent output (3,430 metric tons), water usage (5.5 million gallons), and land usage (3.25 acres). A final field was created to represent the environmental index values. We defined ranges based on these results and ranked them from 1-5 according to the potential environmental hazard that each county faces, with 5 being the most hazardous (Fig 1). To analyze the freshwater impact, we used a layer from PASDA that contained the specific water bodies serving as sources for frack water withdrawal. Using the average daily withdrawal values from each source, we were able to determine the overall freshwater depletion value per county. We used a graduated colors map to display county values along with graduated symbols to represent the magnitude of withdrawal per water source (Fig 2). We delineated the chemical air emissions zone based on a striking statistic. Areas within a 10 mile radius of a fracking site have been proven to exhibit significantly higher concentrations of airborne toxins, many of which are carcinogenic. We used a dissolved buffer surrounding these fracking sites to display the regions affected most by fracking air pollution (Fig 3). We thought it was surprising that even state forests are not exempt from fracking destruction. We displayed these vulnerable forested areas by spatially comparing their position to the Marcellus shale land coverage (Fig 4).

Results & Discussion

As displayed in figure 1, the counties that are most affected overall by fracking are Bradford, Susquehanna, and Washington county. Overall, negative environmental effects are directly related to the Marcellus shale formation. There was an increase in freshwater depletion (Fig 2), chemical air emissions (Fig 3), and deforestation risk (Fig 4) along the gradient of the shale formation. With the increasing implementation of these hydraulic fracturing processes, we can expect to see the detrimental environmental effects spread across the Appalachian Basin.

Sources

Data provided by PASDA and EPA
Fracking by the Numbers: Key impacts of dirty drilling at the state and national level. 2013. Environment America.
Drilling 101. <http://shaleshock.org/drilling-101/>
Explore Shale: An exploration of natural gas drilling and development in the Marcellus Shale. <exploreshale.org>

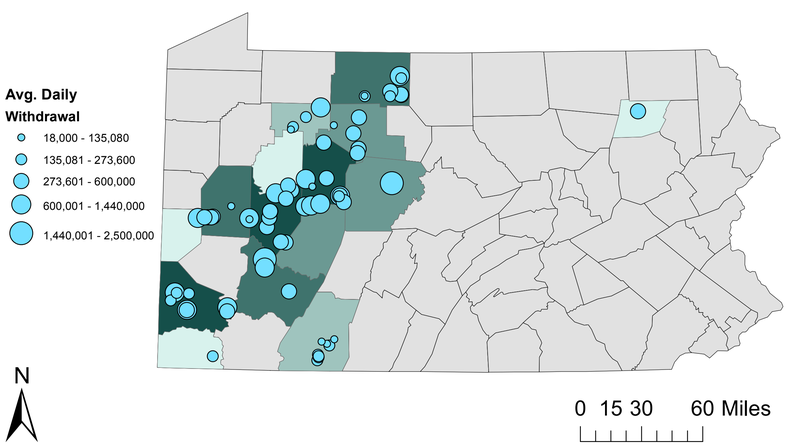

Figure 2. The data projected represents the average daily depletion of freshwater sources used to maintain fracking sites. Data is represented on a county and source location basis.

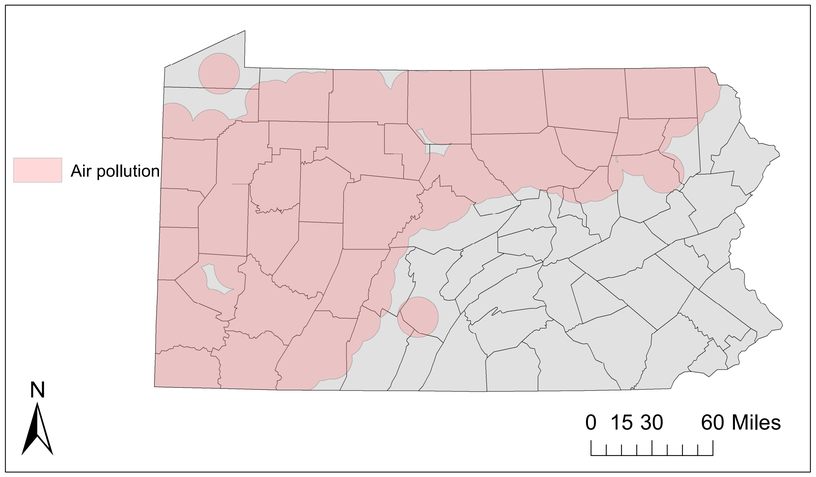

Figure 3. This map displays the regions of Pennsylvania that are exposed to increased chemical concentrations in the air.

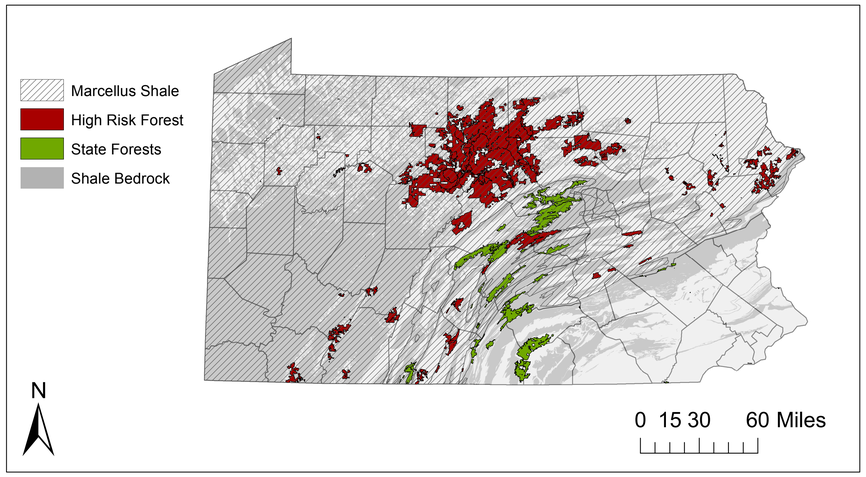

Figure 4. The data projected shows the underlying shale bedrock with emphasis on the Marcellus formation. The high risk forest regions represent the areas of state forest that are vulnerable to being altered for fracking purposes.