FRACKED OR FICTION:

Analyzing the Impact of Hydraulic Fracturing on Groundwater Quality in Northern Pennsylvania

What is Fracking & Why Should You Care?

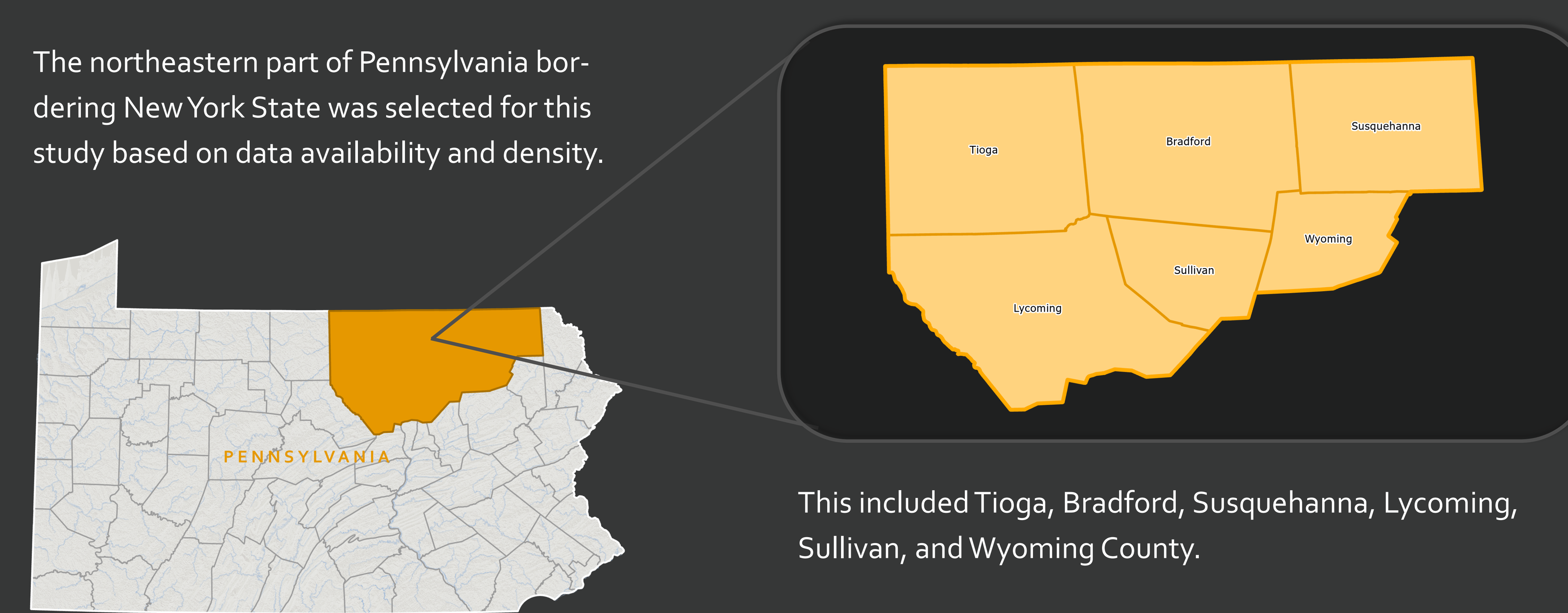
Hydraulic fracturing, dubbed fracking, has been a topic of public discourse regarding environmental impacts since the shale extraction process includes the injection of propriety chemicals into bedrock at high pressures. Fracking emerged as the revolutionary new technology for shale gas extraction in 2008 (DeLeo, Kuei, & Nigl, 2019).

The main concern for groundwater pollution is not actually the liquid that is injected but mishandling of the chemicals on the surface causing spills into surface waters and subsequently seeping below the water table. Some of the contaminants that may be included in this mixture are heavy metals, volatile organic compounds, and other compounds that cause high salinity (Soeder, 2018).

These contaminants in drinking water have been known to cause increases in asthma, headaches, sleep disruption and have other health consequences (DeLeo, Kuei, & Nigl, 2019).

Study Area

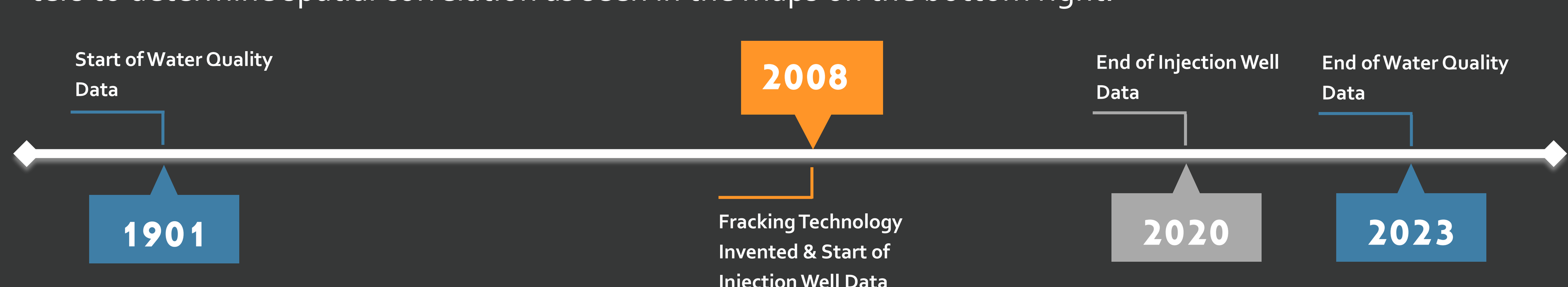
The northeastern part of Pennsylvania bordering New York State was selected for this study based on data availability and density.



This included Tioga, Bradford, Susquehanna, Lycoming, Sullivan, and Wyoming County.

Methods

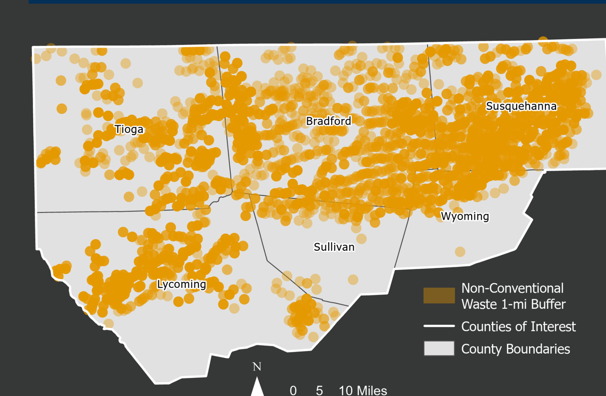
A correlation analysis was performed between fracking indicators (non-conventional waste production and crude oil production) and groundwater quality markers of interest (sodium and uranium concentrations) post 2008. The groundwater quality data was queried and rasterized, then a 1-mile buffer zone was created around each injection site. Zonal statistics for the buffer zones were analyzed to determine if there was a significant relationship between variables. A second analysis was performed by subtracting two normalized rasters to determine spatial correlation as seen in the maps on the bottom right.



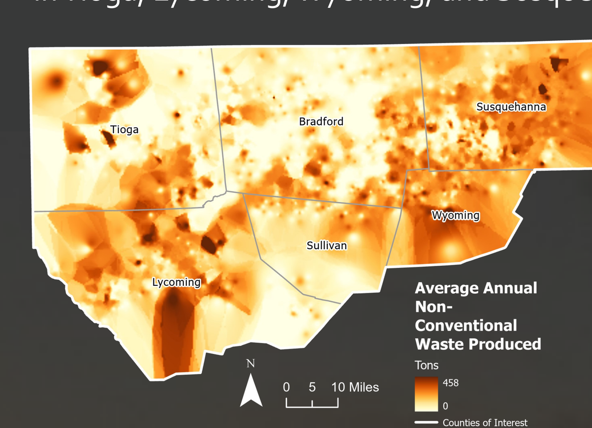
Fracking Markers

The maps below show the 1-mi buffer zones surrounding the data points for non-conventional waste and oil production, respectively. Further below are the maps showing average annual production and waste generation created using the inverse distance weighting tool on the X,Y point data. Both variables were used as fracking markers.

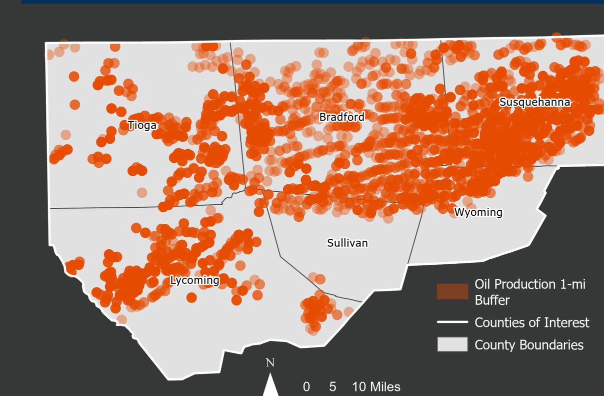
Non-Conventional Waste

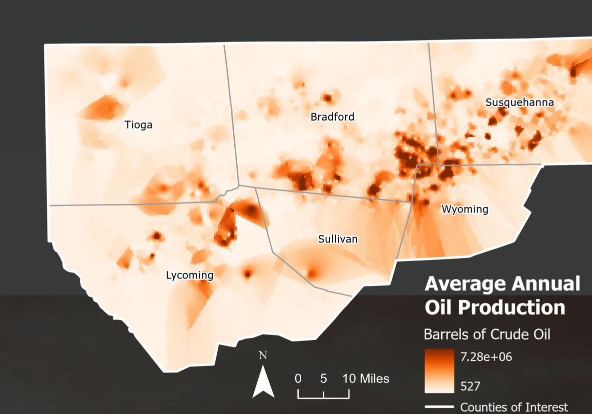


Non-conventional waste generation does not appear to have a pattern but there is a significant amount produced in Tioga, Lycoming, Wyoming, and Susquehanna county.



Oil Production

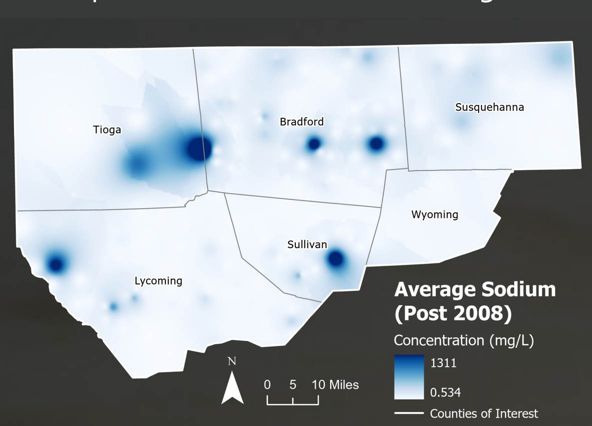




The highest production of crude oil appears to follow a diagonal path from southwest to northeast consistent with the direction of the Marcellus Shale Formation.

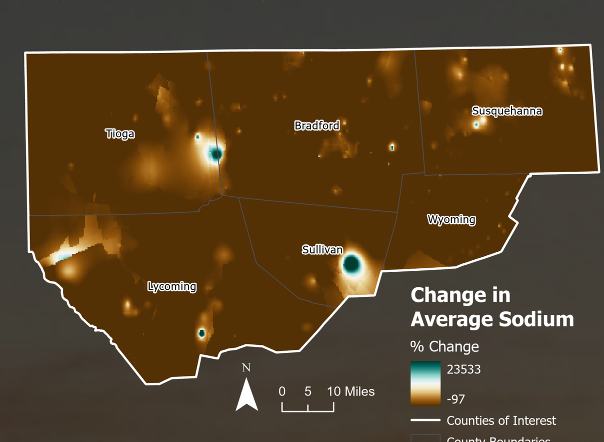
Sodium Data

Sodium concentration is directly related to high salinity which was determined to be a potential indicator for fracking fluids in groundwater.



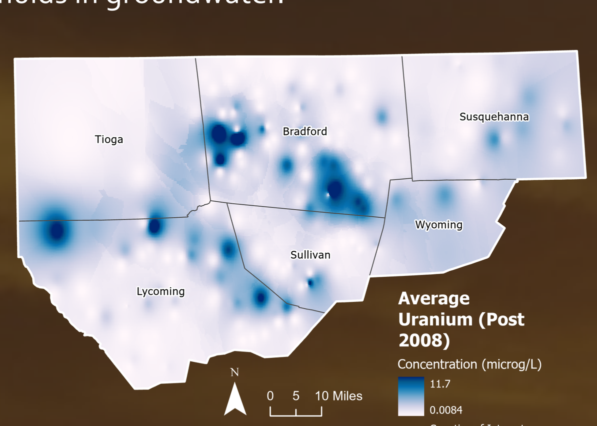
Inverse distance weighting was performed on the X,Y to point data for sodium concentration post 2008. The raster is displayed on a stretched scale from lowest to highest concentration.

Raster math was performed on the pre/post 2008 data to get percent change in sodium concentration.



Uranium Data

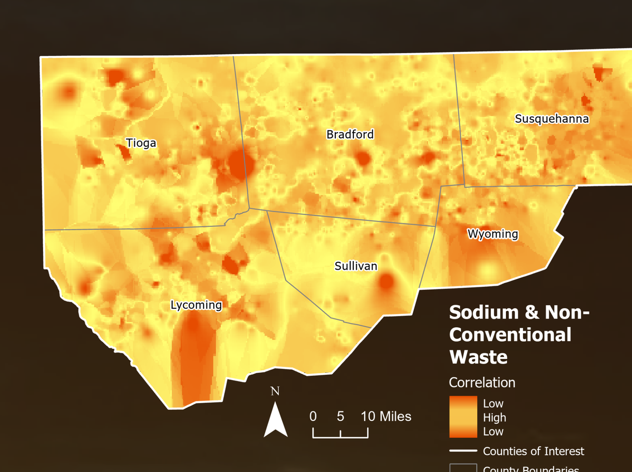
Uranium is a heavy metal that may be another potential indicator for fracking fluids in groundwater.

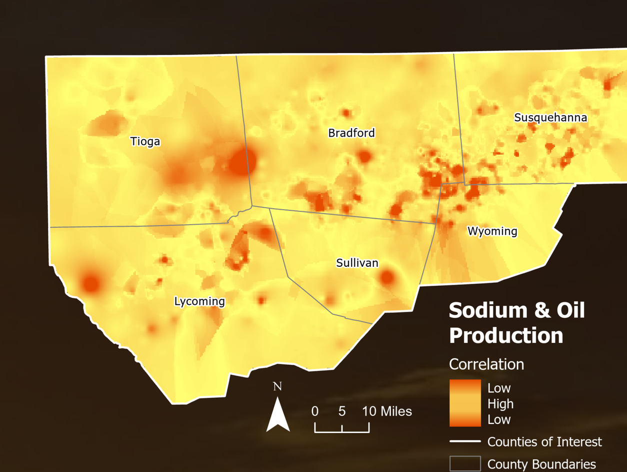


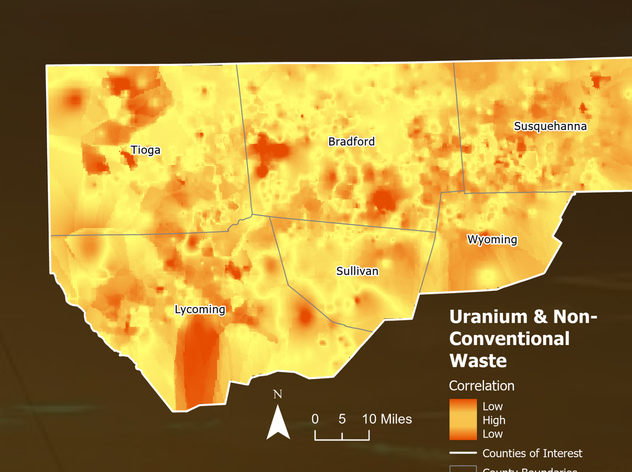
Same as the sodium dataset the X,Y points were converted to a raster using inverse distance weighting. Note that uranium concentrations are significantly lower, measured in micrograms per liter instead of milligrams per liter. This is expected based on normal uranium levels in groundwater.

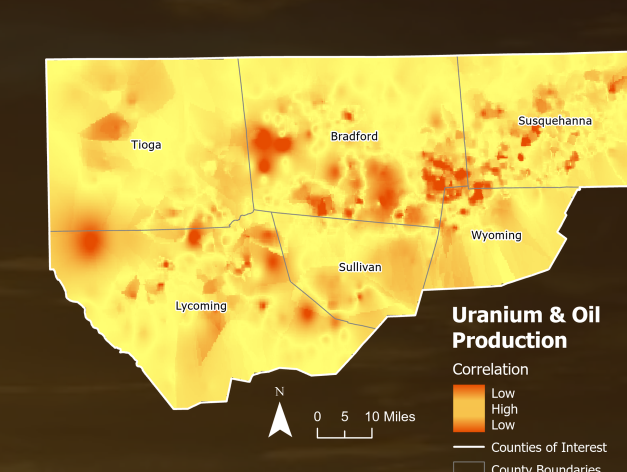
Spatial Correlation

Each raster (sodium pre/post, non-conventional waste generation, crude oil production) was normalized to a 0-1 scale and then raster subtraction was performed to determine areas of highest and lowest correlation.



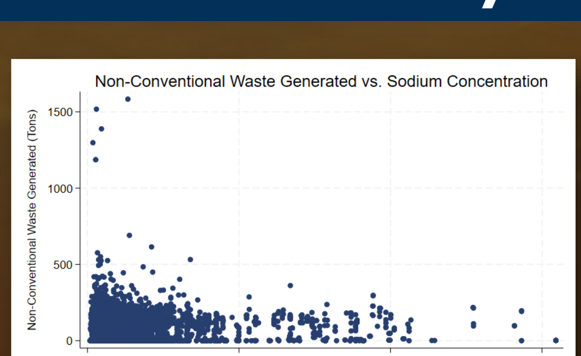




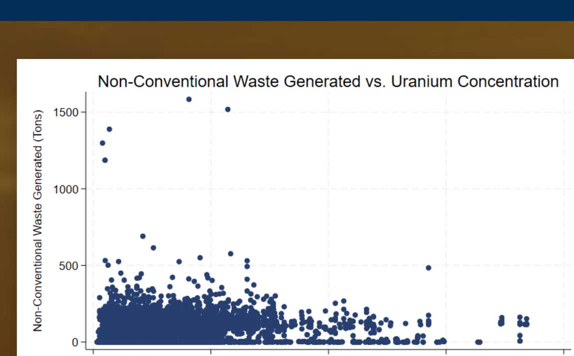


All maps generally indicate higher correlation in areas where both sets of data have low values. They are least correlated in areas of high groundwater contaminant concentration or fracking indicators, which means there is likely low meaningful correlation between the two variables in all cases.

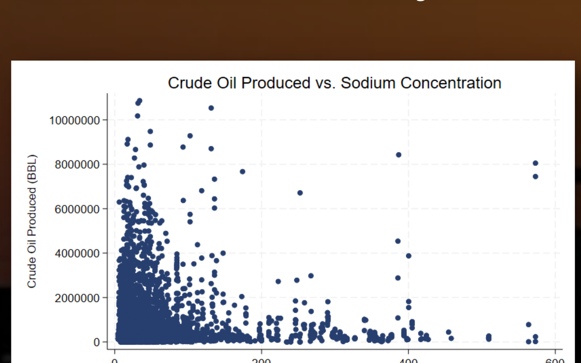
Data Analysis & Conclusions



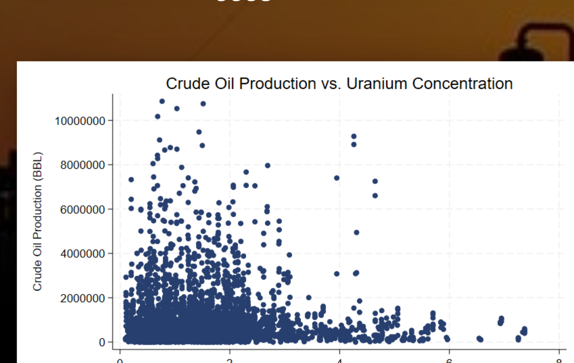
P > F = 0.00001 & R2 = 0.0089



P > F = 0.9993 & R2 = 0.00001



P > F = 0.0001 & R2 = 0.0037



P > F = 0.0012 & R2 = 0.002

Zonal statistics as a table was run using each 1-mi buffer layer to get the average groundwater contaminant concentration within each buffer. Linear regression was run on each relationship shown on the left. Visual interpretation of the scatter plots reveals no observable relationship. Although some regressions yielded significant P-values, all R2 values were extremely low indicating the models explain very little variation in the data.

Based on this analysis there is no significant relationship between sodium and uranium concentrations in the groundwater and fracking markers.

Tufts University | School of Engineering

Katie Webster

Tufts Graduate School of Engineering, MS Candidate 2025

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Projection: NAD 1983 StatePLane Pennsylvania North FIPS 3701 (Meters)

Data Sources: Pennsylvania Spatial Data Access (PASDA), FrackTracker, United States Census, HydroSheds, WaterQuality US

Literature Sources: DeLeo, V., Kueu, B., T. (2019 June) The Effects of Drilling the Marcellus Shale in Pennsylvania Addresses to: The General Assembly of Pennsylvania. POLICY MEMO: DRILLING THE MARCELLUS SHALE.

Soder, D.J. (2018). Groundwater quality and hydraulic fracturing; current understanding and science needs. Ground Water, 56(6), 852-858. https://doi.org/10.1111/gwat.12810

Photo Sources: MyMigraine Team, Tasnim News Agency, QUVIVIQ, 21stcentech.com