

Analysis of Methane Concentrations in Pennsylvania Stream and Groundwater in Collaboration with Citizen Scientists

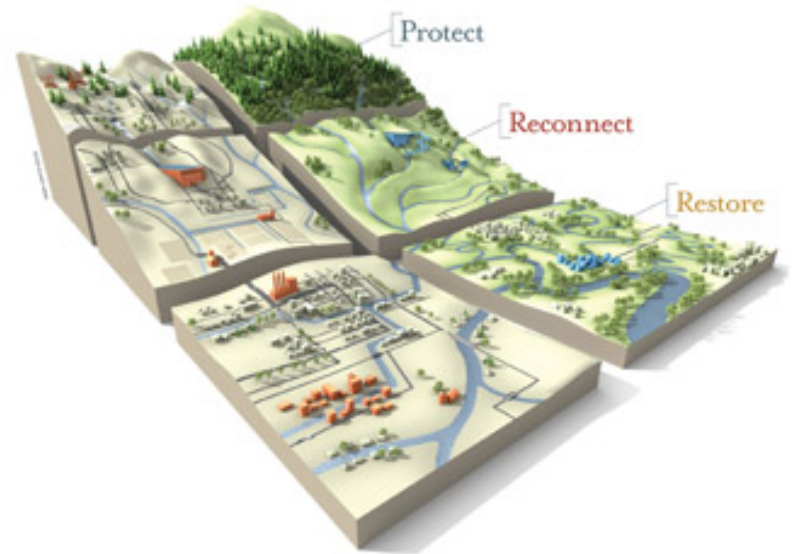
2016 Shale Network Workshop

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EESI Director
Penn State University

- TU's works to **protect**, reconnect, restore and sustain North America's coldwater fisheries and their watersheds.



Anglers gathering scientific information
about the fish and the places they love



Benefits to Volunteer-based Stream Monitoring Programs

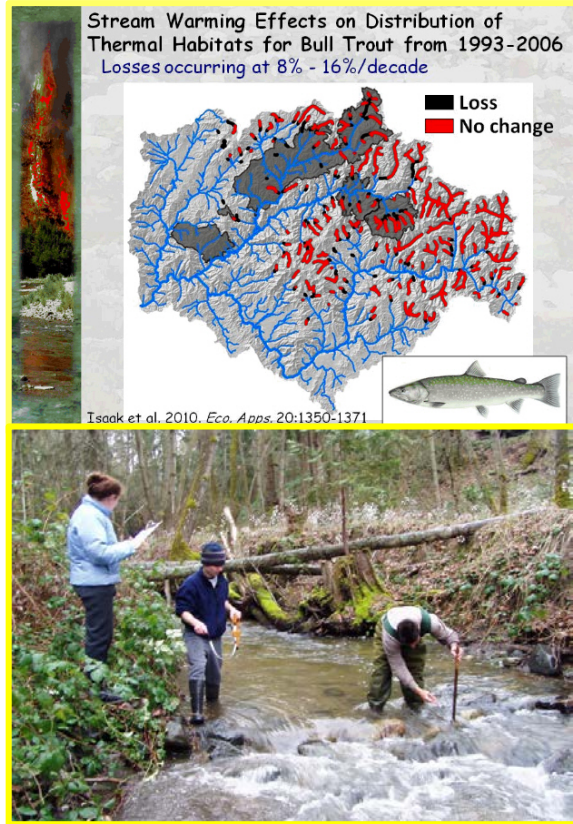


Education and Outreach

- ✦ Better understanding of our home waters
- ✦ Expand and diversify organization activities
- ✦ Collaboration between volunteers and agencies

Conservation Outcomes

- ✦ Early identification and tracking of emerging threats
- ✦ Determine effectiveness of restoration and management
- ✦ Monitor impacts from climate change
- ✦ Tracks impacts from oil/gas development



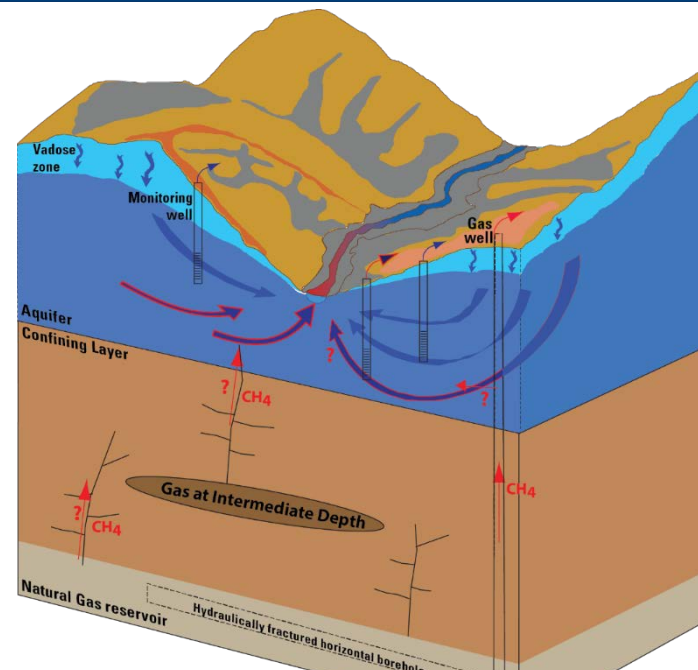
Natural Gas Extraction in Pennsylvania

- ✎ 10,000 new shale gas wells
- ✎ Legacy Wells
 - Estimated over 300,000 conventional oil and gas wells drilled in PA since 1859
- ✎ 200,000 abandoned
- ✎ Many leak methane into the atmosphere or into aquifers
- ✎ DEP has records of around 120,000 abandoned wells but the location of the rest are unknown



Using streams to analyze for groundwater

- Groundwater measurements from individual homeowner wells (academic researchers, U.S.G.S., gas companies, PA DEP, etc.)
- Atmospheric measurements (ongoing, through leadership of Ken Davis and Thomas Lauvaux at Penn State)
- Stream measurements: streams collect groundwater and can be used to canvas for natural gas leakage



Locating problematic areas or leaking sites



Make methane measurements in gaining streams



Use analysis to locate zones of high upflow of methane into groundwater (natural and anthropogenic)



Intensely sample hotspot areas for isotopic analysis



Draw conclusions about controls on gas emissions into aquifers, foster data sharing and collaboration between scientists and nonscientists

- ✎ Working to protect fish and wildlife habitat from gas drilling
- ✎ Advocate for strong regulations to protect fish and wildlife habitat.
- ✎ Engage Hunters and Anglers to be watchdogs and advocates for their local watersheds



Why Shale Gas? And Why Trout?



- ❖ Overlap between areas of shale gas extraction and pipeline development and high quality wild and native trout waters.
- ❖ Trout are indicators of good water quality and intact habitat.



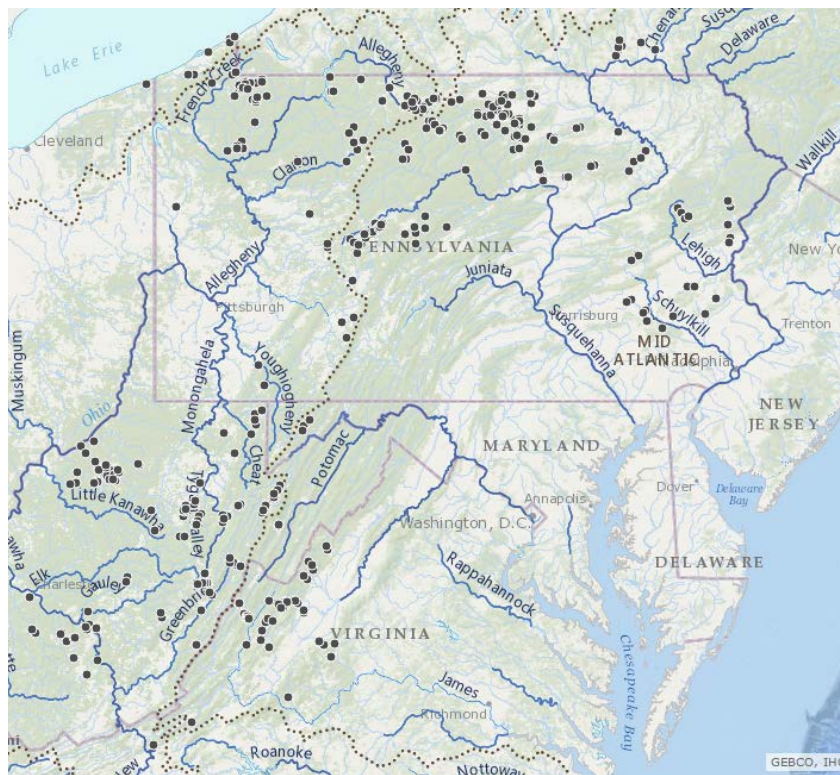
Role of the Citizen Scientist

Collect data in advance of construction to establish baseline conditions.

Serve as eyes and ears on the ground, identifying pollution events if they occur and reporting them to the proper authorities.



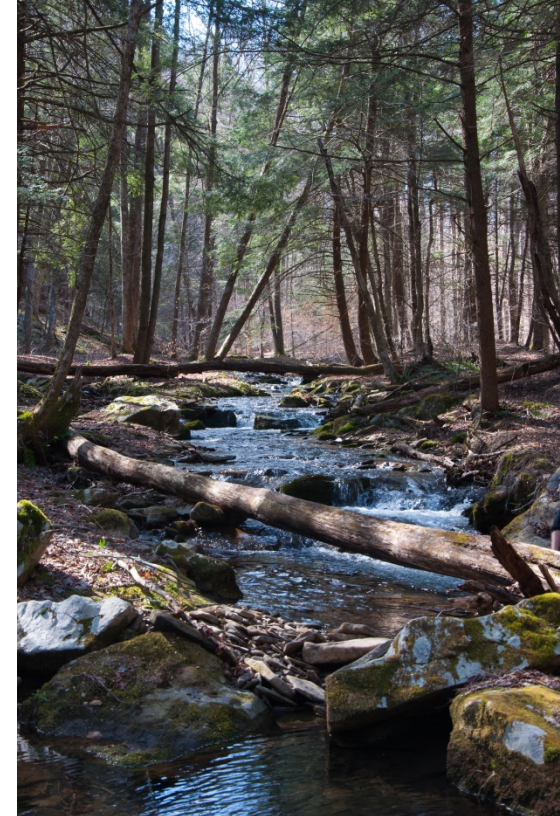
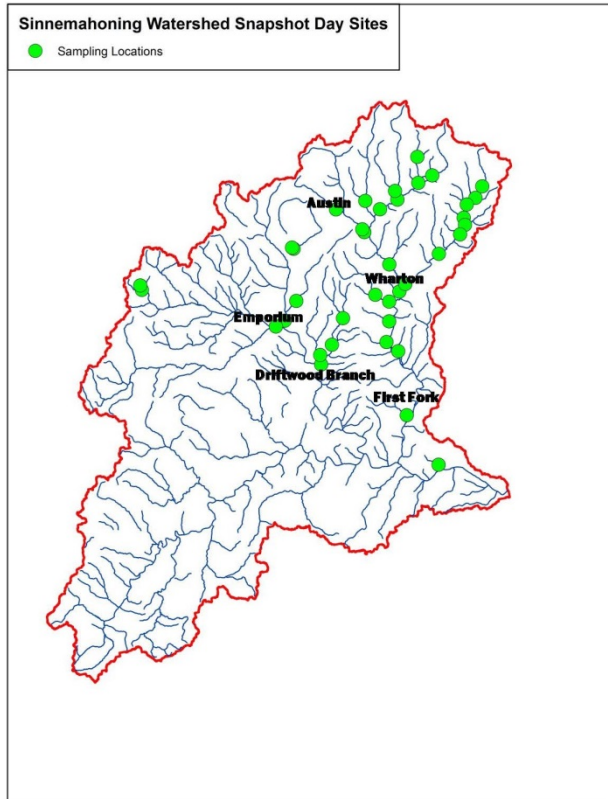
Where We Monitor



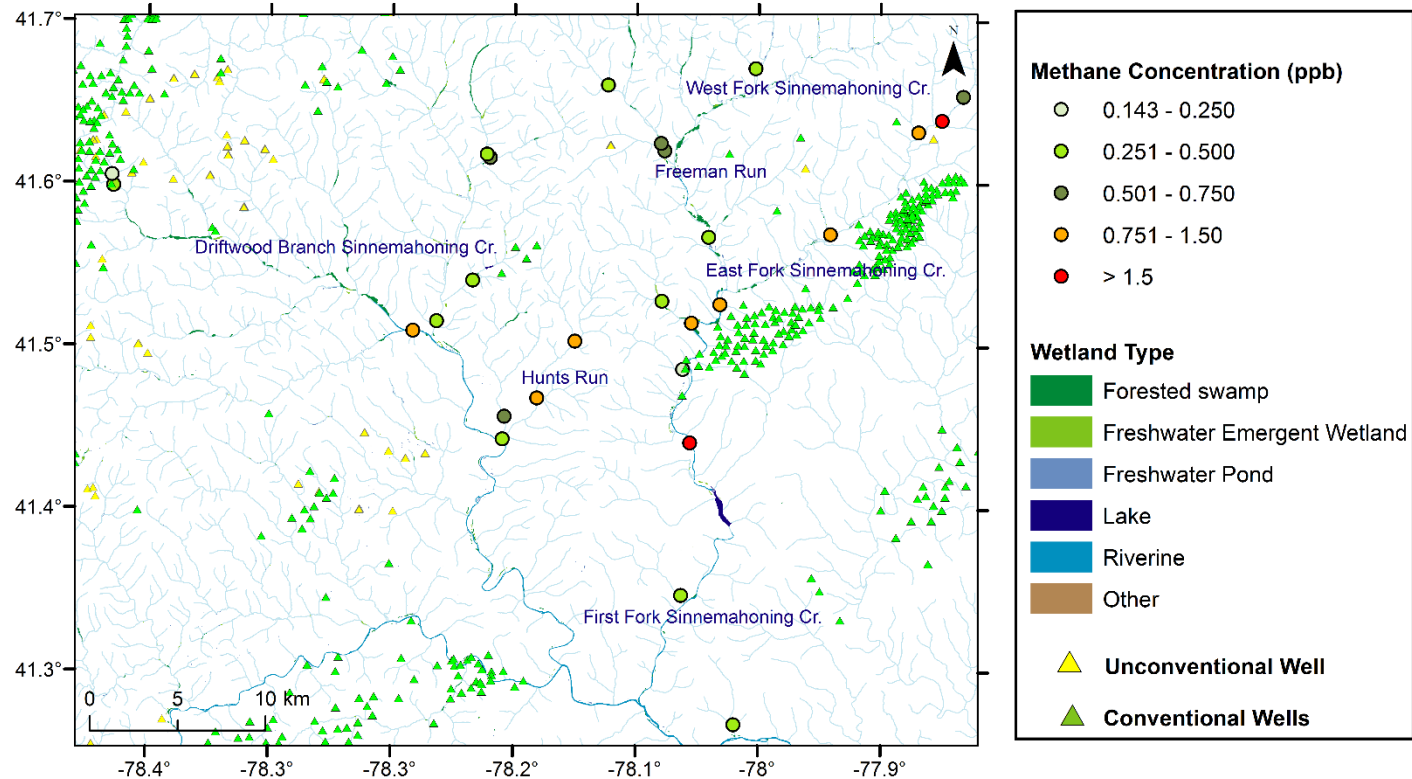
2015 Sinnemahoning Watershed Snapshot Day



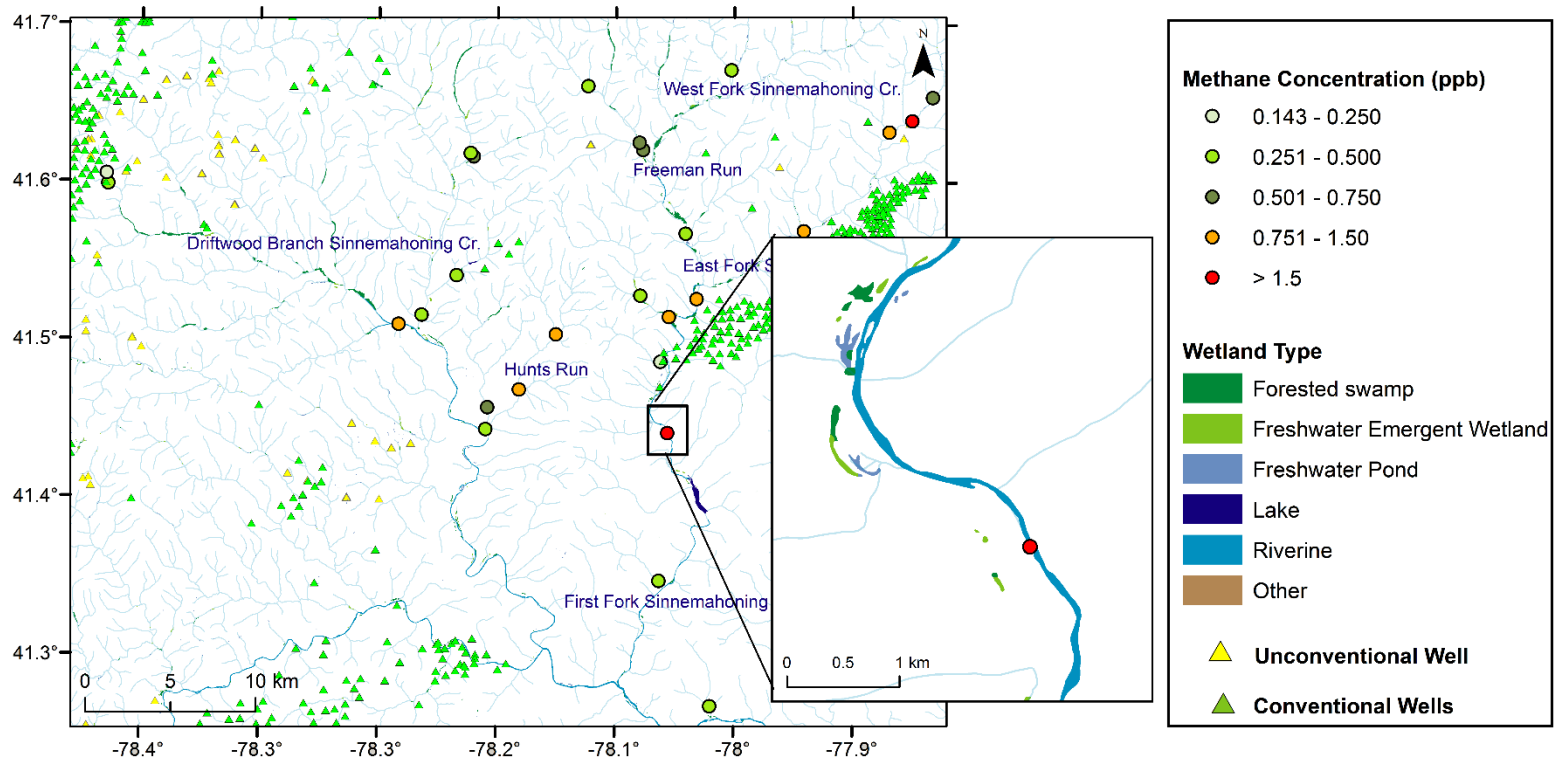
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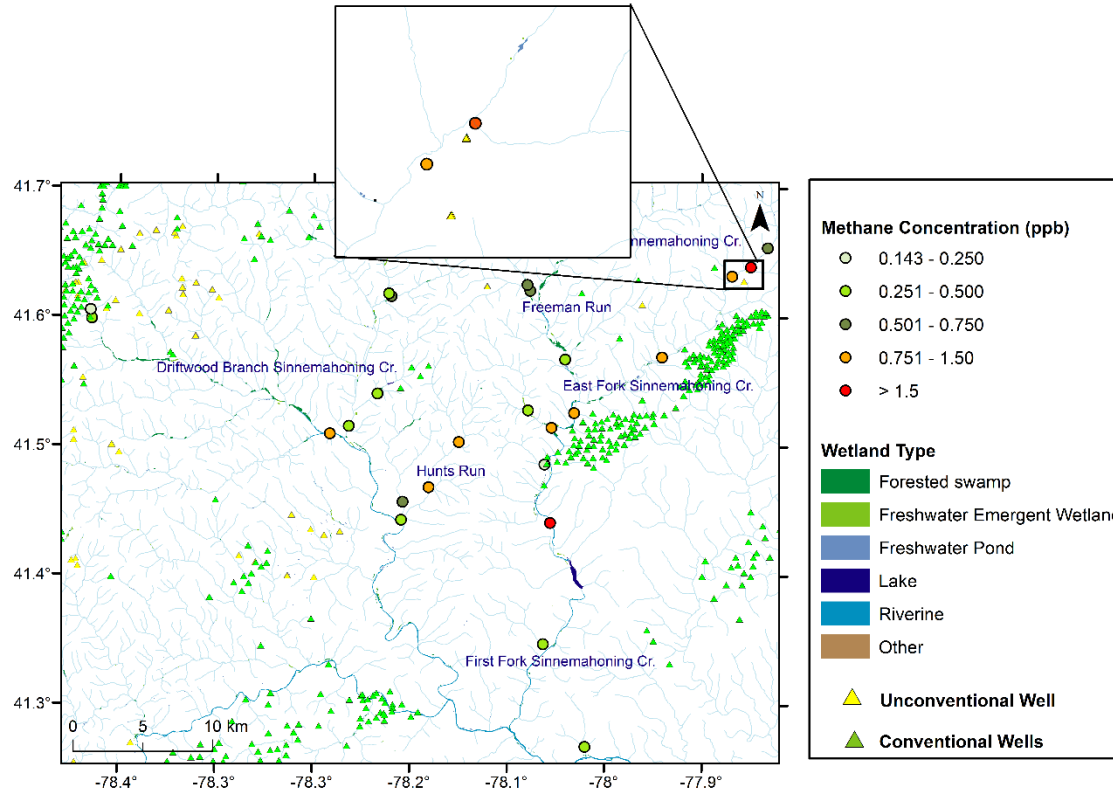
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Initial target regions

- **Northeastern PA:**

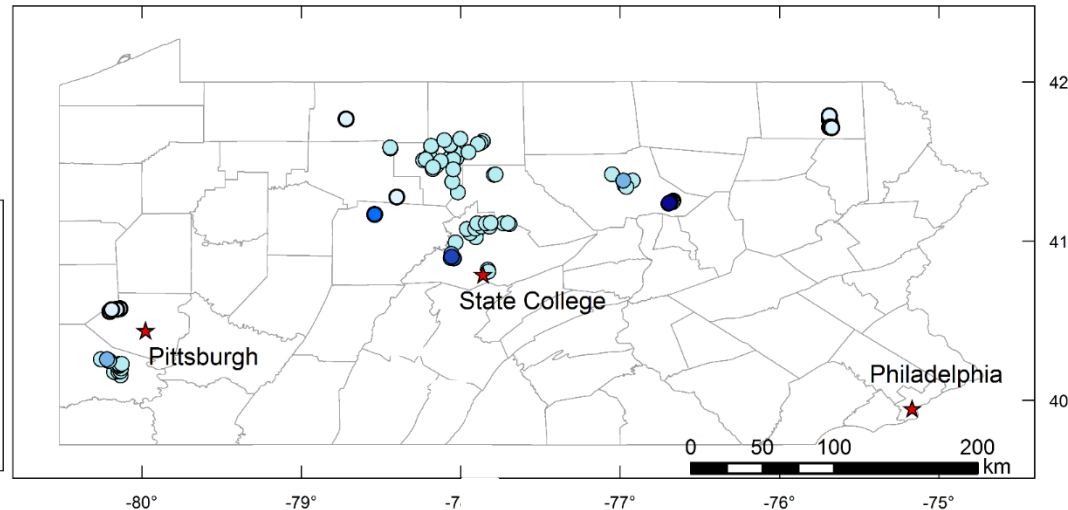
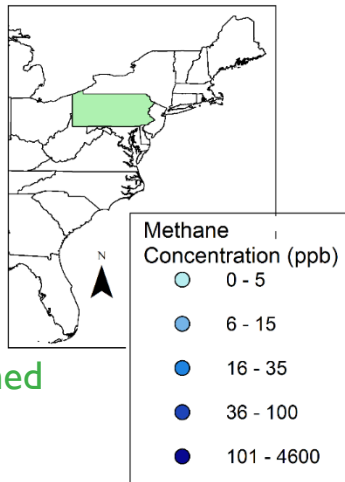
- Sugar Run Watershed
- Nine Panther Creek Watershed
- Mill Creek Watershed

- **Northcentral PA:**

- Beech Creek Watershed
- Black Moshannon Watershed
- Sinnemahoning Watershed
- Slab Cabin/Spring Creek

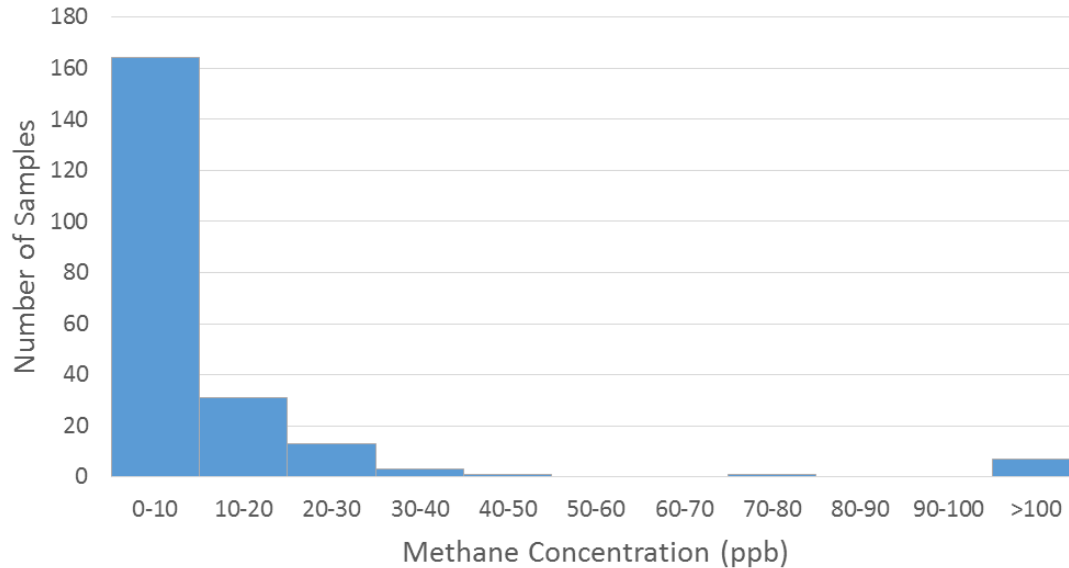
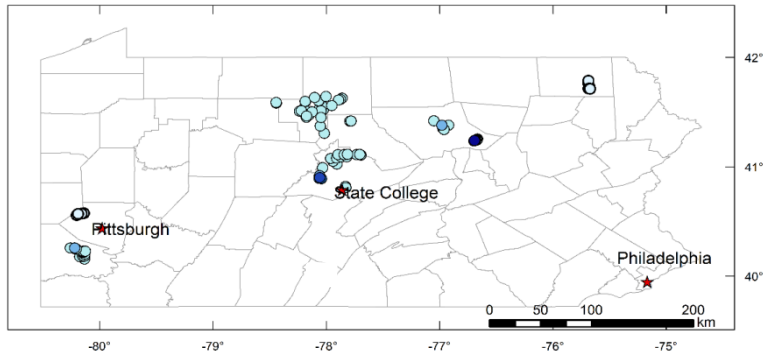
- **Southwestern PA:**

- Chartiers Creek Watershed
- Little Sewickley Creek



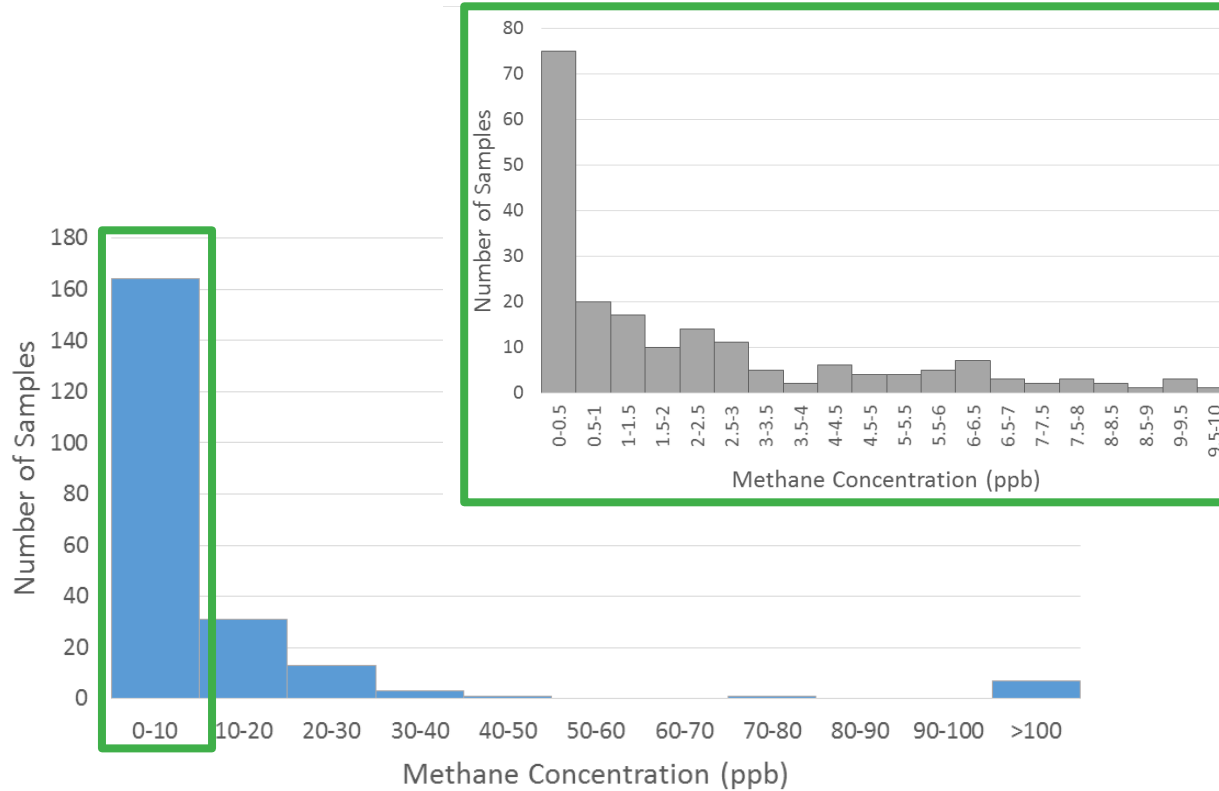
More than 200 samples collected from 175 sites

Methane Results – All Sites



- Methane Concentration for all sites:
 - Mean: 87.28 ppb
 - Standard Deviation: 536.78 ppb
 - N = 220
- 7 samples with concentrations greater than 100 ppb (2700 – 4600 ppb)
- Includes data from Heilweil et al., 2014 and Grieve, 2014.

Methane Results – All Sites



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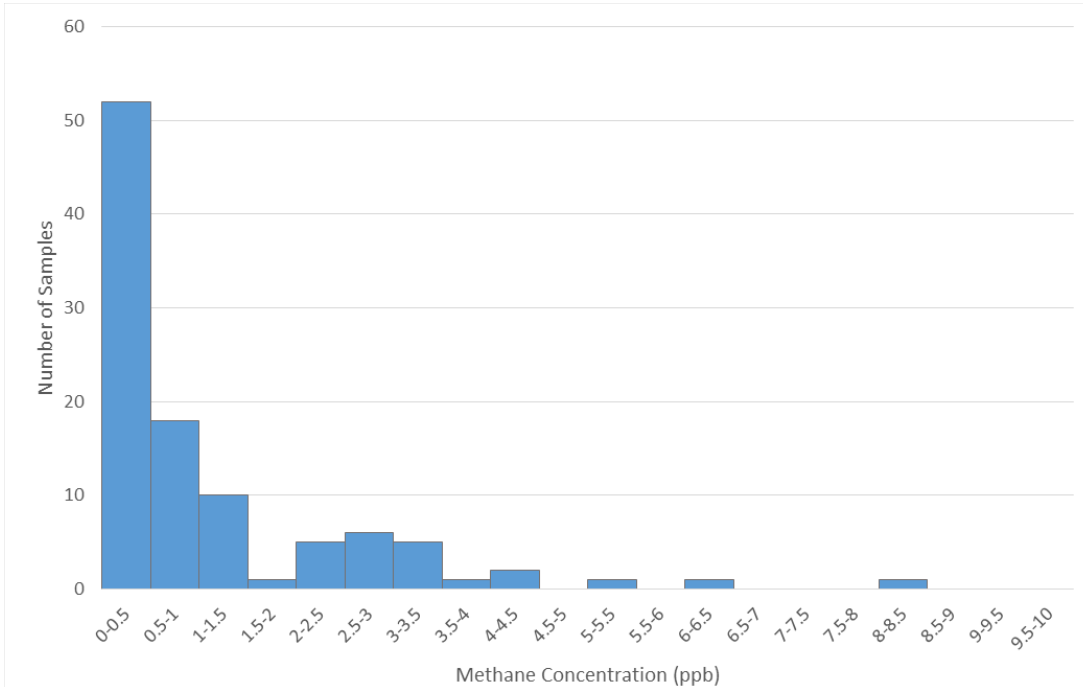
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- Includes data from Heilweil et al., 2014 and Grieve, 2014.
- Approximately 85% < 10 ppb

How do we start looking for problems?

Subsampling from parent results:

- 👉 Wetland (Biogenic methane source)
- 👉 Natural Thermogenic Methane (Grieve, 2014)
- 👉 Thermogenic Methane with leaking gas well (Heilweil et al., 2014 and Grieve, 2014)
- 👉 All other non wetland, no known leaking gas or oil well

Results- All other sites



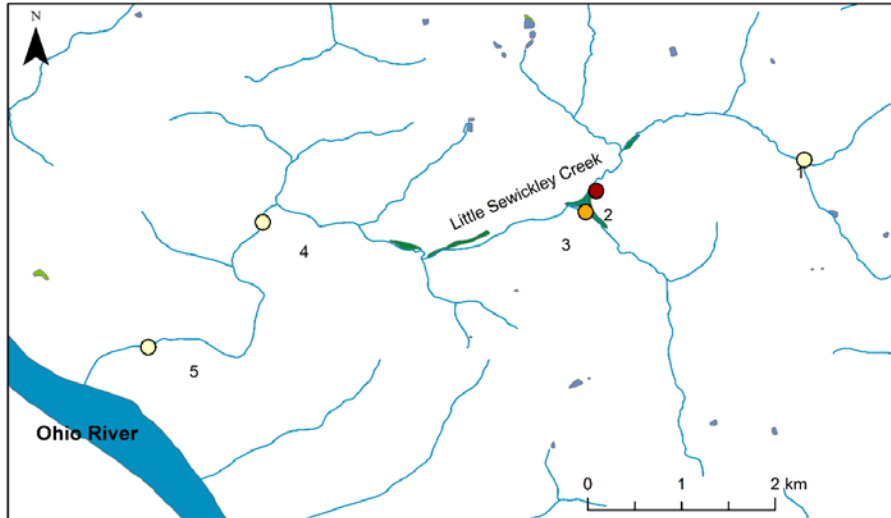
- Non-wetland, no known leaking gas well
- Methane Concentration:
 - Mean: 1.14 ppb
 - Standard Deviation: 1.39 ppb
 - N = 103
- No concentrations higher than 10 ppb

Can think of this as baseline for our sample sites

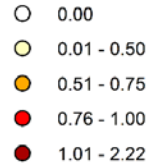
Results - Wetland



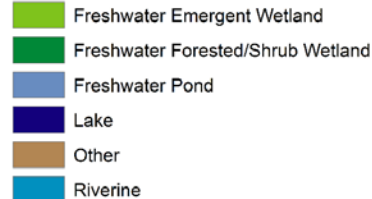
- Sample site is located within a wetland as defined by the US Fish and Wildlife Service National Wetlands Inventory
 - Emergent: Vegetation present most of the growing season (marsh, meadow)
 - Forested/Shrub: Wetland dominated by woody plants (swamps)



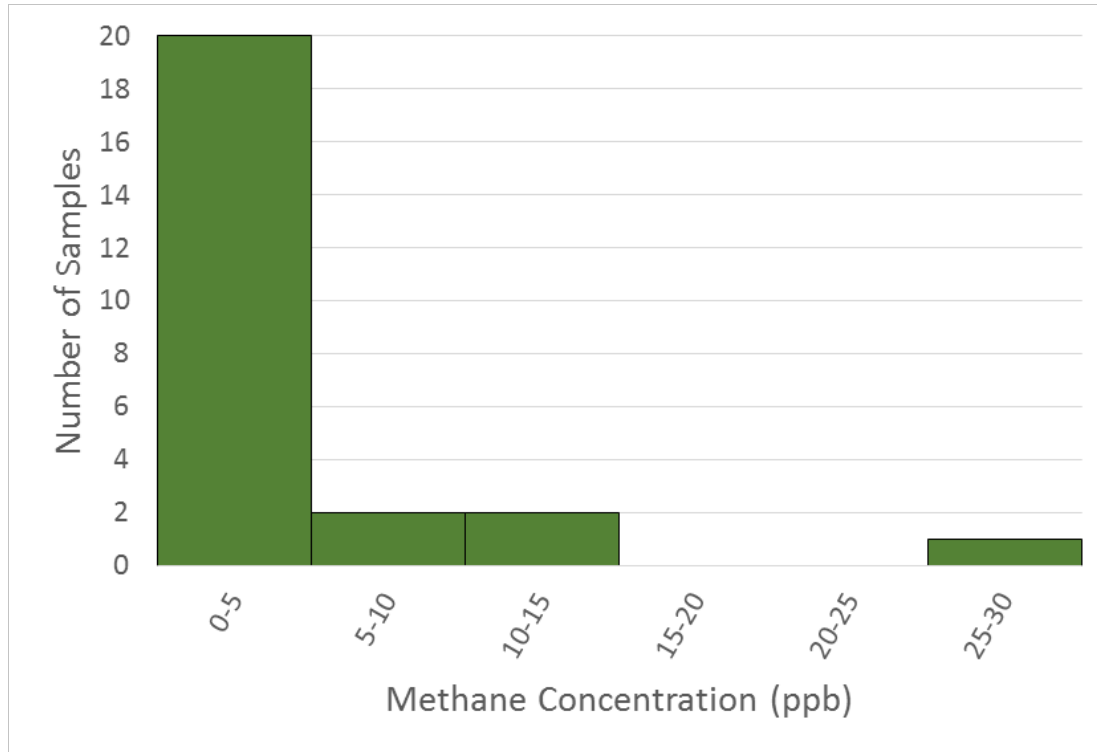
Average Methane Concentration (ppb)



Wetland Type

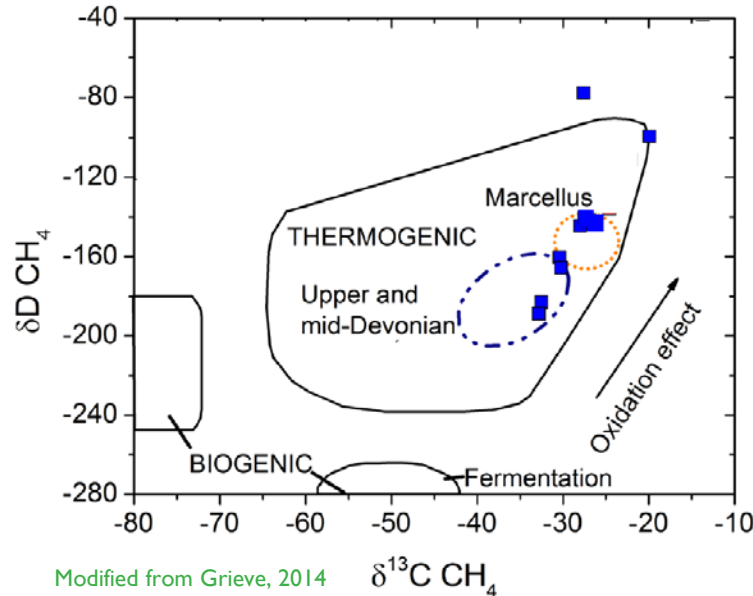
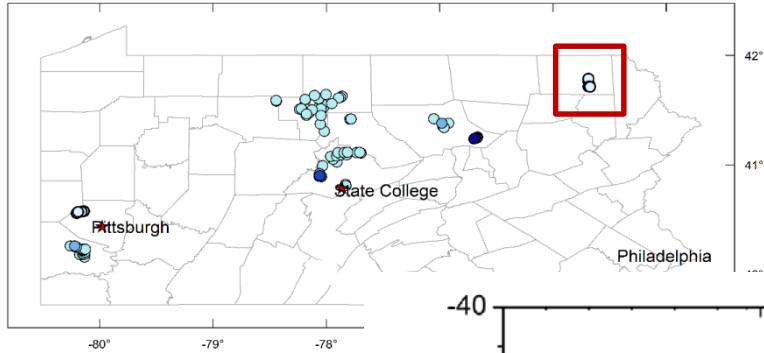


Results - Wetland



- Methane Concentration for wetland sites:
 - Mean: 3.95 ppb
 - Standard Deviation: 5.78 ppb
 - N = 24

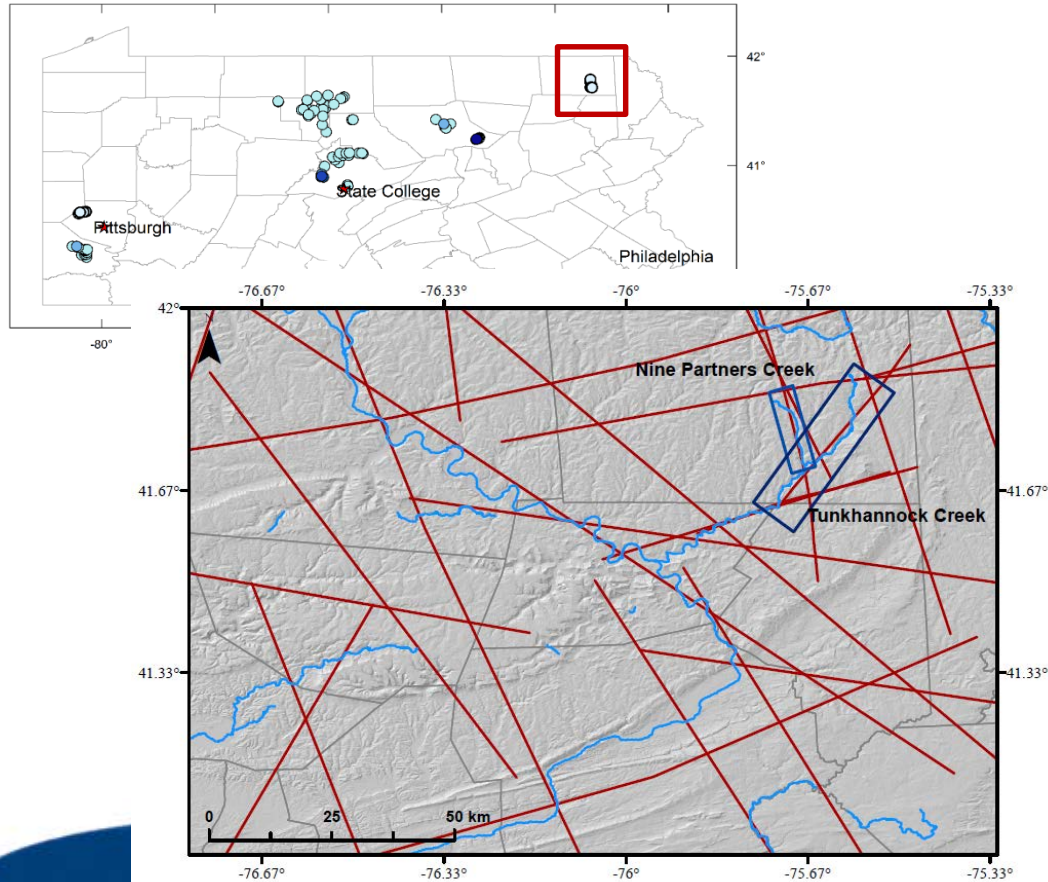
Results-Natural Thermogenic



Modified from Grieve, 2014

- Carbon isotopic values suggest thermogenic type of natural gas in water samples (Grieve, 2014)
 - $\delta^{13}\text{C CH}_4 = -20$ to -50 per mil
 - $\delta\text{D CH}_4 = -100$ to -250 per mil

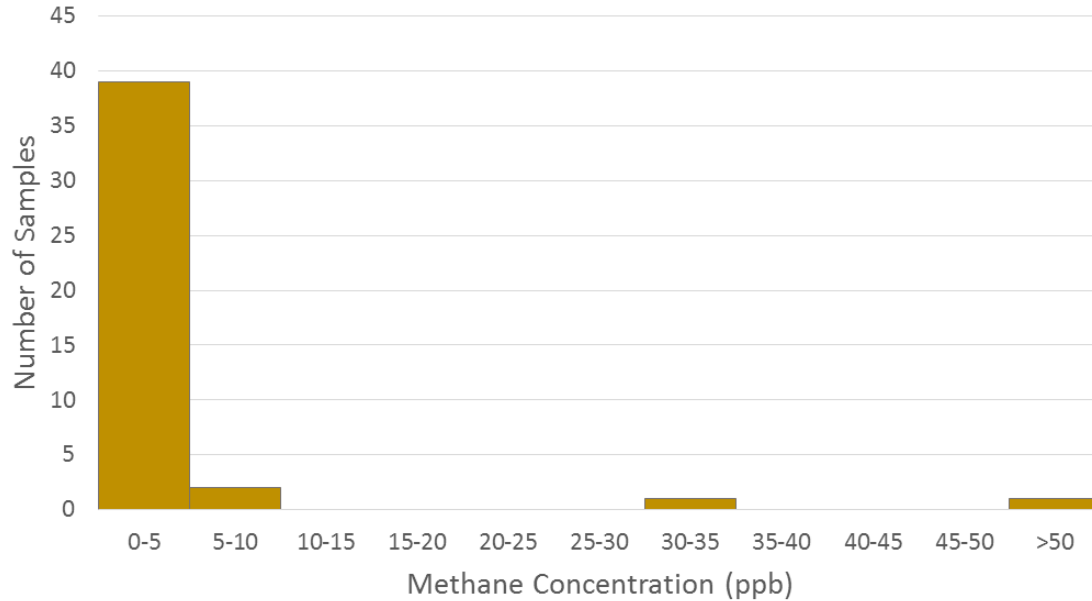
Results-Natural Thermogenic



- Sites follow natural Lineaments

- Defined by valleys or lines of springs, (Llewellyn, 2014)
- Location of faults allow for migration of methane from depth

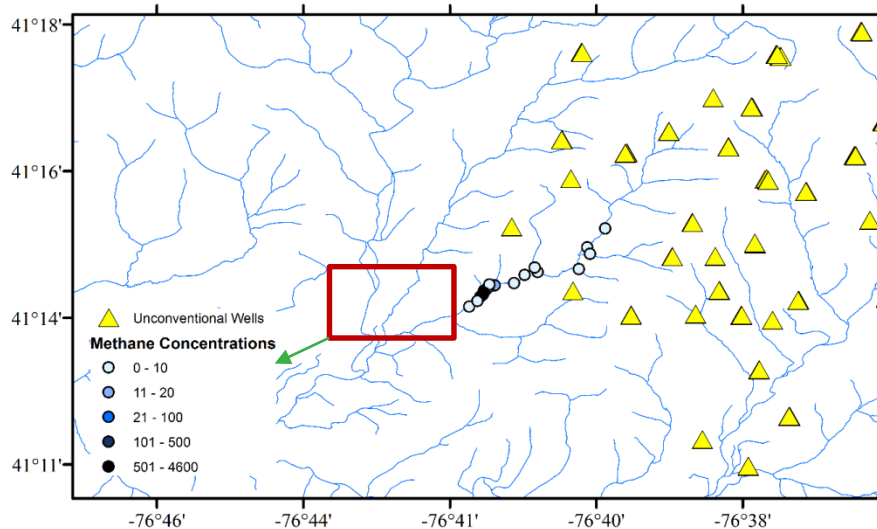
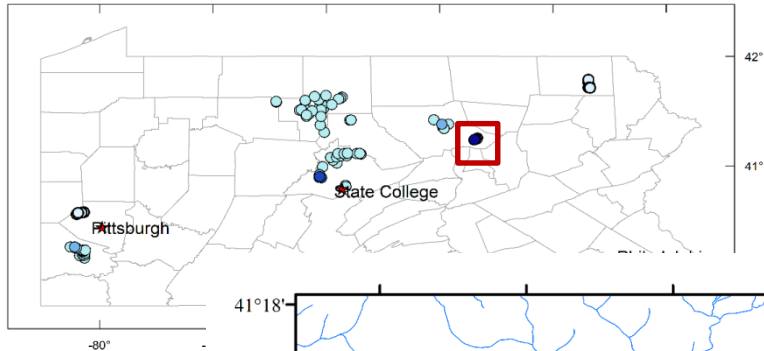
Results-Natural Thermogenic



- Methane Concentration:

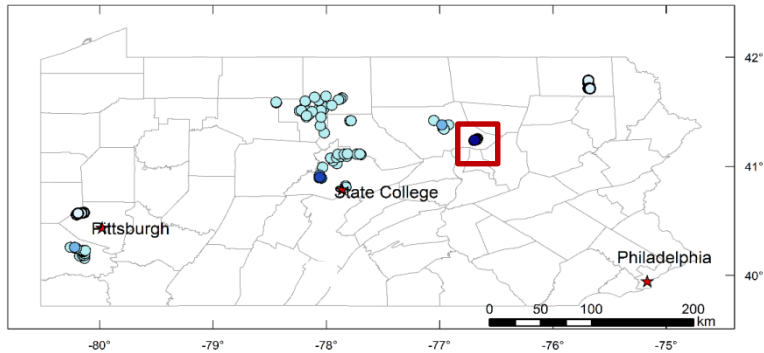
- Mean: 7.08 ppb
- Standard Deviation: 31.43 ppb
- N = 43

Results- Thermogenic with Leaking Gas Well

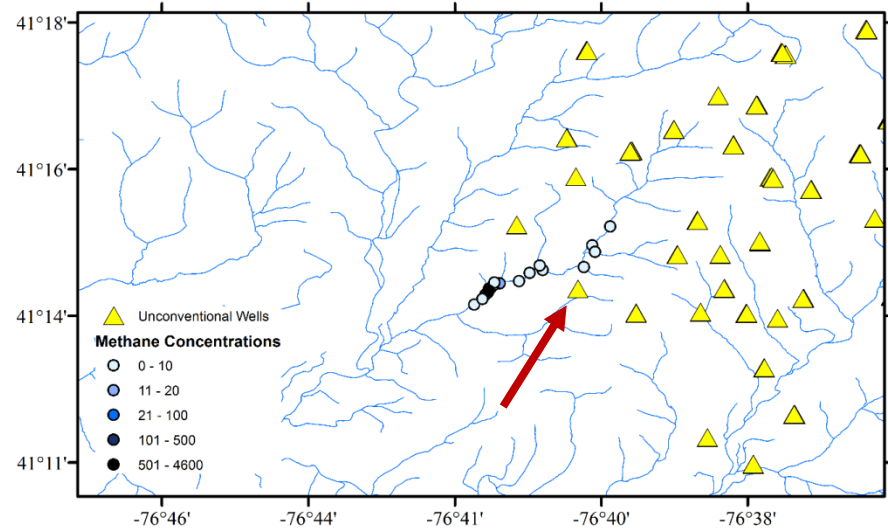


- Sugar Run, Lycoming County PA (Heilweil et al., 20140)
 - Known leaking Marcellus gas well
 - Nearby domestic water supplies were reportedly contaminated
 - Isotopes show thermogenic signature

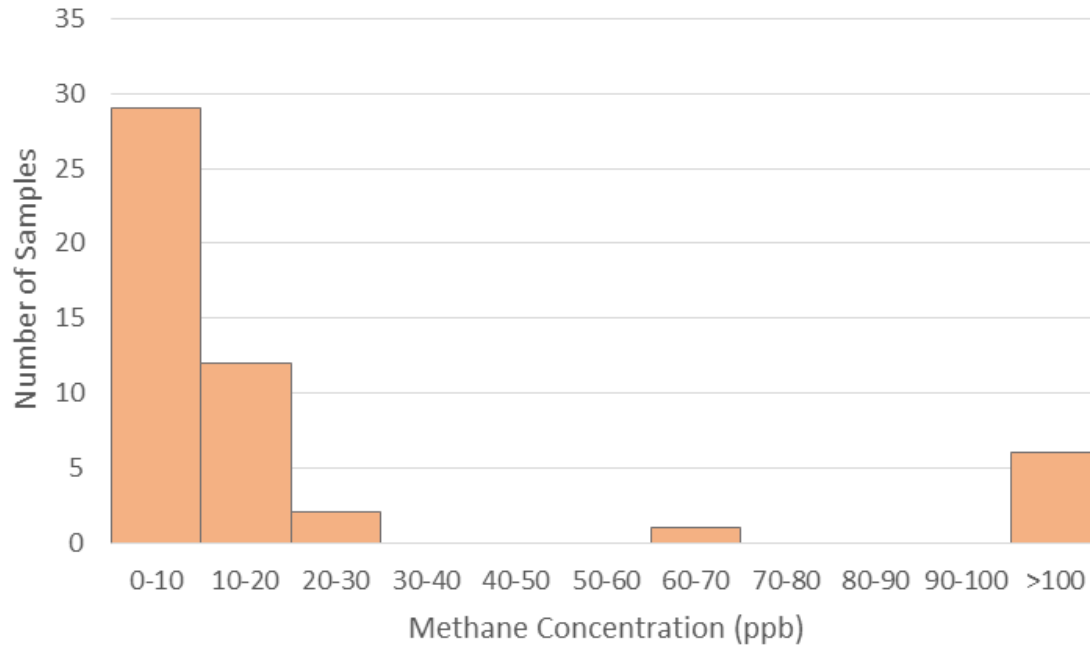
Results- Thermogenic with Leaking Gas Well



- Operator cited for failure to report defective, insufficient, improperly cemented casing



Results- Thermogenic with Leaking Gas Well

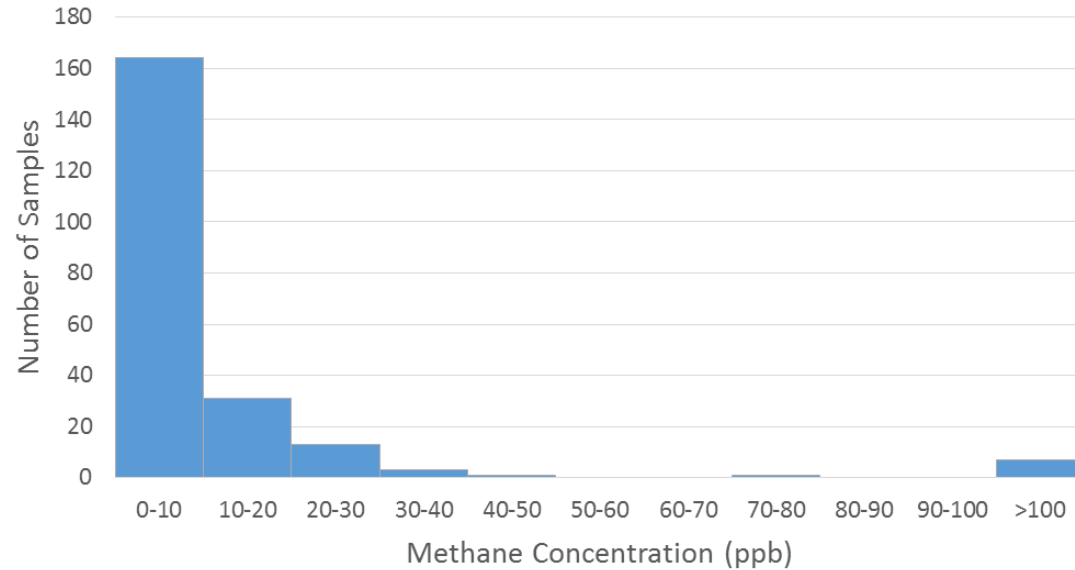


- Methane Concentration

- Mean: 348
- Standard Deviation: 105 l
- N = 50

- 6 samples with concentrations greater than 100 ppb (2700 – 4600 ppb)

Summary of Results



- ✎ Average of all sites: 87.3 ± 536 ppb
- ✎ Average of non wetland, no leaking oil and gas well is 1.14 ± 1.39 ppb
- ✎ The average concentration of wetland is less than natural thermogenic methane (3.95 ± 5.78 ppb < 7.09 ± 31 ppb)
- ✎ Average concentration at sites with a known leaking gas well is 348 ± 1051 ppb

What Is Next?



- ✦ PSU and TU partner to engage TU chapters and volunteers to collect additional samples for methane analysis
- ✦ Develop products to communicate findings and data usage to volunteers