

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

2016 Shale Network Workshop

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



# Angler-based monitoring opportunities



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



# Benefits to Volunteer-based Stream Monitoring Programs

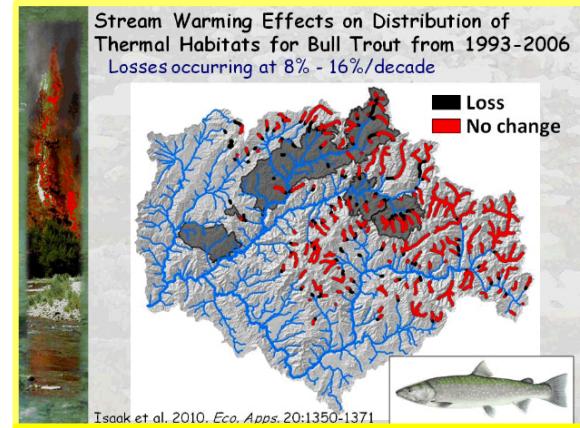


## Education and Outreach

- ⚡ 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



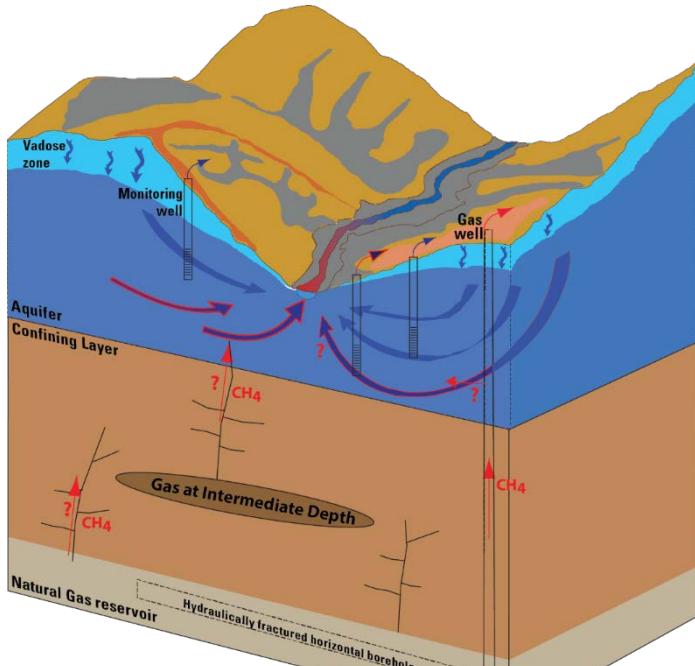
# Natural Gas Extraction in Pennsylvania

- ⚡ 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

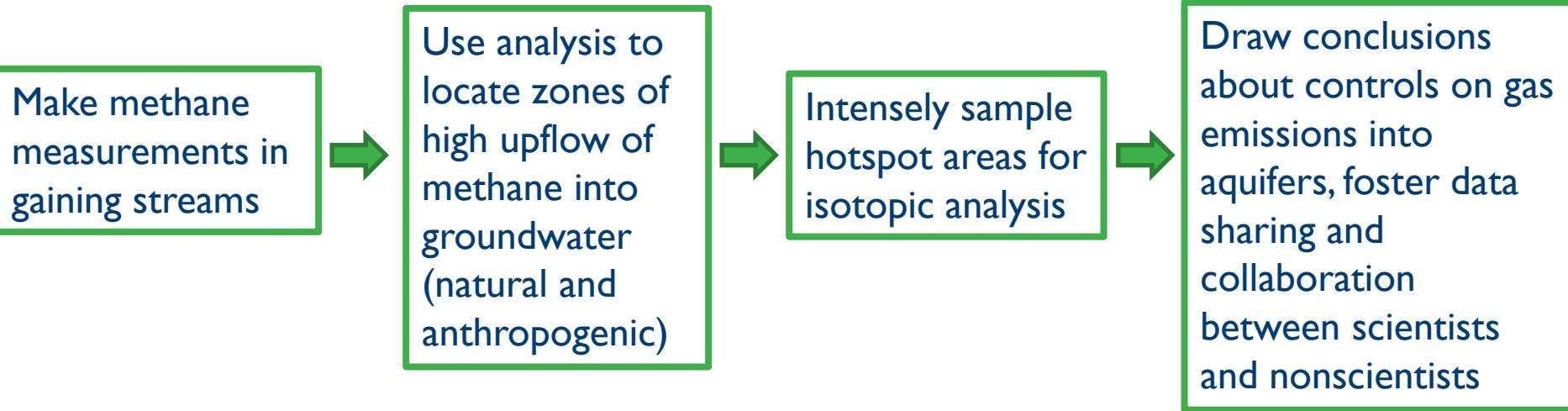


# Using streams to analyze for groundwater

- ☞ 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



# TU's Eastern Shale Gas Campaign



- 🕒 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?



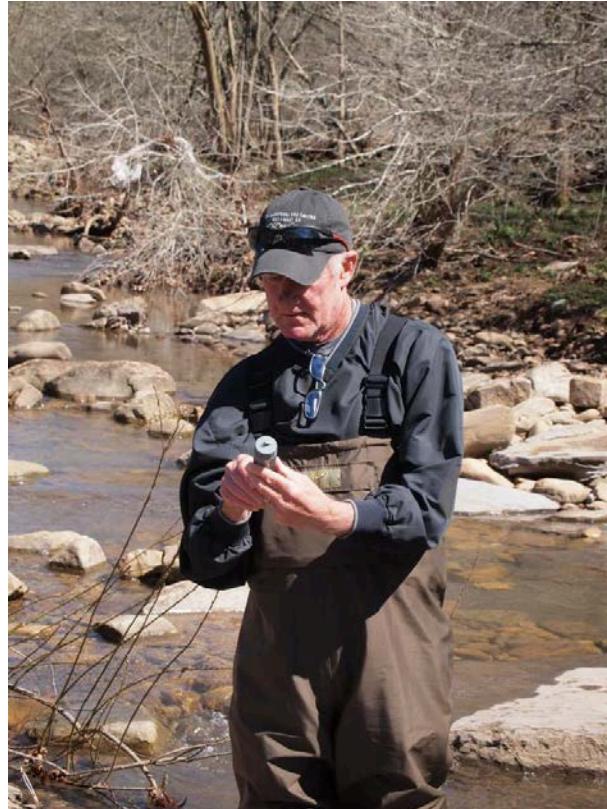
- Overlap between areas of shale gas extraction and pipeline development and high quality wild and native trout waters.
- Trout are indicators of good water quality and intact habitat.



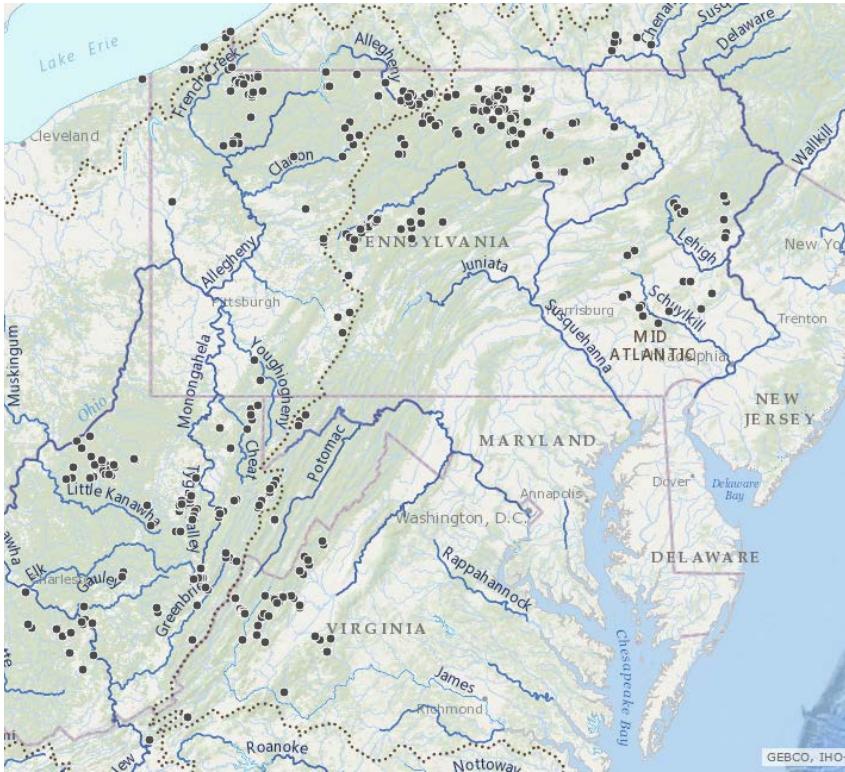
# Role of the Citizen Scientist

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.



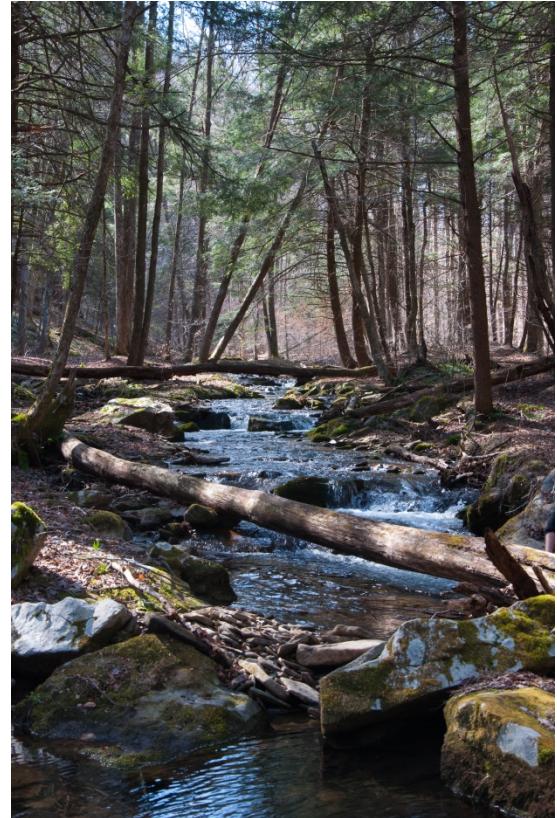
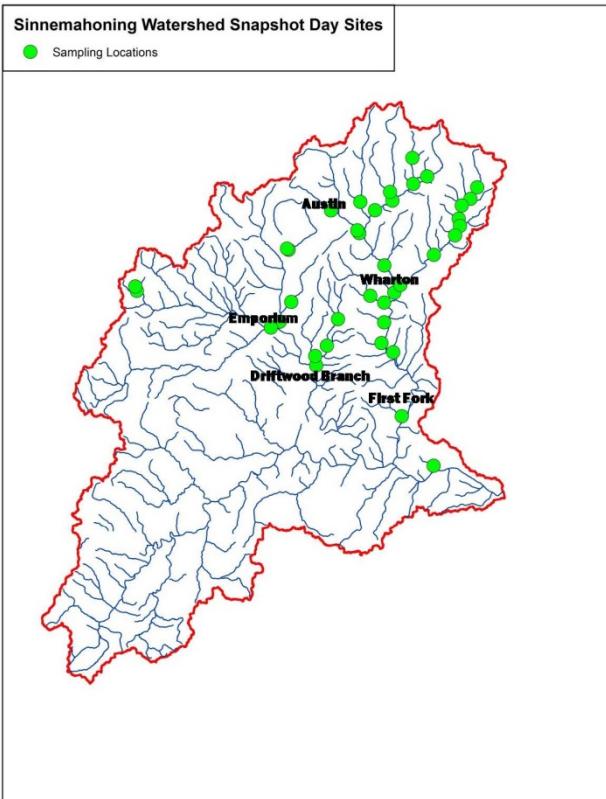
# Where We Monitor



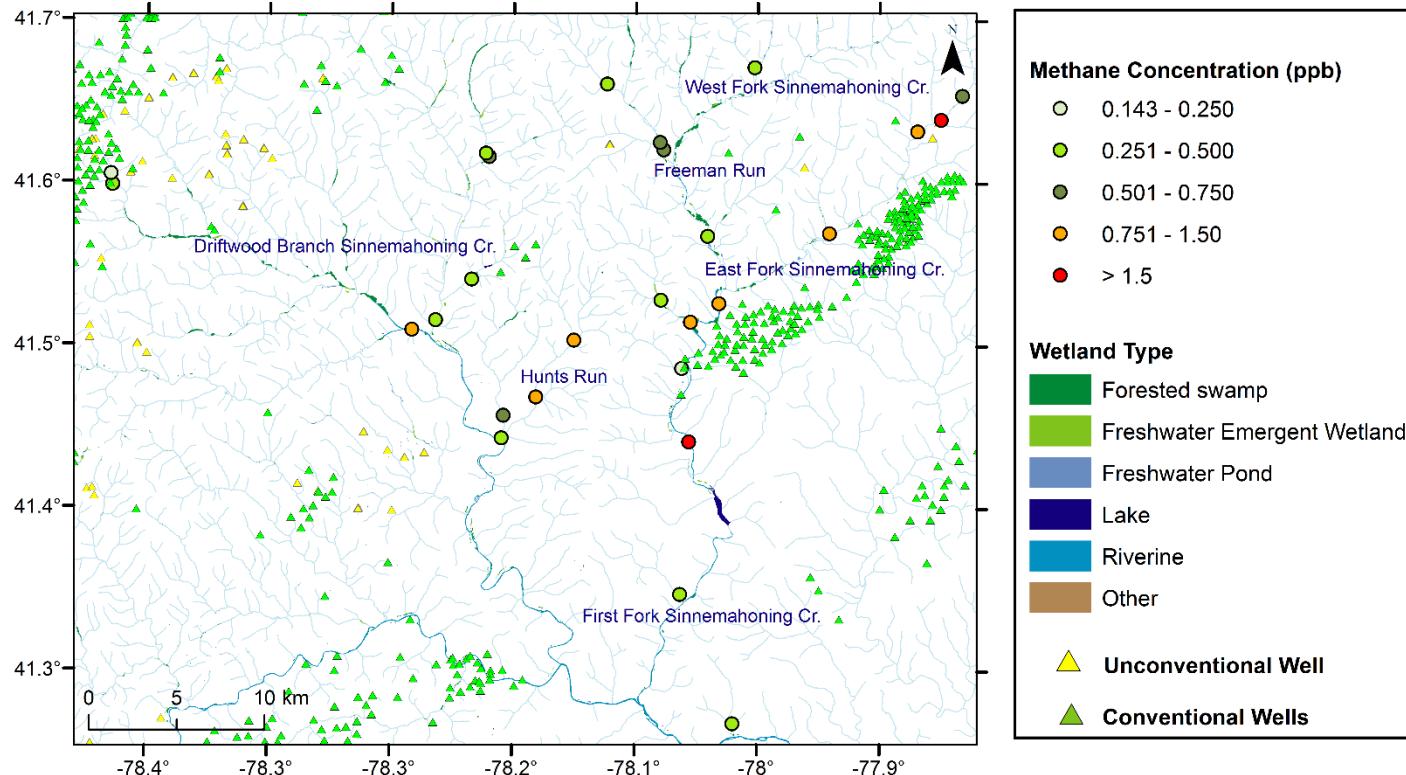
# 2015 Sinnemahoning Watershed Snapshot Day



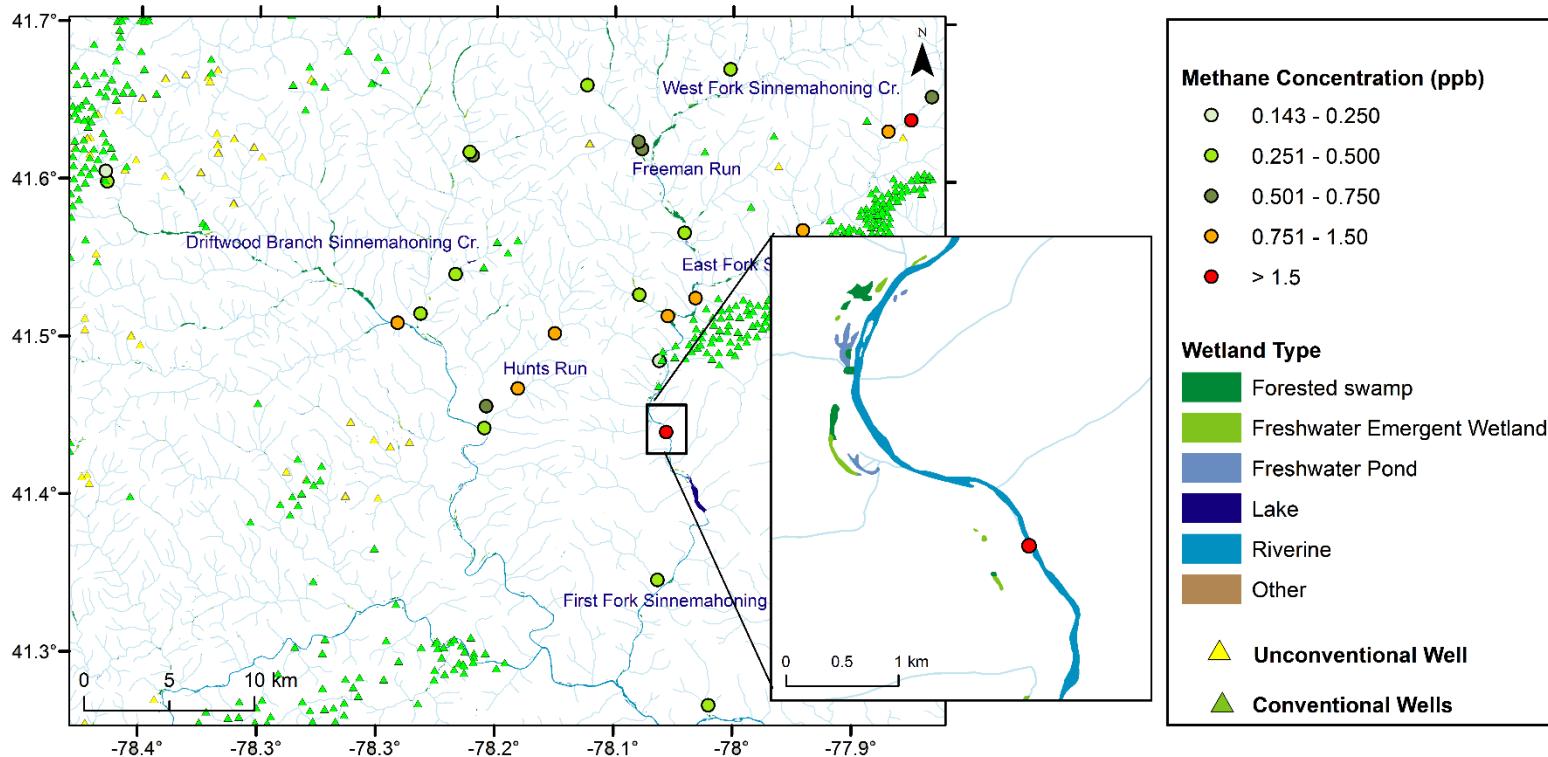
# 2016 Sinnemahoning Watershed Snapshot Day



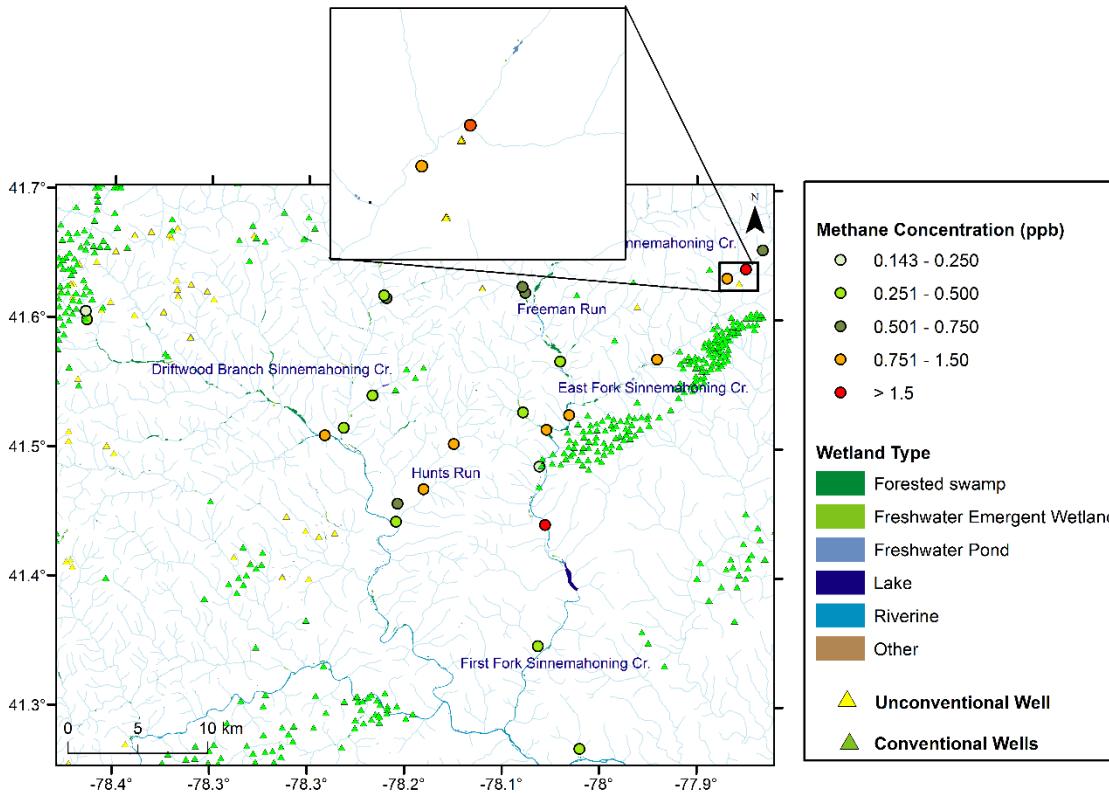
# 2016 Sinnemahoning Watershed Snapshot Day



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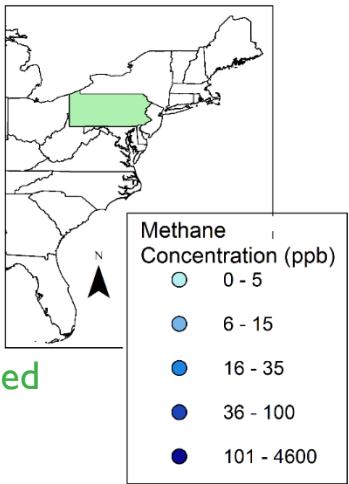


# 2016 Sinnemahoning Watershed Snapshot Day



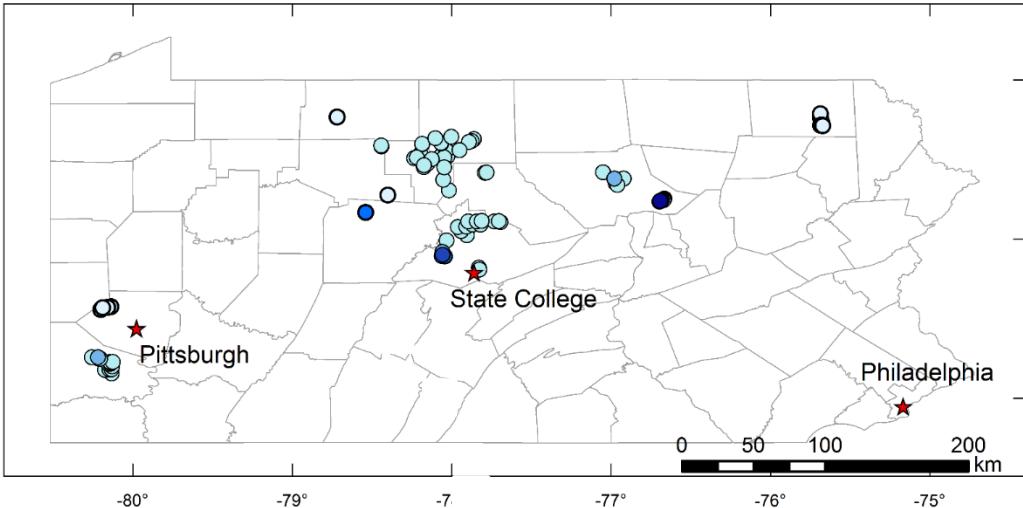
# Initial target regions

- **Northeastern PA:**
  - Sugar Run Watershed
  - Nine Panther Creek Watershed
  - Mill Creek Watershed



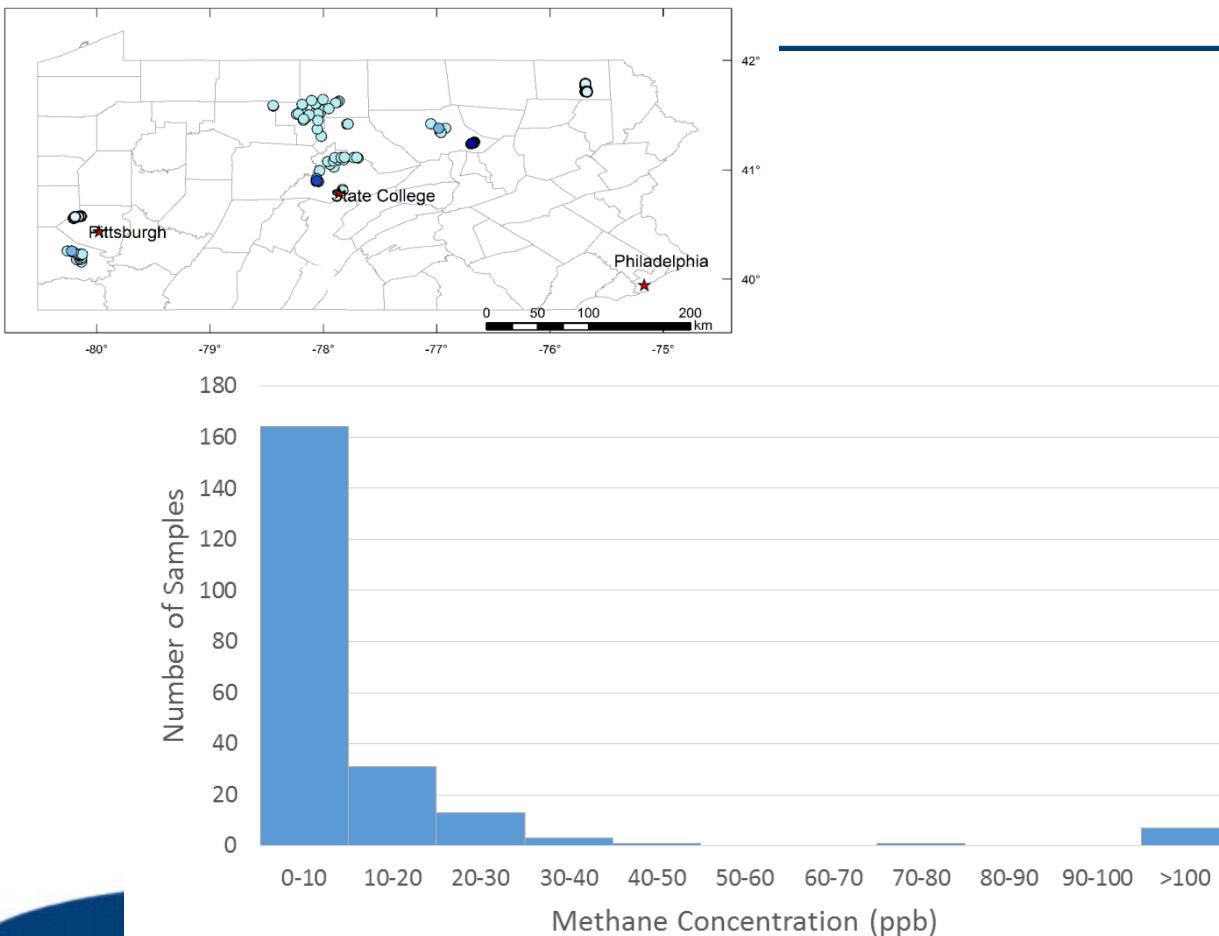
- **Northcentral PA:**
  - Beech Creek Watershed
  - Black Moshannon Watershed
  - Sinnemahoning Watershed
  - Slab Cabin/Spring Creek

- **Southwestern PA:**
  - Chartiers Creek Watershed
  - Little Sewickley Creek



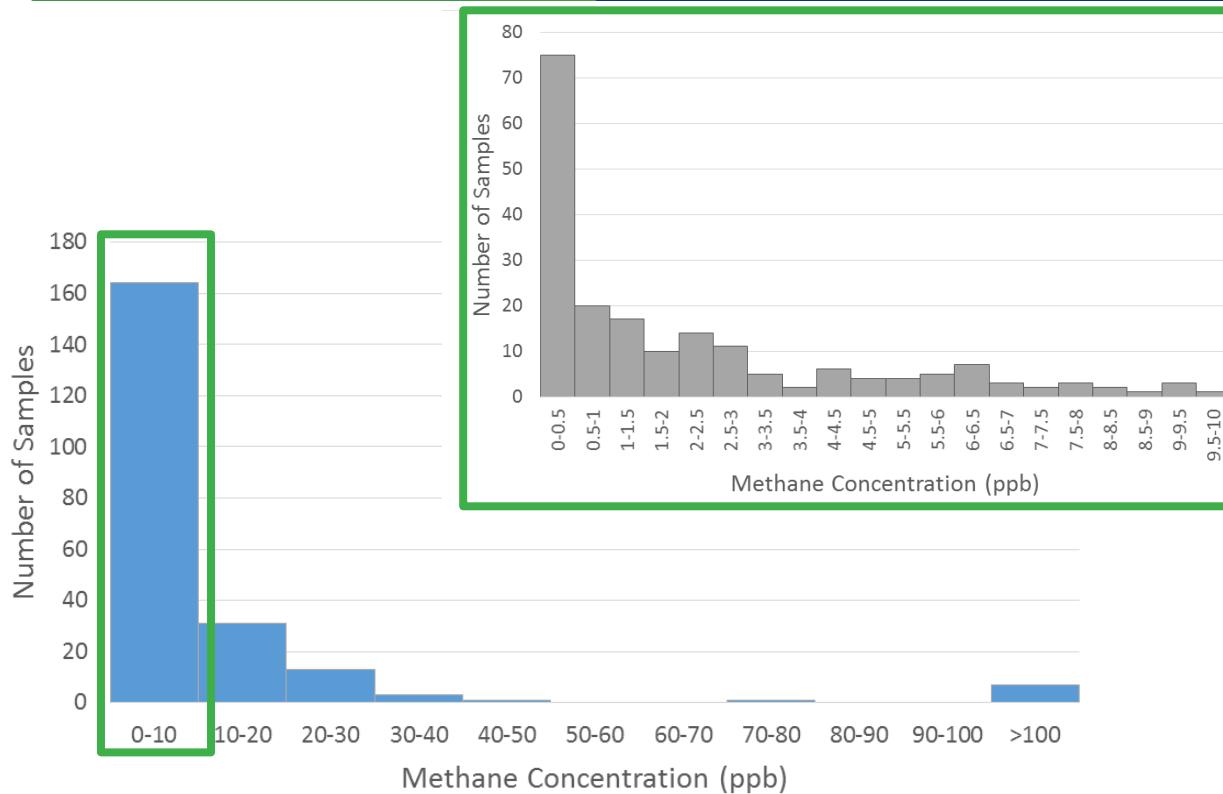
**More than 200 samples  
collected from 175 sites**

# 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.

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  - Approximately 85% < 10 ppb



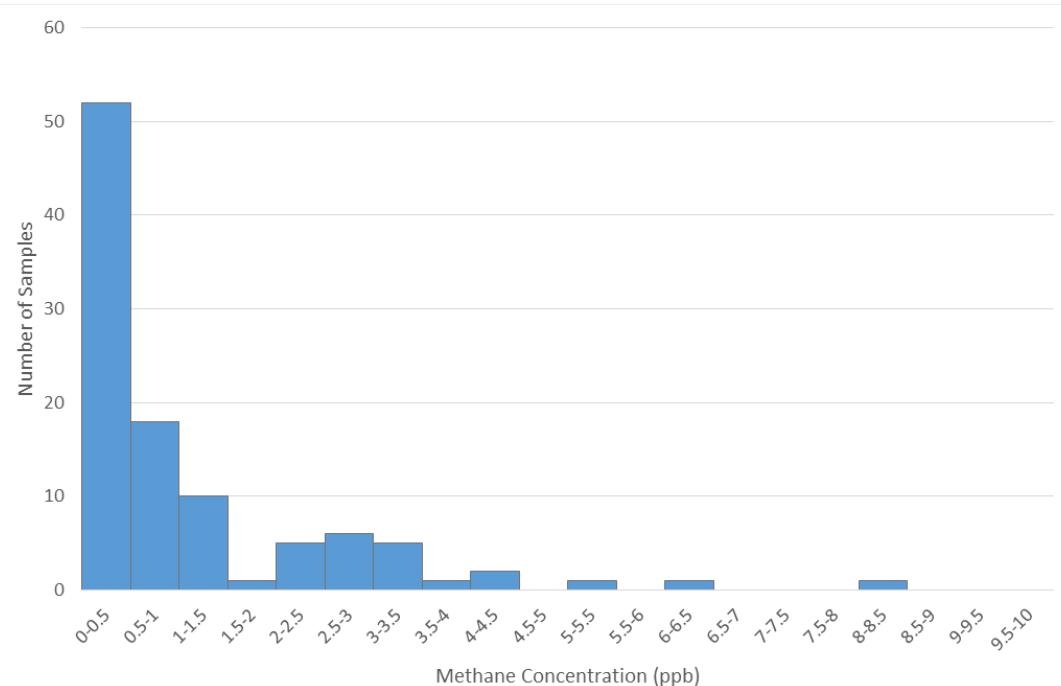
# How do we start looking for problems?

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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

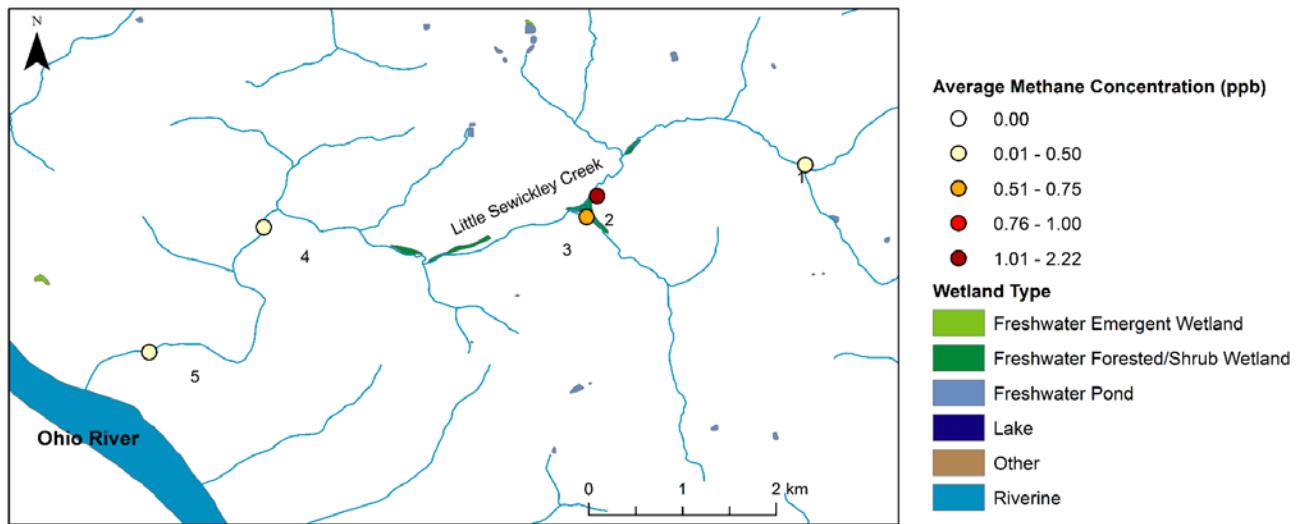
## Results- All other sites



- 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

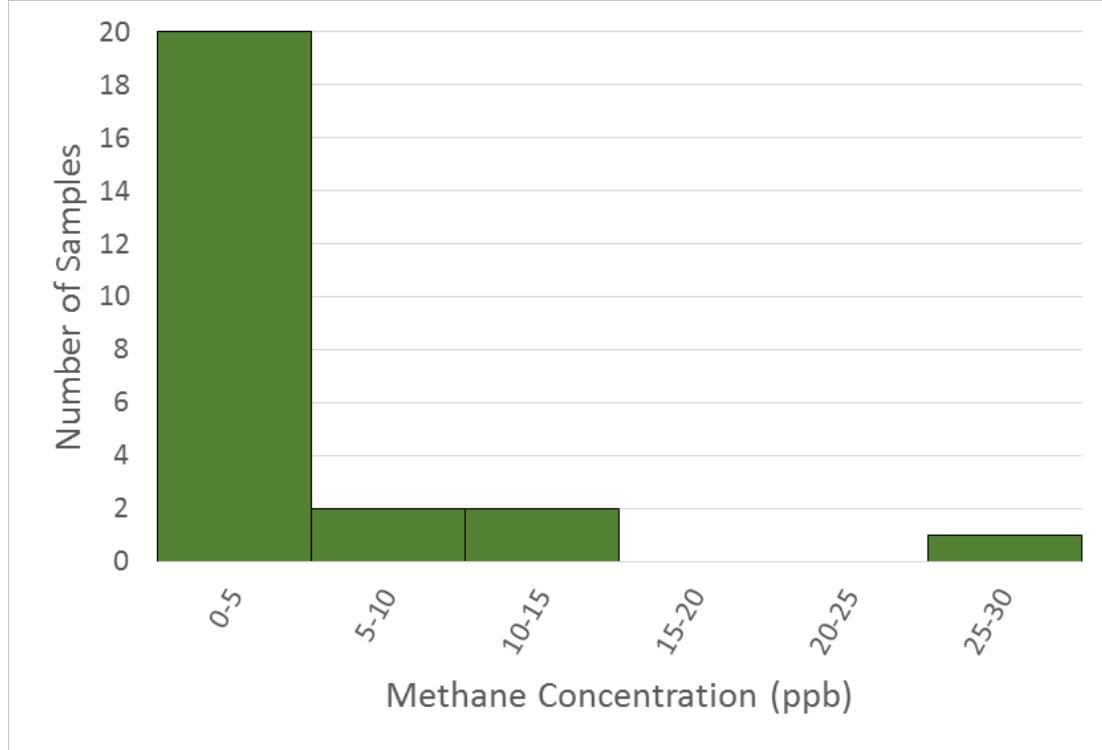
Can think of this as baseline  
for our sample sites

# Results - Wetland



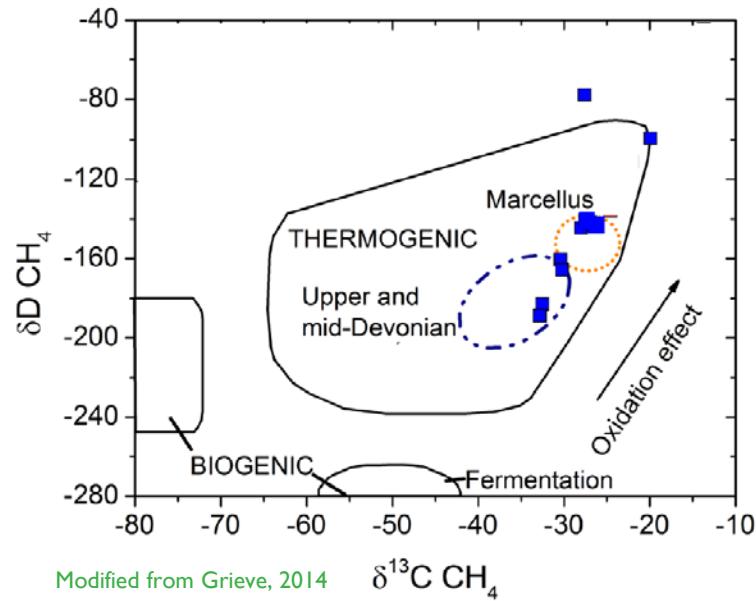
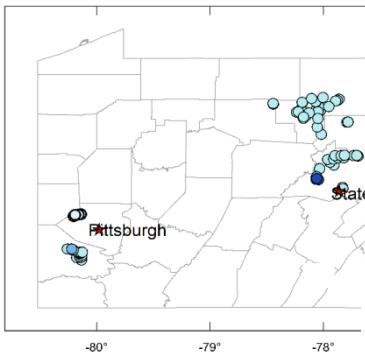
- Sample site is located within a wetland as defined by the US Fish and Wildlife Service National Wetlands Inventory
  - Emergent: Vegetation present most of the growing season (marsh, meadow)
  - Forested/Shrub: Wetland dominated by woody plants (swamps)

# Results - Wetland



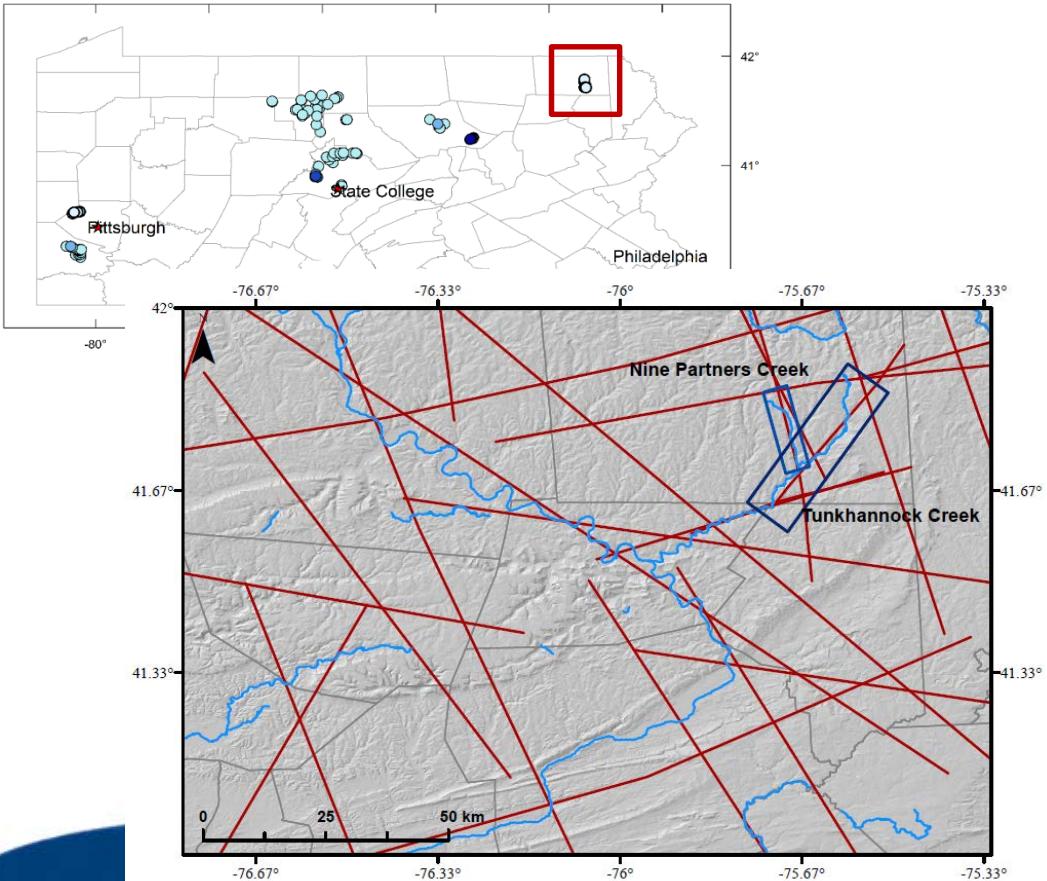
- Methane Concentration for wetland sites:
  - Mean: 3.95 ppb
  - Standard Deviation: 5.78 ppb
  - N = 24

# Results-Natural Thermogenic



- 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

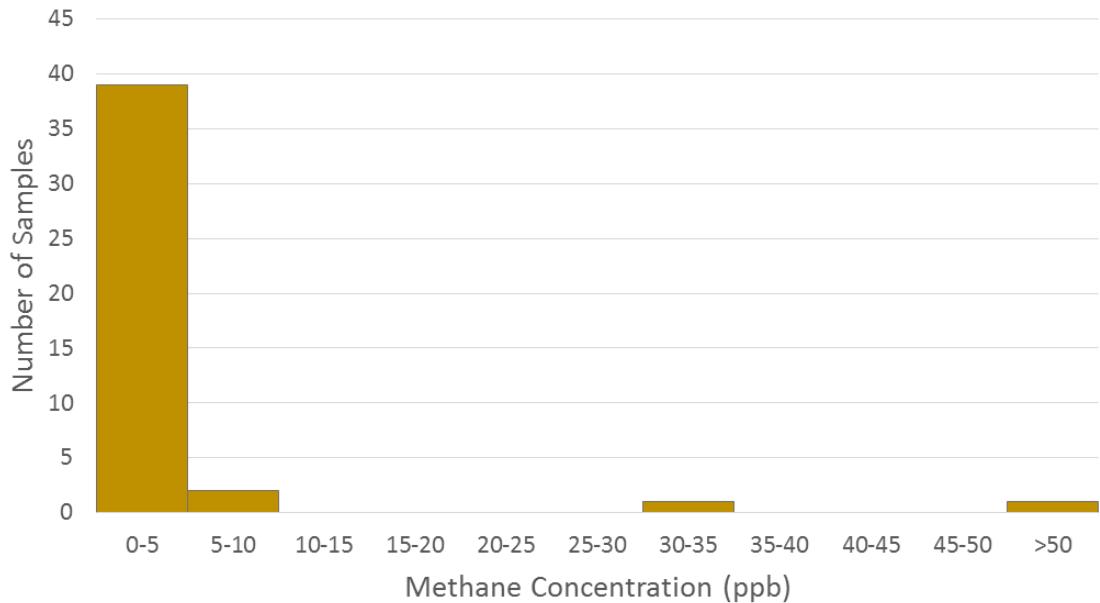


- **Sites follow natural Lineaments**

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



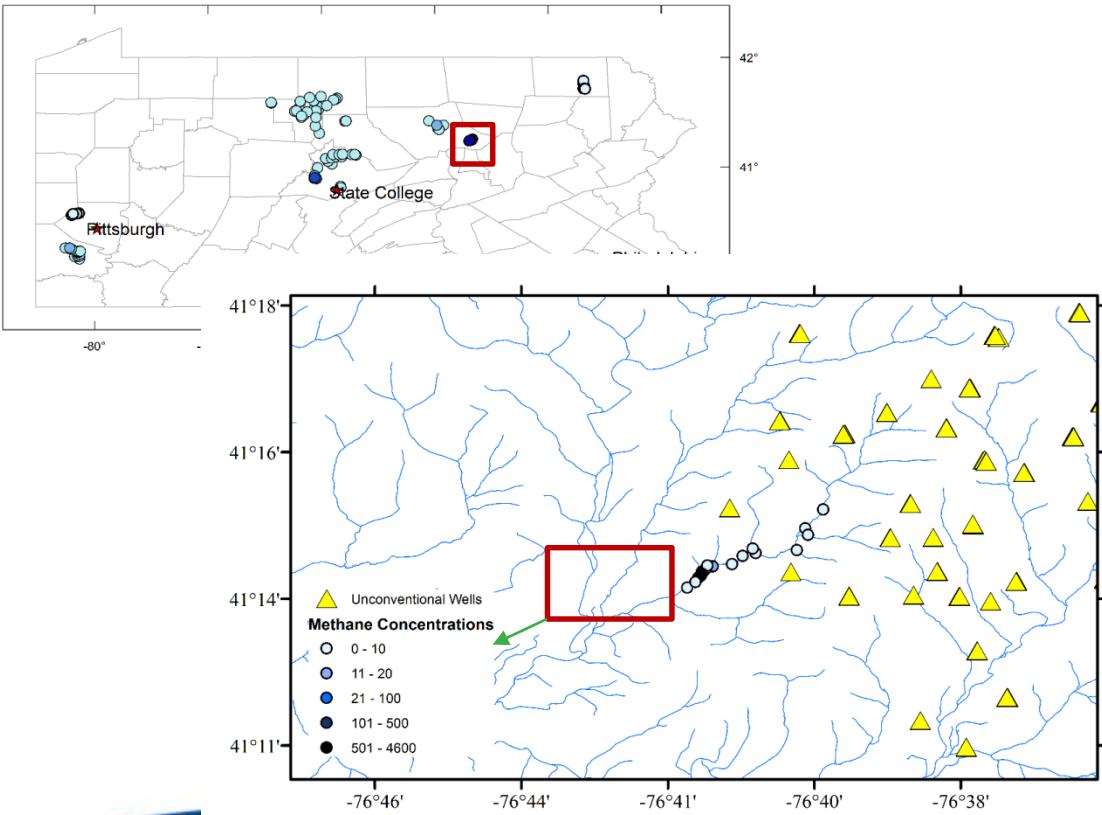
# Results-Natural Thermogenic



- Methane Concentration:

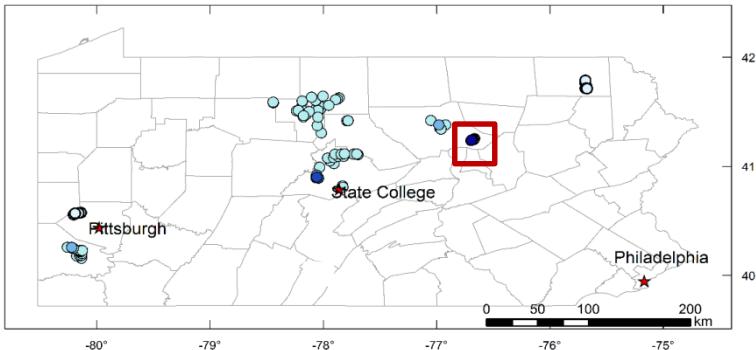
- Mean: 7.08 ppb
- Standard Deviation: 31.43 ppb
- N = 43

# Results- Thermogenic with Leaking Gas Well

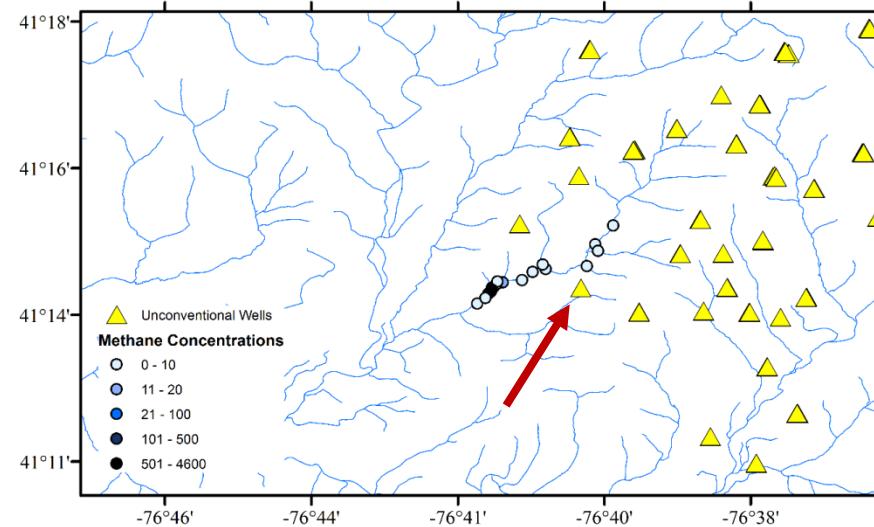


- Sugar Run, Lycoming County PA (Heilweil et al., 20140
  - Known leaking Marcellus gas well
  - Nearby domestic water supplies were reportedly contaminated
  - Isotopes show thermogenic signature

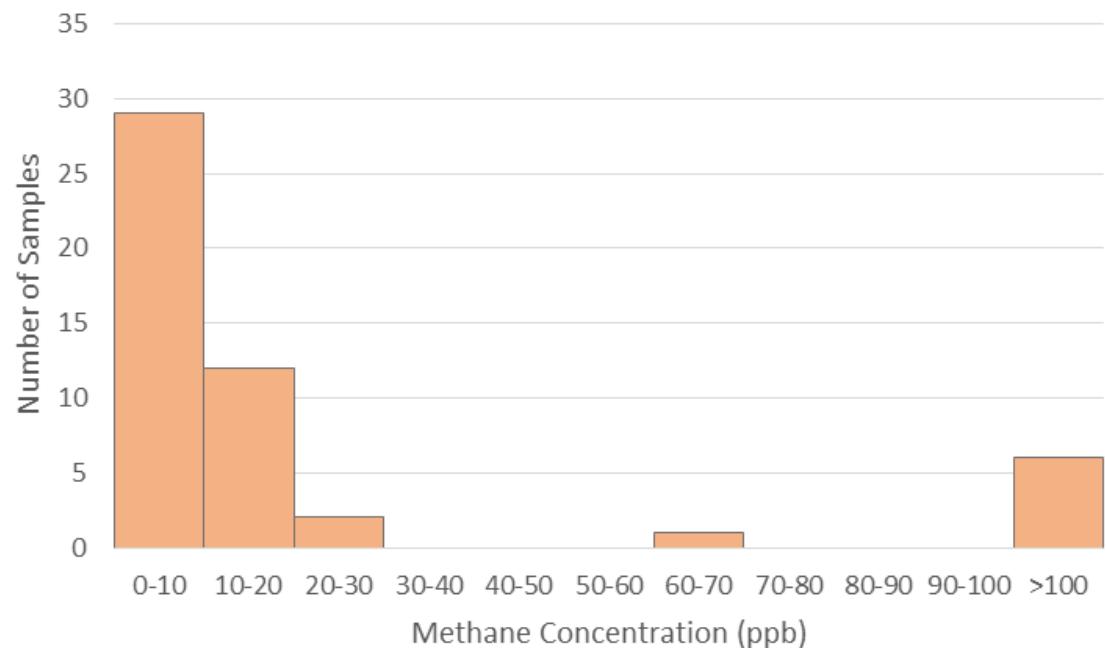
# Results- Thermogenic with Leaking Gas Well



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

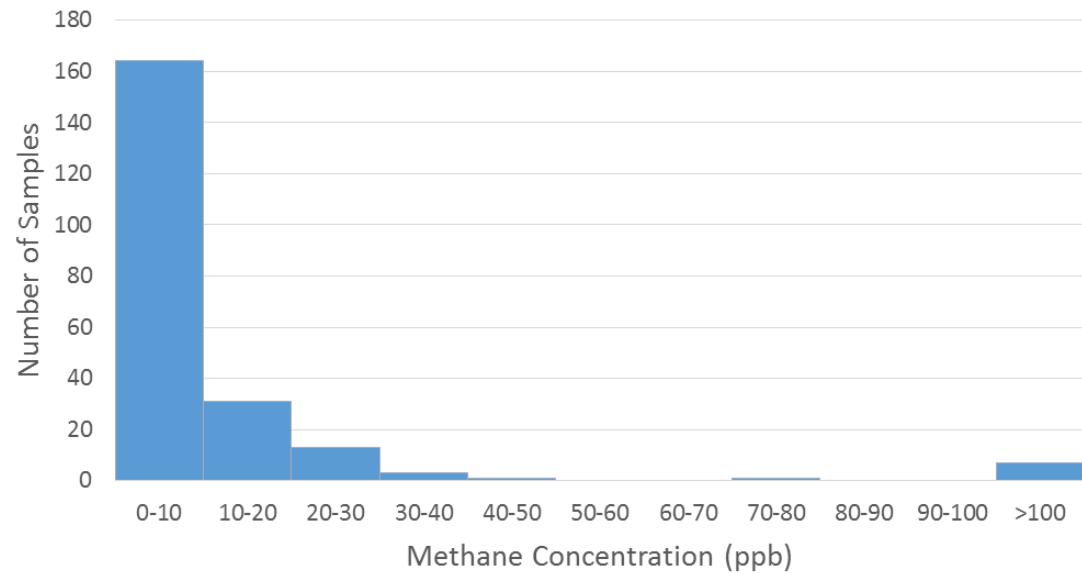


# Results- Thermogenic with Leaking Gas Well



- Methane Concentration
  - Mean: 348
  - Standard Deviation: 1051
  - N = 50
- 6 samples with concentrations greater than 100 ppb (2700 – 4600 ppb)

# Summary of Results



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



## What Is Next?

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- ☛ 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