



# **Emissions of coalbed and natural gas methane from abandoned oil and gas wells in the United States**

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## RESEARCH LETTER

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### Key Points:

- Abandoned wells are likely a minor source of methane in four production regions
- Plugging of inactive wells may be an effective means to reduce gas leakage
- Coalbed and natural gas methane both contribute to emissions from abandoned wells

## Emissions of coalbed and natural gas methane from abandoned oil and gas wells in the United States

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# Background

- Legacy of oil and gas extraction means there are millions of abandoned oil and gas wells in the onshore United States
  - 2.3 million in state databases
  - May be up to 3 million (Brandt et al., 2014)
- Types of abandoned wells:
  - wells without recent production (terminology includes inactive, temporarily abandoned, shut in, and/or dormant)
  - wells without a responsible operator (orphaned or abandoned)
  - wells that have been plugged with a cement or mechanical plug to prevent migration of fluids (plugged)



# Previous Work



- Two studies of methane leakage from abandoned wells in Appalachian Basin implied they may be a regionally significant methane source (Etiope et al., 2013; Kang et al., 2014)
- Comparison of top-down and bottom-up methane inventories indicated a missing (possibly thermogenic) source – implicating abandoned wells (Brandt et al., 2014)

# Are emissions from abandoned wells significant at regional or national scales?

- Initial assessment of CH<sub>4</sub> emissions from abandoned wells in four active production areas across the country
- Also measured stable isotope ( $\delta^{13}\text{C}$  and  $\delta^2\text{H}$ ) signatures to elucidate sources of CH<sub>4</sub>

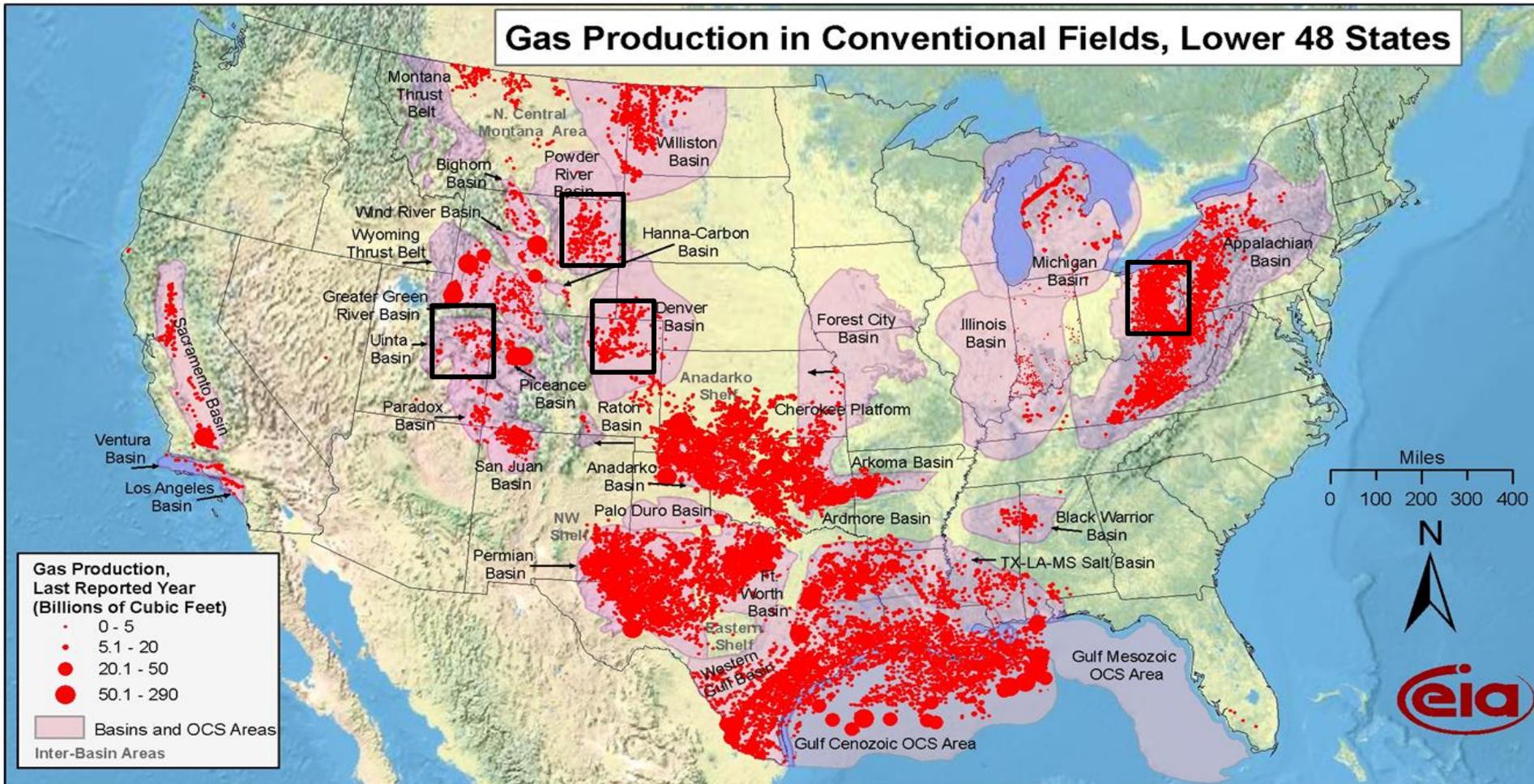


# Study basins: Appalachian, Powder River, Denver Julesburg, and Uintah.

In total 138 wells were measured



### Gas Production in Conventional Fields, Lower 48 States





# Approach



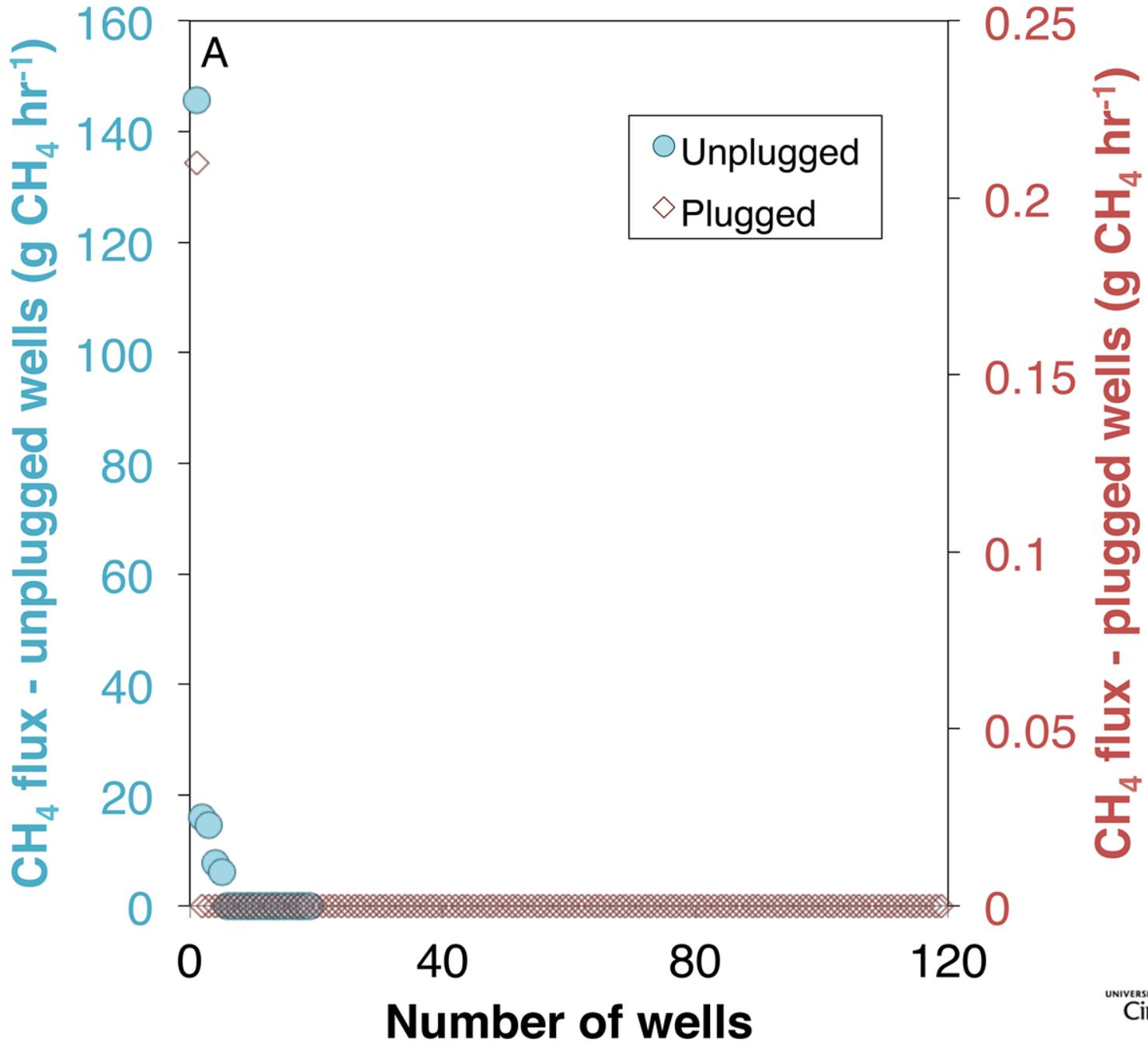
- Identify random selection of plugged and unplugged abandoned wells on public land
- Screening of methane concentrations on and around wellhead
- If screening value = 0, emission rate = 0
- If positive screening value, emission rate measured with hi-flow sampler or flux chamber with CRDS methane analyzer

# Plugged Wells



# Unplugged Wells



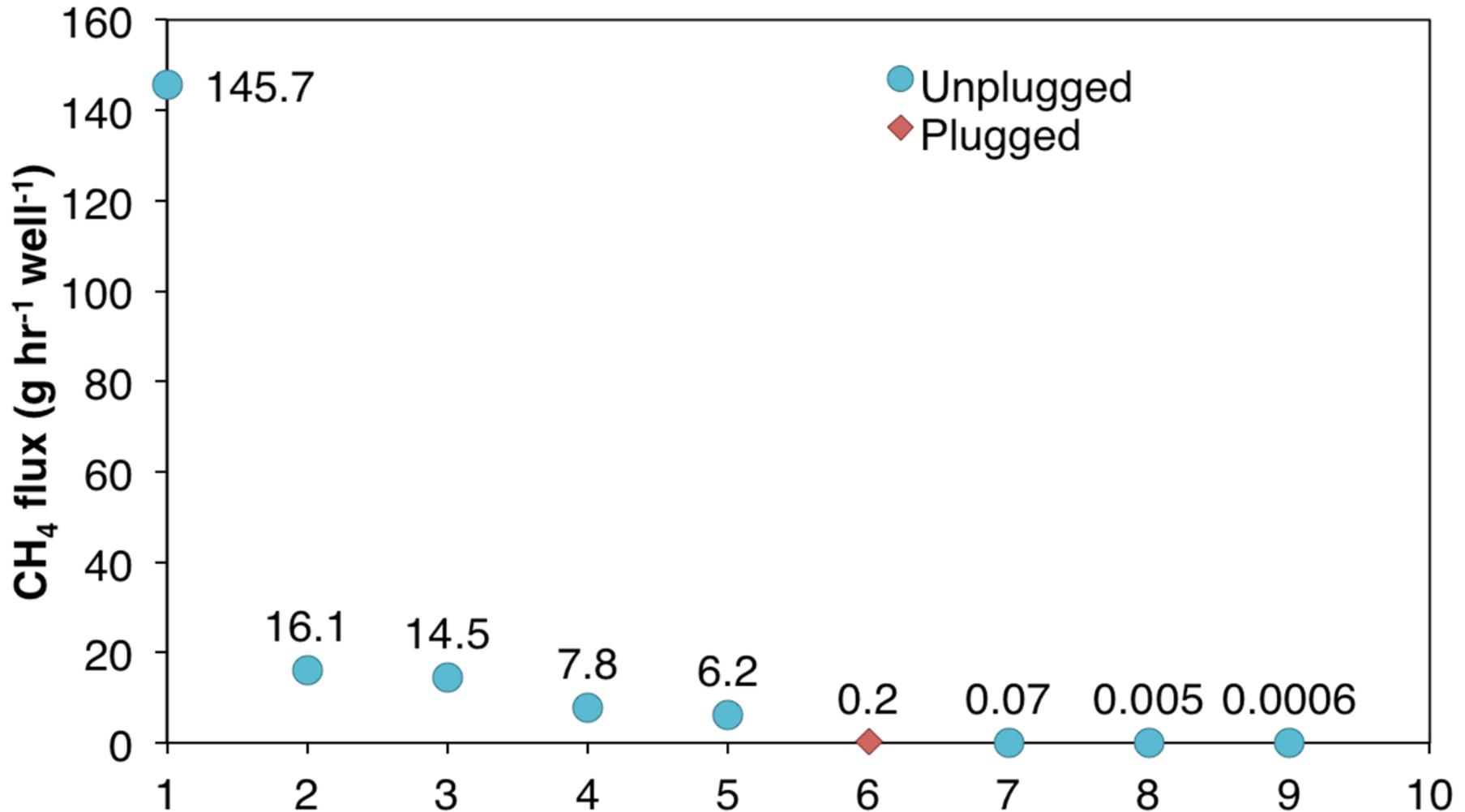




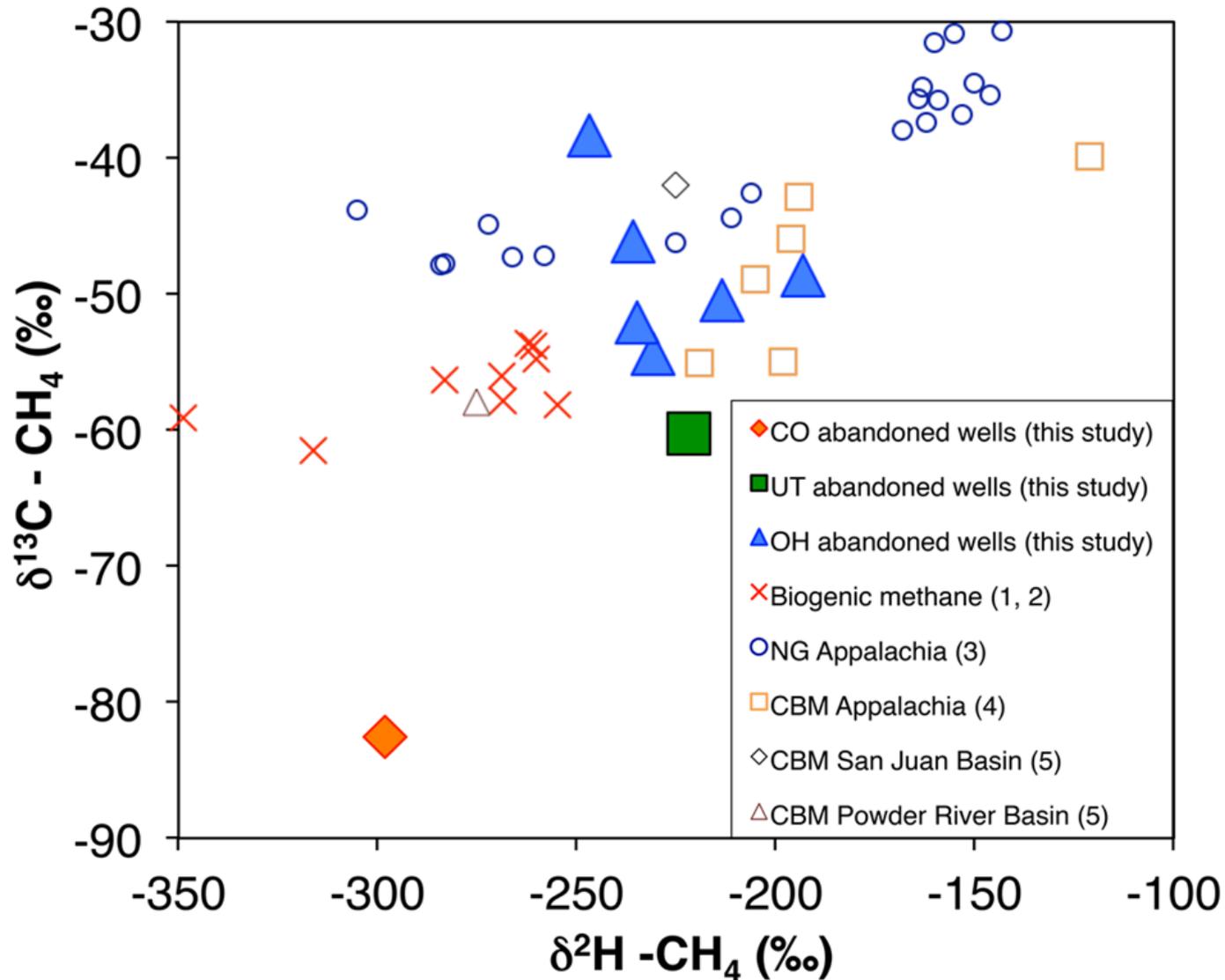
8 out of 20 unplugged wells were a positive source of atmospheric CH<sub>4</sub> (mean = 10.0 g hr<sup>-1</sup>) (95% UCL: 22.5 g hr<sup>-1</sup>)



Only 1 out of 119 plugged wells was a positive source of CH<sub>4</sub> (mean = 1.9 mg hr<sup>-1</sup>) (95% UCL: 4.9 mg hr<sup>-1</sup>)



# Wells are a source of thermogenic and biogenic CH<sub>4</sub>





# Are abandoned wells a significant CH<sub>4</sub> source?

- ✧ Preliminary results suggest that abandoned wells may account for
  - ◆ 0 – 0.2% of CH<sub>4</sub> emissions in the Uintah and Denver-Julesburg basins (as measured by top-down studies)
  - ◆ 0.1 – 0.3 % of CH<sub>4</sub> emissions in the NE Marcellus Basin
  - ◆ 1.6 x 10<sup>4</sup> kg CH<sub>4</sub> hr<sup>-1</sup> nationally (2 – 4% of oil and gas CH<sub>4</sub> in the EPA emissions inventory)
  
- ✧ Proper plugging of abandoned wells is an effective strategy for reducing CH<sub>4</sub> emissions from legacy oil and gas operations
  
- ✧ Highest emissions were from wells in the Appalachian Basin – the oldest oil and gas producing region in the country (starting 1859)
  - ◆ This region also has poor record keeping of abandoned well status and location



# Implications



- Abandoned wells may provide a conduit for generation and/or release of biogenic coal bed  $\text{CH}_4$  in addition to natural gas
- State databases are lacking in accounting of abandoned wells, especially unplugged wells
- More work is needed to constrain the number of “super-emitters” regionally and nationally



# Missing Information



- Texas did not have any accessible abandoned wells for this study
- Measurements of abandoned well emissions in California are currently under investigation at Stanford University (Rob Jackson's group)



# Questions?

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