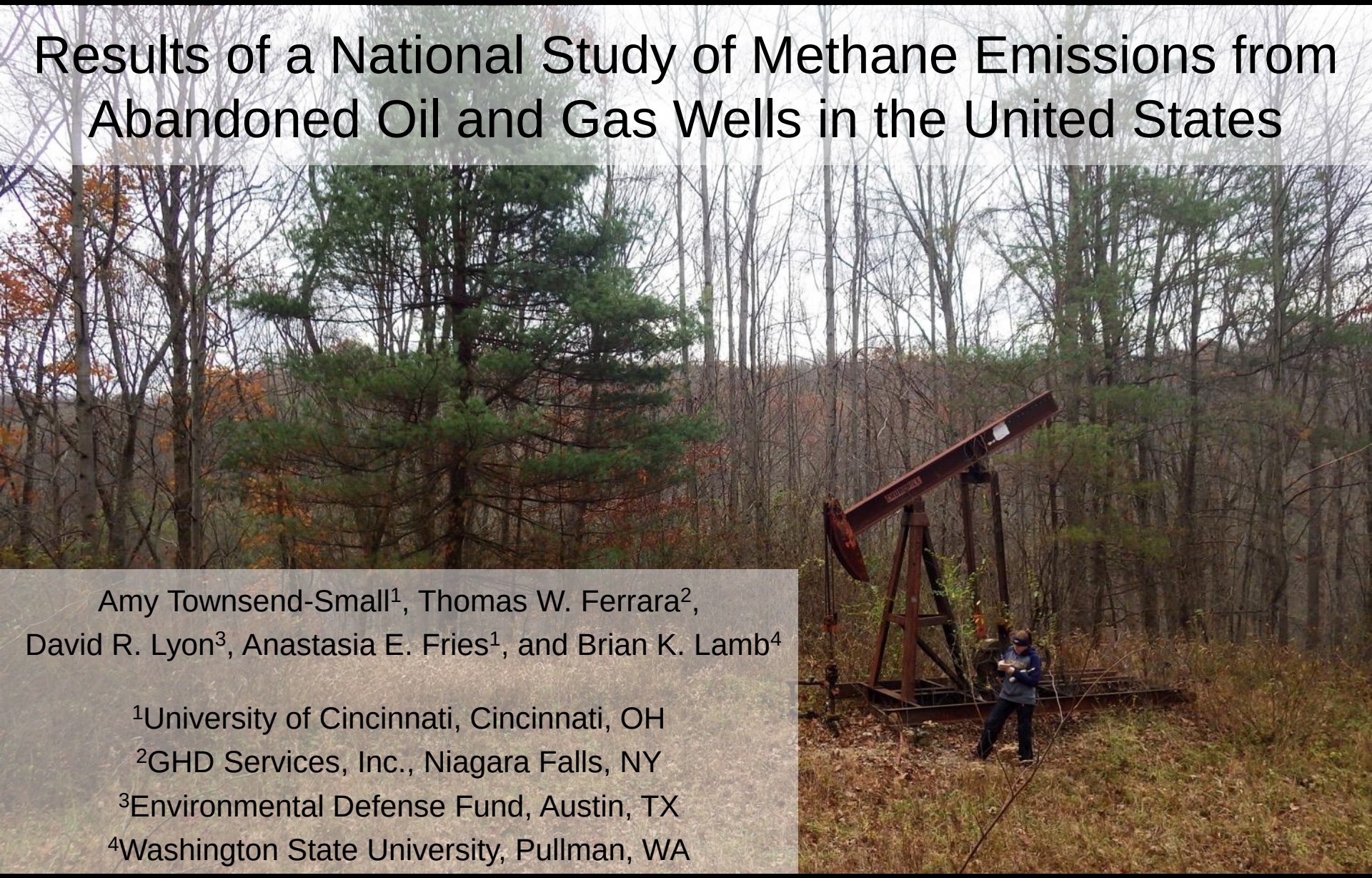
Results of a National Study of Methane Emissions from Abandoned Oil and Gas Wells in the United States



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

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Finding the ways that work

Why study abandoned wells?

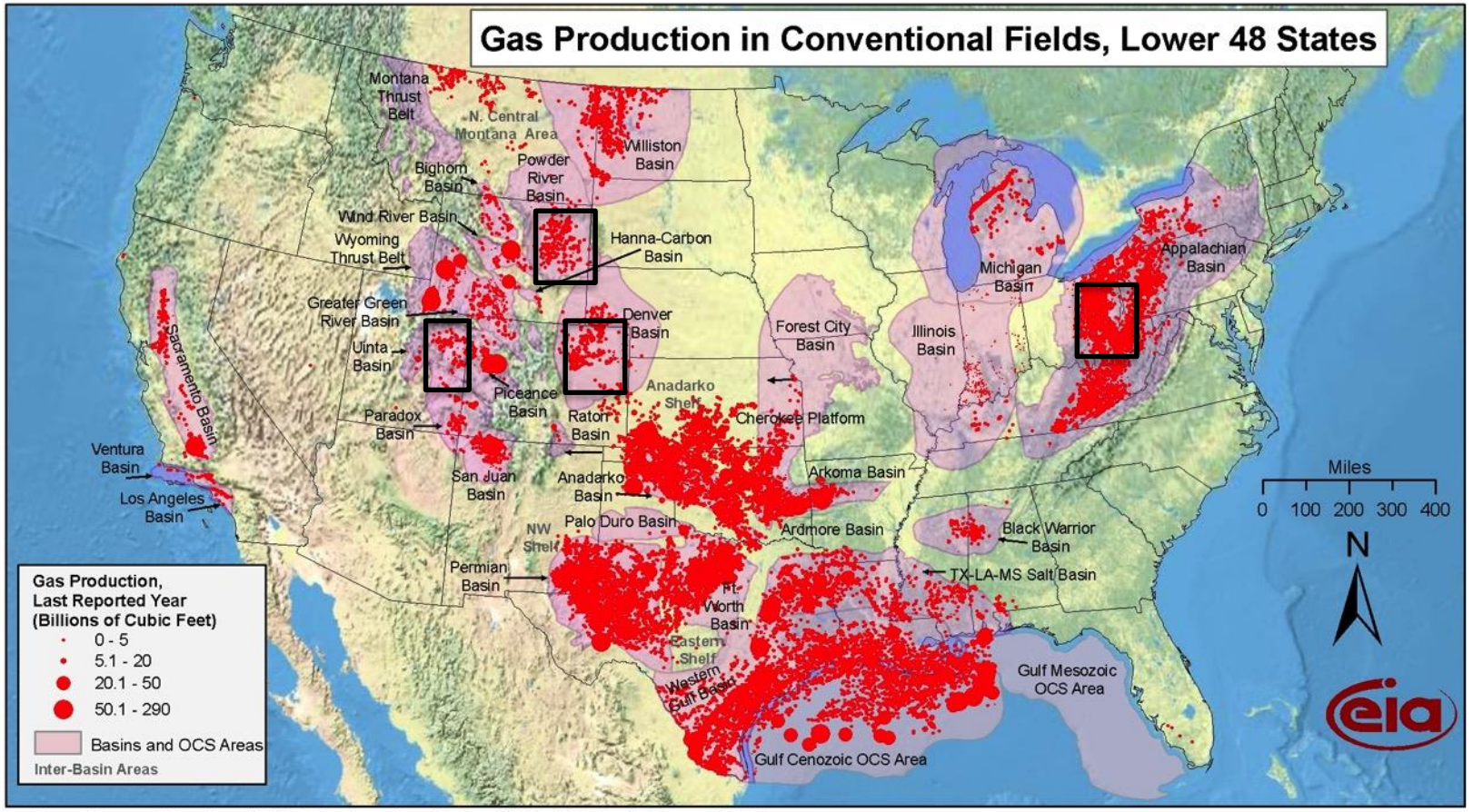
- May be up to 3 million in the onshore United States, even more offshore
- Not included in USEPA or international GHG inventories (such as IPCC)
- May be source of the discrepancy between inventories and observations if they are a significant CH_4 source

Types of abandoned wells:
Each state has their own terminology

1. No recent production
   - Inactive, temporarily abandoned, shut-in, dormant, abandoned
2. No responsible operator
   - Orphaned, abandoned
3. Plugged with a cement or mechanical plug to prevent migration of gas or fluids
   - Plugged, plugged & abandoned

Study areas:

138 wells sampled nationally



Source: Energy Information Administration based on data from HPDI, IN Geological Survey, USGS
Updated: April 8, 2009

Appalachian Basin, Ohio
Powder River Basin, Wyoming
Denver Julesburg Basin, Colorado
Uintah Basin, Utah

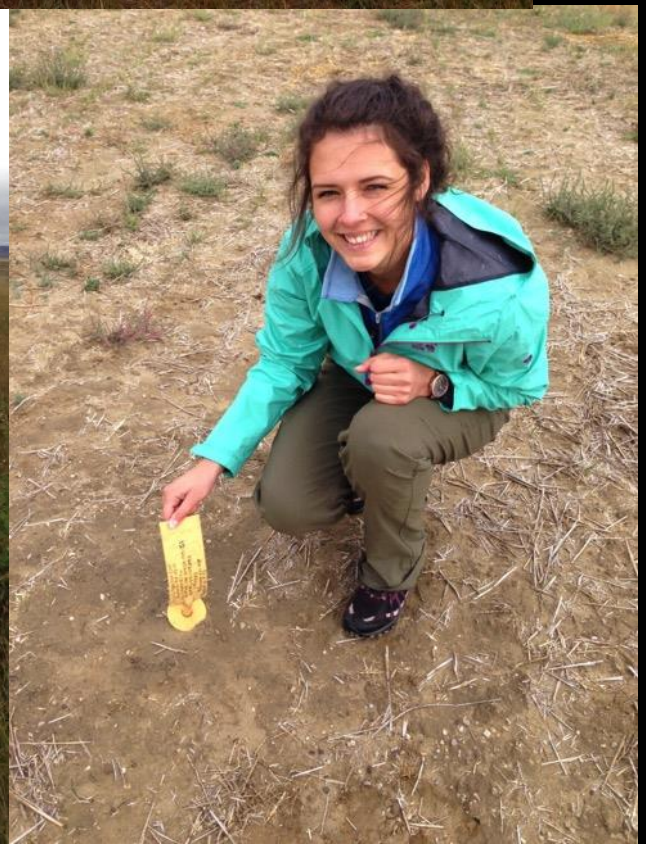
All sampling was conducted on public land. No operator or land owner cooperation was required and all wells were selected randomly from state databases.

Appalachia

Appalachia

Highest emitter in our study
– orphaned/“historical” well from ~early 1900s?
– no drilling or production data

Western basins



Methods

- Screening measurements were made to detect CH_4 enhancements and find leaking components
- Flux measurements made with range of tools scaled to concentration level from ppm to percent range
  - Picarro analyzer + flux chamber
  - Indaco High Flow sampler
- Also made measurements from soils within 10 m radius from wellhead or plug
- Stable isotopic measurements of CH_4 for determination of source pathway


Gas Rover


DPIR


Flux Chamber


High Flow

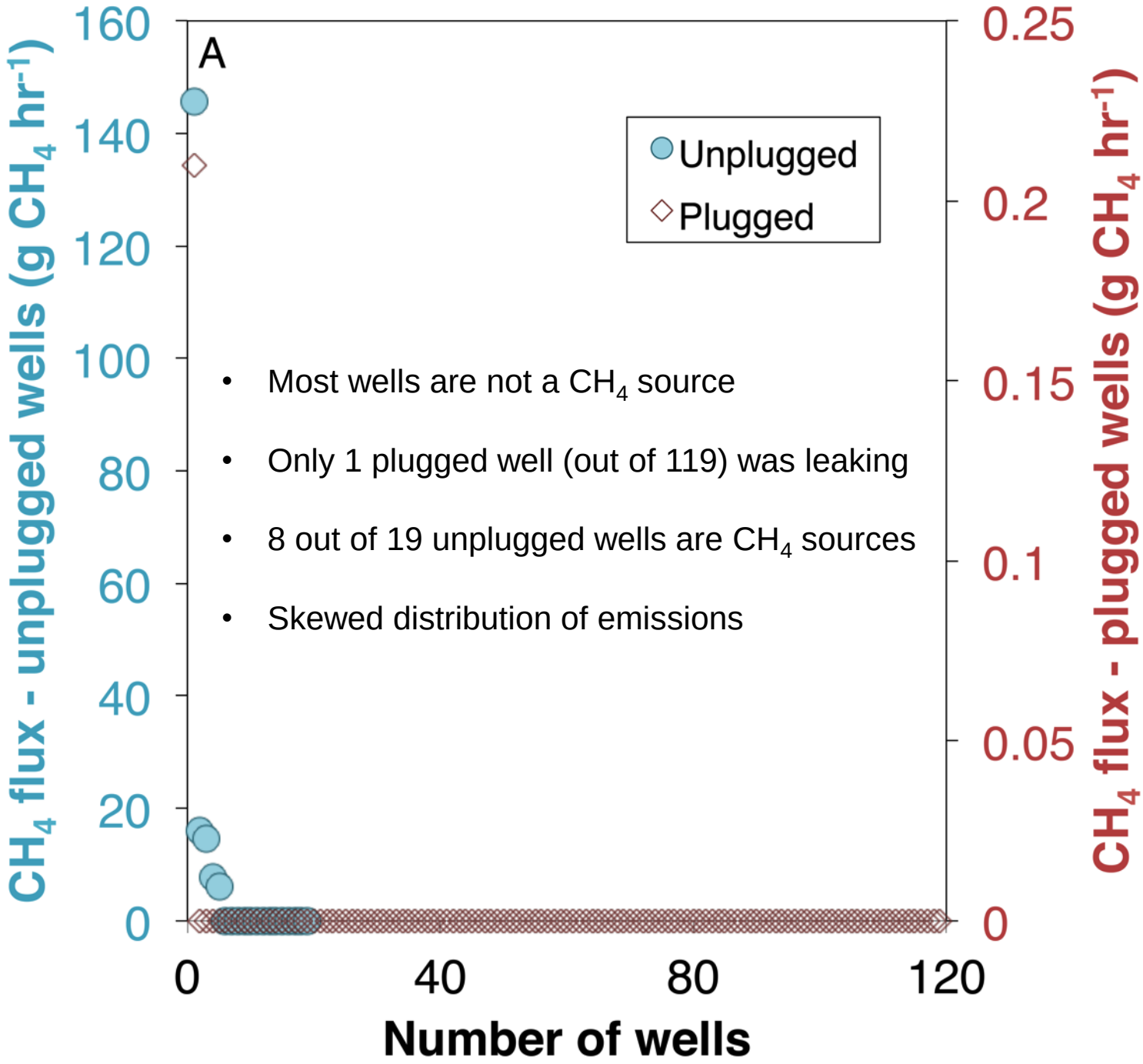
Types of abandoned wells:
Categories assigned in our paper

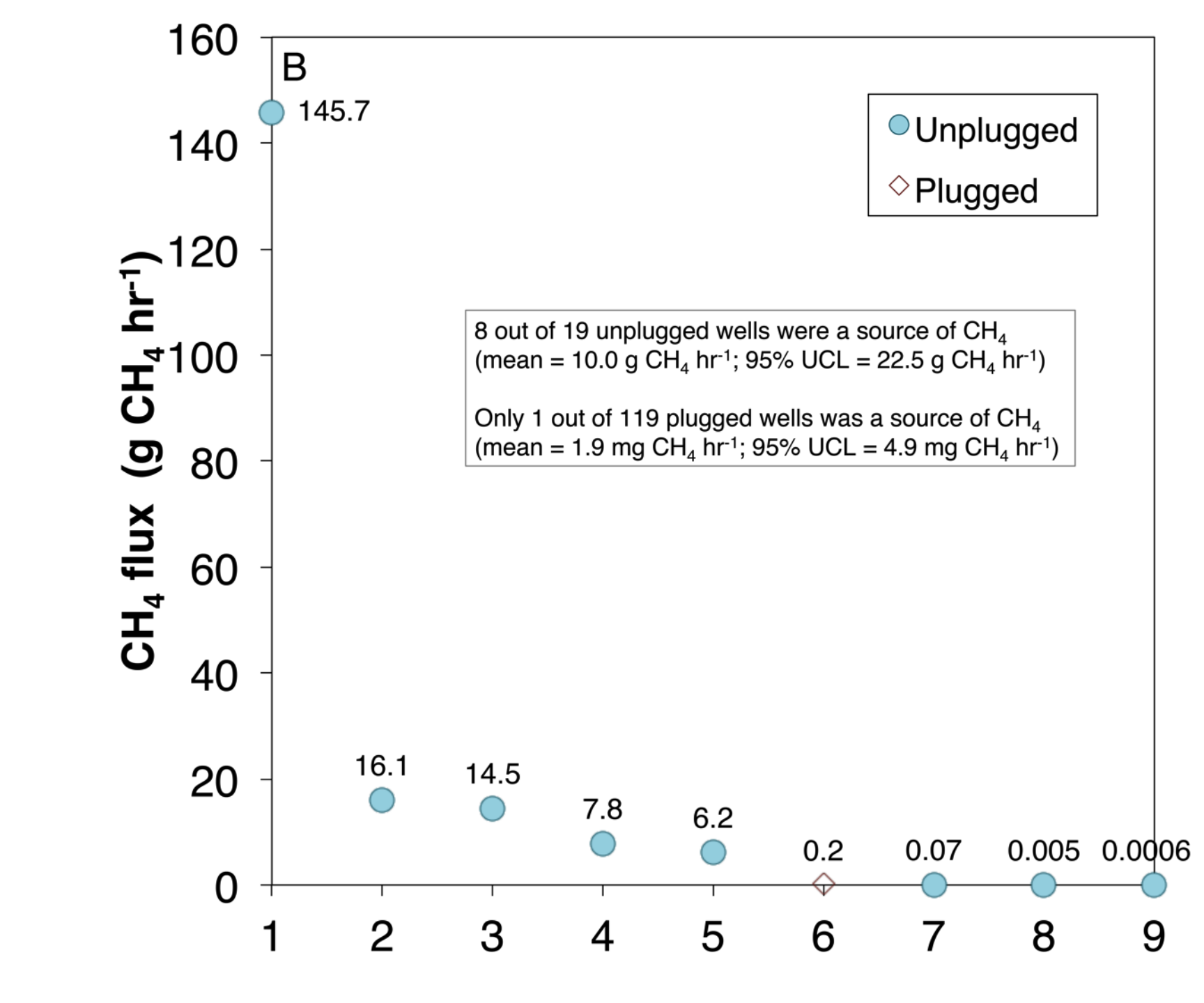
Unplugged

1. No recent production
   - Inactive, temporarily abandoned, shut-in, dormant
2. No responsible operator
   - Orphaned, abandoned

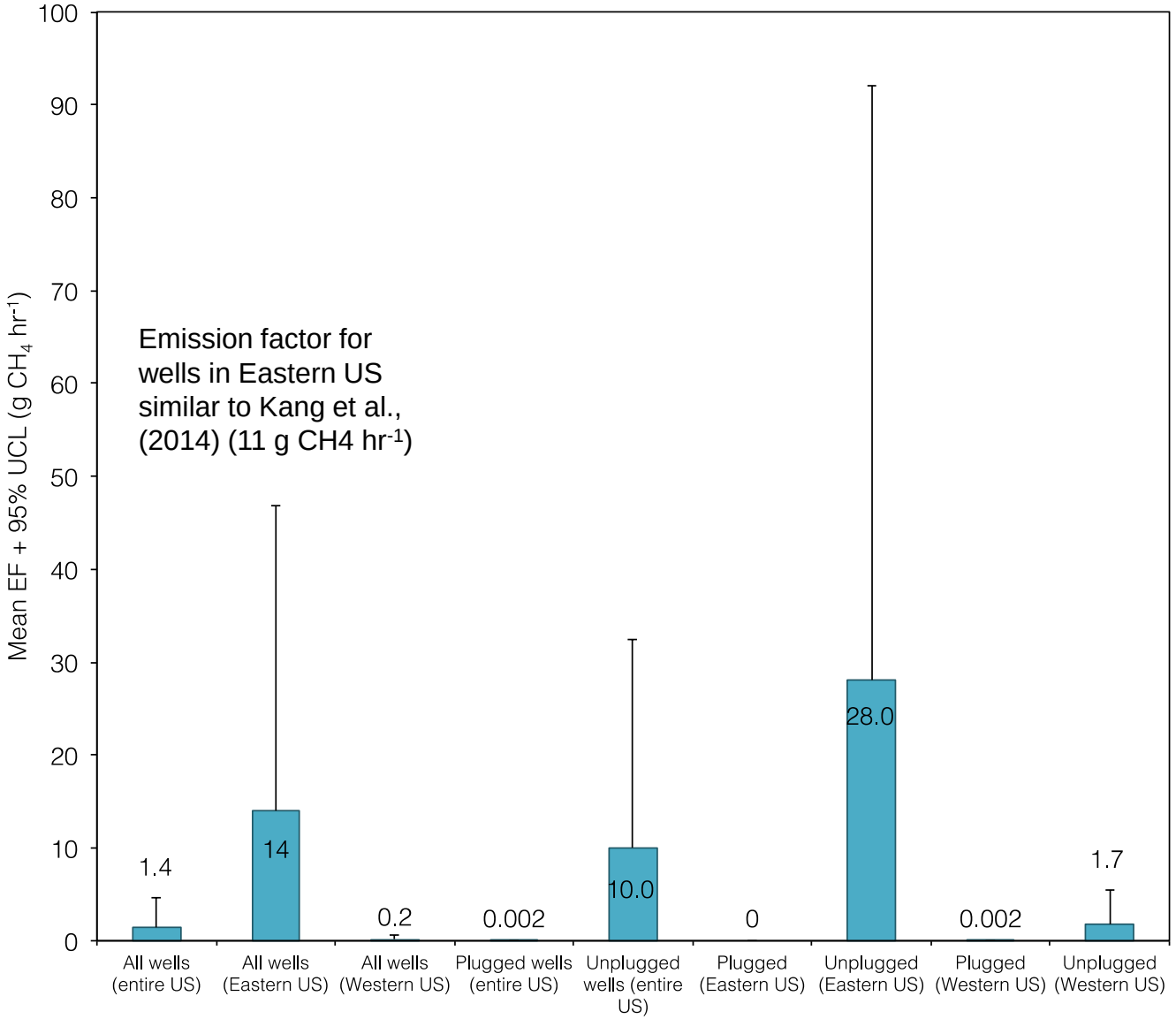
Plugged

3. Plugged with a cement or mechanical plug to prevent migration of gas or fluids
   - Plugged

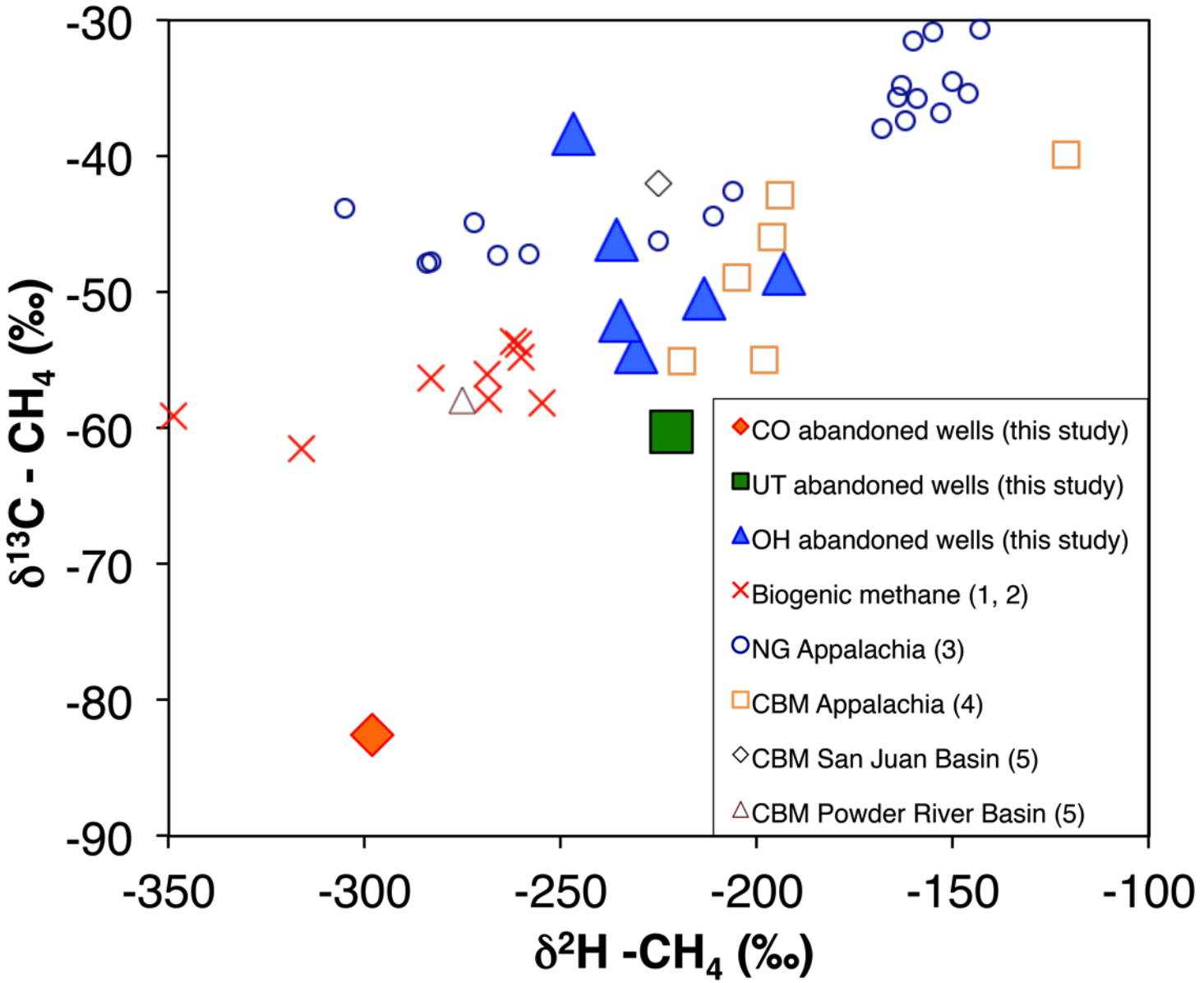

A
Unplugged
Plugged
• Most wells are not a CH_4 source
• Only 1 plugged well (out of 119) was leaking
• 8 out of 19 unplugged wells are CH_4 sources
• Skewed distribution of emissions
CH_4 flux - unplugged wells (g CH_4 hr^{-1})
CH_4 flux - plugged wells (g CH_4 hr^{-1})
0
20
40
60
80
100
120
140
160
0
0.05
0.1
0.15
0.2
0.25
0
40
80
120
Number of wells


B
145.7
Unplugged
Plugged
8 out of 19 unplugged wells were a source of CH4
(mean = 10.0 g CH4 hr-1; 95% UCL = 22.5 g CH4 hr-1)
Only 1 out of 119 plugged wells was a source of CH4
(mean = 1.9 mg CH4 hr-1; 95% UCL = 4.9 mg CH4 hr-1)
16.1
14.5
7.8
6.2
0.2
0.07
0.005
0.0006
CH4 flux (g CH4 hr-1)
160
140
120
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9

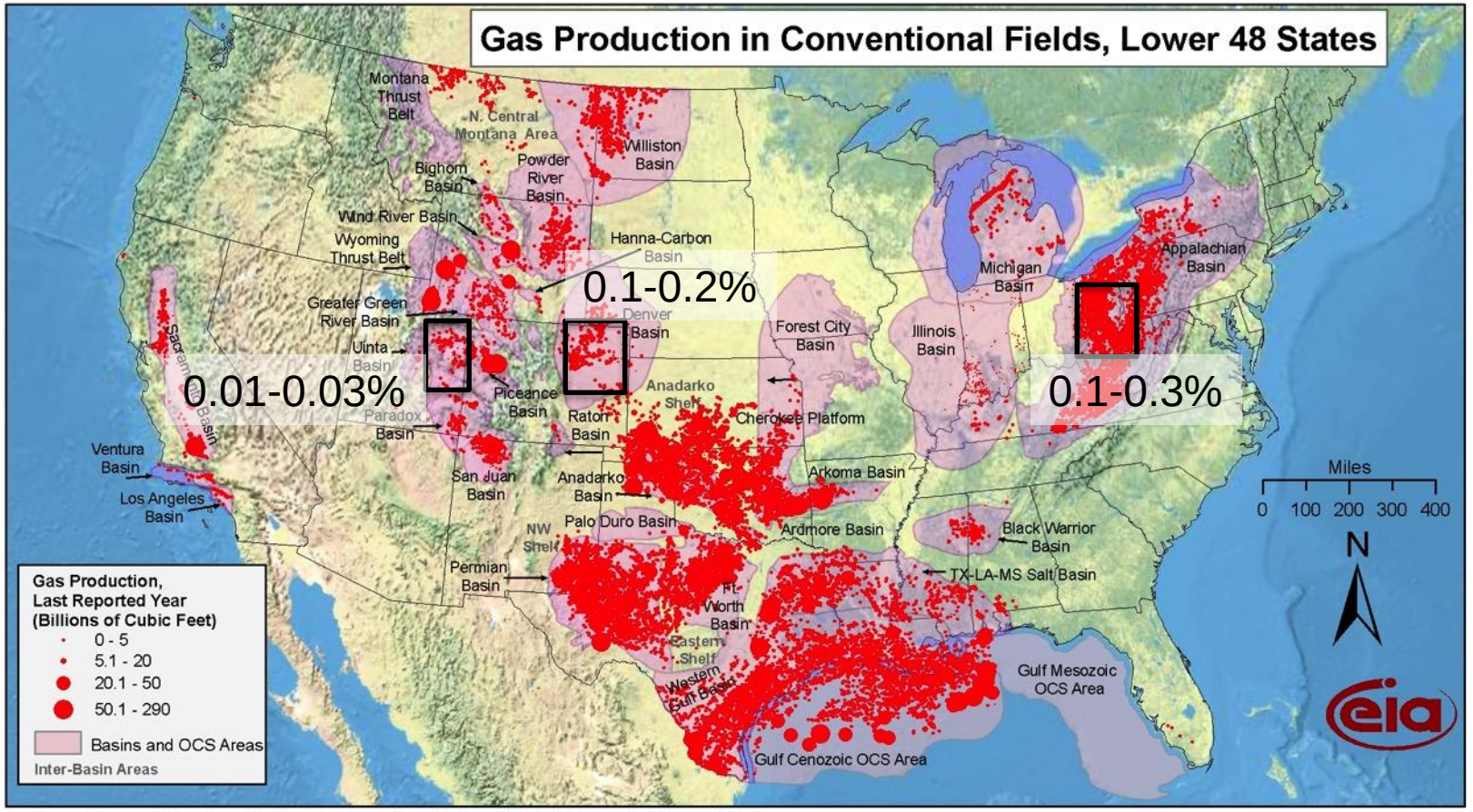
Abandoned wells in the Eastern US (Appalachian Basin) have a higher emission factor than the Western US – especially for unplugged wells



Some wells emit natural gas, others may be a conduit for biogenic coalbed CH_4 release: a "new" CH_4 source?



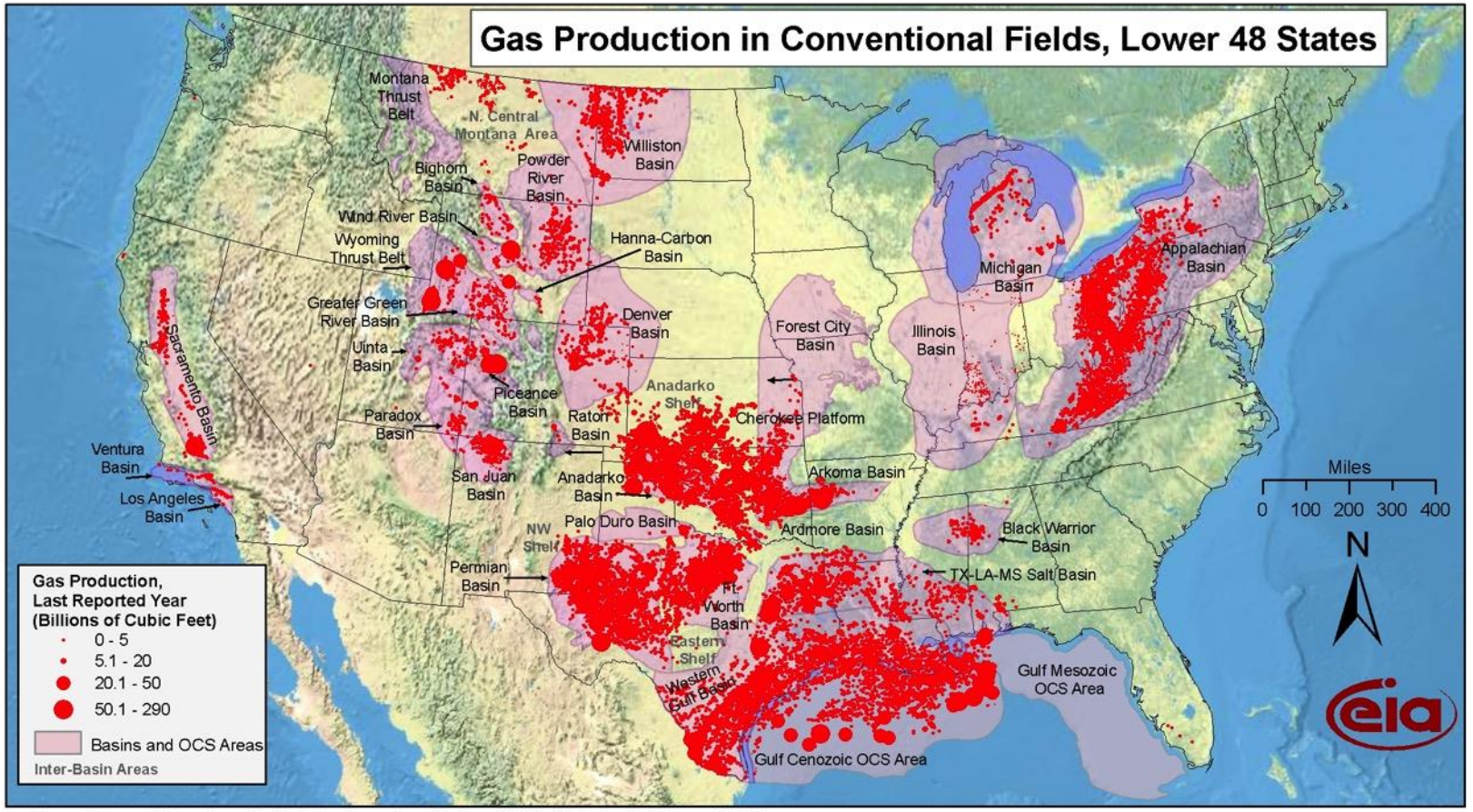
Comparison to top-down CH_4 measurements



Source: Energy Information Administration based on data from HPDI, IN Geological Survey, USGS
Updated: April 8, 2009

0.1 – 0.3% of CH_4 emissions in Appalachian Basin (Peischl et al., 2015)
0.1 – 0.2% of CH_4 emissions in Denver Julesburg Basin, Colorado (Petron et al., 2014)
0.01 – 0.03% of CH_4 emissions in the Uintah Basin, Utah (Karion et al., 2013)

National emissions (from our paper)



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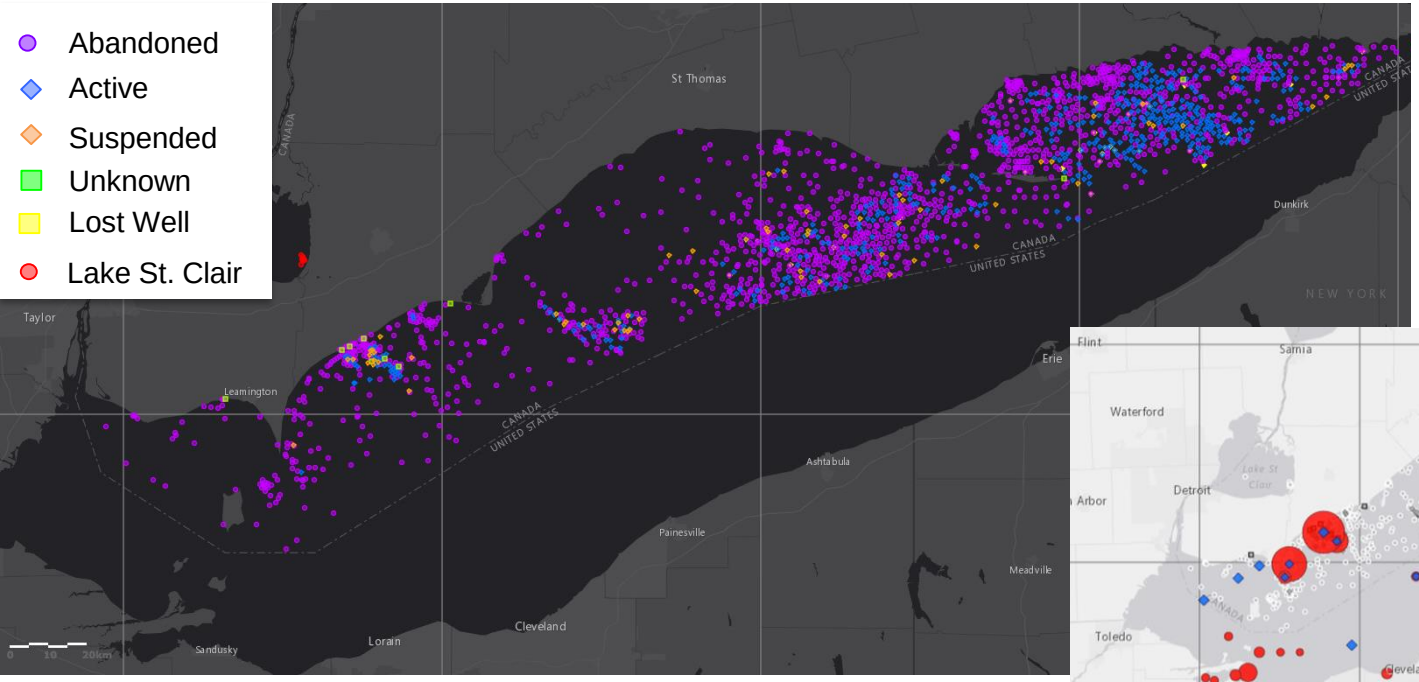
~2.3 million abandoned wells in the **onshore** United States (including Alaska) = 1.6 x 10^4 kg hr^{-1}, an additional 2-4% of the USEPA inventory for CH_4 emissions from oil and gas

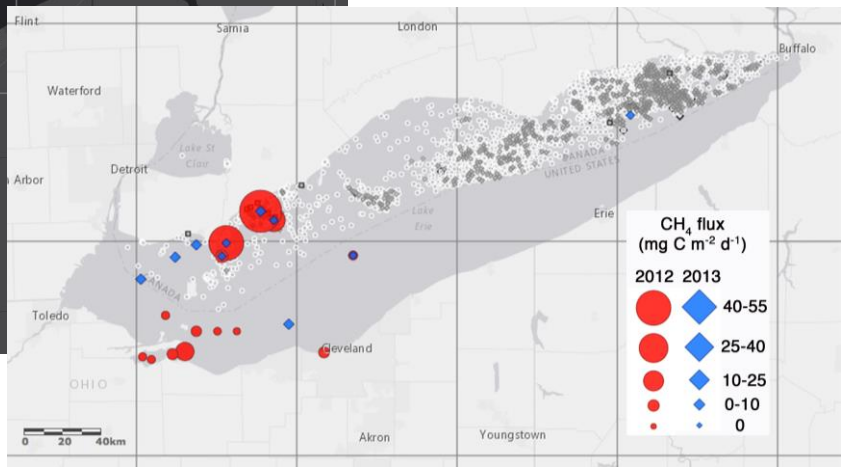
Open questions

- How many high emitters are there?
  - Easy to assume many of them are not in state databases (Kang et al., 2014)
- How do we find and quantify high emitting abandoned wells, especially those not on public land?
- Are offshore wells a source of atmospheric CH_4?
- Are active conventional wells in Appalachian basin a similarly disproportionate source?

Contributions of biogenic and thermogenic CH_4 in Lake Erie



- Biogenic CH_4 is the dominant source of CH_4 in Lake Erie
- Natural gas wells contribute an additional 30% of CH_4 emissions



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Quantifying emissions of methane derived from anaerobic organic matter respiration and natural gas extraction in Lake Erie

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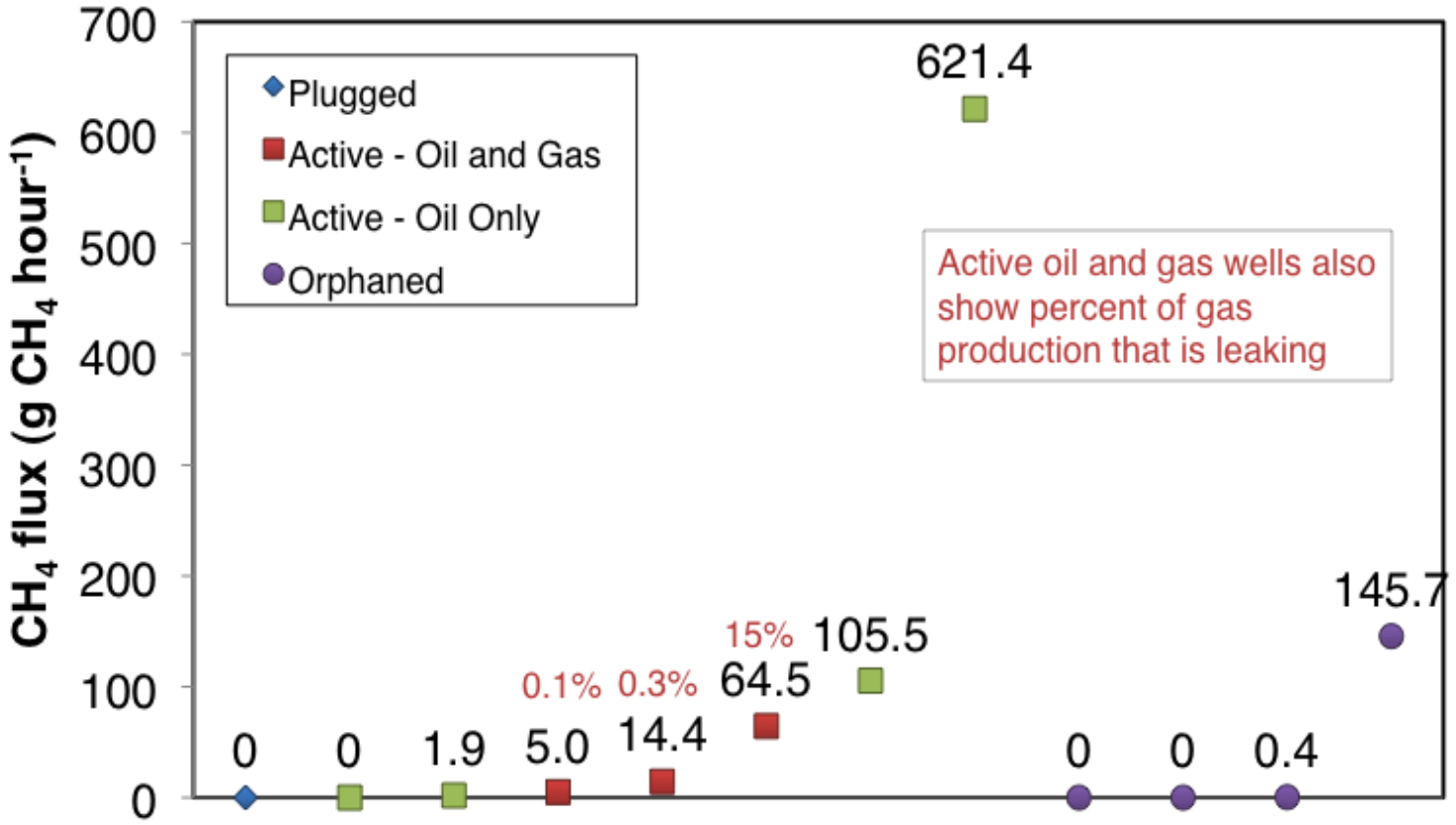
Ongoing work in Appalachian Basin

- Relative contributions of unconventional/conventional/abandoned wells to CH_4



Thank you

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- Bo Wood and Rich Jones – US Forest Service
- Mary Kang and Rob Jackson – Stanford

Questions?