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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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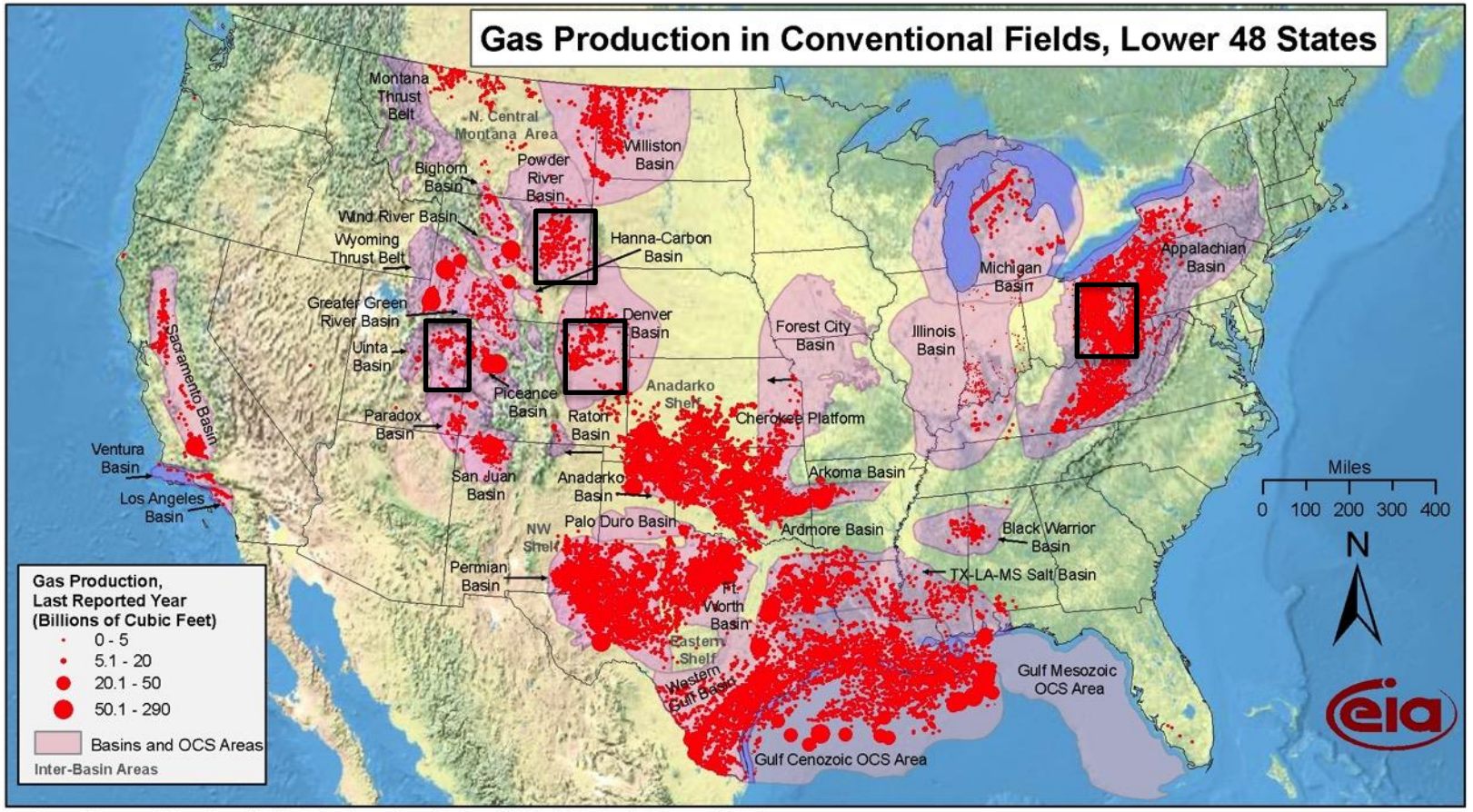
Finding the ways that work

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.

Types of abandoned wells:

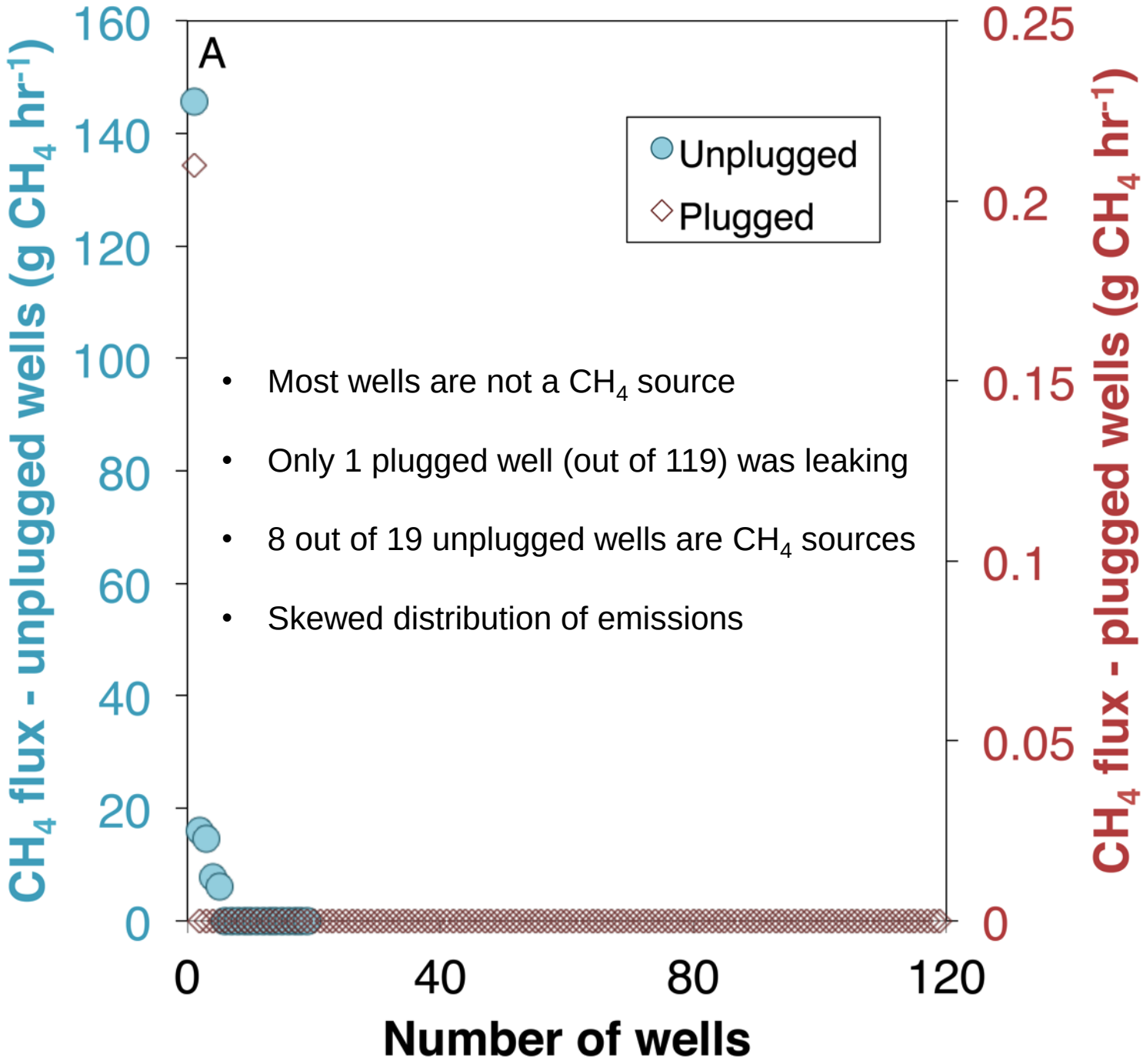
Each state has their own terminology

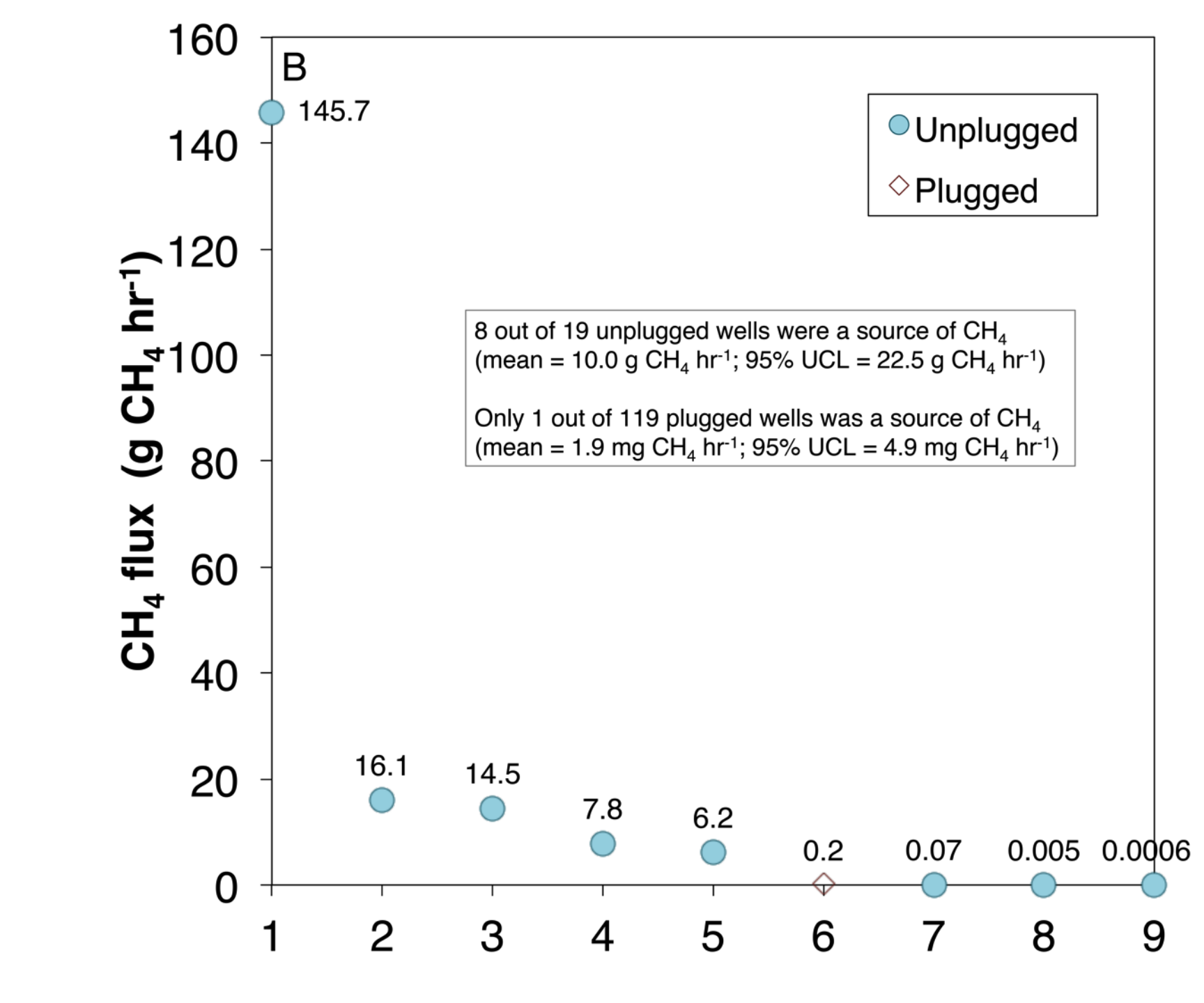
Unplugged

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

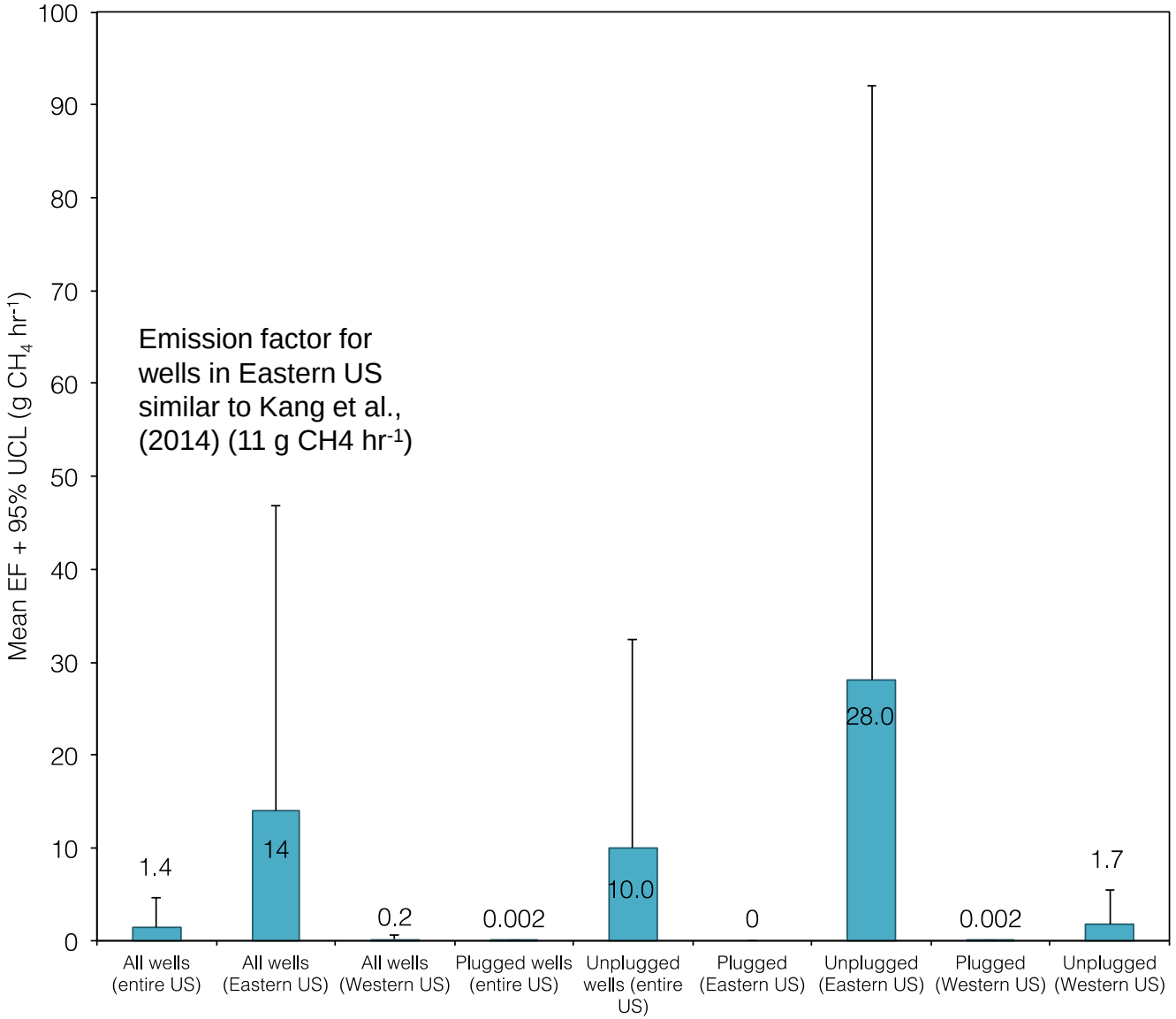

A
Unplugged
Plugged
• Most wells are not a CH_4 source
• Only 1 plugged well (out of 119) was leaking
• 8 out of 19 unplugged wells are CH_4 sources
• Skewed distribution of emissions
CH_4 flux - unplugged wells (g CH_4 hr^{-1})
CH_4 flux - plugged wells (g CH_4 hr^{-1})
0
20
40
60
80
100
120
140
160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

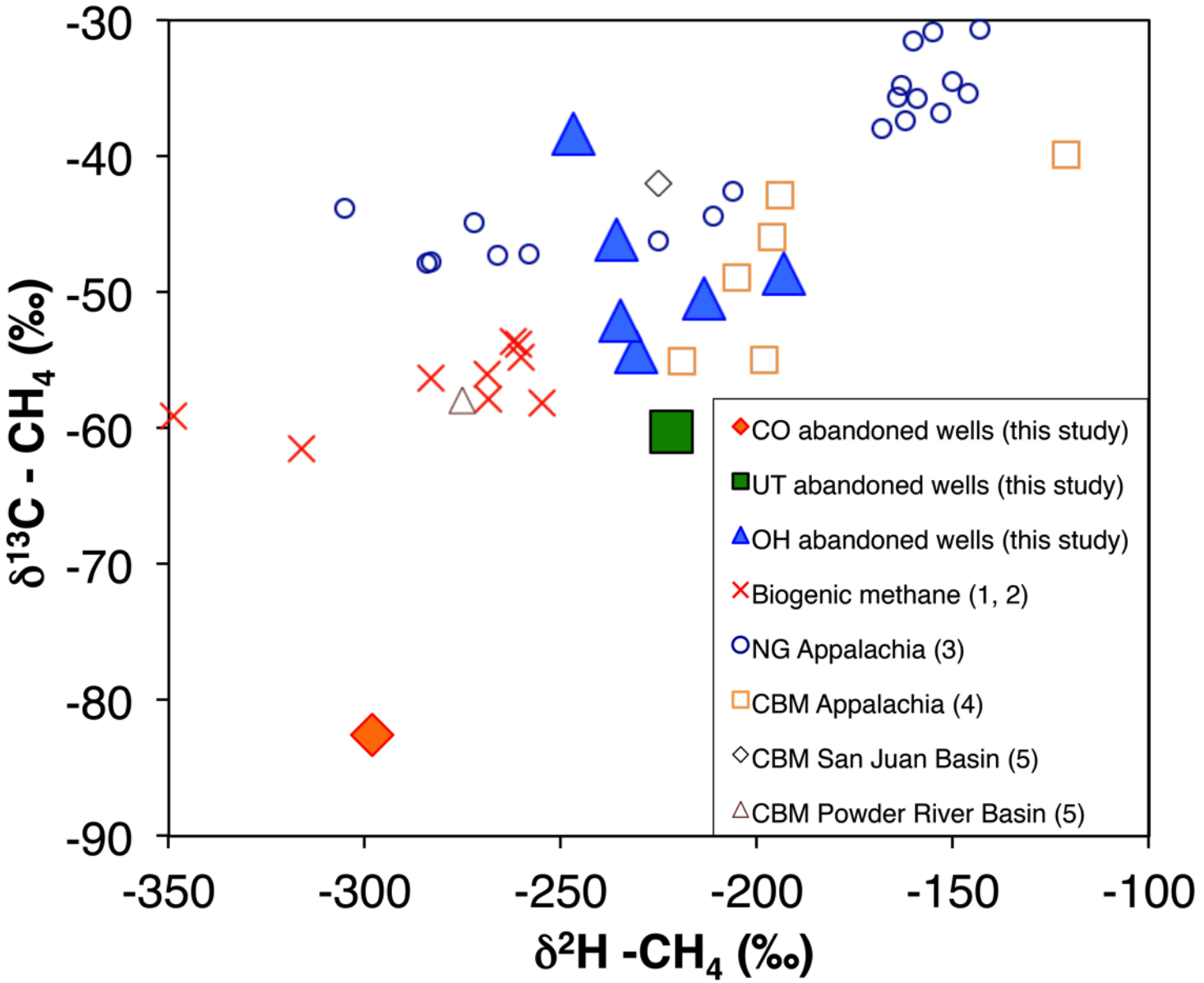
Measurement specifications

- All of our measurements were made and distinguished from “natural background”
  - All of our measurements are significantly greater than zero/background CH_4 in air
  - We made measurements of “natural seepage” at all sites for comparison to direct emissions from abandoned wells

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 biological coalbed CH_4 release



Biological vs thermogenic CH_4

- Thermogenic CH_4: Produced from plant organic matter under high pressure and/or temperature conditions, generally over very long periods of time (like all fossil fuels)
- Biological CH_4: Two production pathways
  - Acetate fermentation: anaerobic reduction of plant materials (as in cows and landfills)
  - Carbonate reduction: Biological reduction of CO_2 and H_2O to CH_4. Common source of coalbed CH_4

Biological vs thermogenic CH_4

- Both biological and thermogenic CH_4 can be anthropogenic sources in the case of abandoned wells
- Many of our samples were taken in areas with coal seams
  - Well bore can be a conduit for water to enter coal seam and produce CH_4; also provides pathway for CH_4 to vent to atmosphere
- No evidence for natural seepage of CH_4 in any of our measurement sites
  - We measured soil CH_4 emissions in all sites

Most abandoned wells emitting biological CH_4 were not a large or positive source of CH_4

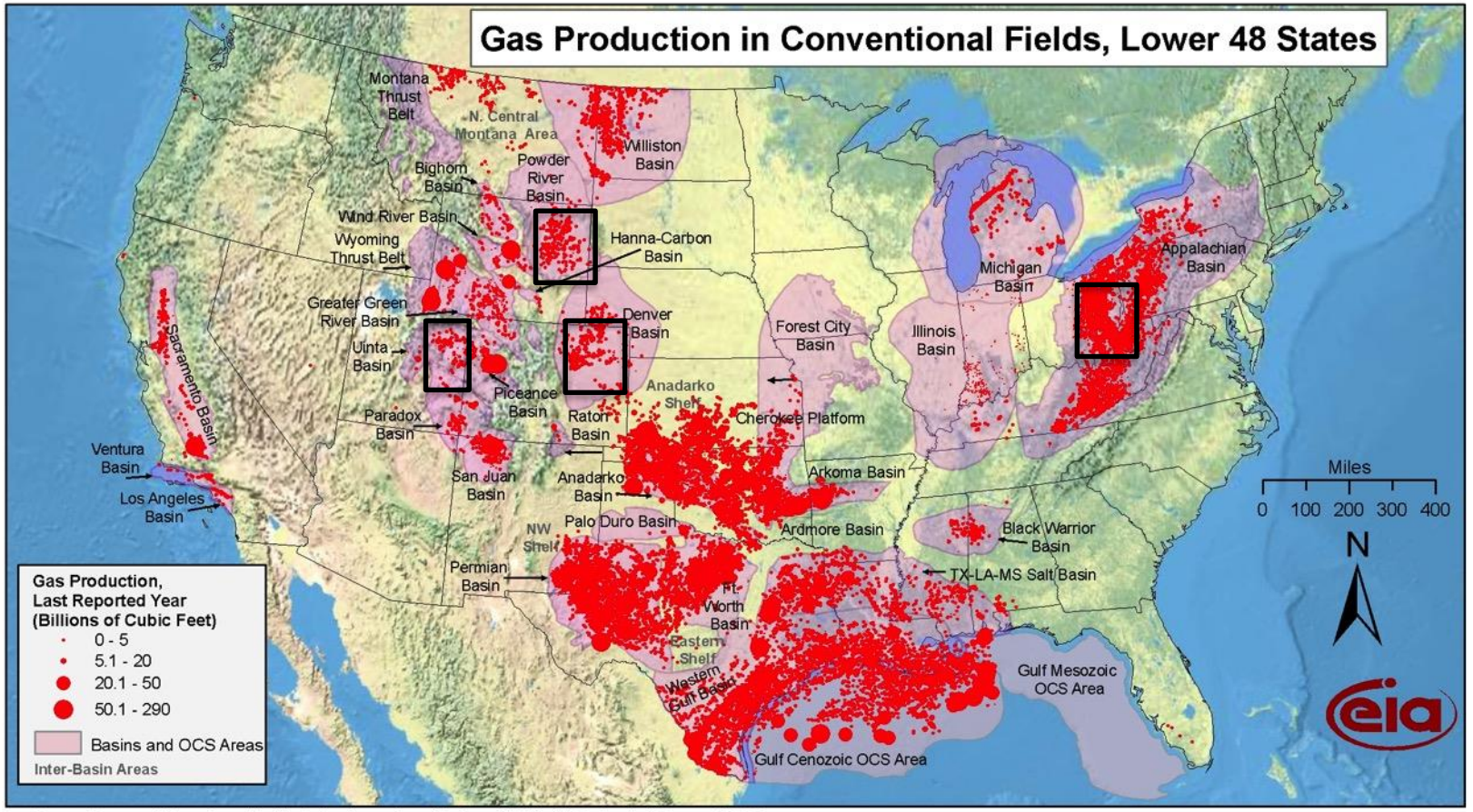
Table 2. Flux Values and Stable Isotopic Composition of CH_4 From Abandoned Wells[a]

Well ID and Leak Location	CH_4 flux (g/h)	δ^{13}C-CH_4 (‰)	δ^{2}H-CH_4 (‰)
UT-127, Abandoned well marker	0.21	-60.3	-222
OH-10, Middle of wellhead, broken pipe	ND	-52.1	-235
OH-10, Bottom of wellhead (active well)	0.003	-46.1	-236
OH-11, Valve on well tubing	145.7	-50.4	-213
OH-13, Well casing vent,	0.0054	-54.4	-231
OH-13, Broken well tubing	ND	-38.4	-247
OH-18, Rusted pipe	7.82	-48.6	-193
CO-115*, plugged and abandoned monument	0	-82.6	-298

[a]ND = not determined.

Most studies have used a δ^{13}C-CH_4 of -52‰ or higher as indicative of a thermogenic or natural gas source for the Appalachian Basin (Jenden et al., 1993; Laughrey and Baldassare, 1998). Those are highlighted in pink here

What about the Central US?



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My instinct is to use an emissions factor for Appalachia and then a separate emissions factor for basins west of the Mississippi. Clearly more research is needed on abandoned wells in Texas and Oklahoma

Questions?

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