

# Hydrofracking: Risk and Uncertainty

The background of the slide features a composite image. In the foreground, the dark silhouette of an oil pumpjack is visible on the left. To the right, a large, bright orange and red plume of fire or smoke rises vertically. The background is a textured, golden-brown map of the United States, with the map's outline appearing as a glowing pattern against a darker, mottled background.

Scientific Uncertainty Workshop | Environmental Law Institute | 09.14

Dr. Marcia McNutt  
Editor in Chief, *Science*

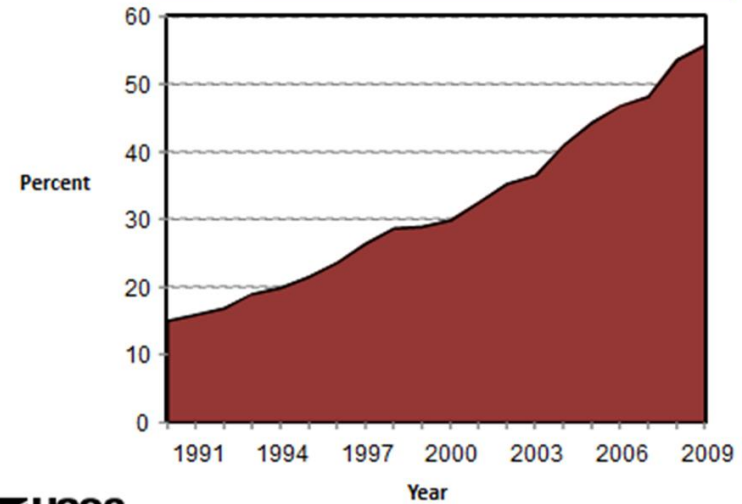
American Association for the Advancement of Science, Washington, D.C.

# Unconventional Resources

an important part of the national energy potential

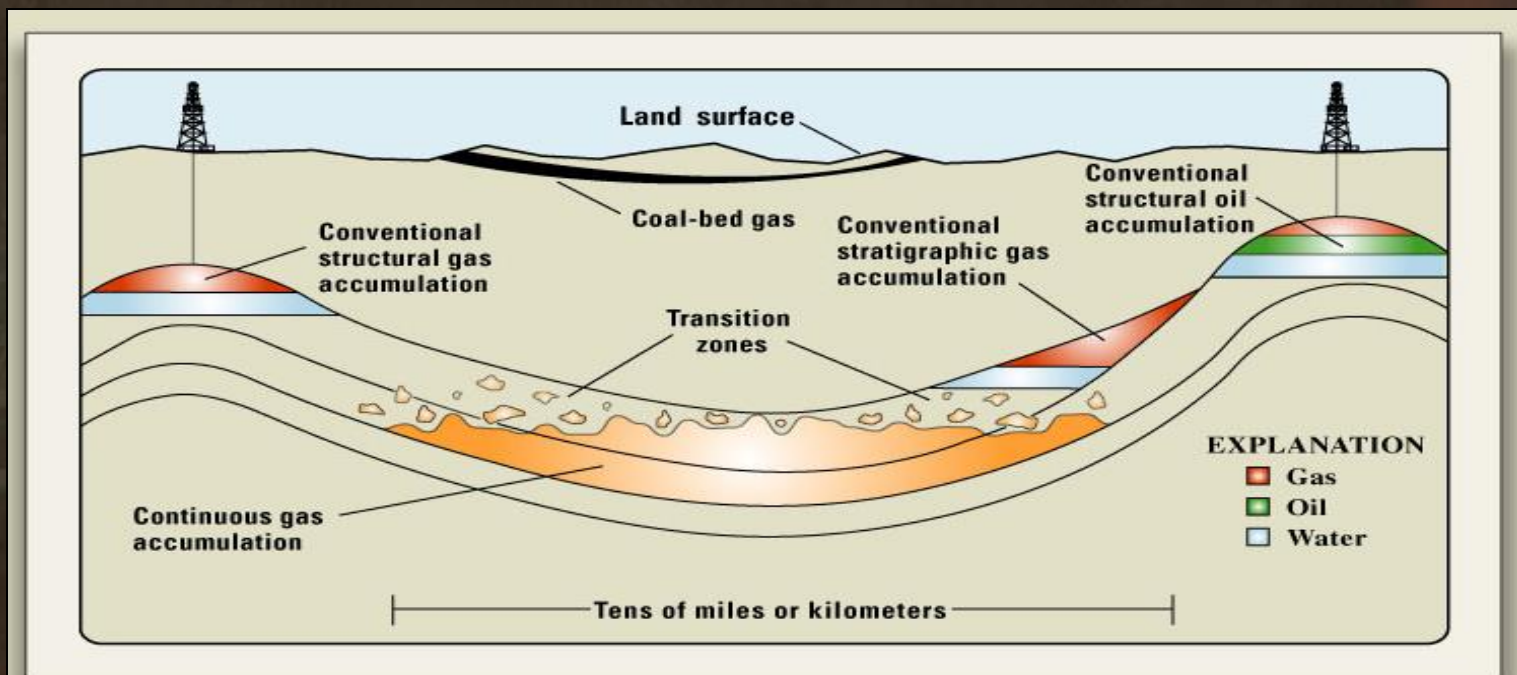
Unconventional Gas:  
Percent of Total U.S. Natural Gas Production, 1990-2009

2009 Total U.S. natural gas production, dry: 21 TCF



USGS

Data Source: EIA



# New Challenges: “The Fracking Debate”

- **Consumptive water use**
- **Induced seismicity**
- **Potential for aquifer contamination**
- **Landscape impacts**



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# Establishing Anthropogenic Cause

- Do you know the natural baseline?
- Is there a mechanism that can connect the anthropogenic action to the environmental effect?
- Is there a temporal connection between the anthropogenic action and the environmental effect, accounting for known lags?
- Is there a “smoking gun”?

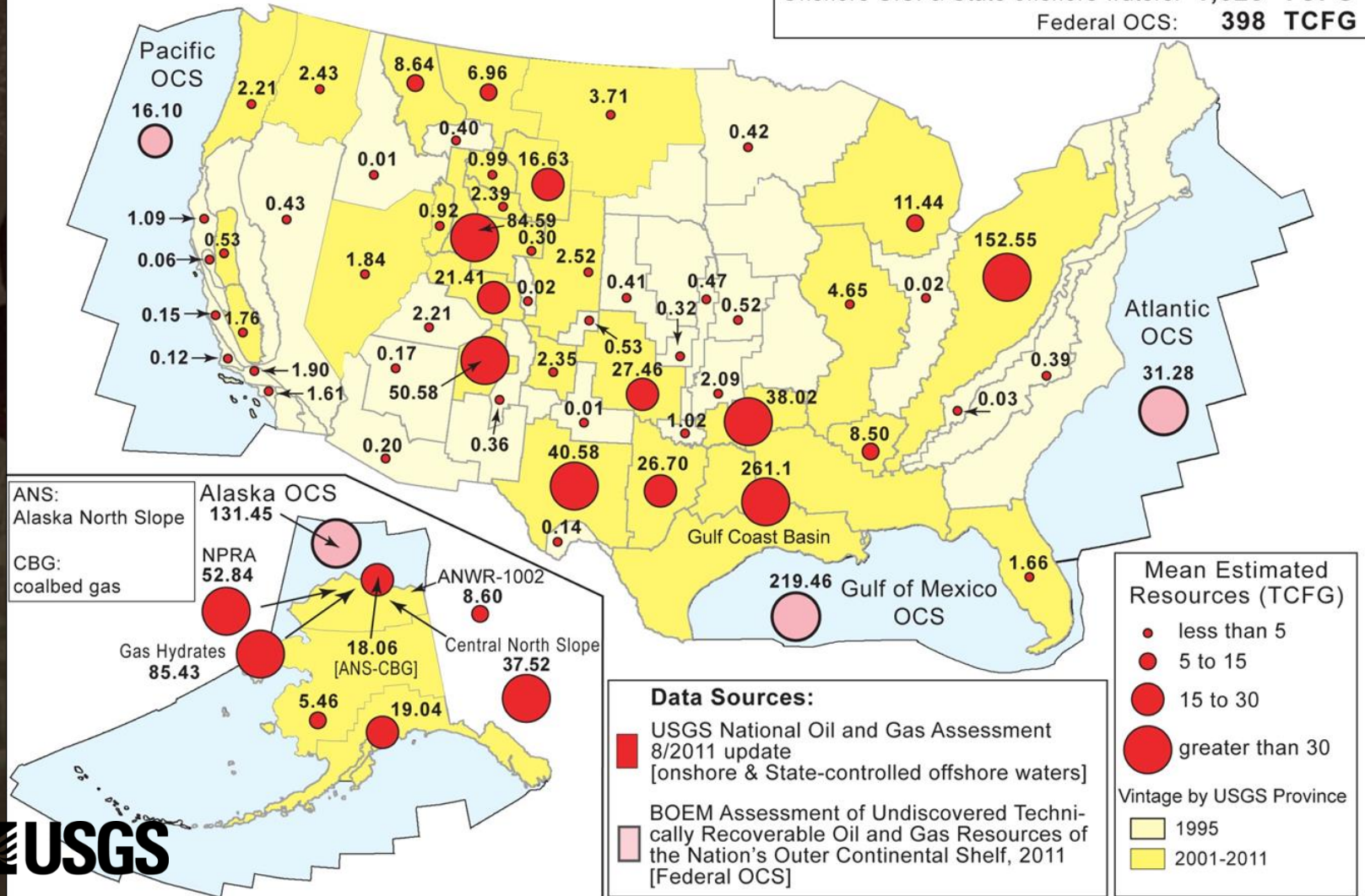
# Where are the Resources? Unconventional Gas

## Natural Gas (thru 12/2011):

Mean estimate – total undiscovered, technically recoverable resources

Aggregate mean estimate:  
(trillions of cubic feet of gas)

Onshore U.S. & State offshore waters: **1,025 TCFG**  
Federal OCS: **398 TCFG**



# Where are the Resources? Unconventional Oil

## Oil (thru 12/2011):

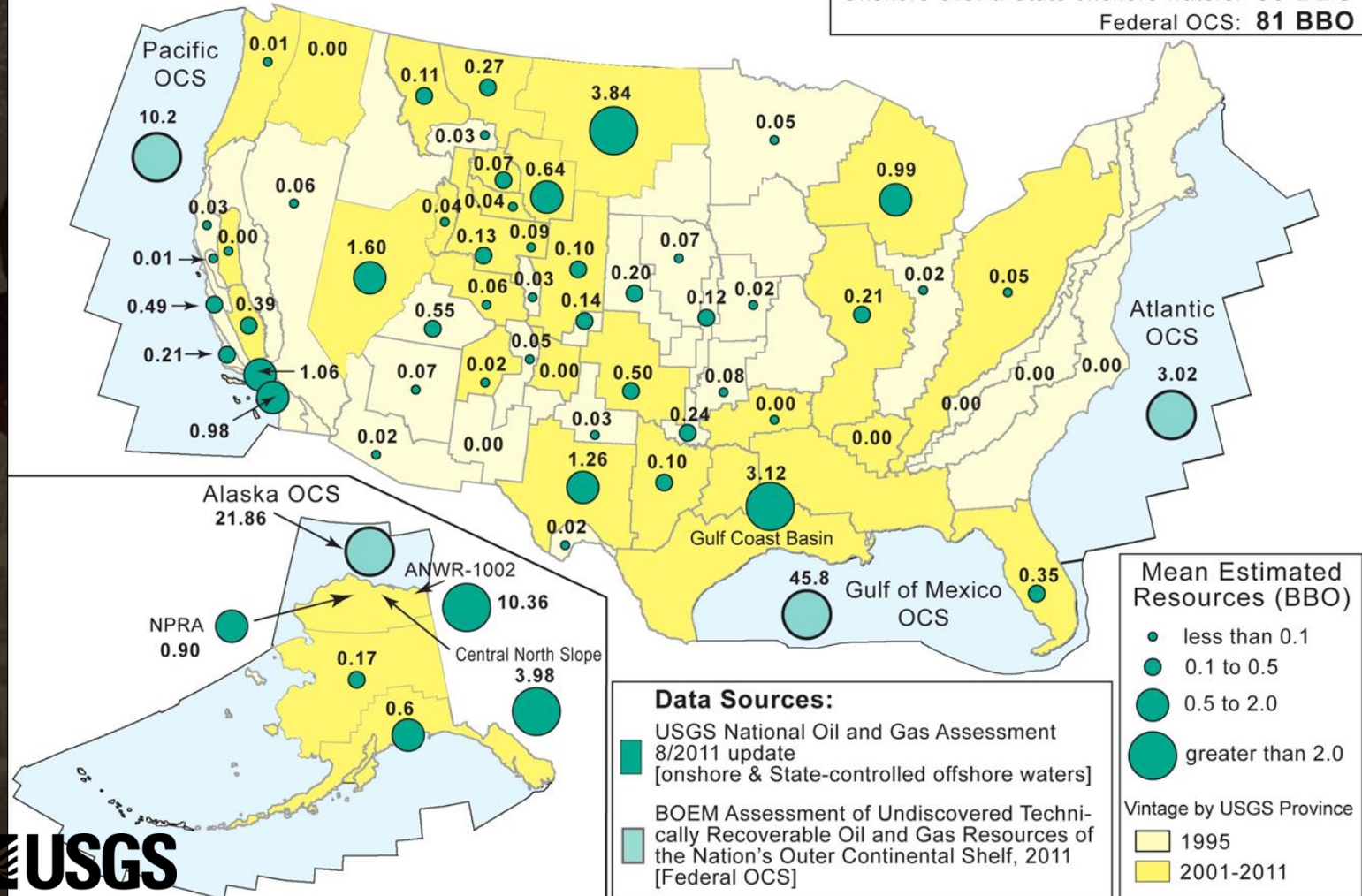
Mean estimate – total undiscovered, technically recoverable resources

### Aggregate mean estimate:

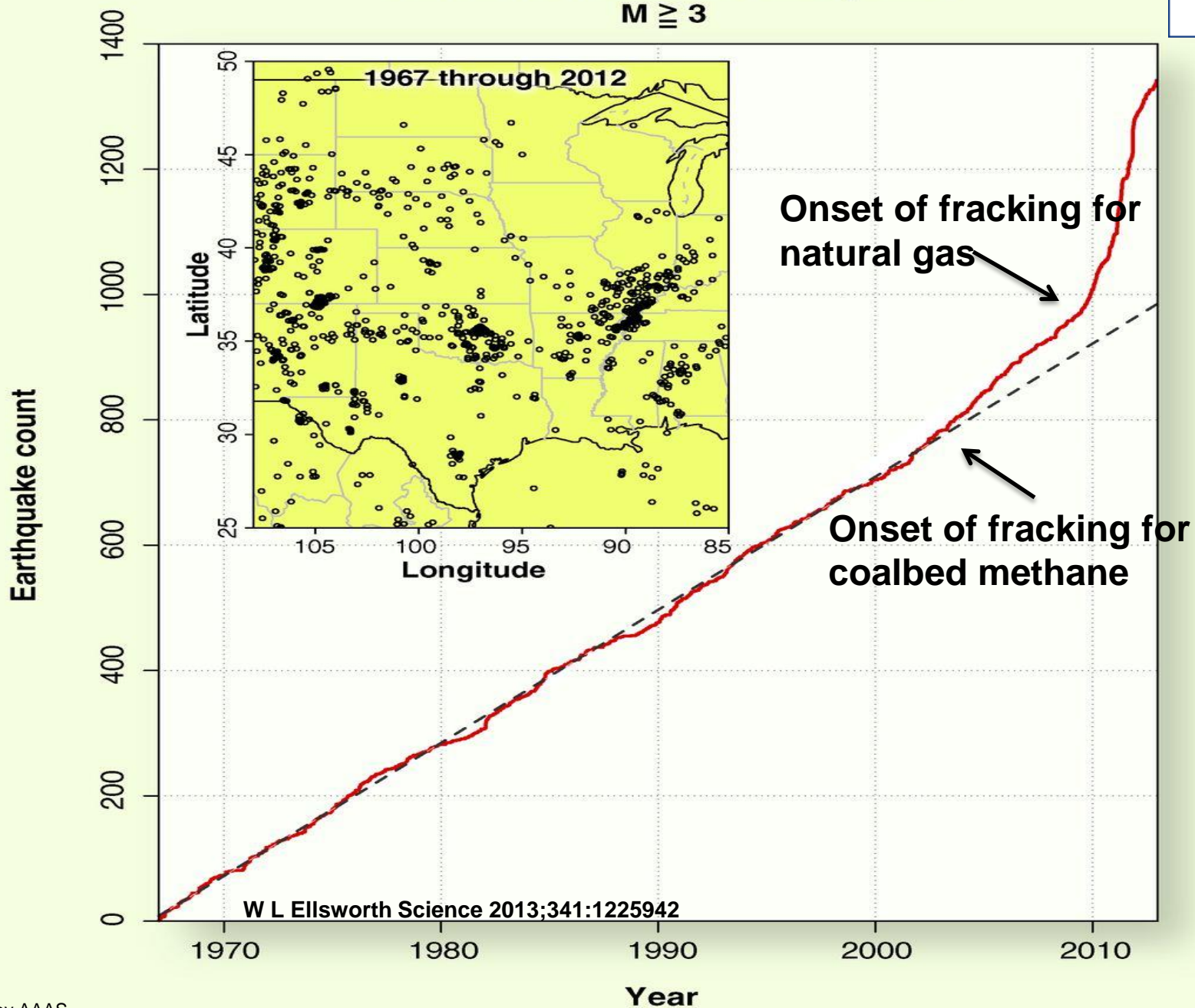
(billions of barrels of oil)

Onshore U.S. & State offshore waters: **35 BBO**

Federal OCS: **81 BBO**



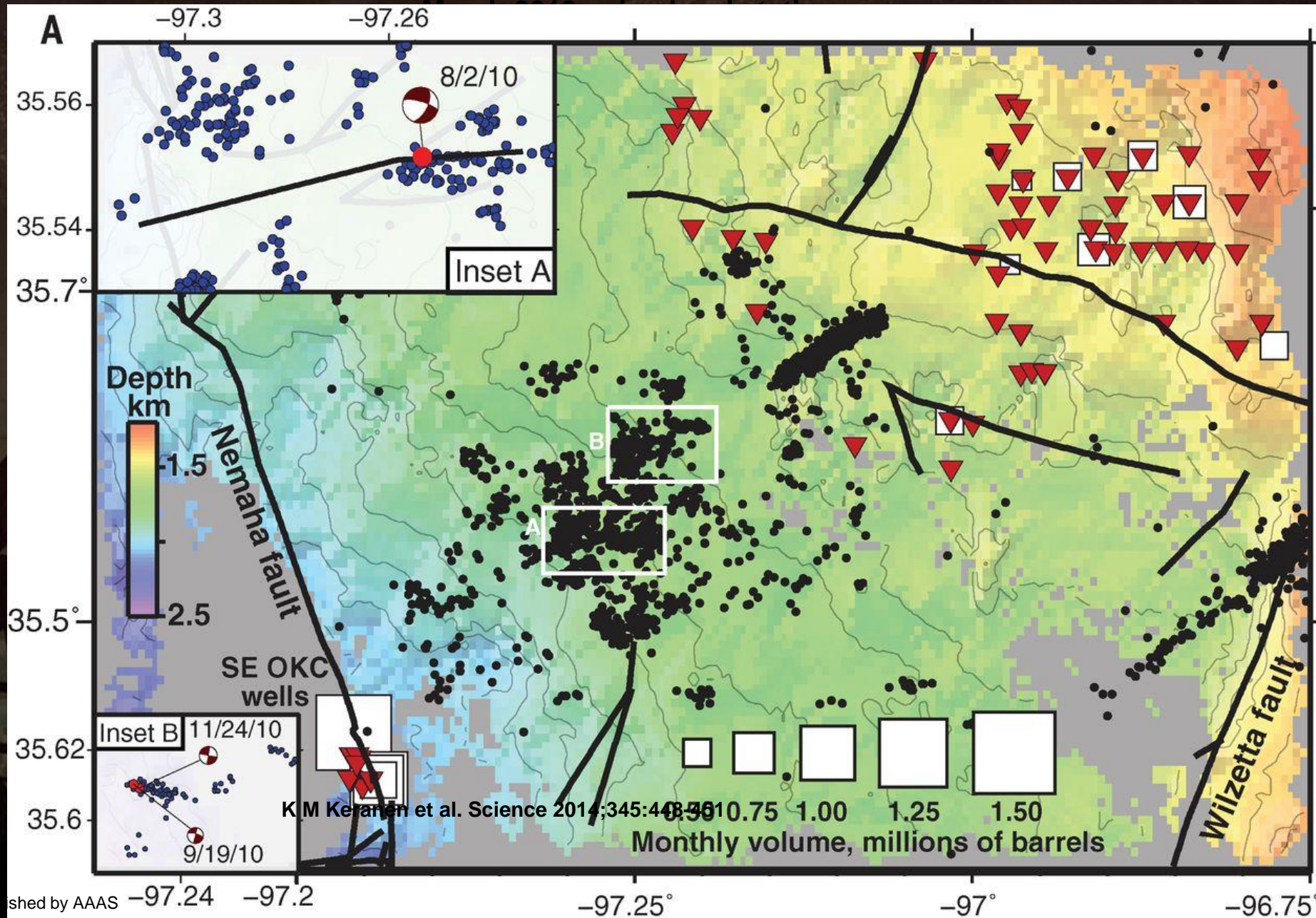
### Cumulative number of earthquakes $M \geq 3$

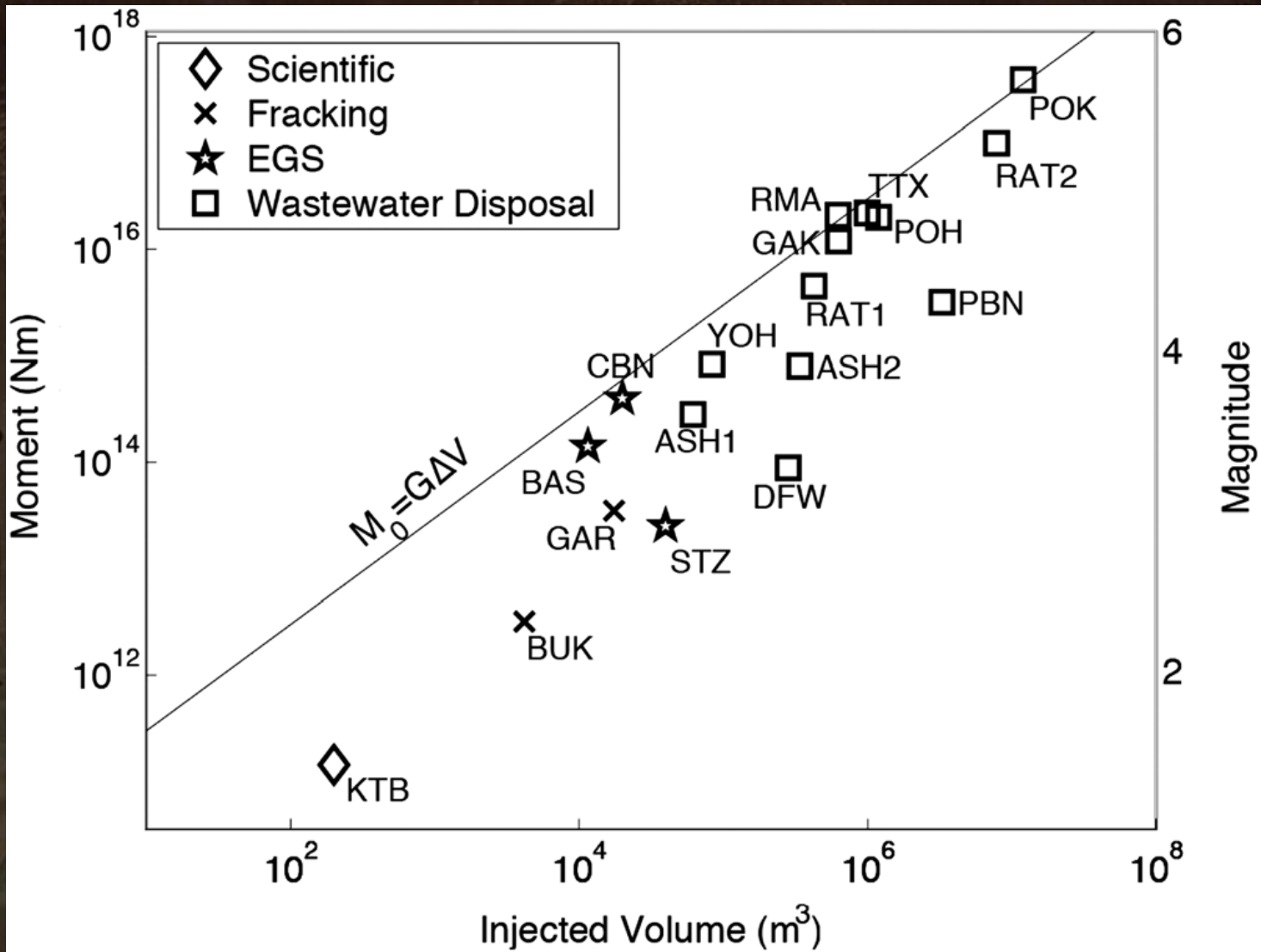


W L Ellsworth Science 2013;341:1225942



Fig. 2 Earthquake catalog and swarm migration. (A) Jones earthquake catalog March



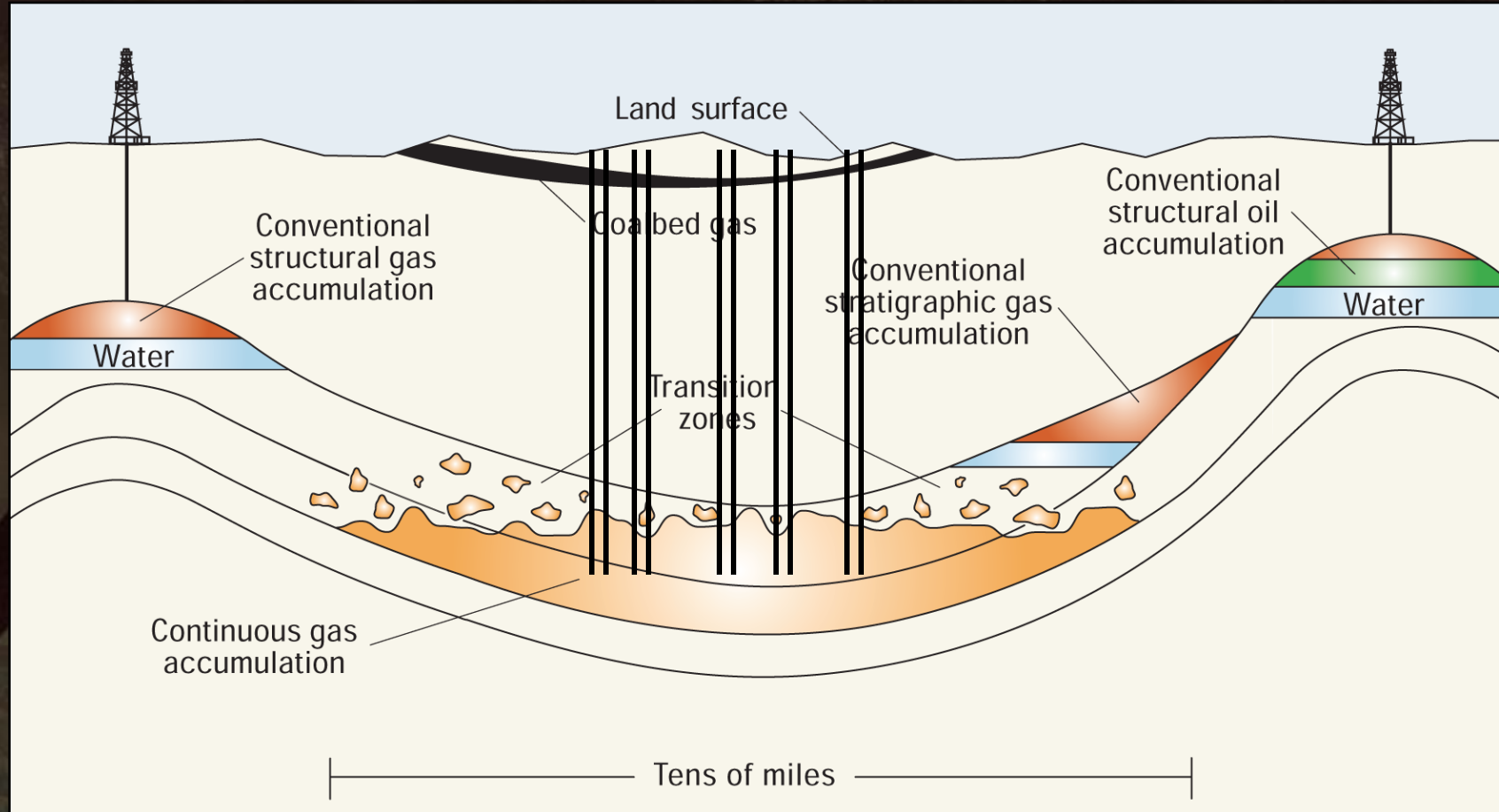


From McGarr, JGR, 2013

# Reducing Uncertainty on Cause and Effect

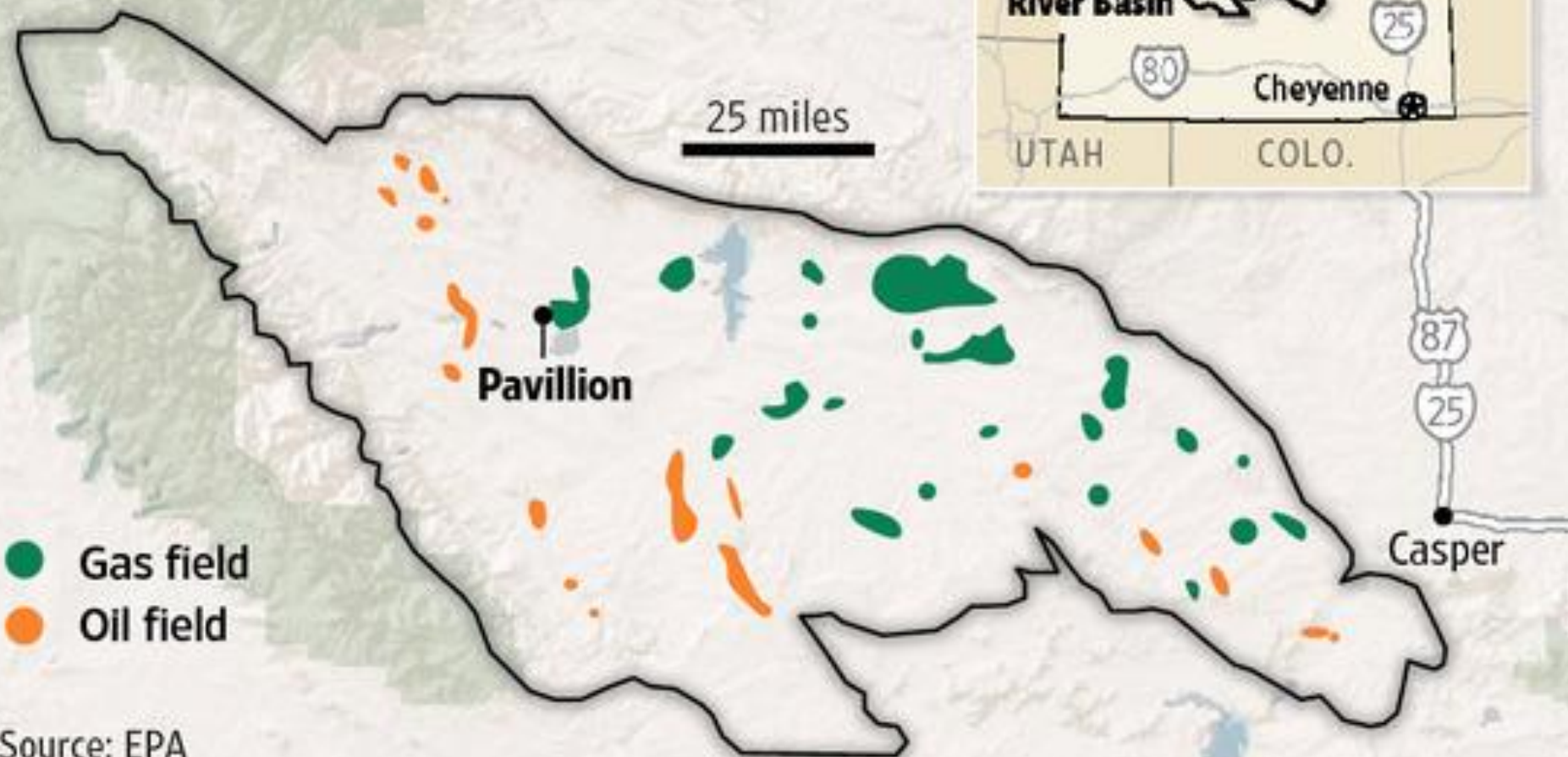
- More dense seismic arrays to constrain earthquake locations and depth
- Industry information on timing, rate, and amount of fluid injection in wastewater injection wells (Both would connect temporal relation and confirm physical mechanism)

# Water Impacts from Fracking



# Troubled Waters

Groundwater contamination was found near Pavillion, Wyo.

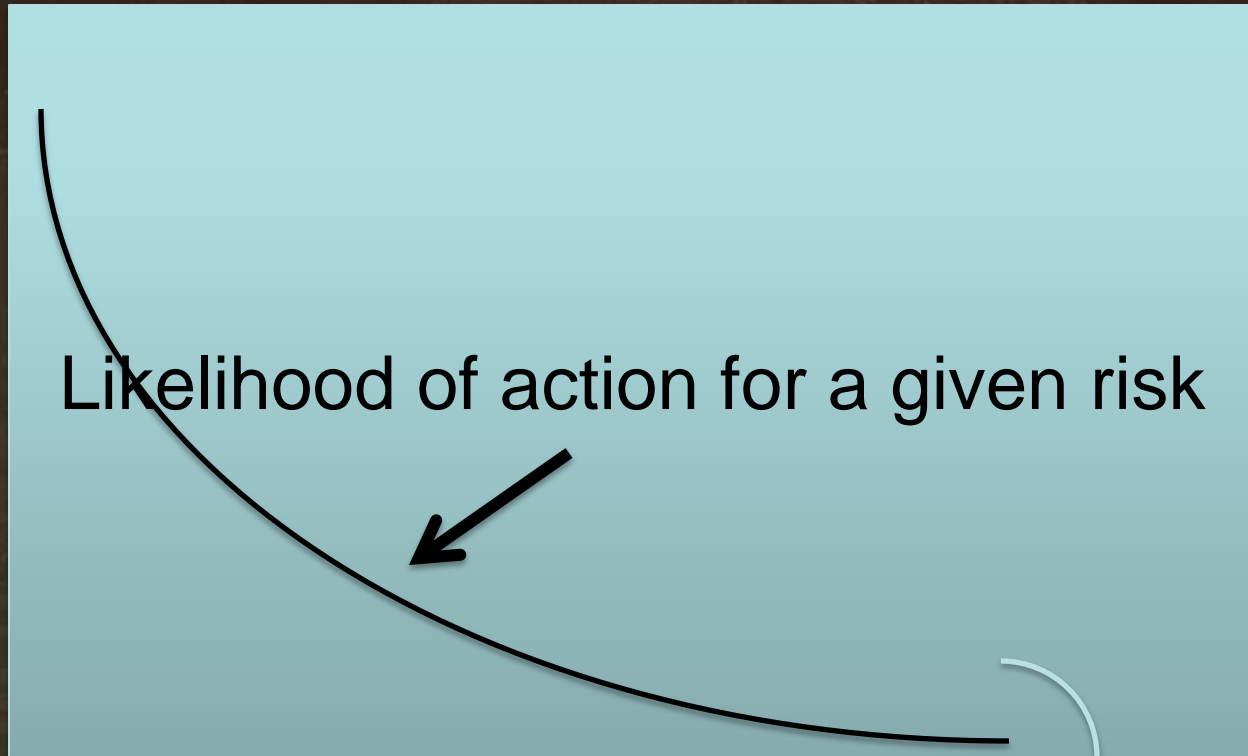


# Problems Connecting Cause and Effect with Water Contamination

- Lack of pre-production baseline on water quality (Getting natural baseline)
- Constituents in fracking fluids are proprietary and not uniquely diagnostic (the “smoking gun”)

# Effect of Uncertainty is Relative

Scientific Uncertainty



Cost of Solutions