Society of Toxicology Risk Assessment Specialty Section (RASS) Monthly Webinar: Co-sponsored with the International Society for Exposure Science

February 12, 2020

Challenges and Opportunities in Assessing Health Risk from Unconventional Oil and Gas Development

HEI energy

Overview of presentation

- An introduction to HEI-Energy
- Unconventional oil and natural gas development (UOGD) defined
- Exposure and health literature related to UOGD
- Challenges and opportunities in understanding the potential for exposures and health risks
- Suggested features of future exposure study designs

An introduction to HEI-Energy

Why is a Boston-based nonprofit scientific organization studying oil and natural gas development?

Origin of HEI-Energy

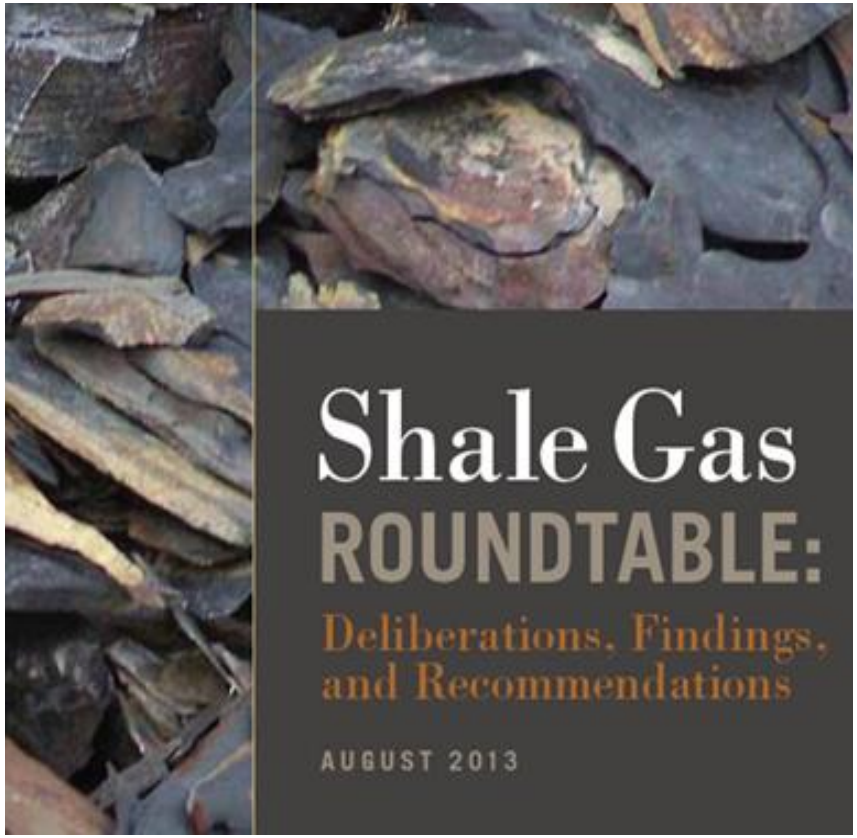
Pennsylvania-based Shale Gas Roundtable formed in 2011 by leaders from government, industry, academia, environmental groups, and civil society.

The central question for the Roundtable:

"As a region, how can we most effectively and responsibly safeguard our communities and environment, grow our economy, and manage unconventional oil and gas development?"

The Roundtable called for "efforts to increase balanced research and rigorous monitoring of the possible impacts of unconventional oil and gas development."

HEI-Energy was formed as a direct result of the Roundtable's recommendation.



HEI energy

HEI-Energy Purpose

A ***new national research program***, focused initially on:

- Research on human exposures associated with onshore development of oil and natural gas from shale and other unconventional resources (UOGD) across the United States
- As feasible and appropriate based on findings from the exposure studies, targeted efforts to assess the potential health effects that might result from exposures

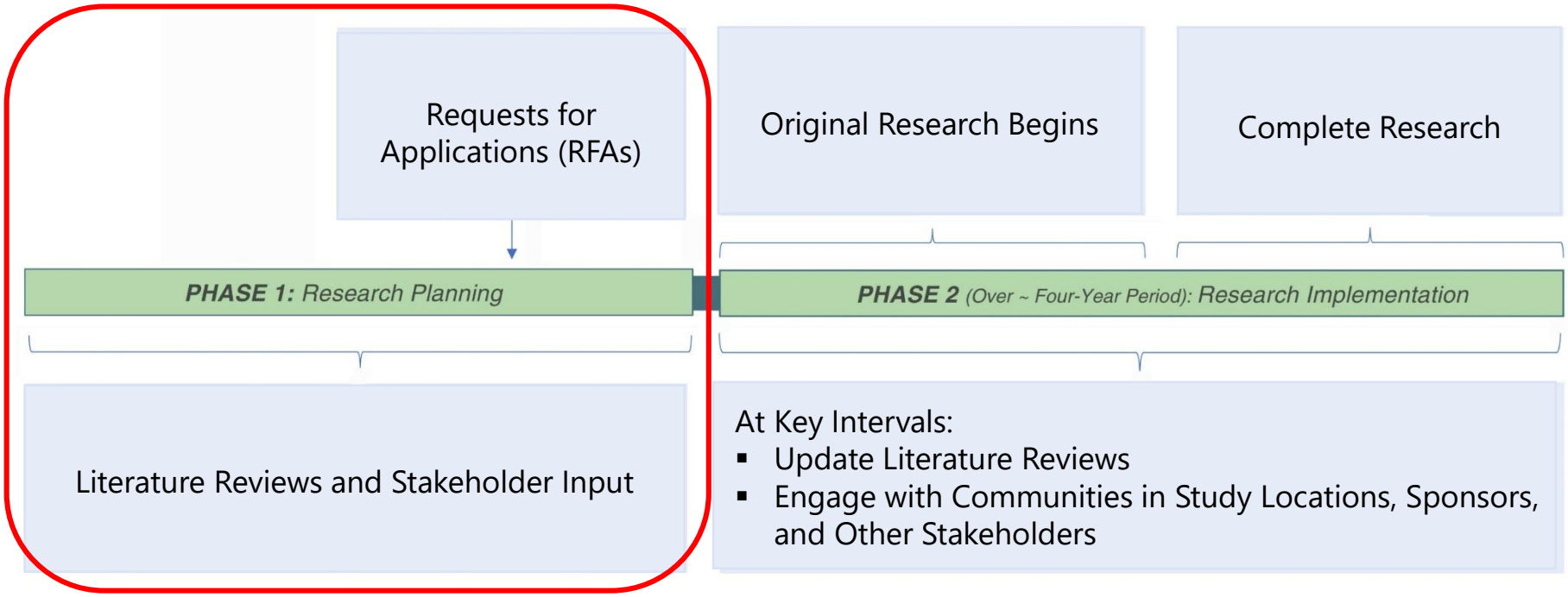
Overarching goal:

- Enhance understanding and inform public and private decision-making about potential exposures associated with UOGD

HEI-Energy is modeled after its parent organization: *the Health Effects Institute (HEI)*

- An independent, nonprofit corporation
- Chartered to provide policy-relevant high-quality and impartial, science
- Funded jointly by government and the oil and natural gas industry and, occasionally, private foundations
- Funds research that is selected, conducted, overseen, and reviewed independently of HEI-Energy's sponsors

HEI-Energy progress to date and where we're headed



Ensuring the quality of research funded by HEI-Energy

HEI Energy Research Committee

George Hornberger, Chair
Vanderbilt University, Nashville, Tennessee

Shari Dunn-Norman
Missouri University, Rollo

Stefanie Ebelt
Emory University, Atlanta, Georgia

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University of Washington, Seattle

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University of Michigan, Ann Arbor

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Georgia Institute of Technology, Atlanta

Peter S. Thorne
University of Iowa, Iowa City

HEI-Energy staff work with the *Energy Research Committee* on:

- Workshops with Stakeholders
- Literature Reviews
- Defining research needs in Requests for Applications (RFAs)

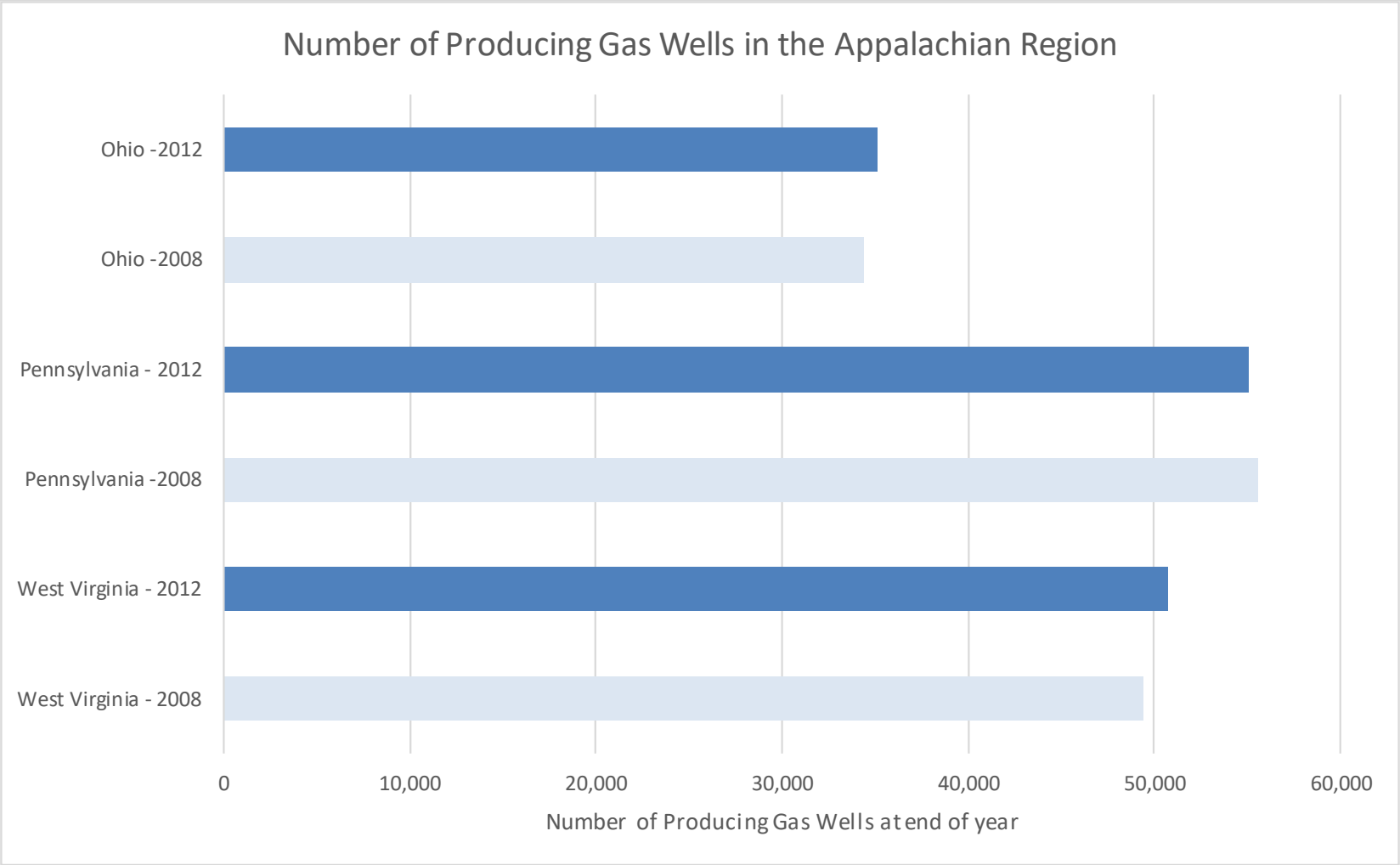
Ensuring the relevance and utility of research funded by HEI-Energy

A stakeholder workshop to hear information needs and research priorities

Unconventional oil and natural gas development (UOGD) defined

UOGD refers to the development and production of oil and natural gas as practiced starting around the beginning of the 21st century through multistage hydraulic fracturing in horizontal wells

Why are we talking about oil and natural gas now when it's been around since the 1800s?



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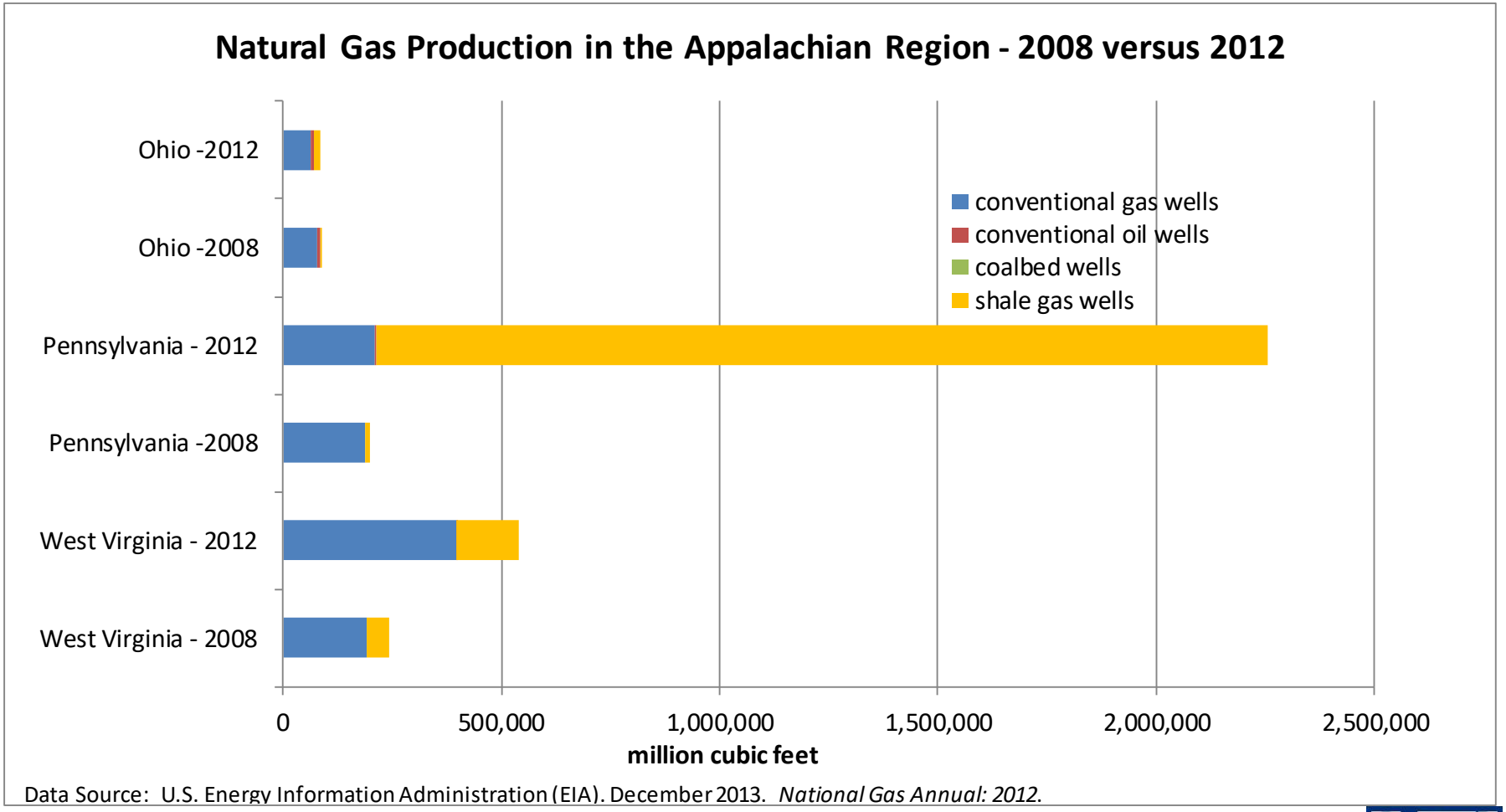
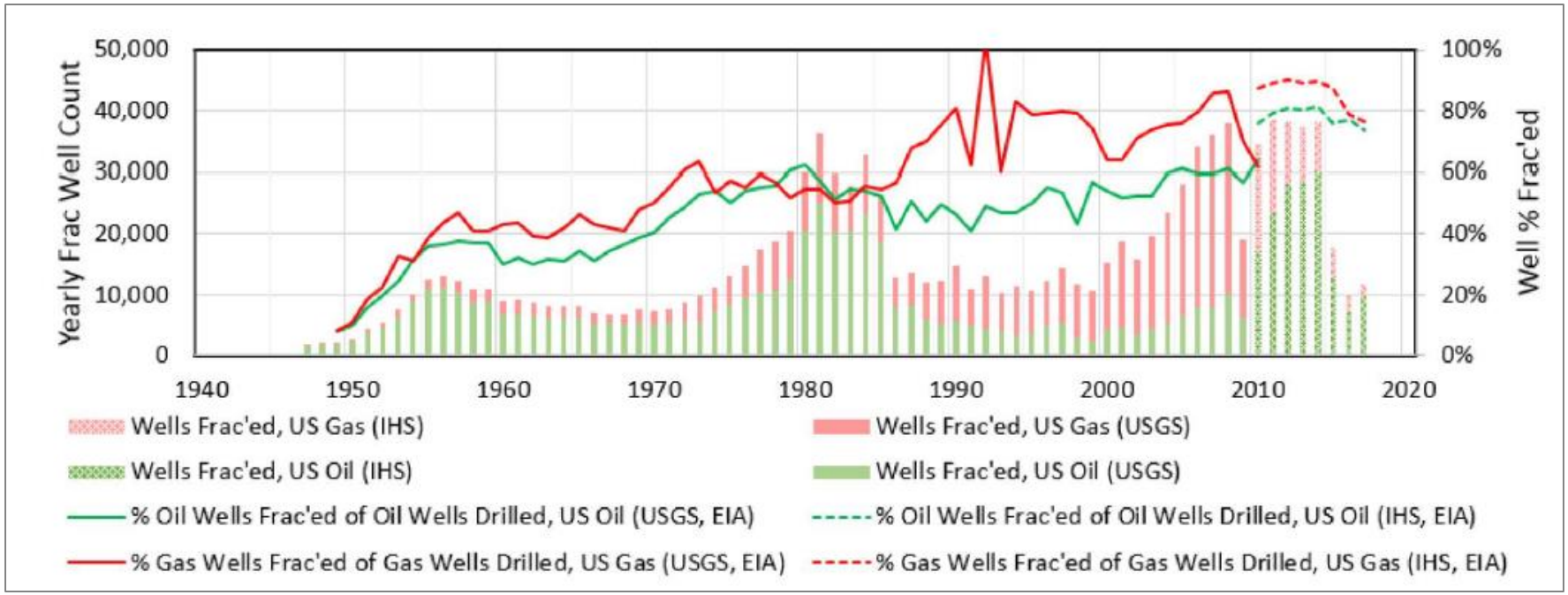


Data Source: U.S. Energy Information Administration (EIA). December 2013. *National Gas Annual: 2012.*

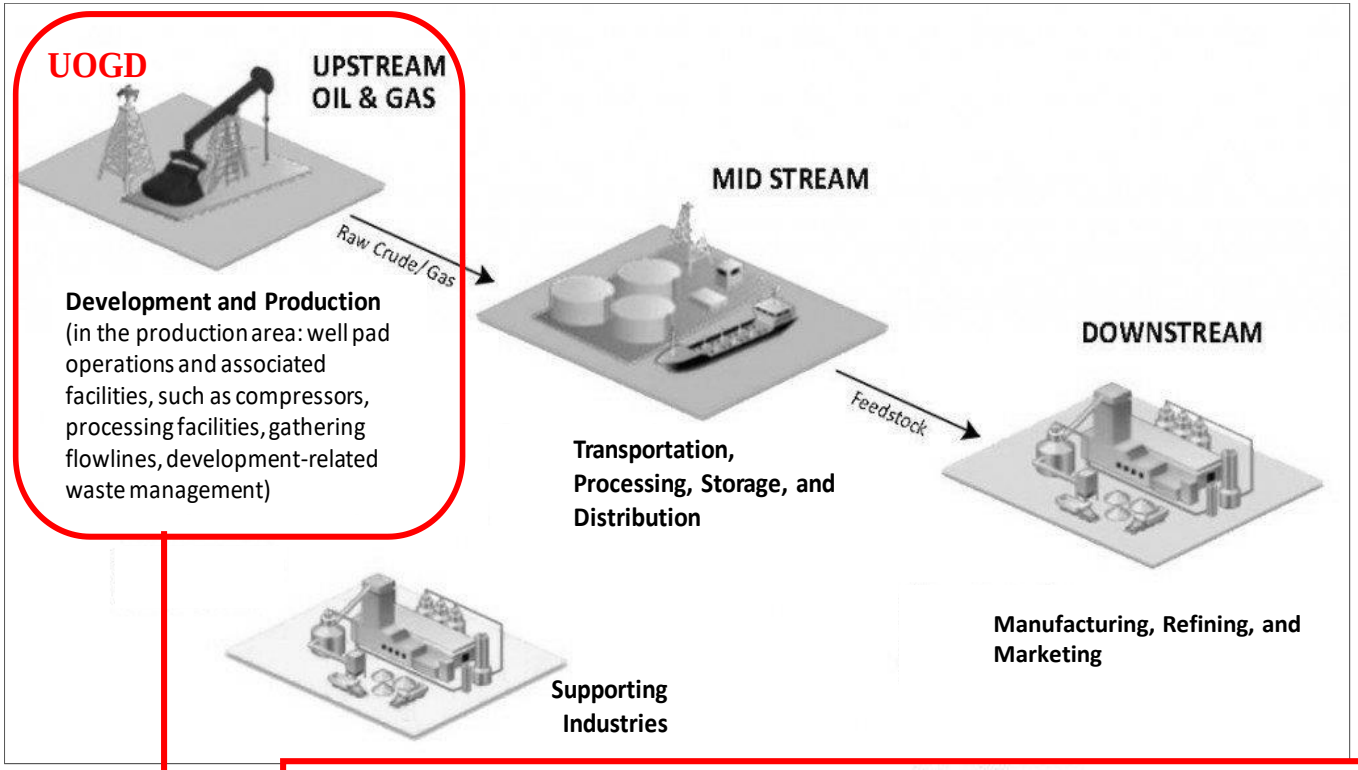
Rise in the number of hydraulically fractured wells

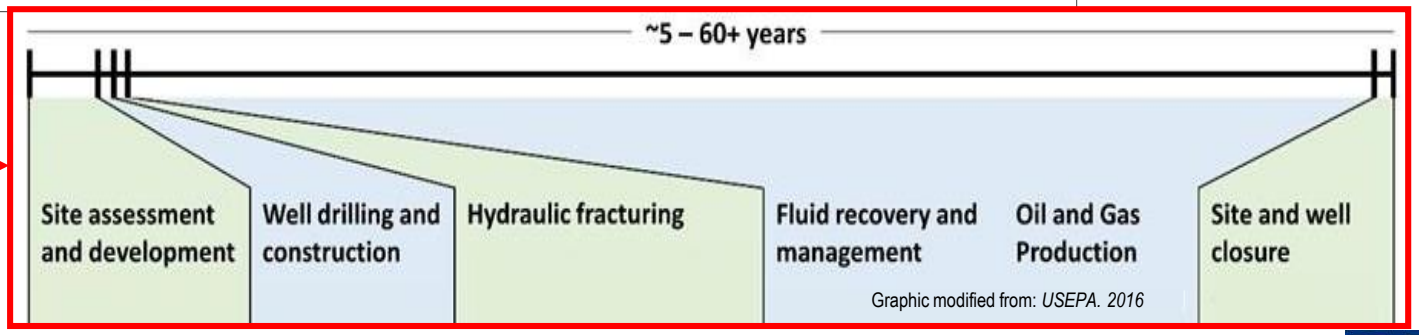


Technological innovation and market conditions influenced the scale and location of development

- Larger well pads and more equipment transported to and from the pad;
- More raw materials that must be transported to the well pad;
- More liquid and solid waste from multiple wells drilled on one well pad;
- A longer period of industrial activity required at a single well pad when multiple wells are developed on it; and
- Increased truck traffic, changing demands on community infrastructure, and other possible community effects associated with population mobility.

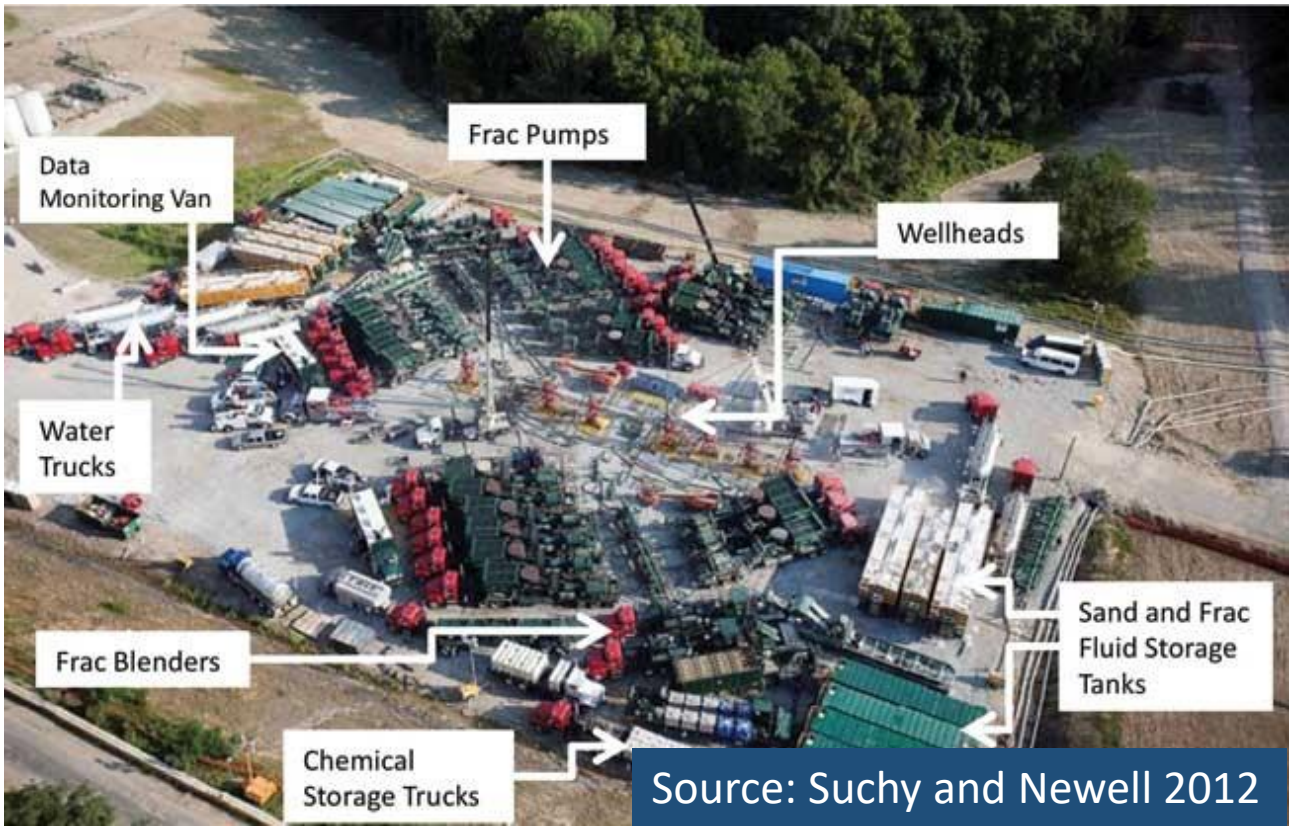
UOGD in space and time





Potential for releases to air

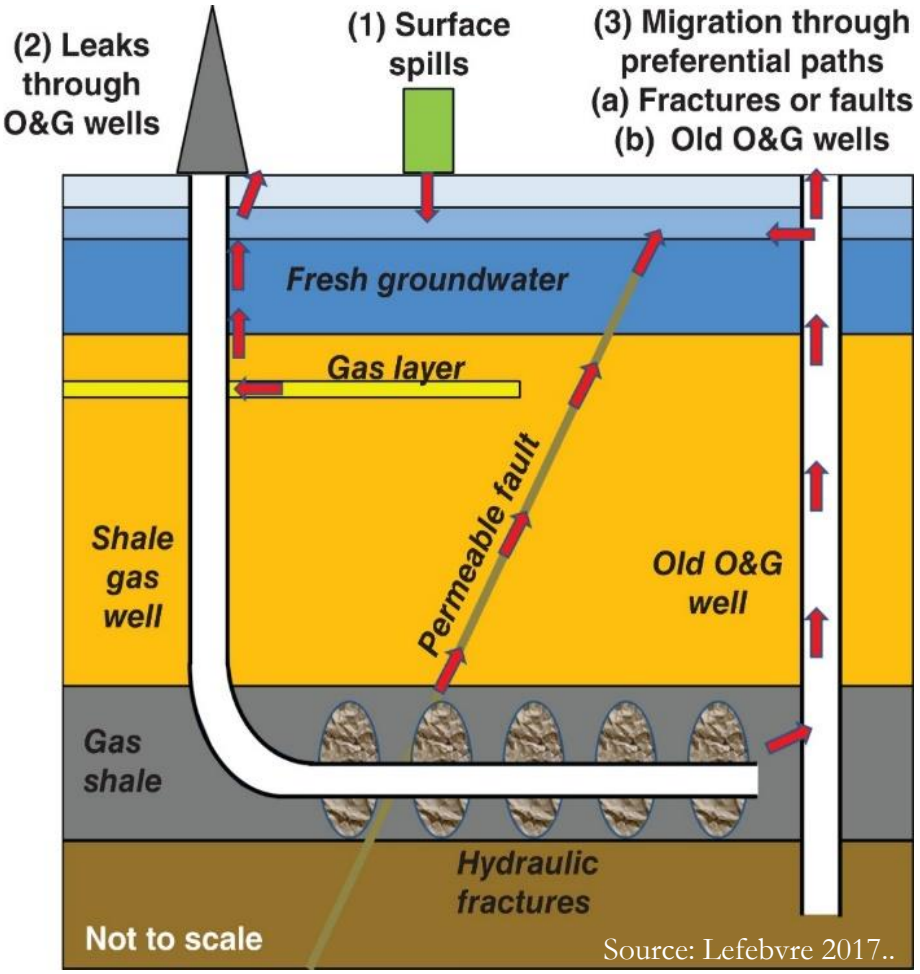
Example: UOGD well pad with tank- and truck-based hydraulic fracturing equipment



Source: Suchy and Newell 2012

Potential for releases to water

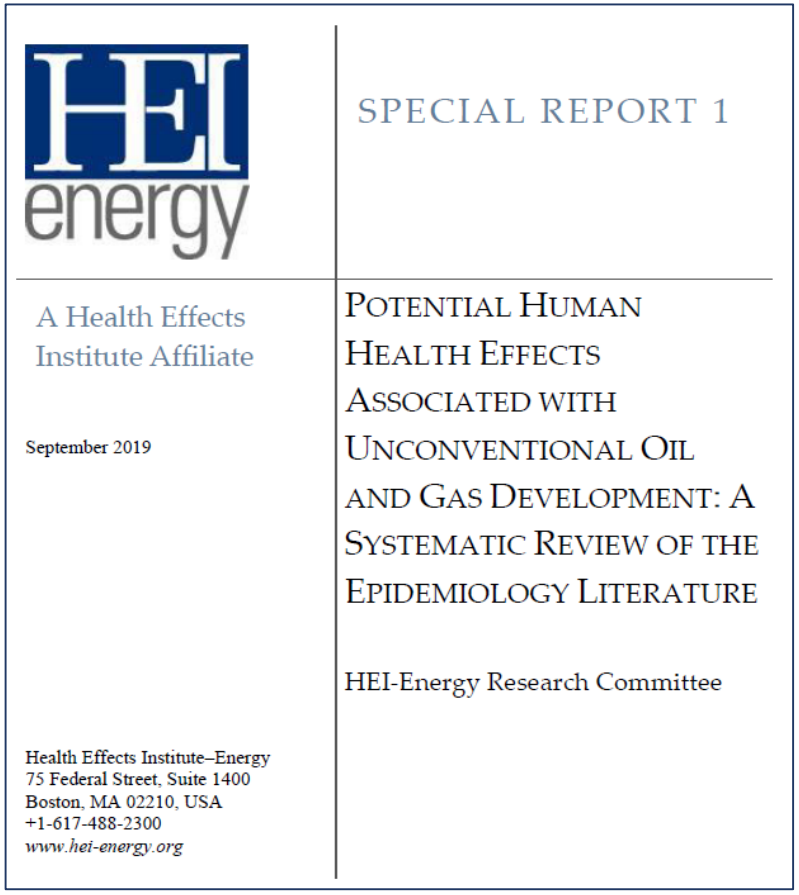
***Example*:** Mechanisms related to groundwater contamination from shale gas production

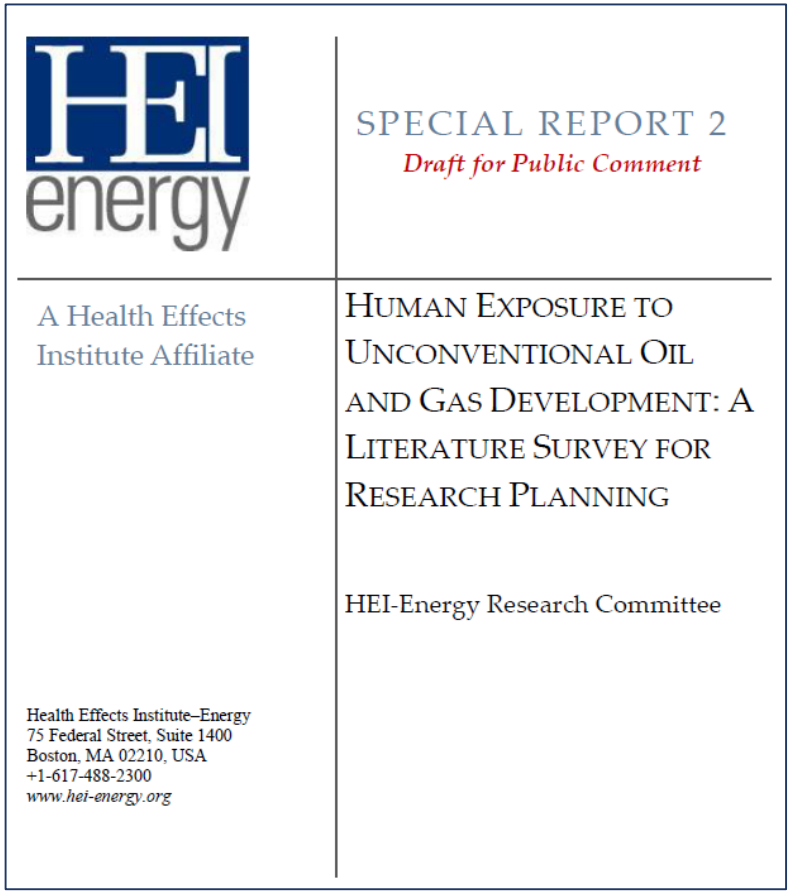


Exposure and health literature related to UOGD

Peer-reviewed literature and gray literature through July 2019

HEI-Energy reports on exposure and health literature related to UOGD

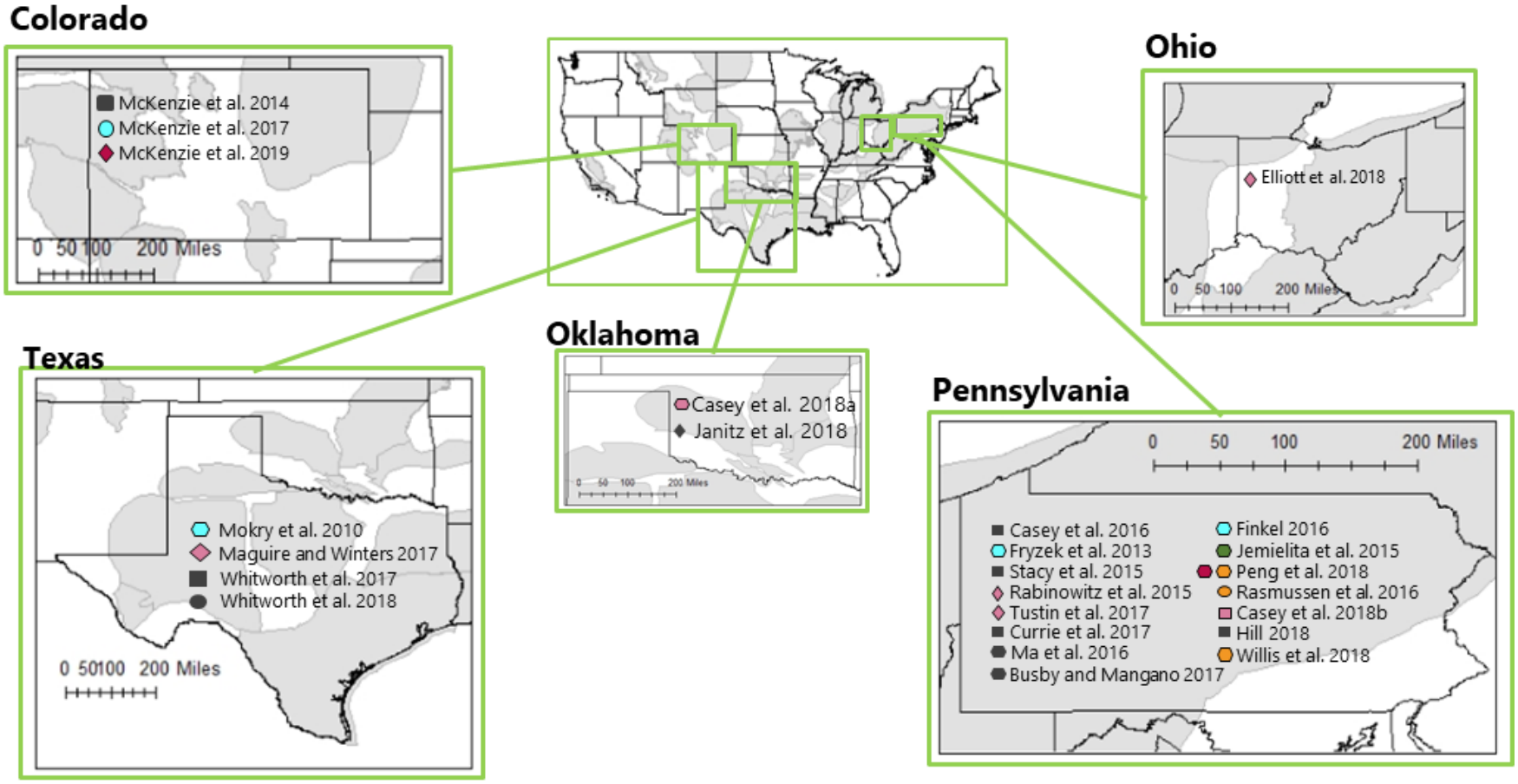




Reports available at hei-energy.org

HEI-Energy 2019 review of epidemiology literature

Studies displayed by location, study design, and assessed outcomes



Study Design	Outcome Assessed	
Retrospective Cohort	Perinatal	Shale Play
Case-Control	Cancer	
Cross-Sectional	Respiratory	
Ecologic	Cardiovascular	
	Symptoms	
	Other	

Exposure assessment in epidemiology research

Metric Type	Description
Distance	Distance between household and closest well
Earthquakes	USGS-recorded earthquakes ≥4 in magnitude
Emissions	Annual tons of pollutants emitted by zip code
Inverse Distance Weighting	$IDW_a = \sum_{i=1}^{n} \frac{1}{d_i}$ $IDW_a = \sum_{i=1}^{n} \frac{1}{d_i^2}$ IDW for separate UOGD phases: Patient j$= \sum_{i=1}^{n} \frac{X}{d_{ij}^2}$
Spatiotemporal Activity Model	Score incorporating location, number of wells, activity phase, use of green completion, production volume, number of tanks on well pad, and estimated emission rates of select VOCs by phase.
Spud date with time-series component	Product vector with indicator for spud date and proximity indicator
Time-Period	Effect estimates compared between time periods (years; before or after spud date)
Well density or count	Number of ever-spudded wells; number of newly-spudded wells; number of wells ever drilled; number of active wells per km^2 within zip code

What we would like to know about potential exposures to assess health risk

UOGD processes:

- Identify UOGD processes
- How releases vary over space and time
- Isolate UOGD from other sources

Release mechanisms and transport pathways:

- How variability in regional conditions and other factors affects levels of UOGD agents

Media or type of exposure:

- The levels of the agent to which people might be exposed
- Route of exposure

Community exposures:

- Duration, frequency, and magnitude of exposure

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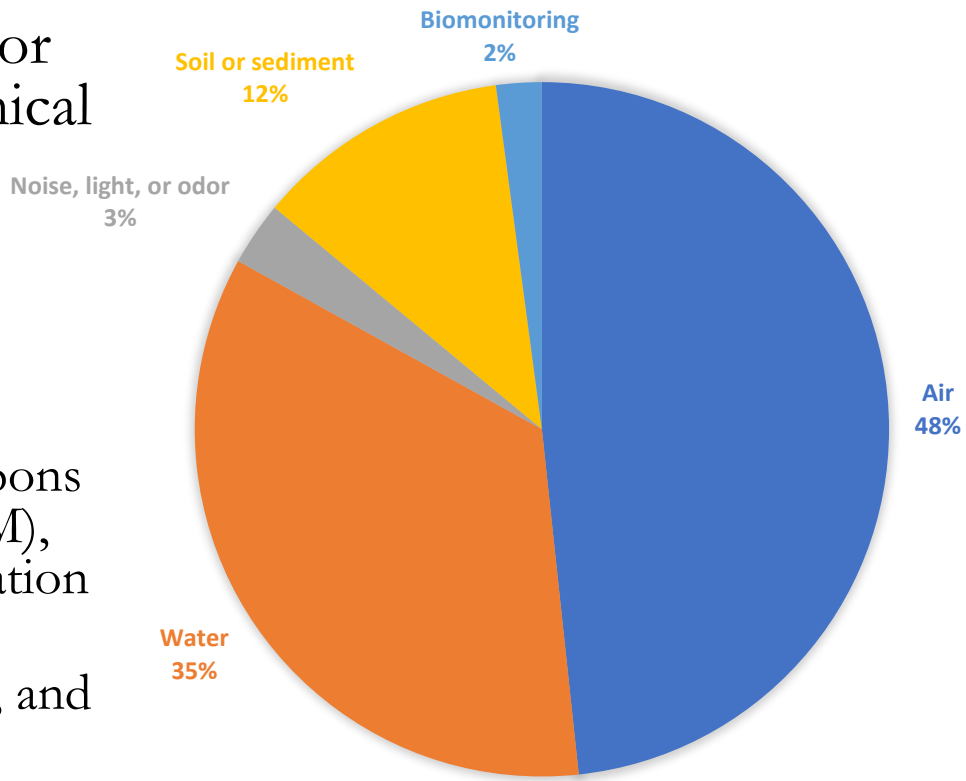
HEI-Energy 2019 survey of exposure-related literature

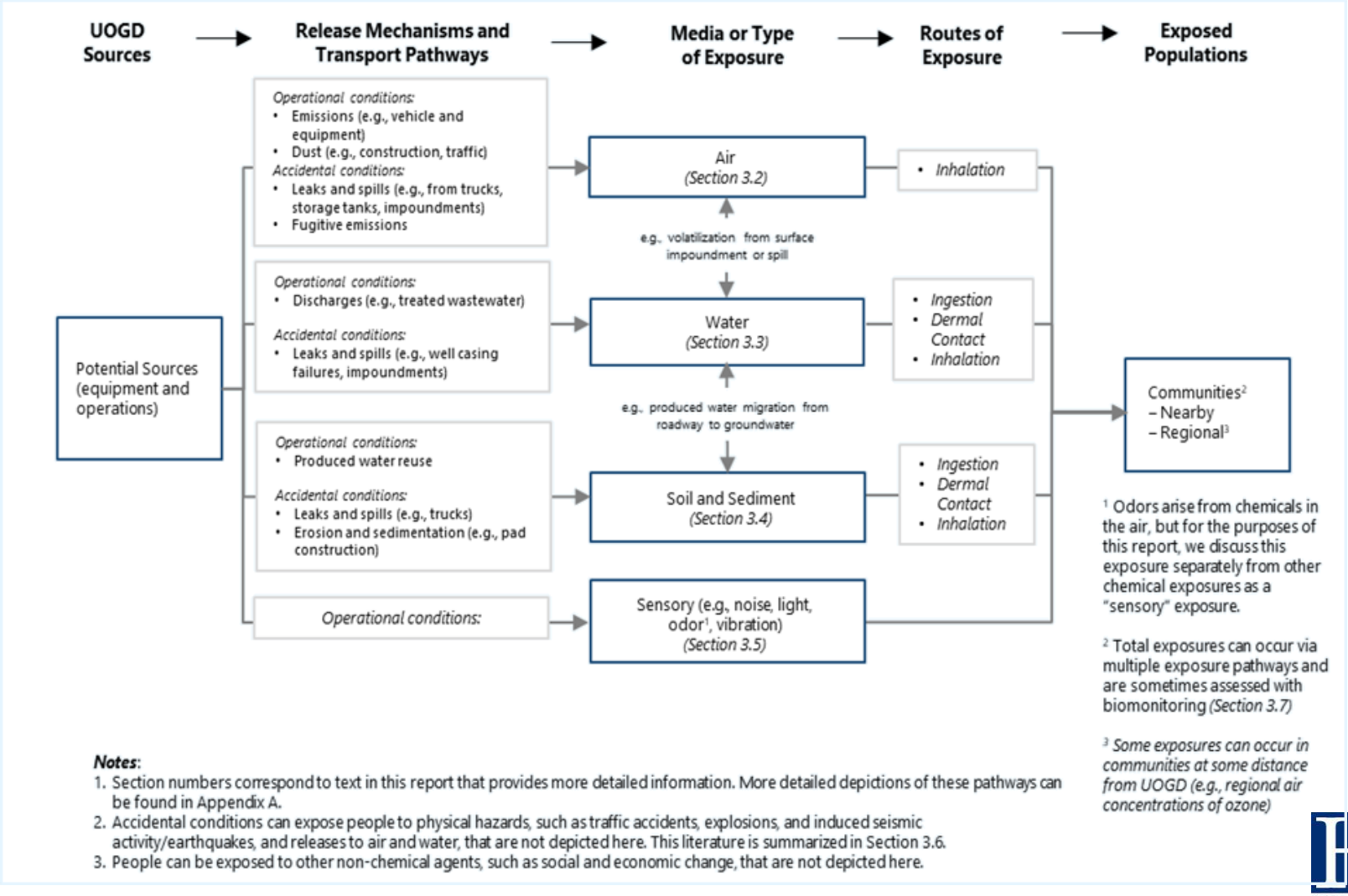
- 204 publications measured or modeled one or more chemical or non-chemical agents

- Compounds commonly measured or modeled:
  - Air: Volatile organic hydrocarbons (VOCs), particulate matter (PM), and secondary pollutant formation (e.g., ozone)
  - Water: brine indicators, VOCs, and metals
  - More noise research in recent years

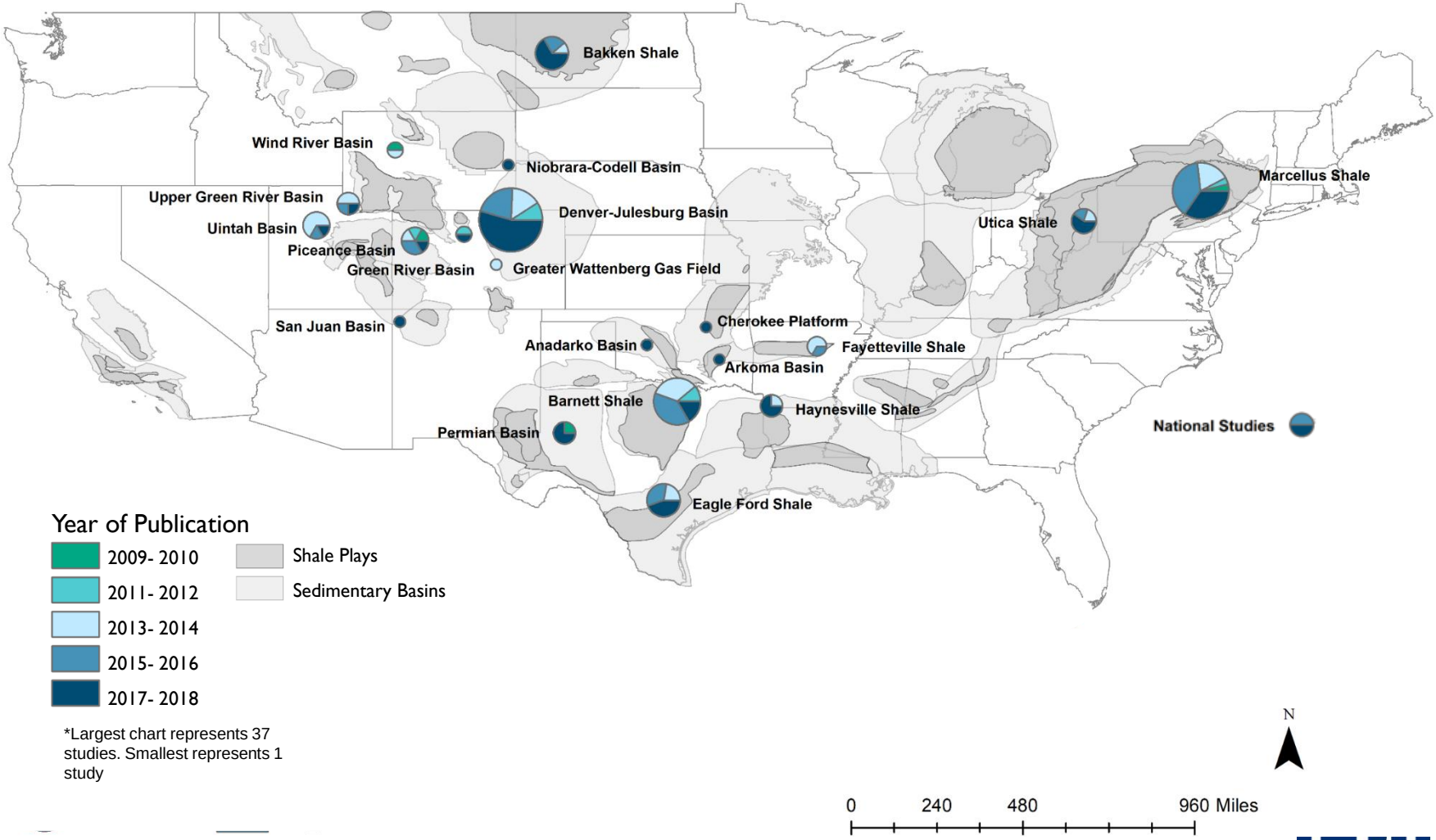


Exposure pathways assessed in the literature

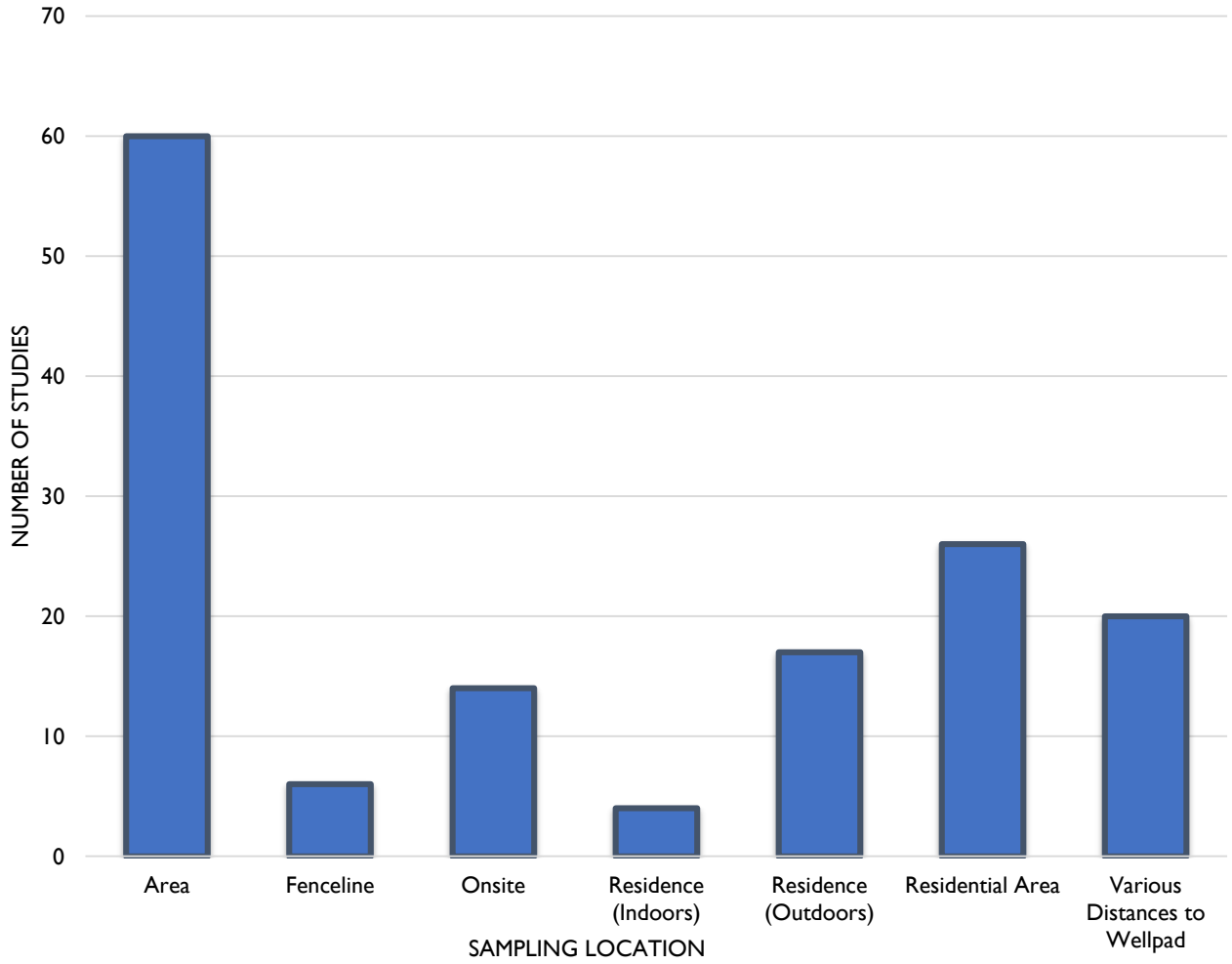
(excerpt from HEI Energy Research Committee (2019, draft report)



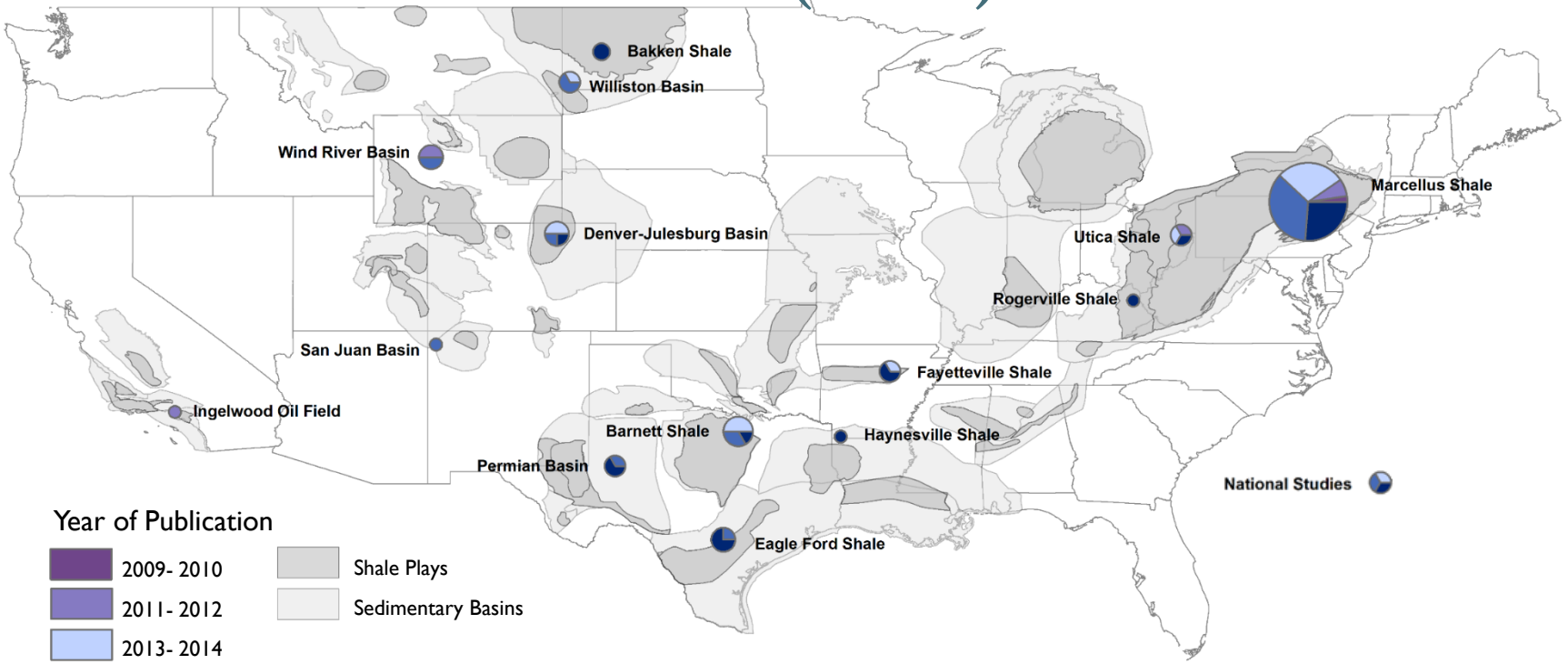
Air Studies by Location and Year of Publication for 2009-2018 (n= 113)



Sampler placement in air monitoring studies



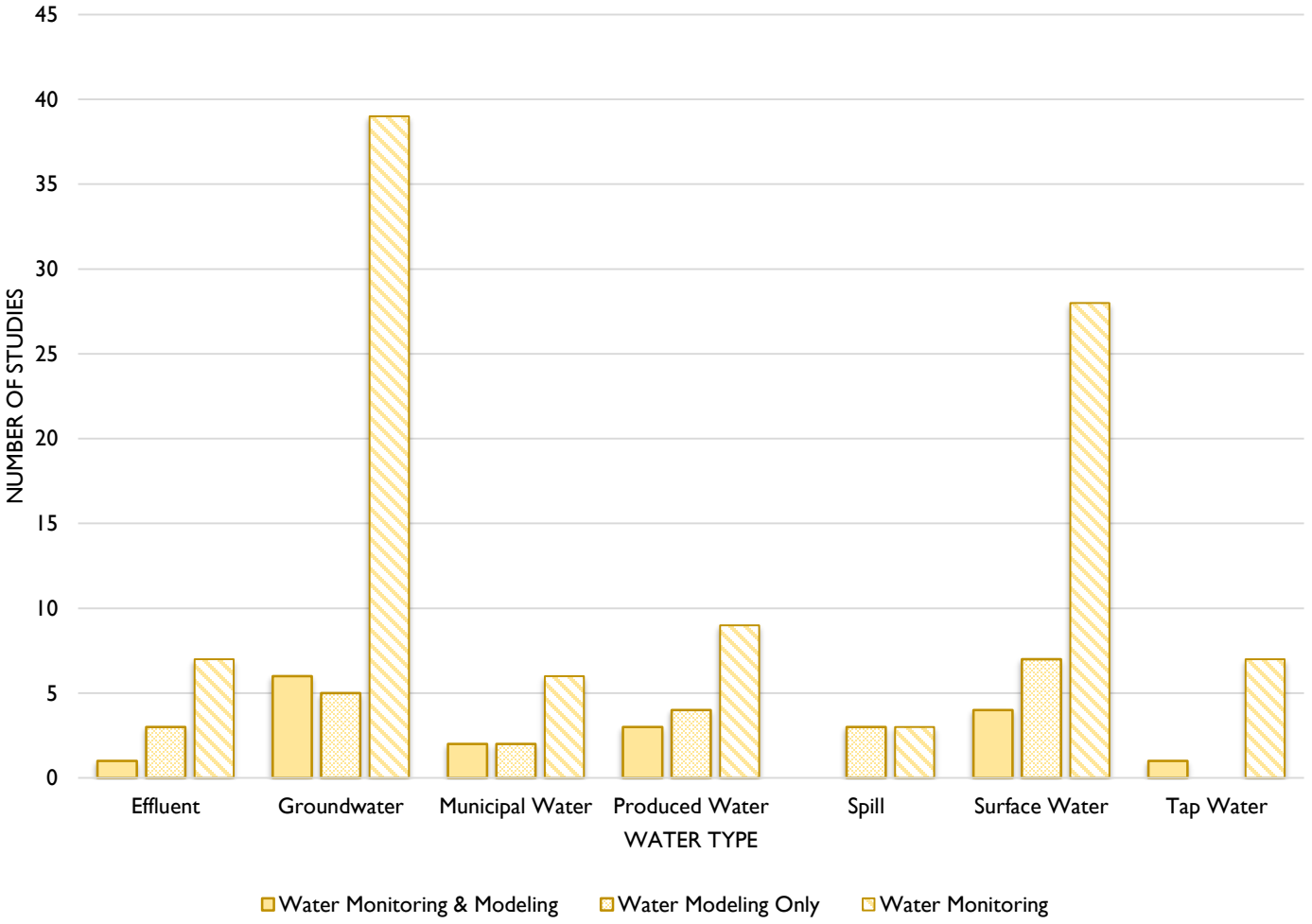
Water Studies by Location and Year of Publication for 2009-2018 (n= 80)



*Largest chart represents 45 studies. Smallest represents 1 study

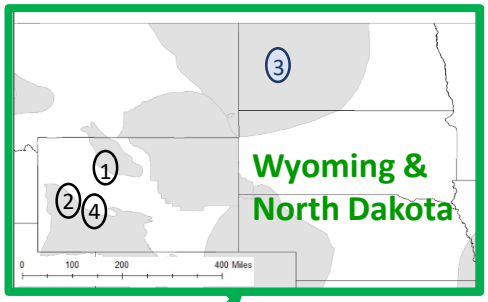
+ The Inglewood Oil Field study was conducted on vertical wells but was designed to be generalizable to UOGD (Tormey 2012)

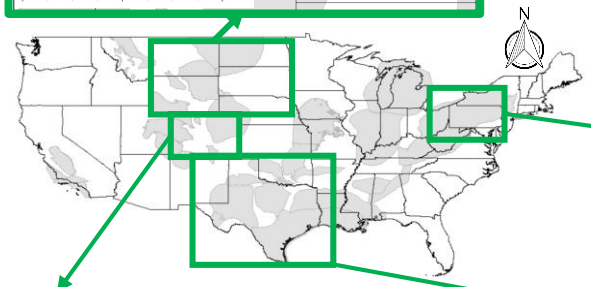
Water sample sources

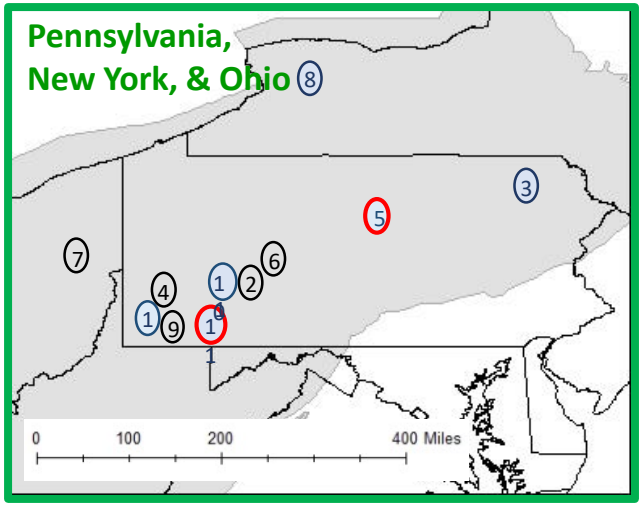


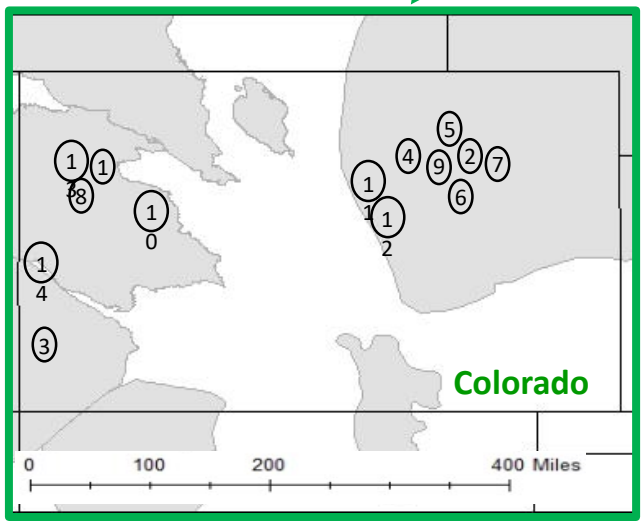
UOGD Human Health Risk Assessments

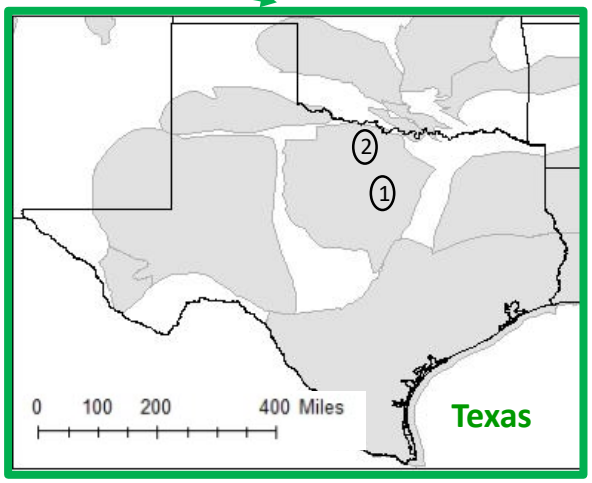
- Water-related
- Air-related
- Occupational











*Plus 5 others that are either national in scope or focus on oil and natural gas operations outside the U.S.

Important to adopt holistic view of exposures to understand health risks, but risk assessments to date are focused primarily on chemical exposures only

Utility of Literature in Assessing Exposure: *Strengths*

Isolating UOGD sources. Some studies linked environmental concentrations to UOGD-related sources

Constructive use of existing data. Some effort to quantify exposure (and sometimes health risk) using existing data (e.g., from state agency monitoring programs)

Temporal and spatial variability.

- Multiple sampling periods (covering a variety of UOGD activities, meteorological conditions, seasons, and times of day)
- Multiple sampling locations (e.g., different distances from UOGD)

Intention to quantify exposure. A subset of studies aimed to characterize human exposure. *An example*: collection of air and noise samples during different UOGD phases near residences.

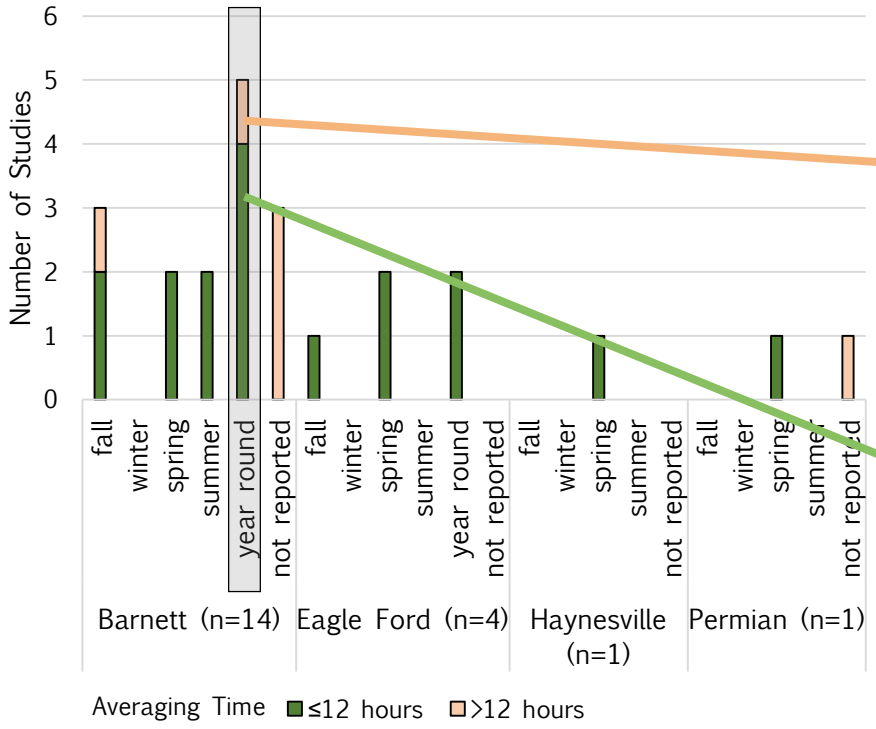
Utility of Literature in Assessing Exposure: *Limitations*

- Not always clear that results can be generalized to other populations, operations, and locations

- Overall, the studies provide an incomplete understanding of the temporal and spatial variability in human exposures across major oil and natural gas-producing regions of the United States

What do we mean by "incomplete understanding variability in human exposures"?

a. Number of Air Studies in Four Texas Shale Basins, by Season and Sample Averaging Time



b. Sampling Locations and Collection Methods Relative to UOGD in the Barnett Shale Play

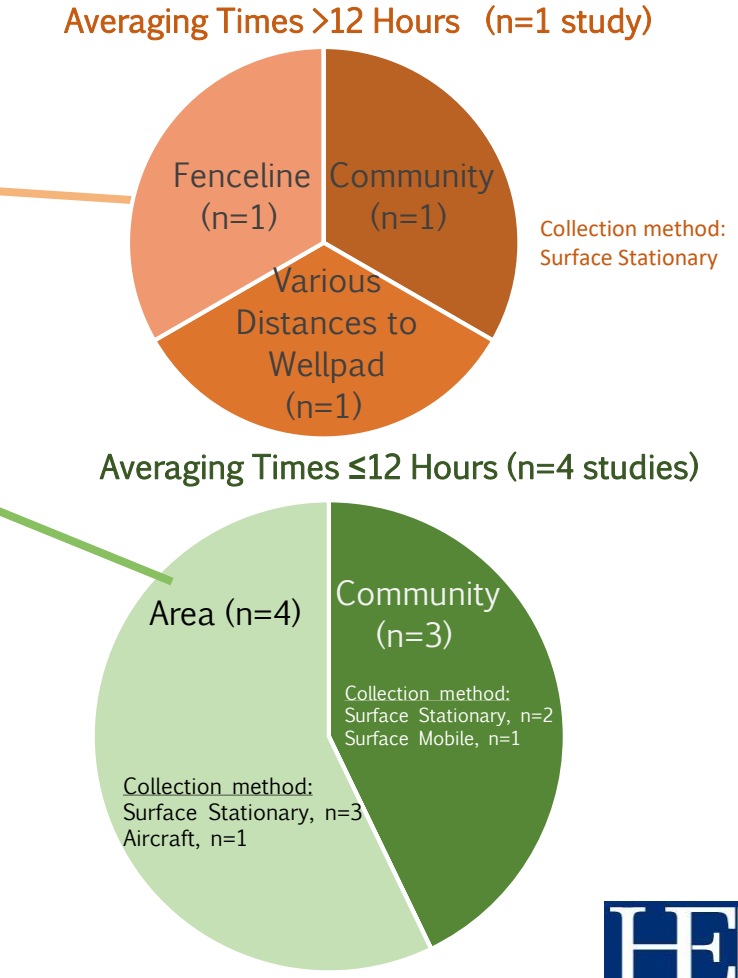
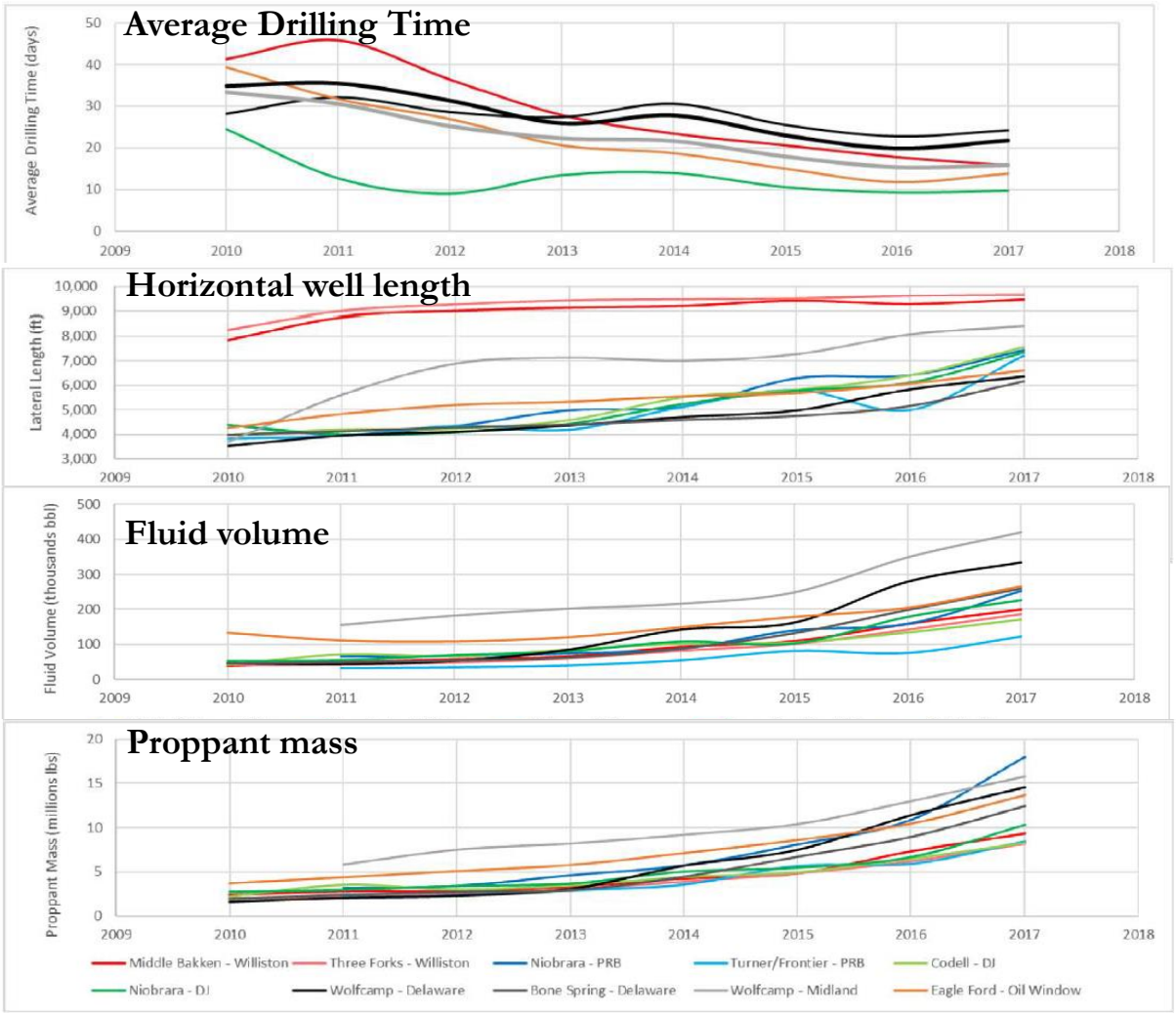


*Figure excludes 4 Texas studies that either did not report the shale play where samples were collected or reported only modeled concentrations.

Challenges and opportunities in understanding the potential for exposures and health risks

Important considerations in designing future UOGD exposure research

Operational Trends



Example: Changes in drilling and hydraulic fracturing

Source: Weijers et al. 2019. Trends in the North American Frac Industry: Invention through the Shale Revolution. *SPE-194345-MS*

How much do operations vary among operators?

Operational Trends

Example: Number of horizontal wells drilled per well pad, or pad density, across U.S. shale plays

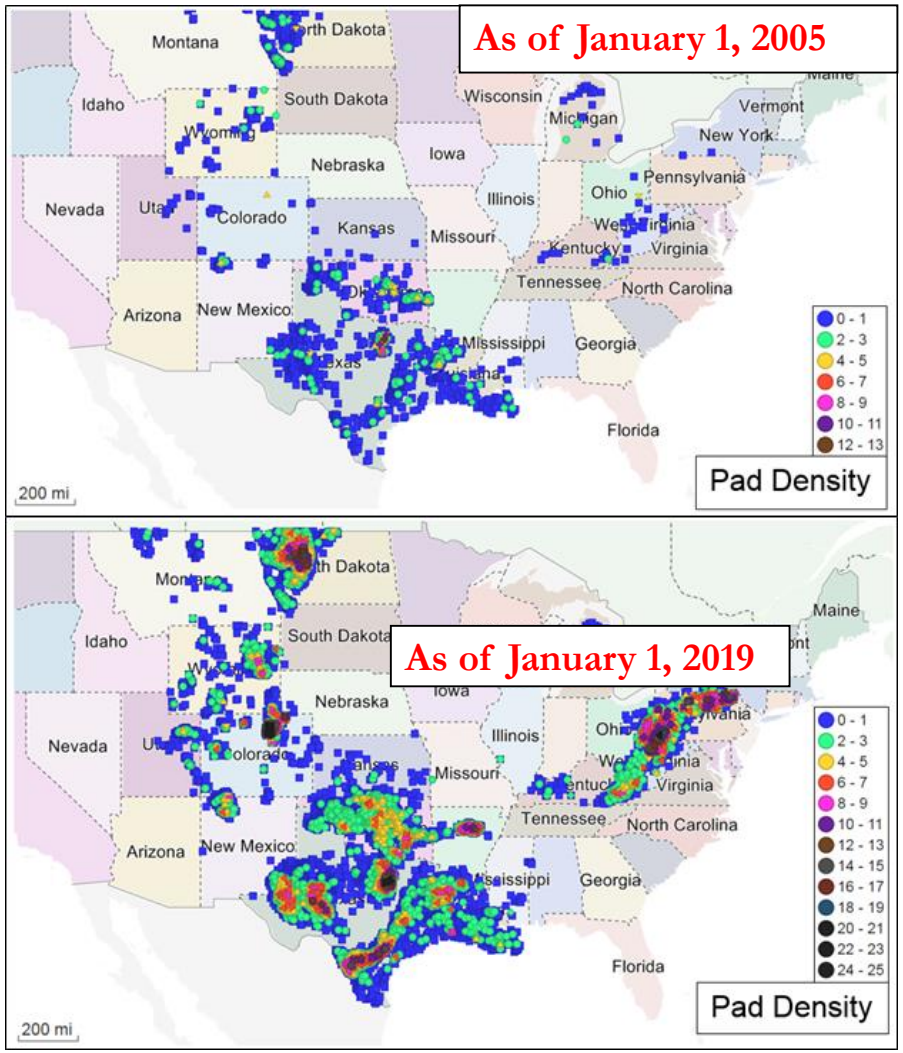


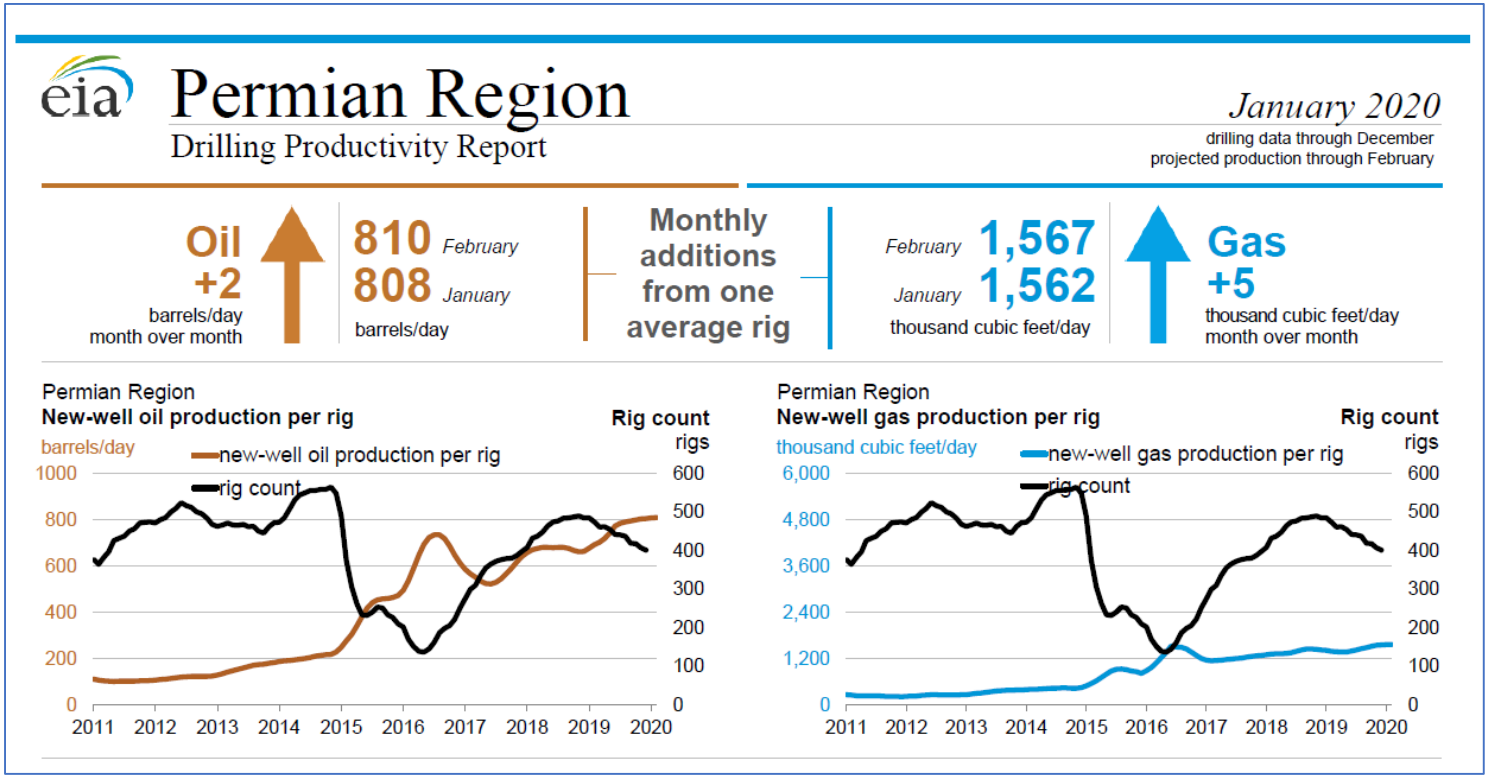
Figure source: Created by M. Al-Alwani, merging horizontal well records from FracFocus and DrillingInfo.)

Notes:

- Each icon represents a single well pad
- Color indicates the number of horizontal wells drilled on each well pad.

Operational Trends

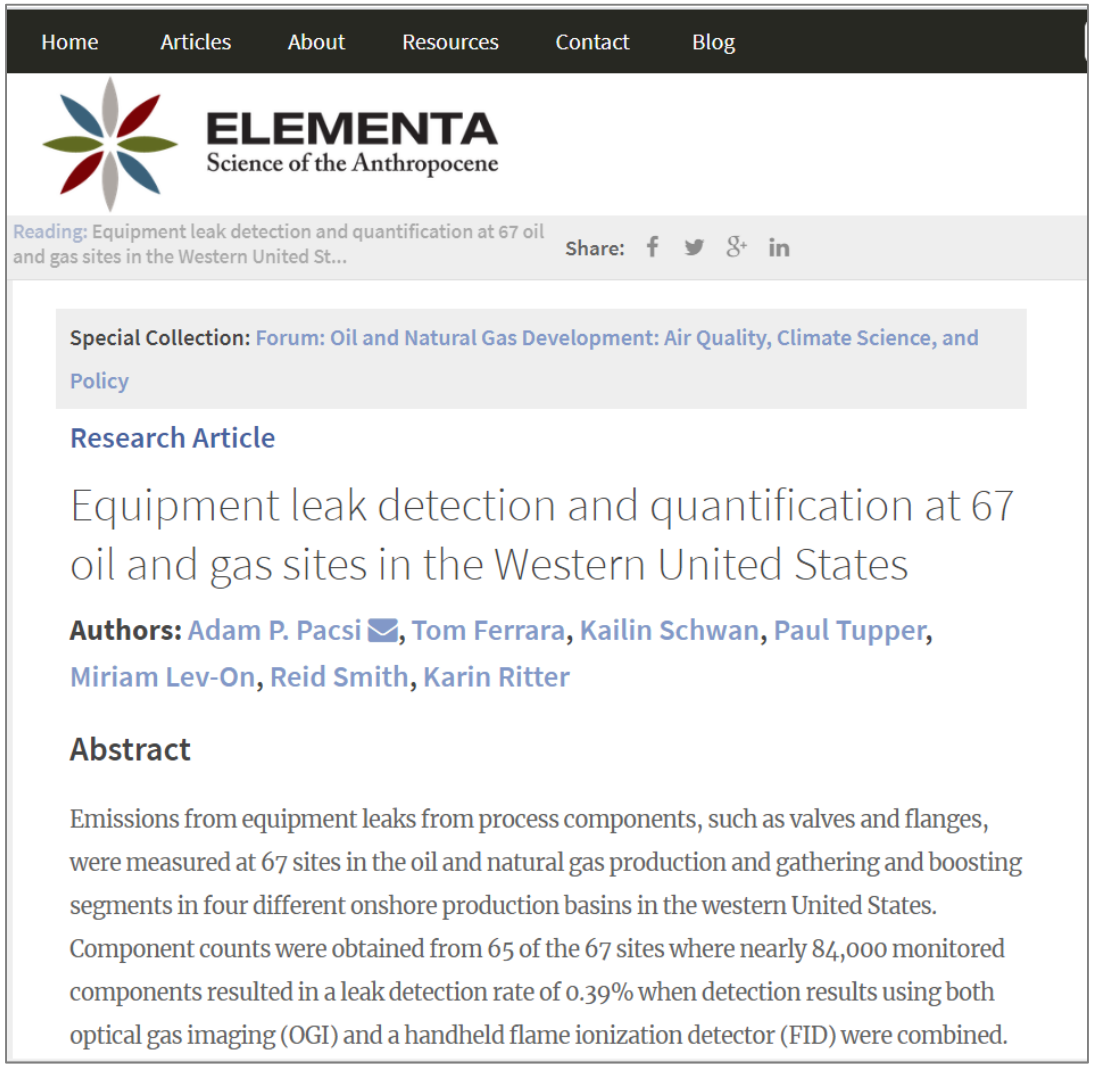
Example: Fluctuating levels of development in the Permian region



When and where will operations happen?

Changing releases to the environment

Example: leak detection and repair



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Science of the Anthropocene

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Special Collection: Forum: Oil and Natural Gas Development: Air Quality, Climate Science, and Policy

Research Article

Equipment leak detection and quantification at 67 oil and gas sites in the Western United States

Authors: Adam P. Pacsi, Tom Ferrara, Kailin Schwan, Paul Tupper, Miriam Lev-On, Reid Smith, Karin Ritter

Abstract

Emissions from equipment leaks from process components, such as valves and flanges, were measured at 67 sites in the oil and natural gas production and gathering and boosting segments in four different onshore production basins in the western United States. Component counts were obtained from 65 of the 67 sites where nearly 84,000 monitored components resulted in a leak detection rate of 0.39% when detection results using both optical gas imaging (OGI) and a handheld flame ionization detector (FID) were combined.

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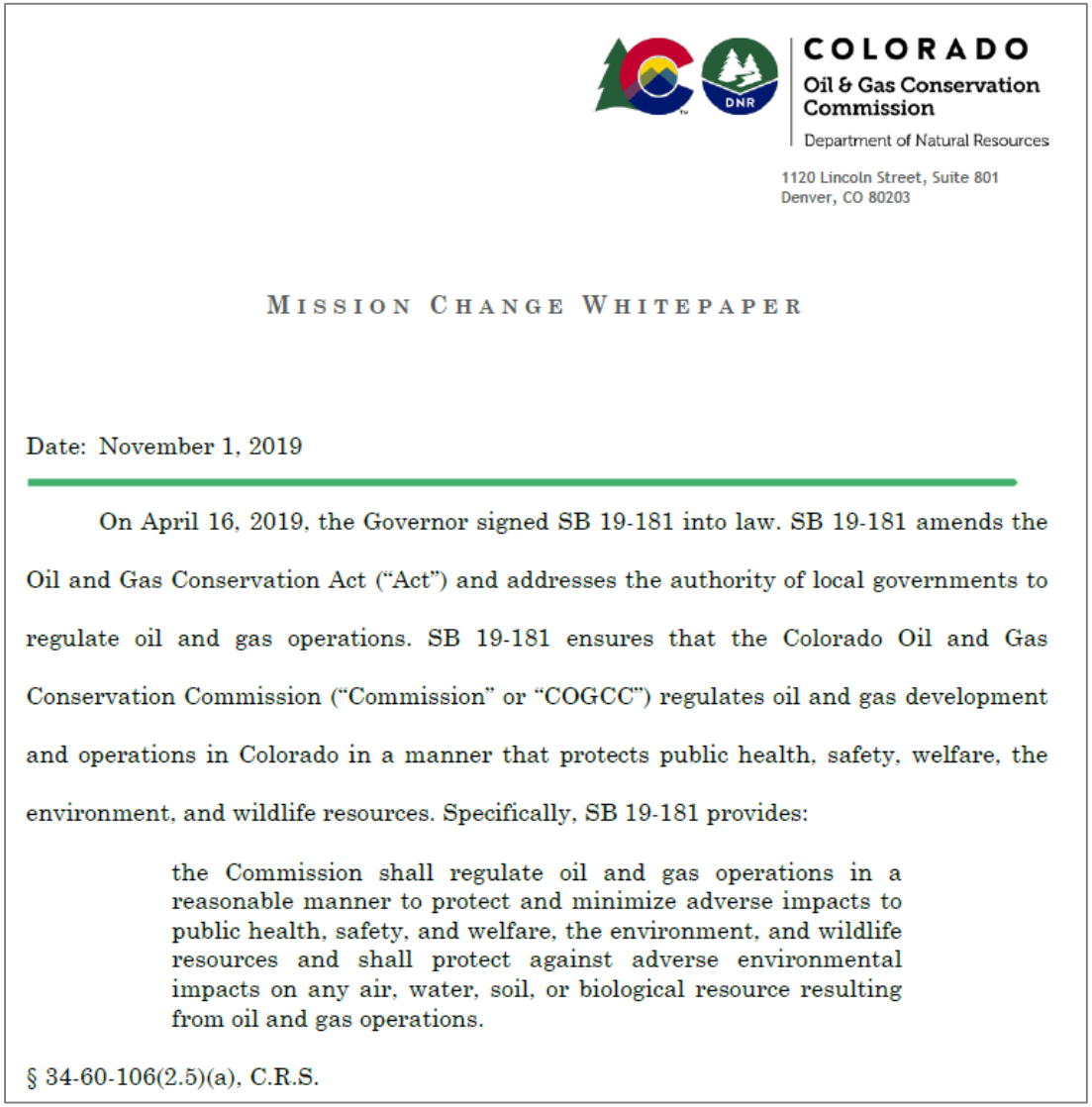
Changing governance

Example: Regulatory change focused on public health, safety, welfare, and the environment

Related research possibility: Accountability research to assess whether anticipated goals are achieved



COLORADO
Oil & Gas Conservation Commission
Department of Natural Resources

1120 Lincoln Street, Suite 801
Denver, CO 80203

MISSION CHANGE WHITEPAPER

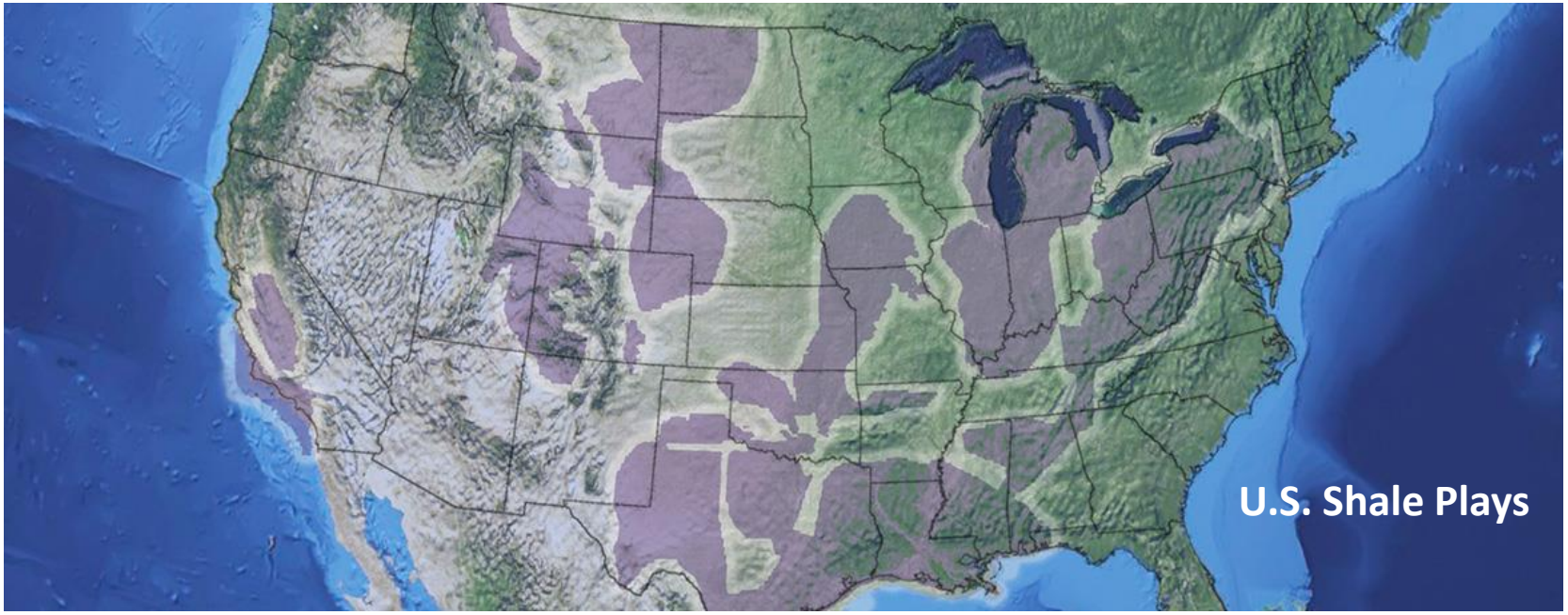
Date: November 1, 2019

On April 16, 2019, the Governor signed SB 19-181 into law. SB 19-181 amends the Oil and Gas Conservation Act ("Act") and addresses the authority of local governments to regulate oil and gas operations. SB 19-181 ensures that the Colorado Oil and Gas Conservation Commission ("Commission" or "COGCC") regulates oil and gas development and operations in Colorado in a manner that protects public health, safety, welfare, the environment, and wildlife resources. Specifically, SB 19-181 provides:

> the Commission shall regulate oil and gas operations in a reasonable manner to protect and minimize adverse impacts to public health, safety, and welfare, the environment, and wildlife resources and shall protect against adverse environmental impacts on any air, water, soil, or biological resource resulting from oil and gas operations.

§ 34-60-106(2.5)(a), C.R.S.

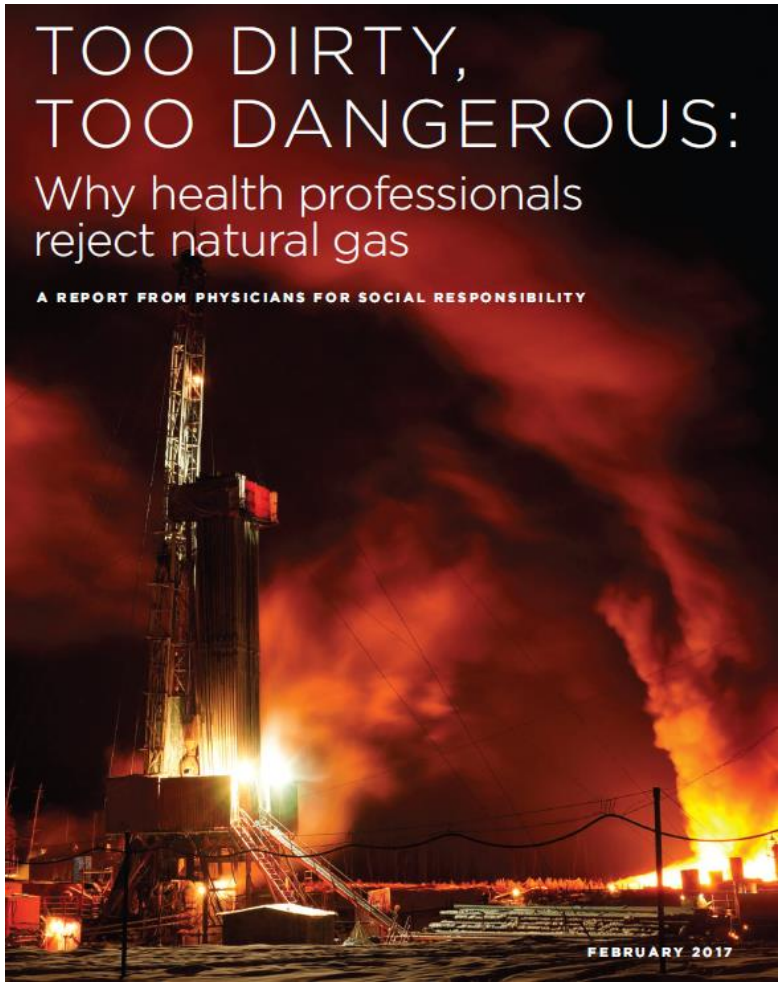
Variable environmental conditions across oil and natural gas-producing regions

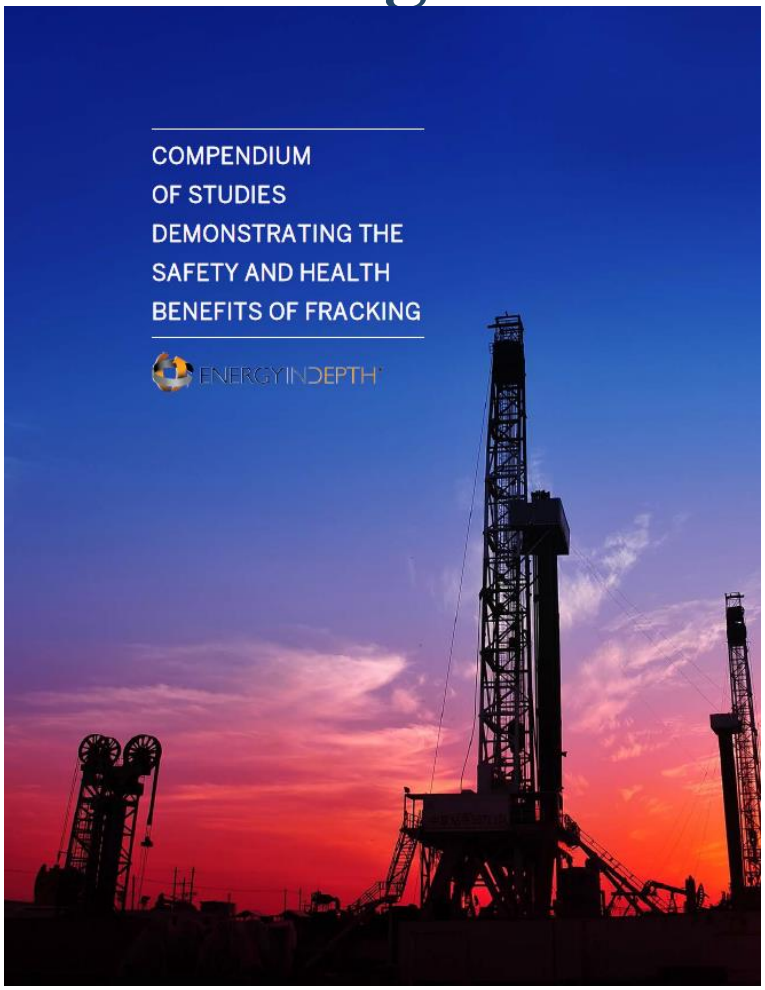


Lots of ongoing work to track

Example: produced water applications

The challenge of pursuing scientific research in a controversial setting





Suggested Features of Future Exposure Study Designs

HEI-Energy research planning

- *Overarching goal*: Improve understanding of UOGD exposures across the United States, the conditions under which they occur, and the likelihood of occurrence.
- *Where*: Multiple U.S. regions.
- *Community Engagement*: Before, during, and after research; need to anticipate how results will be interpreted and communicated BEFORE research begins.

Criteria to guide the design of exposure studies *(alphabetical order)*

- Brings value to and informs decision-making
  - *Useful to communities in study areas, government officials, industry, and other stakeholders.*
- Broadly generalizable
  - *Designed to be applicable across geographic regions, UOGD operating conditions, or communities over time, including periods of low and high UOGD activity, without sacrificing validity.*
- Determines whether an exposure pathway links a chemical or non-chemical agent released from a UOGD process with a community.
  - *And, in so doing, distinguishes between UOGD process and other sources of same agent.*
- Expands understanding of temporal and spatial variability of exposure
  - *Study location and design fill important gaps in understanding variability in exposure over temporal and spatial scales relevant for decision making.*
- Optimizes use of the research budget by maximizing efficiency.
  - *Incorporates/complements existing data and information and prioritizes/sequences data collection to maintain focus on exposures of possible concern.*
- Useful for assessing health risk
  - *Collects data, analyzes existing data, or establishes practical exposure assessment methodologies with applications to epidemiology or risk assessment.*

HEI energy

Thank you

For more information

Our website: hei-energy.org

Contact: energy@healtheffects.org