The Opportunities, Challenges, and Unknowns of Shale Gas Exploration

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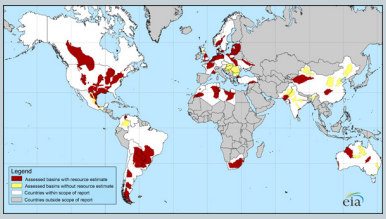
Overview

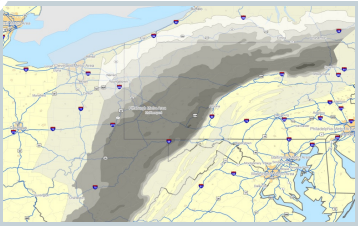
- Location of shale gas
- Description of extraction
- Environmental concerns
- Impacts to neighbors?
  - Future land use and property value implications



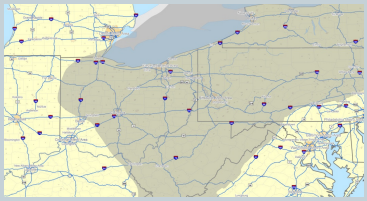
Source: EIA

Shale Gas: A Local Concern

- Marcellus (2007) and Utica shale (2011) are the focus of intense exploration efforts
- Projections suggest this activity will continue for at least 30 years

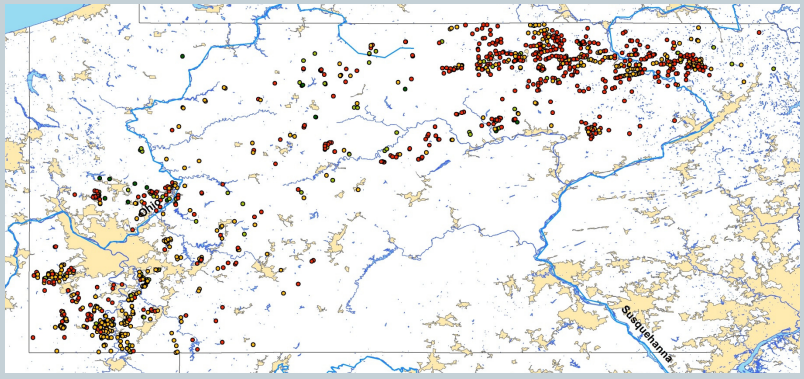


Marcellus Shale (USGS)



Utica Shale (USGS)

Expansion of Activity



Landscape Changes

1993

Stream

2008

Well Pads

Water Storage

Extraction Process

HORIZONTAL DRILLING
HYDRAULIC FRACTURING
WASTE DISPOSAL

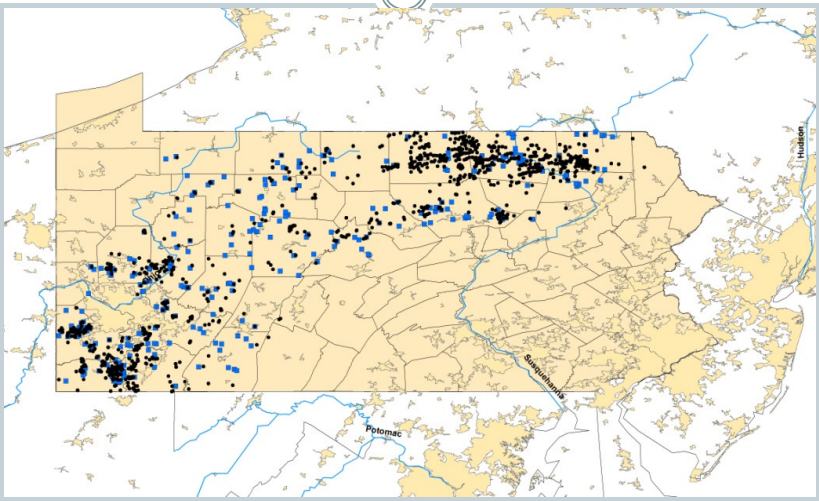
Horizontal Drilling

- Up to a mile horizontal after drilling over a mile deep
- A typical well pad can drill in over 8 different directions
- Must acquire the mineral rights of **all** landowners whose land you drill beneath
  - Bonus payments >$5000
  - Royalties >18%
  - Typical well could generate $15 - $20 million in revenue

Hydraulic Fracturing

- Requires large volumes of water per well (>2 million up to 8 million gallons)
- Must apply and be approved for water withdrawal
- Mix chemicals (fracking fluid) with the water and force the water into the well under pressure to break apart the shale

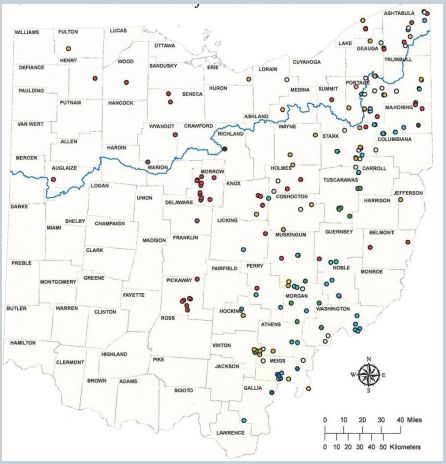
Water Withdrawal



Well Sites and Water Withdrawal Locations

Waste Disposal (Water)

- Must dispose of approx. 20-40% of frack water for each horizontal well drilled
- Initially disposed of at local municipal plants in PA
- Currently: underground injection and treatment with re-use
  - Over 50% of OH injection waste is out of basin as of 2011
  - Injected nearly 9 million barrels in 2010



Underground Injection Wells

Waste Disposal (Solids)

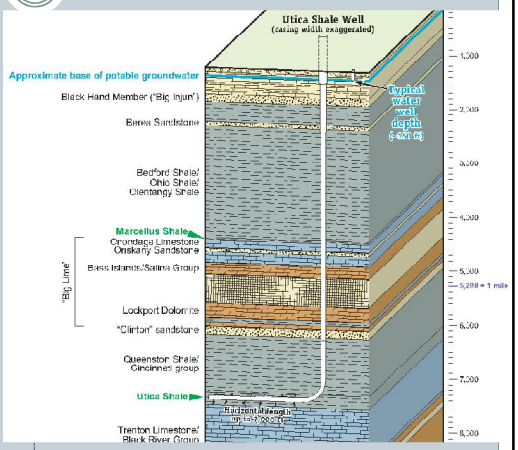
- Most "treated" water results in solid residue resulting after distillation
- "Cuttings" from drilling must also be disposed of
- Together this has created a boom for landfill owners who can handle this type of waste
  - Creates future concerns if seepage or leaks occur
  - Very little oversight is currently involved in this process
  - A potentially long-term environmental problem if leaks occur

Environmental and Economic Concerns

WATER, LAND USE, AND RISK

Drinking Water

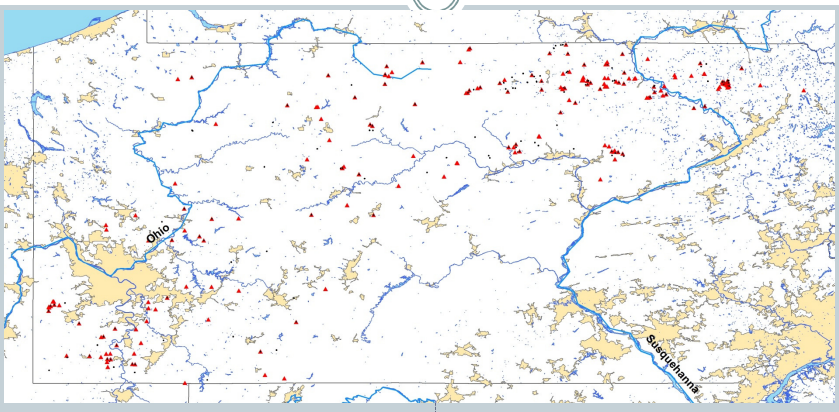
- Main concerns regarding drinking water are:
  - methane contamination
  - contamination from spills
- Methane contamination would occur if the well casing fails along or near the groundwater level
- Spill contamination could occur both on-site or off-site



How Likely is Contamination?

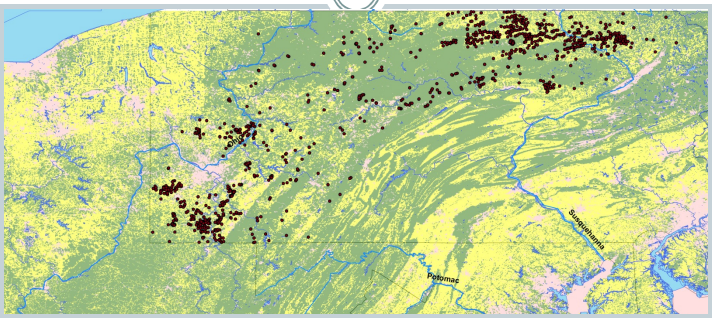
- Duke study found high levels of methane in water surrounding well sites (PNAS, 2011)
  - No baseline for comparison
- Chesapeake energy now requires water testing within ½ mile of all new drilling operations to limit future liability
- Ohio has conducted over 1,000 investigations since 1983 related to fracturing (although not many of these are horizontal wells)
  - None of these investigations found water contamination believed to be caused by fracturing itself– cite surface issues, and spills as the cause

Environmental and Health Incidents



- Incidents include:
  - 80 – Clean Streams violations
  - 75 -- Discharge into ground
  - 82 -- Impoundment violations
  - 52 -- Not structurally sound impoundment
  - 164 -- Erosion into waterways
  - .....

Landscape Changes and Runoff



- Access to sites requires clearing land and constructing roadways (usually gravel)
- Gravel roads are one of the leading contributors to runoff in local streams
- In the future, this roadway network may increase logging activity, development, etc.

A Few Unknowns/Risks

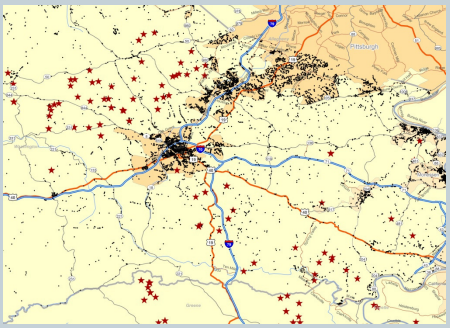
- What impact will shale have on local foods?
  - Are consumers worried about local produce if spills occur nearby?
- Property values in the long run
  - If well water is needed for housing development, does previous exploration create undesirable areas?

Should One Care About Neighbors' Decisions?

AN EXAMPLE OF UNKNOWNS WITH POTENTIALLY **LARGE** IMPACTS!

Spillover Effects to Non-Resource Owners

- Does nearby drilling impact surrounding property prices?
- If these exist, do they limit the future development options of surrounding landowners?
  - Likely depends on persistence of effects…



Property transactions and Marcellus well locations south of Pittsburgh, PA

A Brief Economic Analysis

- Assembled residential property transactions for 5,317 sales occurring from 2007-2009 in Washington County, PA
- Combined this data with drilling activity, housing attributes, municipal service areas, other controls
  - Controls include year effects and 60+ municipal effects

Love thy neighbor?

- Performed a hedonic analysis
  - Explain observed housing prices as a function of recent shale activity and the proximity of that activity to housing
  - Vary distance from 0.5 miles to 3 miles and time from 6 months to 2 years
- Report results as % change in price for a 1 unit change in attribute
  - E.g. baths= .06 implies an additional bath, property price increases by percent. For a $200,000 house, this implies an additional bath would be worth $12,000.

Results

- Estimation results for count of total horizontal wells drilled in previous 24 months to home sale within 1 mile

ln Sale Price	Coef.	Std. Err.	t
Square Feet (100s)	**0.036**	0.004	9.68
Acres	**0.102**	0.011	9.46
Baths	**0.062**	0.018	3.53
Stories	-0.014	0.009	-1.51
Age	**-0.011**	0.001	-7.79
Garage	**0.328**	0.029	11.24
Fireplace	**0.208**	0.020	10.5
Pool	**0.215**	0.047	4.59
Well Water	0.010	0.026	0.38
Distance Pittsburgh	-0.011	0.007	-1.57
Count Wells	**-0.054**	0.017	-3.15
Square Feet ^2	**0.000**	0.000	-3.43
Acres ^2	**-0.004**	0.001	-3.83
Age ^2	0.000	0.000	1.37

An additional well within 1 mile of a residential home reduces property values by approximately 5.4%

Note: Year and Municipal fixed effects not shown

What is Driving This Effect

- Now, we examine the impact of distance – does the impact change at ½ mile?

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Garage	**0.327**	0.029	11.19
Fireplace	**0.207**	0.020	10.38
Pool	**0.216**	0.047	4.59
Well Water	0.006	0.025	0.23
Distance Pittsburgh	-0.011	0.007	-1.58
Count Wells	**-0.068**	0.010	-7.1
Square Feet ^2	**0.000**	0.000	-3.39
Acres ^2	**-0.004**	0.001	-3.86
Age ^2	**0.000**	0.000	1.35

The effect increase as one moves closer to well activity: -6.8%

Implications

- While we have found evidence that nearby drilling activity reduces home values, we do not yet know what is causing this
  - Could be water risk concerns, congestion from truck traffic, …
- Also, there is not yet enough time lapsed in many of these areas to determine how permanent the effects may be…
- Regardless, this evidence suggests that many people perceive impacts and these have real economic consequences

Summary

Lots of Unknowns

- It is clear there will be winners (resource owners, underground injection well owners, landfill owners, water owners, …)
- There also are likely to be losers, particularly those without resource ownership
- For land use and land values, these unknowns create challenges in properly assessing value
  - Does the value today still hold in the future?
  - Will actions of neighbors impact value?
  - How will policy and regulations impact future values

Early Evidence of Land Impacts

- It is nearly impossible to sell land without mineral rights in active exploration areas of Pennsylvania
  - Unclear if this is short term or long term
- In our study, we found clear impacts of negative spillover effects to surrounding residential homeowners
  - If this impact is long-lasting there are potentially large impacts on land values and options for land use

Public Policy Questions

- Ohio DNR regulates well permitting including Class II injection
  - Increased disposal fee in 2010 from $100 to $1000
  - injection disposal fee of $.05 per barrel for brine originating in-district and $.20 per barrel for brine originating out-of-district
- Not yet clear who/how water withdrawal will be regulated in OH
  - In PA, both DEP and river basin commissions regulate this
- Should public lands be exploited
  - May impact tourism, hunting, "aesthetics"
  - Could be a revenue generator
  - Mineral rights previously sold?
- How do local communities handle issues:
  - Traffic/road deterioration
  - Health services, Education, …
  - Environmental fee (Alberta oil sands
- Will river basin commissions, states, and EPA coordinate on water withdrawal and disposal?

Thank You!

COMMENTS OR QUESTIONS?

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