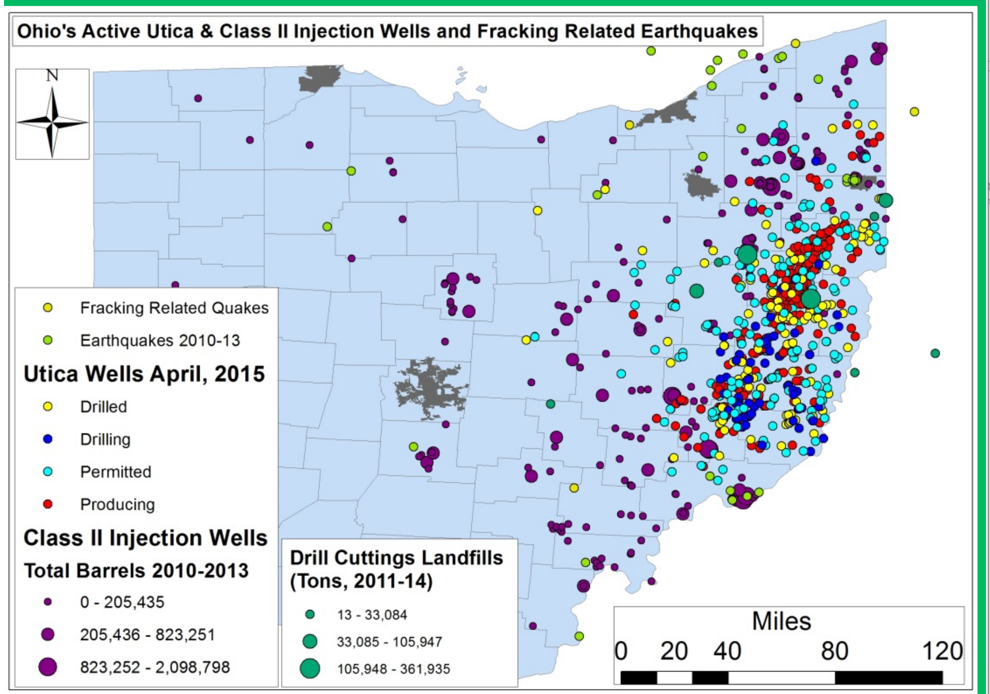
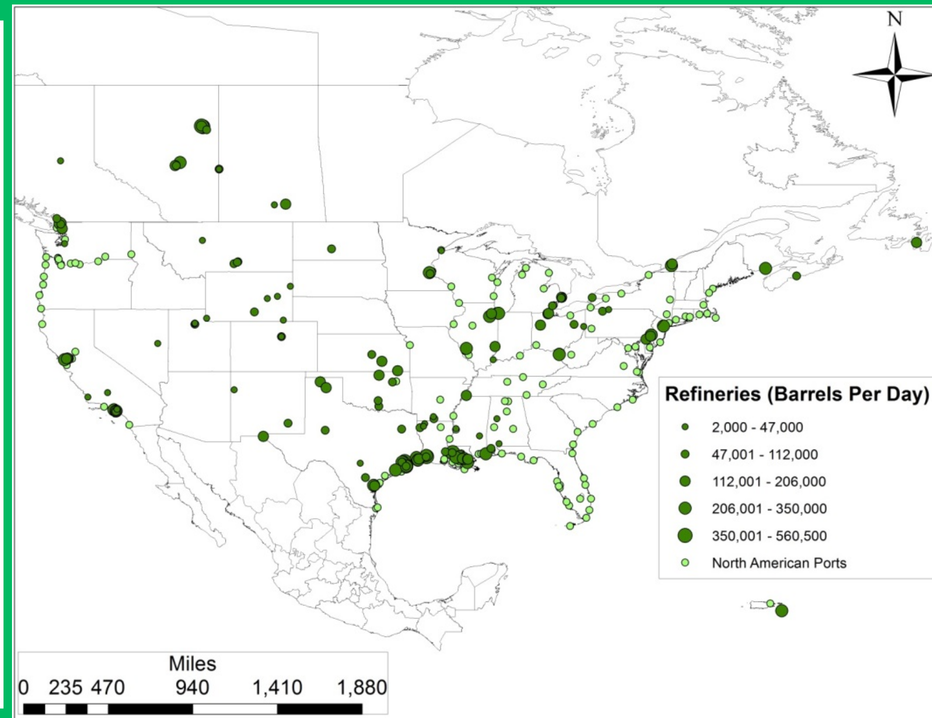
Land-Use, Resource Use in Utica Shale…Now and in the Future (a.k.a., The Resource Curse): Data and Sentiment





Exploring data, sharing perspectives, and mapping impacts of the oil and gas industry

Ted Auch, PhD
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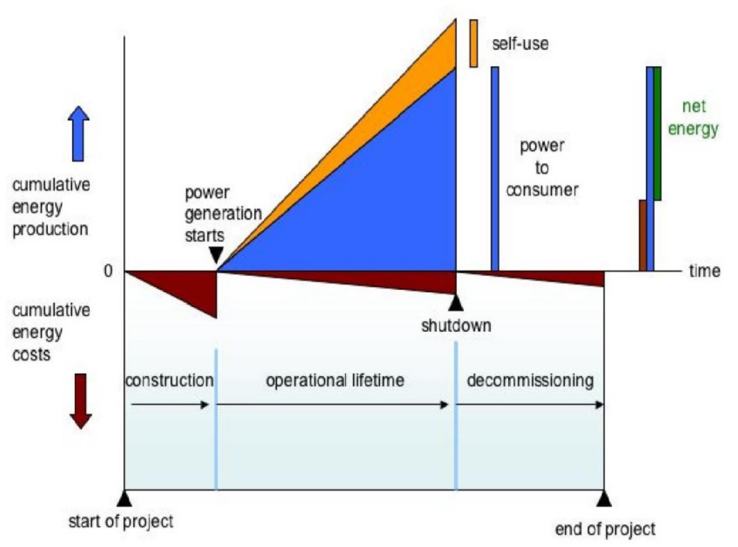
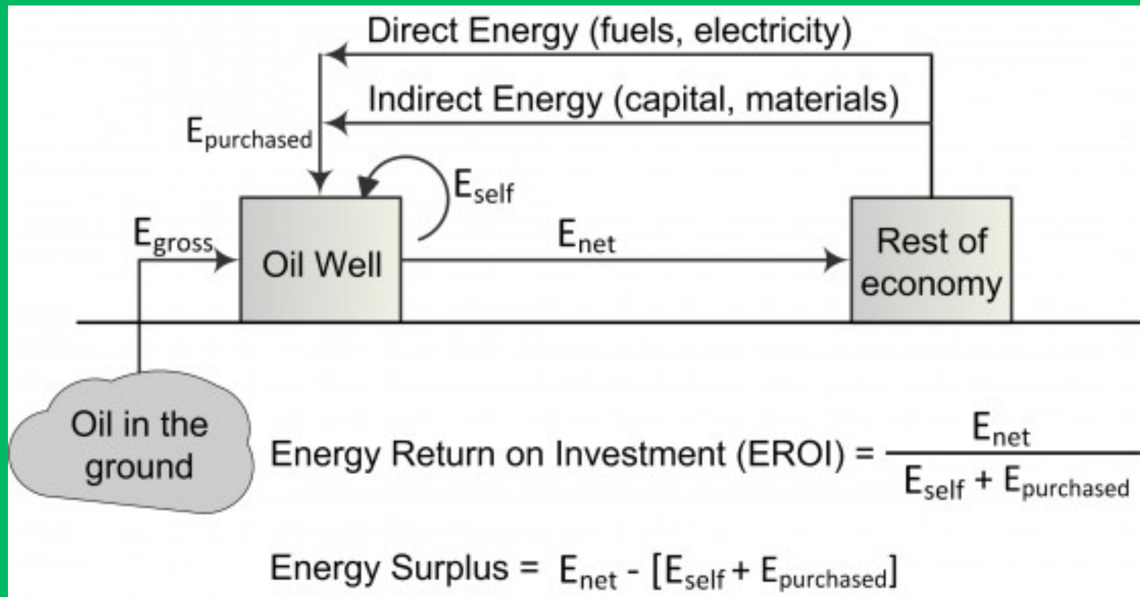
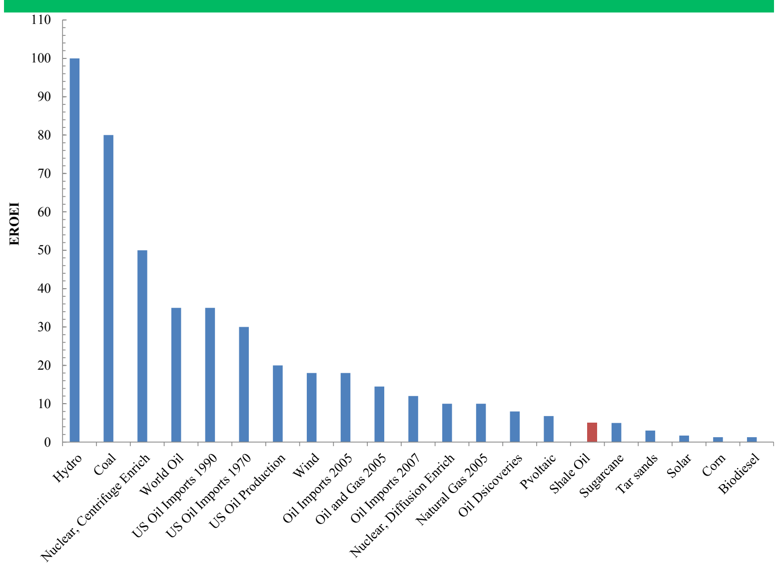
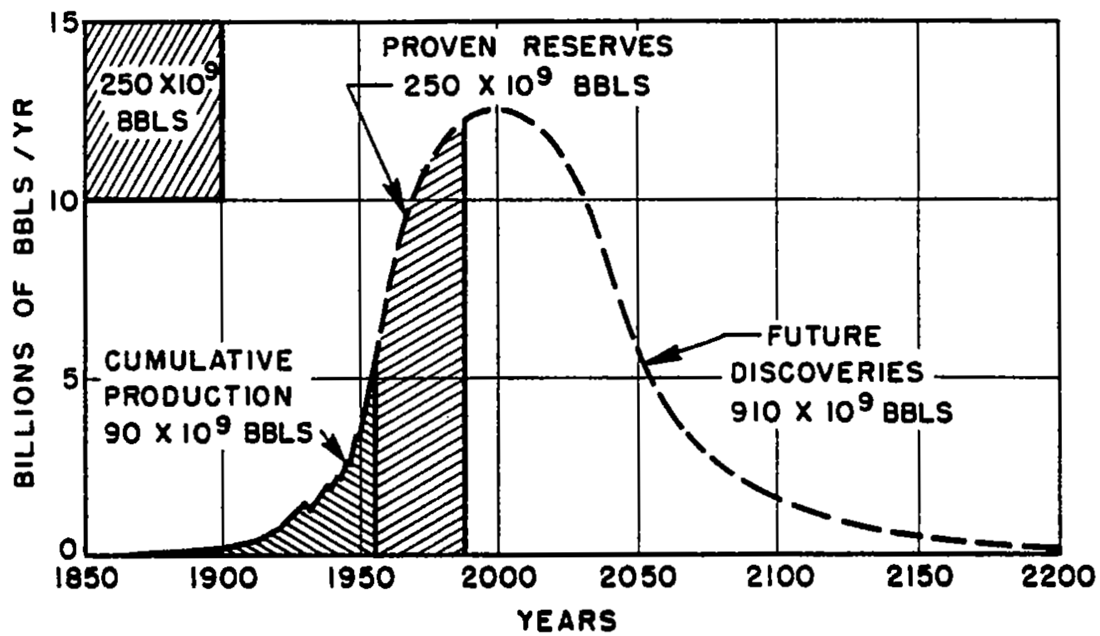
EROEI & Peak Oil



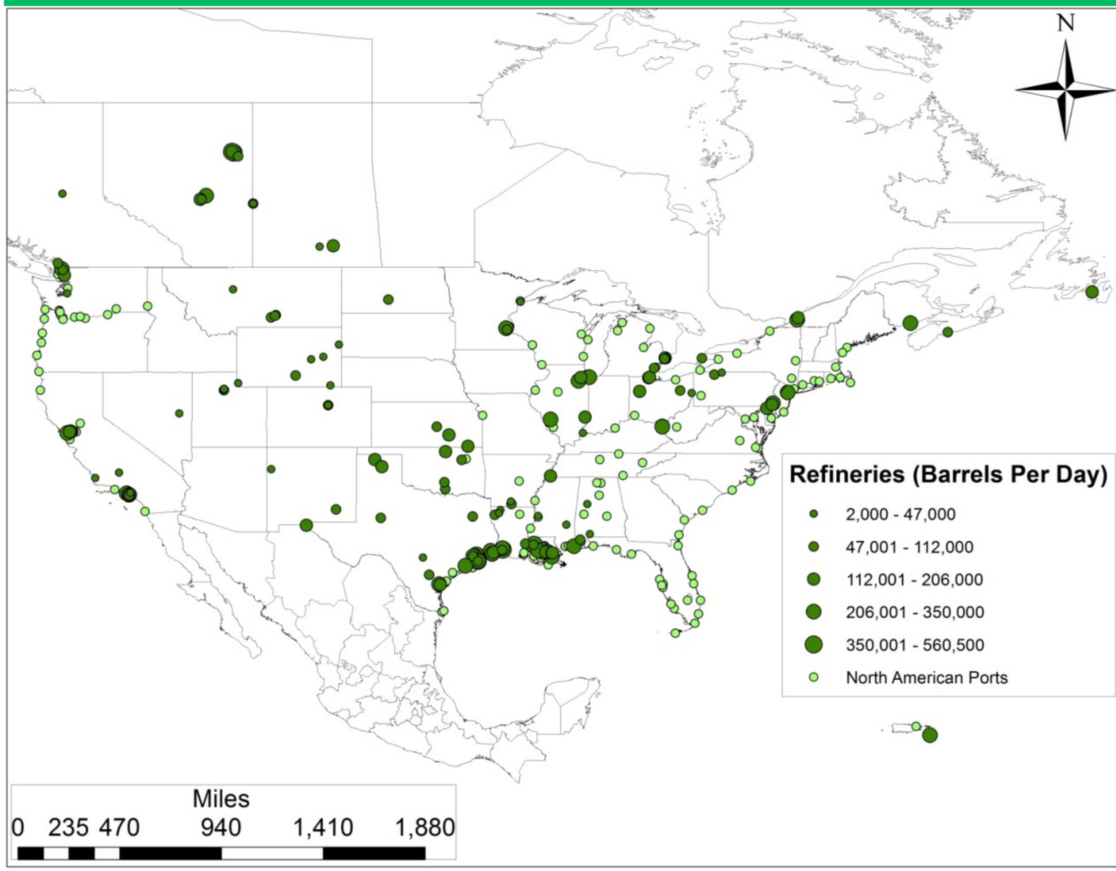






Global Connections

- Build-out of pipelines is not geared towards "energy independence" but rather "energy arbitrage"



Regional Connections

- Nationally
  - 34K pipelines (range <1-302 miles); avg 6 miles in length
    - 195,989 miles total (49% increase proposed or being built)

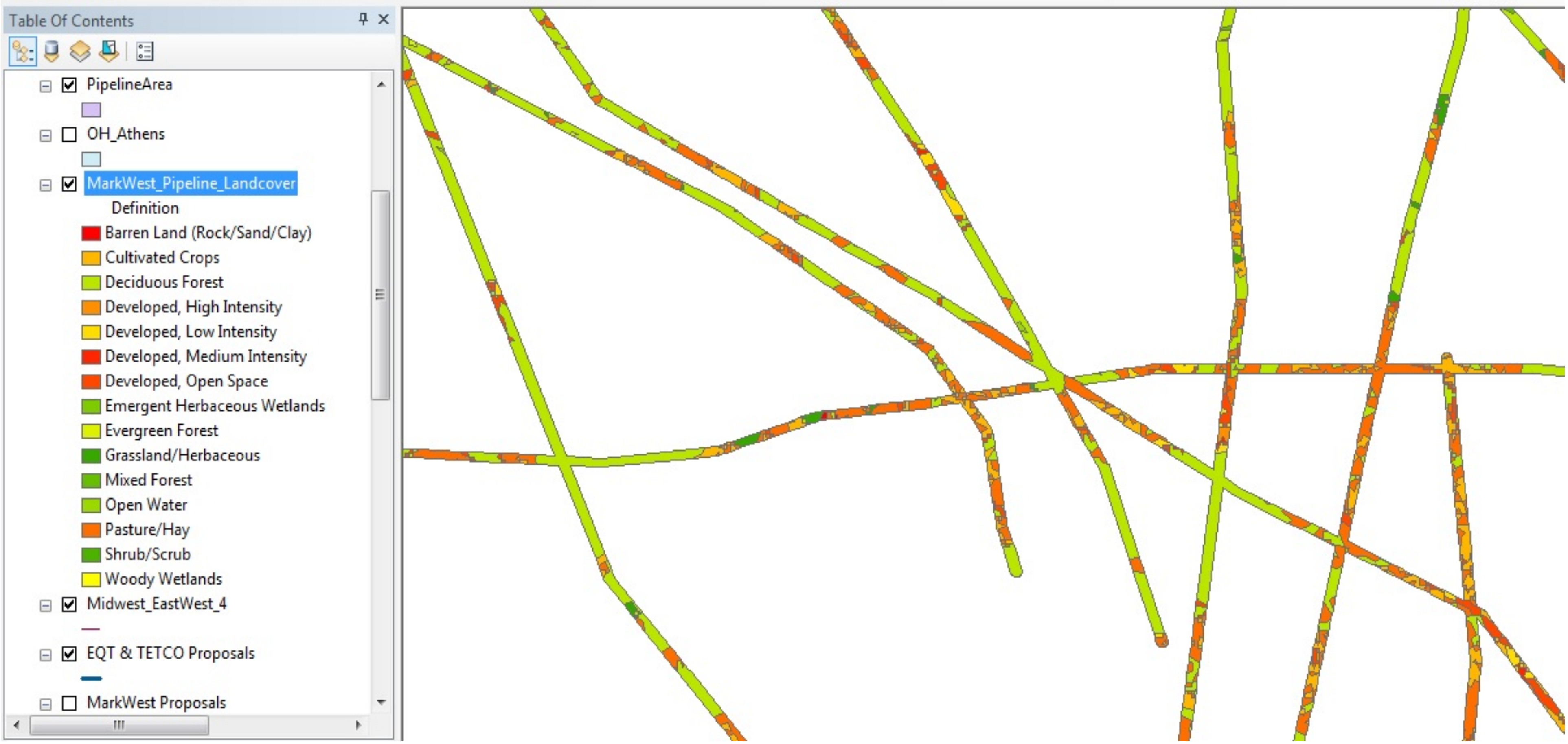
Section	#	Min	Max	Mean	Sum
Bakken	34	18	560	140	4,774
MW East-West	68	5	1,056	300	20,398
Midwest to OK/TX	13	13	1,346	307	3,997
Great Lakes	5	32	1,515	707	3,535
TransCanada	3	612	2,626	1,341	4,021
Liquids Ventures	2	433	590	512	1,023
Alliance et al	3	439	584	527	1,580
Rocky Express	2	247	2,124	1,186	2,371
Overland Pass	6	66	1,685	639	3,839
TX Eastern	15	53	1,755	397	5,958
Keystone Laterals	4	32	917	505	2,020
Gulf Stream	2	541	621	581	1,162
Arbuckle ECHO	25	27	668	217	5,427
Sterling	9	42	793	313	2,817
West TX Gateway	13	1	759	142	1,852
SXL in PA and NY	15	48	461	191	2,864
New England	70	2	855	65	4,581
Spectra BC	9	11	699	302	2,714
Alliance et al	4	69	4,358	2,186	4,358
MarkWest	63	2	113	19	1,196
Mackenzie	46	3	2,551	190	8,745
Wyoming	197	1	329	37	7,314
Total	608	123	1,226	491	96,546[†]

Regional Connections

- 22,127 miles of Midwest pipeline proposals (105 unique segments; range 1-1,056 miles) averaging 211 miles in length
- In Ohio
  - 37 of these segments pass through Ohio (range 3.5-317 miles); averaging 118 miles in length
  - 4,380 miles total or 1/5th of the proposed pipeline length
    - This would amount to 22,298 acres of disturbance
      - 4,460 acres of forest, 8,000 acres of crops, 5,400 acres of hay/pasture, and 1,780 acres of grasslands
        - » Forest would loss 9.5 MT Carbon (6.2-15.9 MT) or 3.3 million Ohioans worth of CO_2
      - Potential ecosystem services, watershed resilience, water/air quality issues rise in parallel.

The MarkWest Proposals

- 63 unique pipeline segments – average length of 19 miles; range of 2.2-113 miles
  - 1,197 miles of pipelines or 0.08 miles of pipeline per mi^2



The MarkWest Proposals

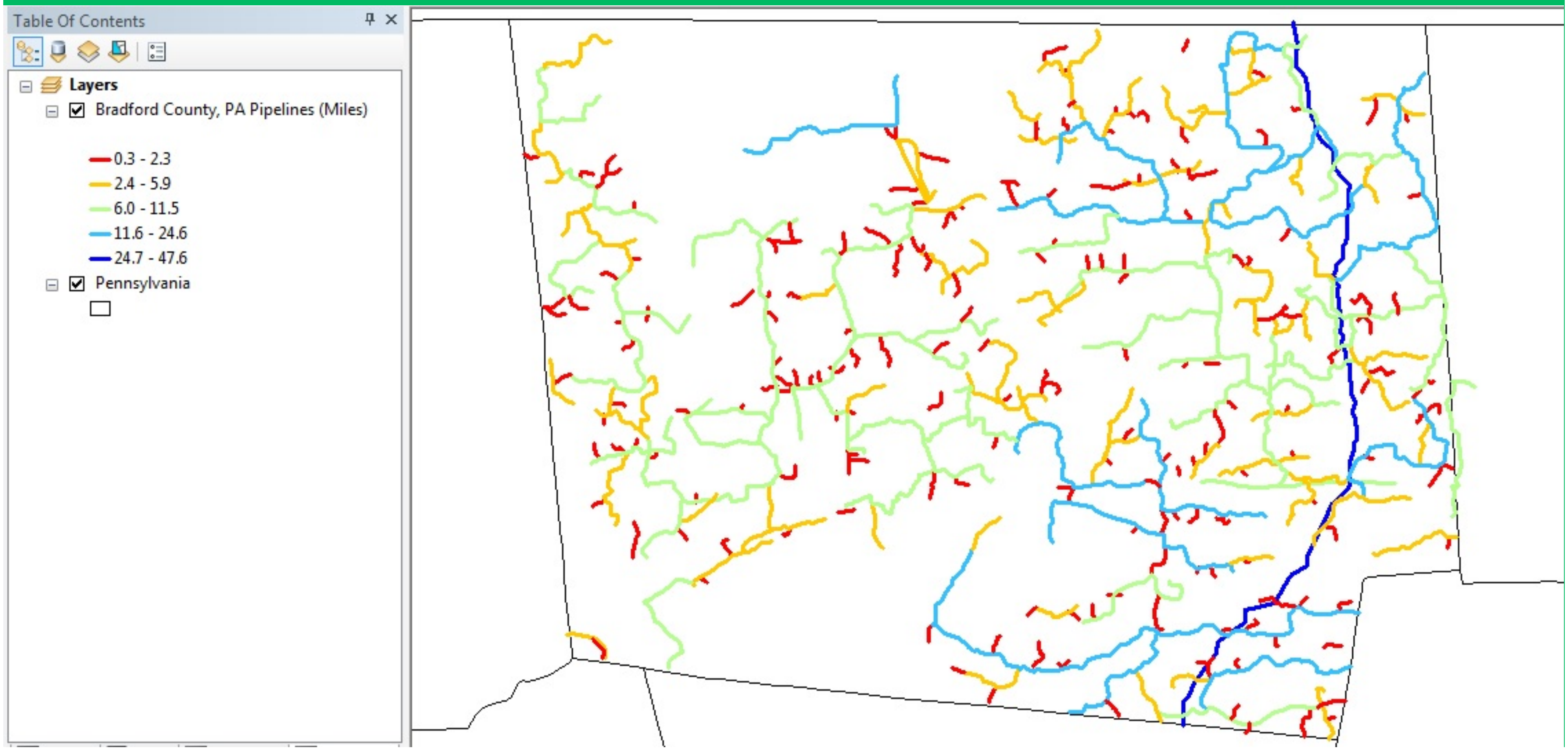
- Nearly 10,200 polygons
  - Average 3.3 acres of disturbance per segment; high of 2.6 mi^2; total of 53 mi^2
  - 1,676 forested segments; 12.4 ac. Average and a total of 32.5 mi^2 of forest removal for this proposal
    - 13.1 mi^2 of agriculture; 5.3 mi^2 of developed; 33 acres of wetlands; 236 acres of open water traversed; 580 acres of grassland
  - Forest displacement would remove 580,545 tons of Carbon (426-1,095K)
    - This is equivalent to 30.3 MT of CO_2 (22.2-57.1 MT CO_2)
    - Amounts to the emissions of 1.69 million Ohioans (1.24-3.18 million Ohioans)

Secondary & Tertiary Facilities

- 1,948 miles of new pipelines
  - 16 mi^2 of disturbance associated with these two projects
    - 2.1K acres of forest, 3.8K acres of crops, 2.5K acres of hay/ pasture, and 819 acres of grassland
  - For every 22 miles of pipeline proposed we see at least 1 facility needed
    - Fractionator, Regulator Station, Compressor Station, Processing Plant, Delivery Point, etc

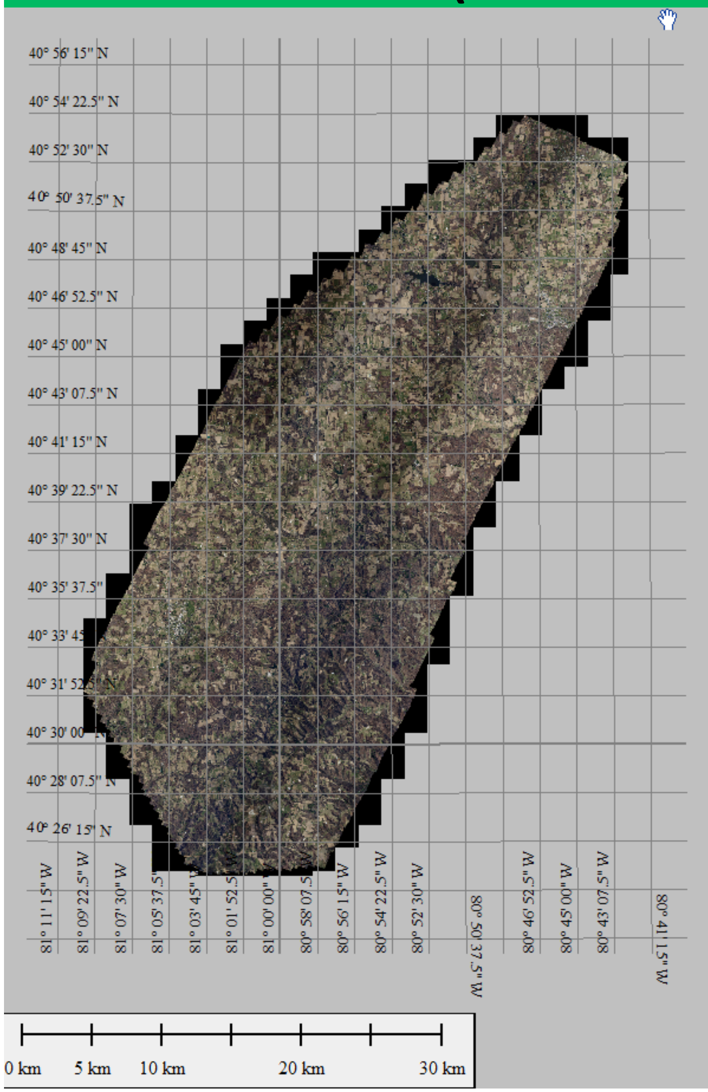
What We've Learned from Bradford County, PA

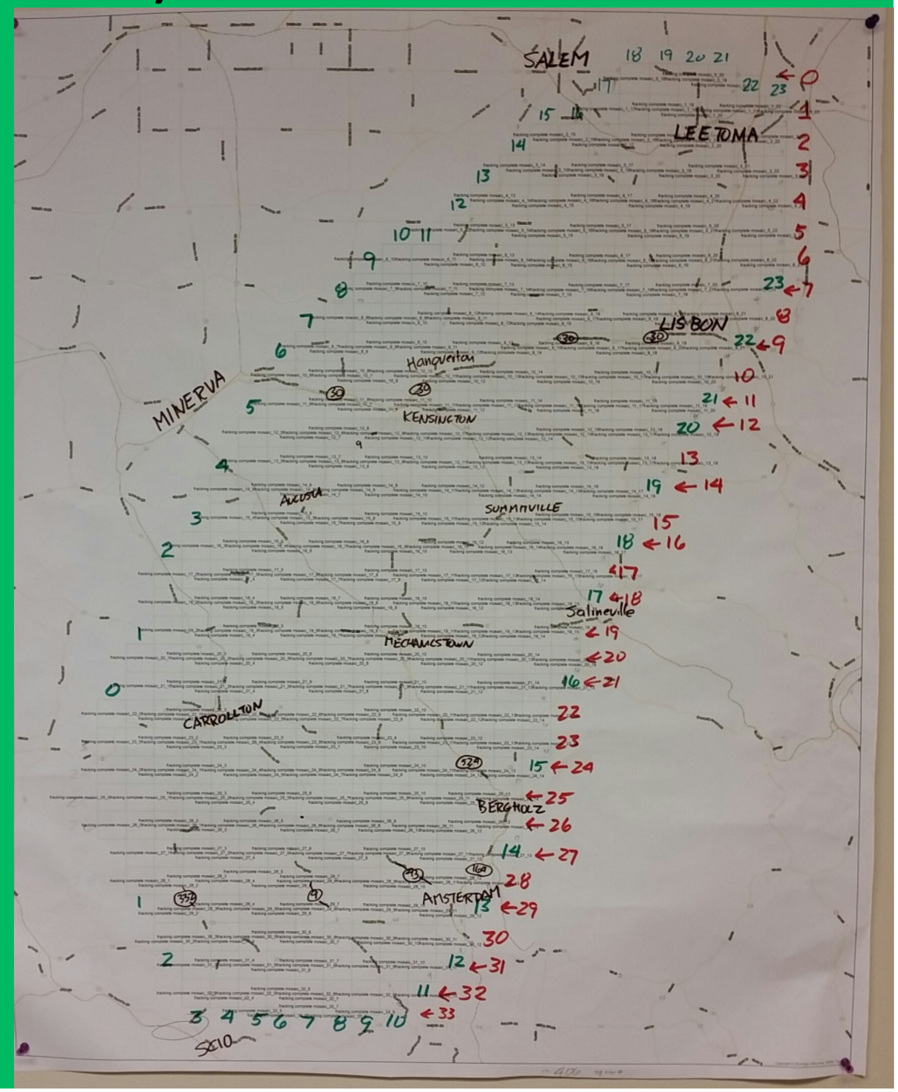
- 306 unique pipeline segments – average length of 3.5 miles ± 4.6 miles; range of 0.26-47.64 miles
  - 1,070 miles of pipelines or 0.93 miles of pipeline per mi^2



What We've Learned from Hoover Grant

- Spring 2014 – 511 mi^2 across Columbiana, Carroll, and Stark (30*30 cm resolution)



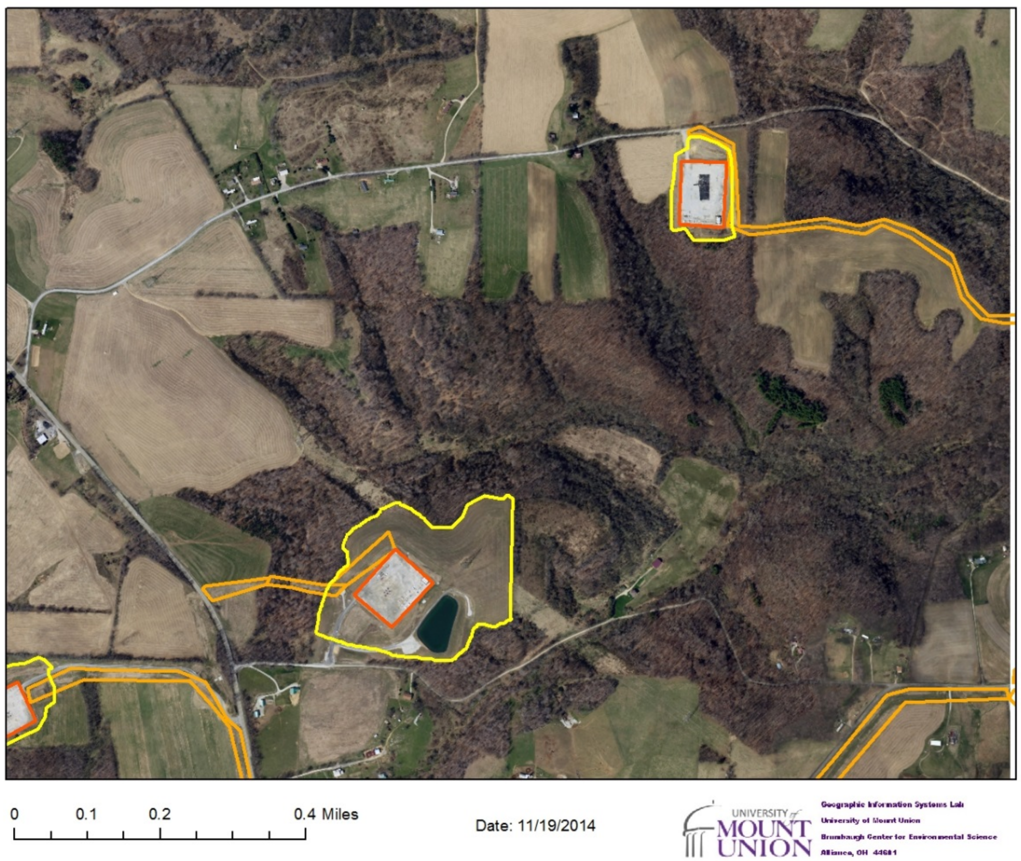


What We've Learned from Mt. Union/Hoover Grant

- 122 Well Pads – Averaging 3.3 acres ± 0.36; range between 1.4 and 3.9 acres
- Limits of Disturbance (LOD) – we define this as pad plus disturbed area; 6.92 acres ± 1.76; range of 3.62-15.05
    - 11,324 acres; 5,751-45,629 acres
    - Land-Use - 2,265 ac. forest; 4,076 ac. crops; 2,717 ac. pasture; 906 ac. grassland

What We've Learned from Hoover Grant

- 630 miles of new pipelines – average width of 42 feet ± 14.1 feet; 2,148 acres of disturbance
- Total footprint excluding roads and retention ponds – 3,399 acres with the ratio of pipelines to well pads being 5.29:1



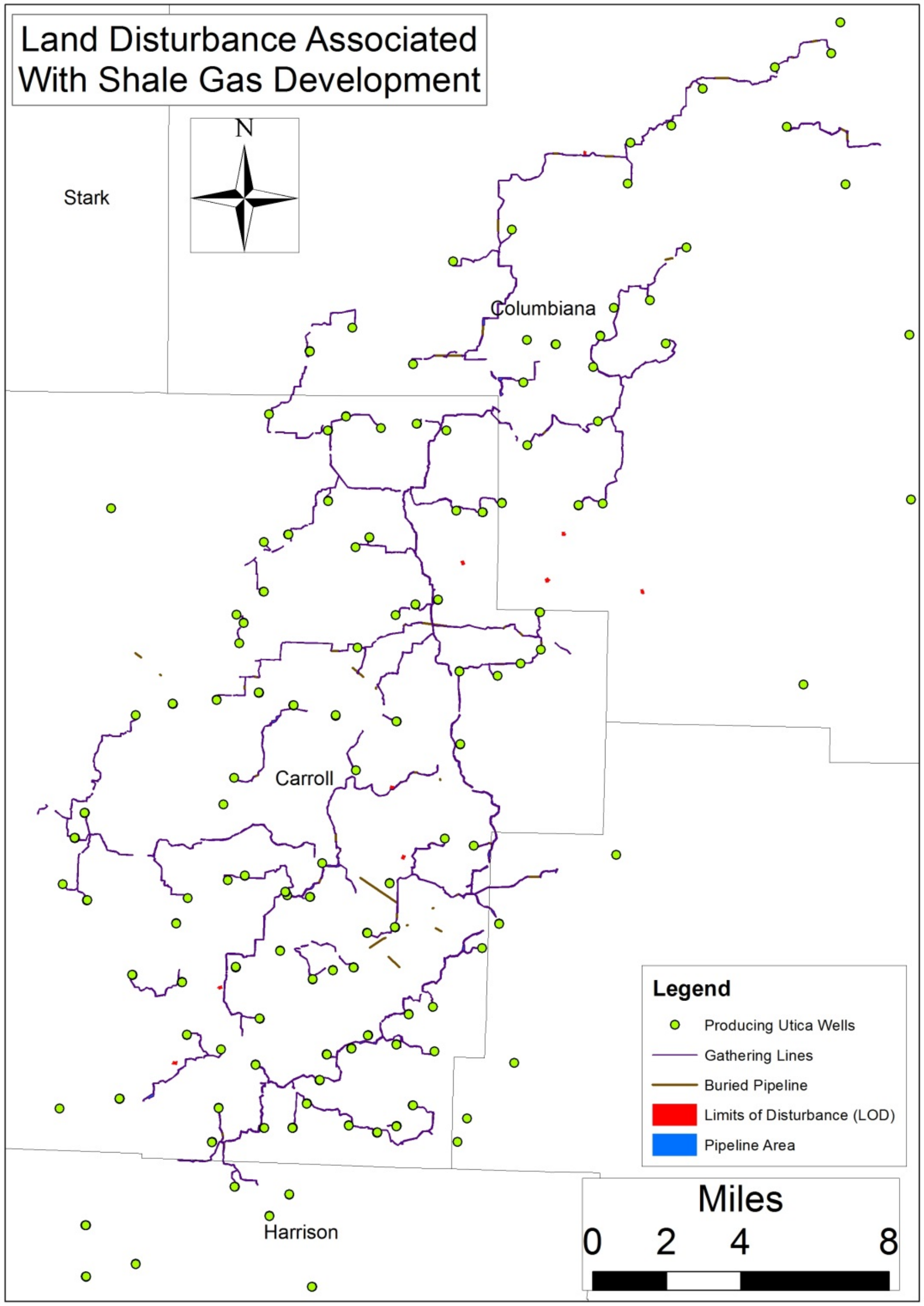
What We've Learned from Hoover Grant

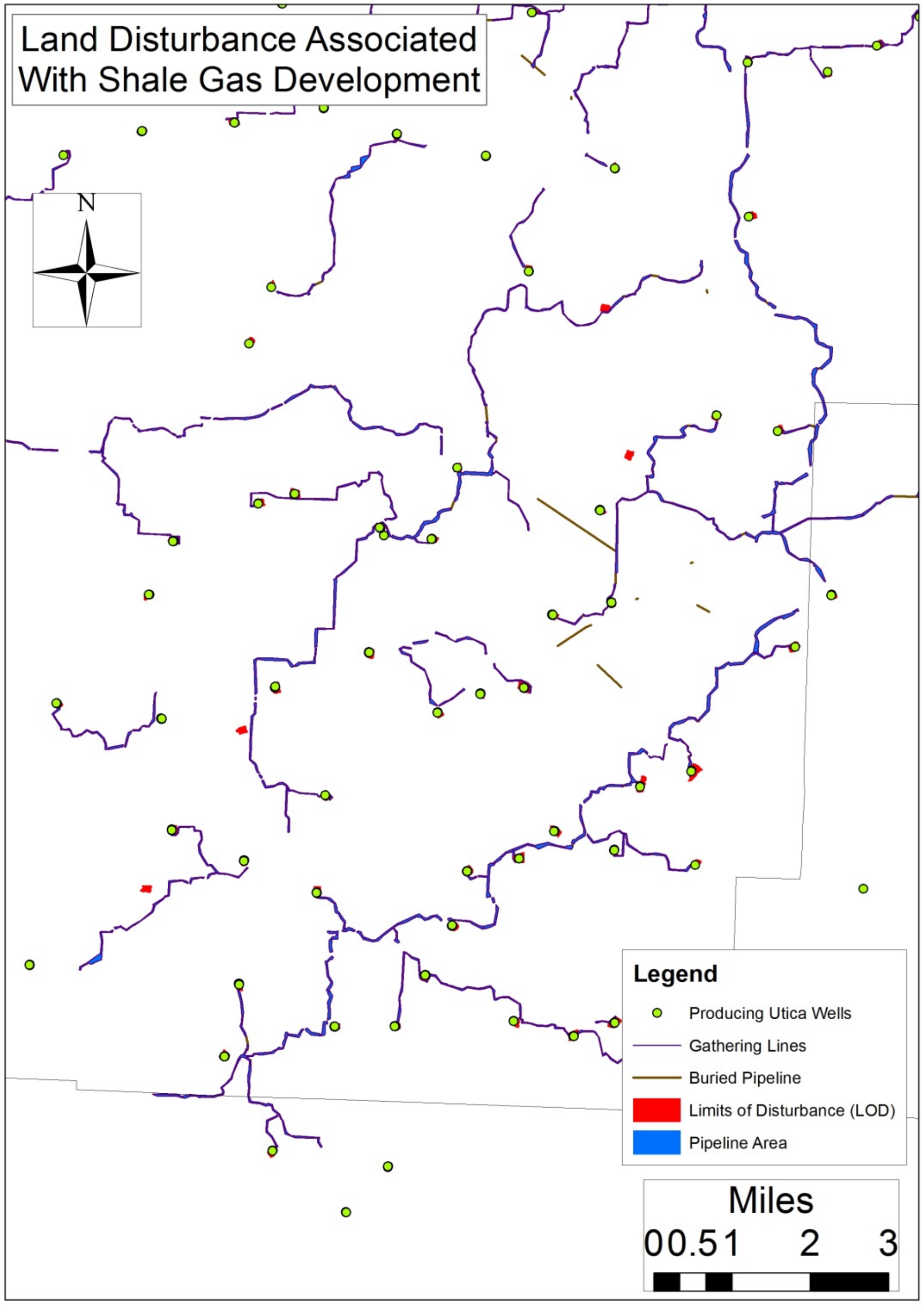
- We have documented 210 unique buried pipelines totaling 13.3 miles (avg. 333 feet; 25-3,566 feet)
- 412 pipelines averaging 5.2 acres of disturbance and totaling 2,148 acres (0.2-86.8 acres)

Future Landscape Projections

- 11 County Core Utica Region – 20-30% of landscape will have been altered by shale gas activity
- 23 County Expanded Utica Region – 10-15% of landscape

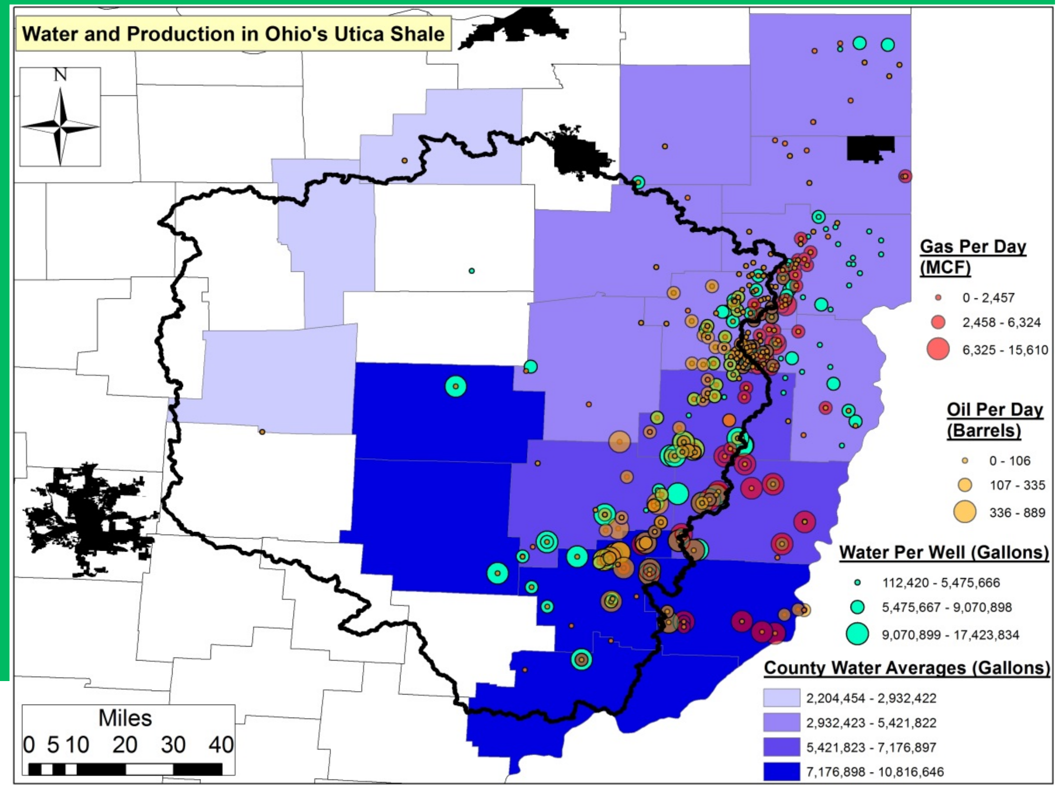
What We've Learned from Hoover Grant

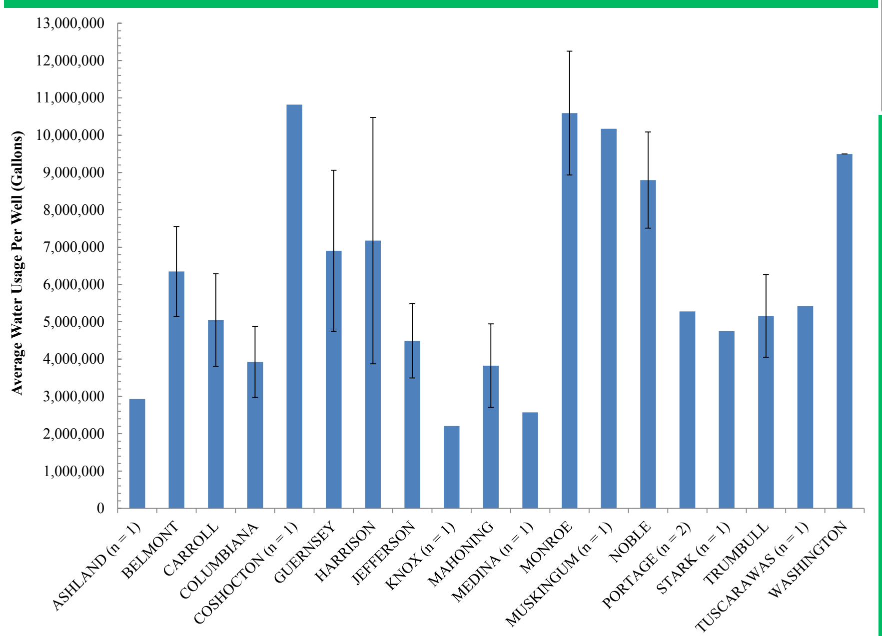


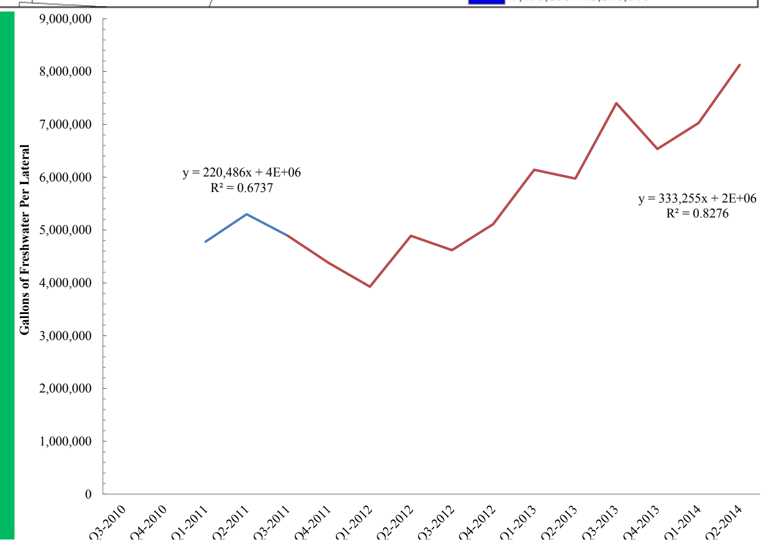


Resource Utilization - Water

- As laterals get longer (i.e., 50-55 feet per lateral per quarter) water, sand, and chemical needs expand in parallel

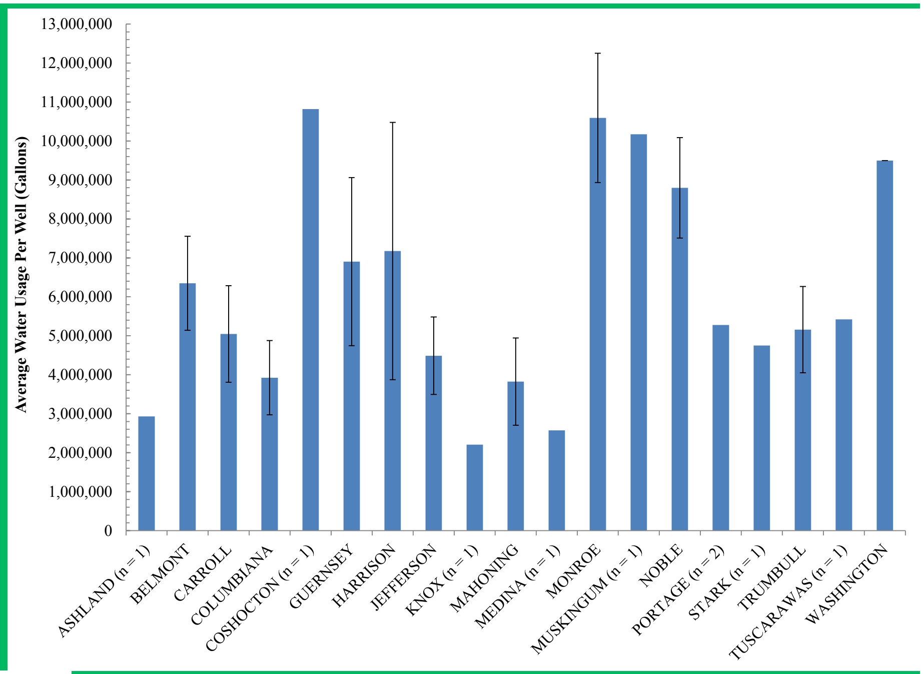


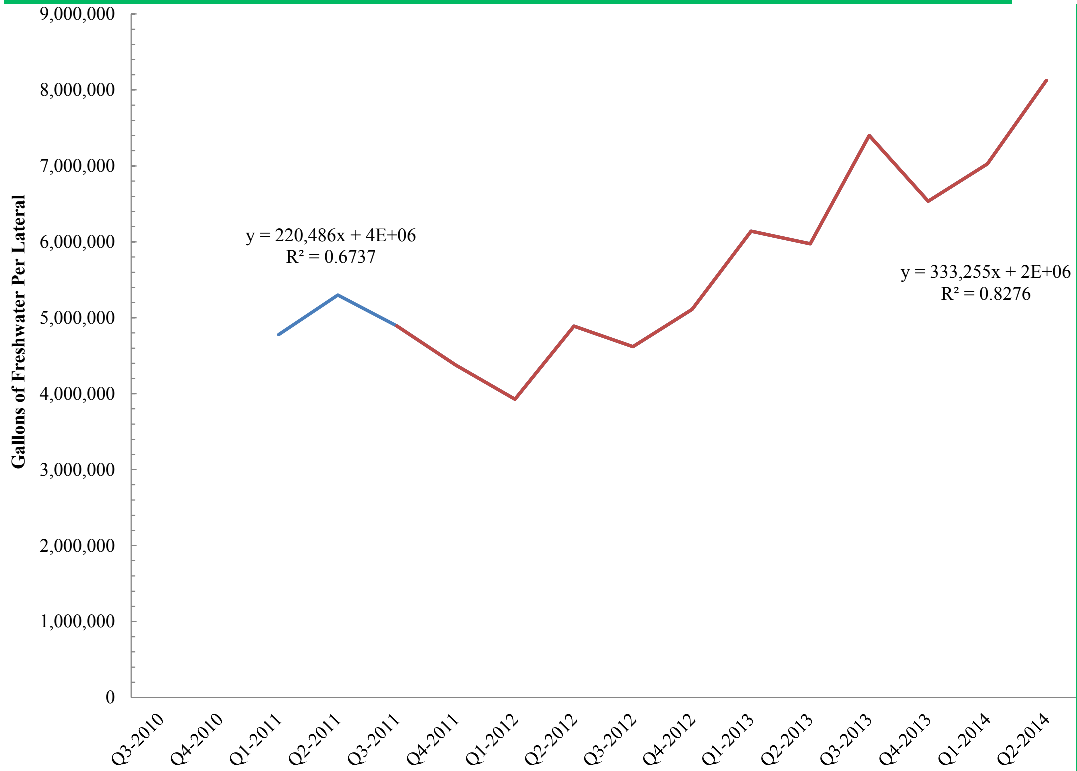




Resource Utilization - Water

- Average Ohio lateral requiring 6.2-7.0 MG
    - WV 6.9-7.6 MG per lateral
- Trend is increasing by 405-411K Per Quarter Per Year
    - WV 450K Per Quarter Per Year



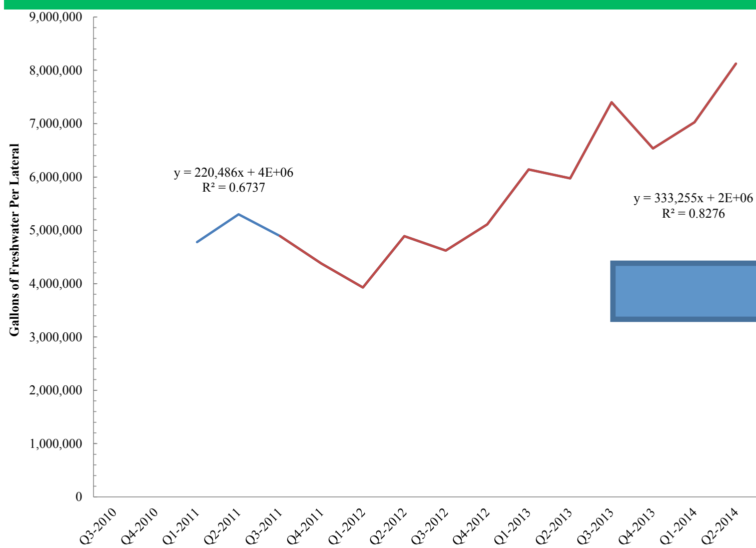


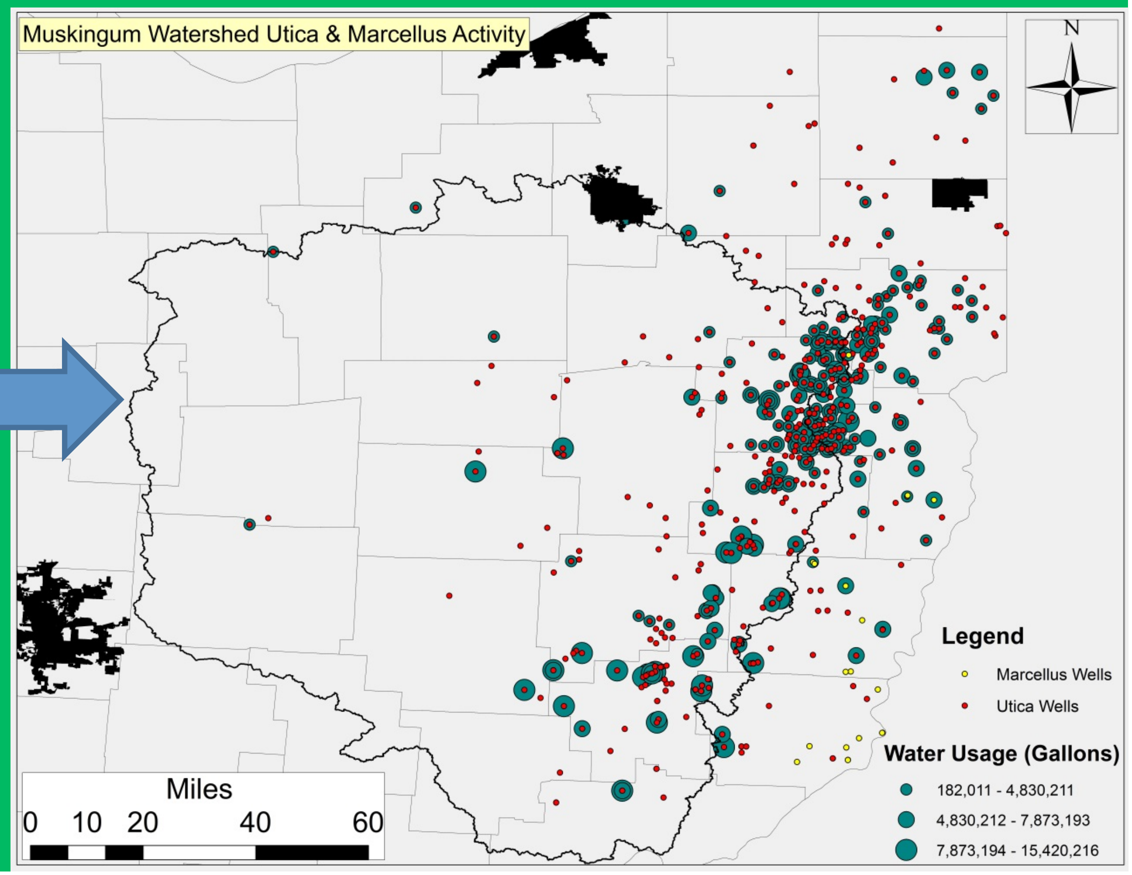
Future Watershed Ramifications

- Watershed resilience
- MWCD freshwater pricing regimes
- Agricultural needs
- Wildlife Costs

Future Watershed Ramifications: The MWCD Case Study

- Residential Demands & Watershed Resilience
  - Industry has used 4.8-7.7% of the Muskingum River Watershed's "available water"
  - Roughly 11-18% of annual residential water demands
- One Year From Now
  - 10.8% of "available water"
  - 25% of residential water demands
    - 5% more than the critical threshold identified by researchers for any one industry





Future Watershed Ramifications: The MWCD Case Study

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  - 25% of residential water demands
    - 5% more than the critical threshold identified by researchers for any one in

"adopting **a precautionary principle setting 20% of the natural runoff in a region as the upper limit of human consumptive use**, where "natural runoff" is defined as the sum of the observed runoff plus the human consumptive use that has reduced runoff below the value it had in the absence of such use. This precautionary limitation in effect defines an environmental flow requirement...Accordingly, human consumptive use that does not leave at least 80% of the natural runoff in a region available for reuse is deemed to pose a serious risk to the health of ecosystems served by the runoff...This limit of 20% on consumptive use is provisional, as is the case for any application of the precautionary principle, but it should be noted that **more than 20% of a natural runoff may be withdrawn, so long as the resulting consumptive use remains below 20% of the natural flow.**"

Special Section: VZJ Anniversary Issue

Garrison Sposito*

Green Water and Global Food Security

It is widely understood that crop production must increase at least twice as fast as human population growth during the coming 40 yr to meet global food demand. Tested strategies for achieving this goal have not yet emerged, but some stipulations to guide in the search for them can be made. Adverse ecological impacts of land conversion to agricultural use and freshwater withdrawals for irrigation will strongly limit the viability of these two traditional approaches to increasing crop production, whereas abundant opportunity exists for optimizing soil water availability to and consumption by rainfed crops to increase their yields by twofold or more. This optimization, however, will require major campaigns in multidisciplinary basic research on positive plant–soil feedbacks that increase crop biomass by influencing the rhizosphere, through which 40% of the global freshwater flow passes annually.

But if the soil breathes steaming vapors out,
Drinks moisture in, and when it wants to, breathes
The moisture out again, and if it's always
Green with the greenness of its grasses and
Never corrodes the blade of the plow with rust,
Then that's the place to drape your flourishing vines
Upon your elms, the place that will produce
Rich olive oil, the place (as the tilling will show)
That makes the plowing easy for the beasts
Because the soil is easy for the plow.

—Publius Vergilius Maro (Virgil), Georgics, Book II (Ferry, 2005)

To ensure global food security, crop production must outpace human population growth significantly during the next 40 yr. This review makes the case that this challenge can largely be met by optimizing the management of "green water" (soil water directly available to plant roots), an often overlooked resource whose annual global flow in fact matches that of all the rivers in the world flowing to the sea.

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Open Access

Despite a decline in growth rate by almost half during the past 40 yr, estimates of the global human population place it at 8 billion in 2024, with more than 9 billion expected by 2050 (Roberts, 2011; Tilman et al., 2011). This latter figure represents an increase of the current world population by about 30%, but the corresponding percentage change in food crop production to meet projected world demand will be much larger because it is driven by not only population growth but also personal income growth (Kearney, 2010; Tilman et al., 2011). Current analyses indicate that, to accommodate both of these upward socioeconomic trends, food crop production has to increase by 50 to 100% during the next 40 yr. That is, it must at least double the percentage change in population (de Fraiture et al., 2009; Hanjra and Qureshi, 2010; Gregory and George, 2011; Tilman et al., 2011). Moreover, as will emerge from arguments to be made in the next section, this large relative increase in food crop production will have to come mainly from increasing crop yield per hectare planted—crop intensification—not from converting more land to agricultural use. The challenge posed becomes even more daunting when considered in light of the evident stagnation or even decline in food crop yield increases over the past decade along with the dramatically increasing competition for resources from nonfood crops, particularly biofuels (Hanjra and Qureshi, 2010; Foley et al., 2011; Gregory and George, 2011).

Framing the Challenge: Constraints

One useful way to approach a challenging problem is to establish the conditions under which any viable solution of it must operate. For the problem of determining ways to increase food crop production sufficiently to meet global demand, the results of recent detailed studies of land and water use worldwide, along with their ecological impacts, lead to three constraints that, in all likelihood, will narrow the range of possible alternatives. One of these constraints limits land conversion, as noted above; another limits agricultural water withdrawals, while the third one reveals a key facet of the consumptive use of water by croplands.

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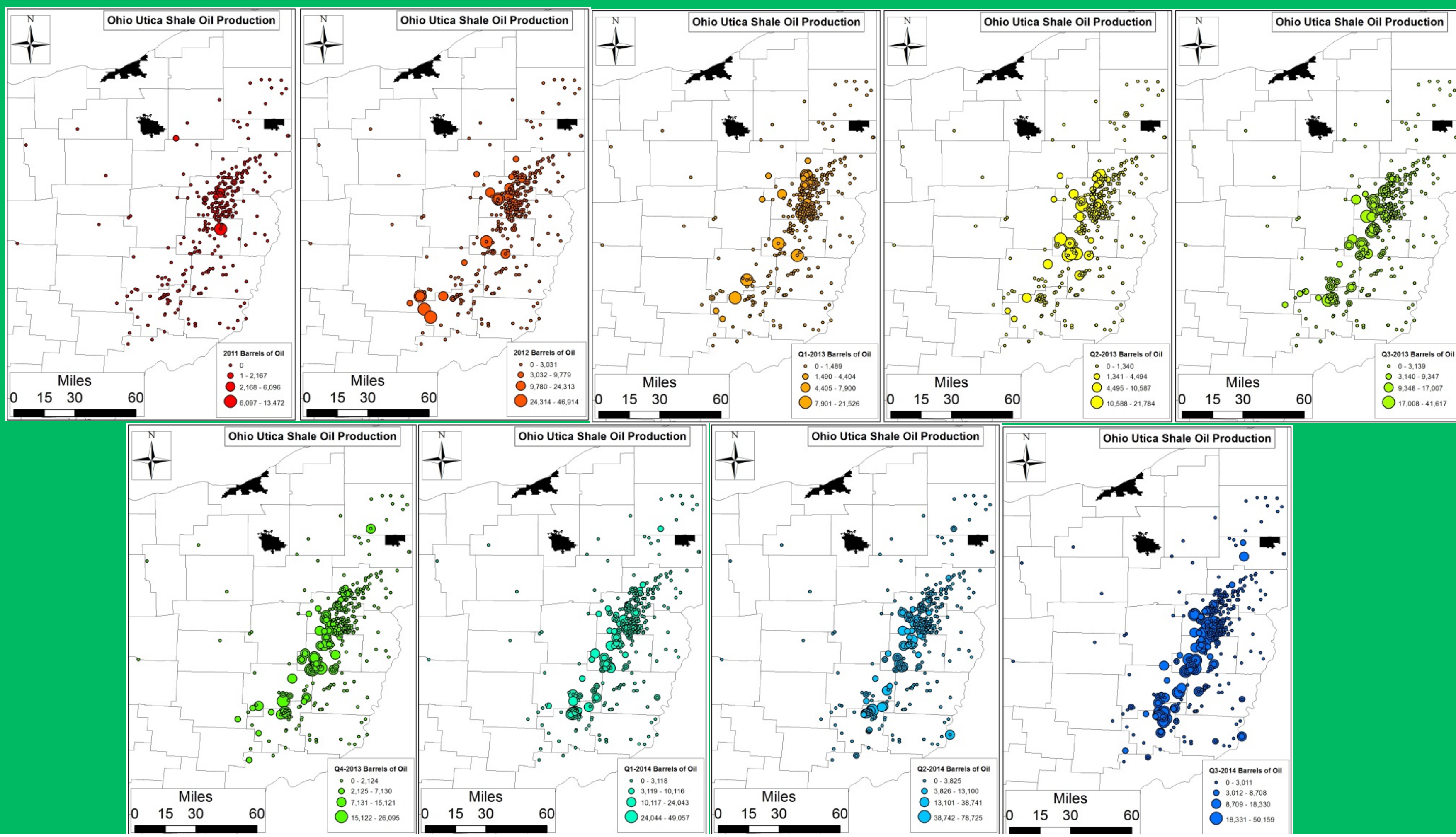
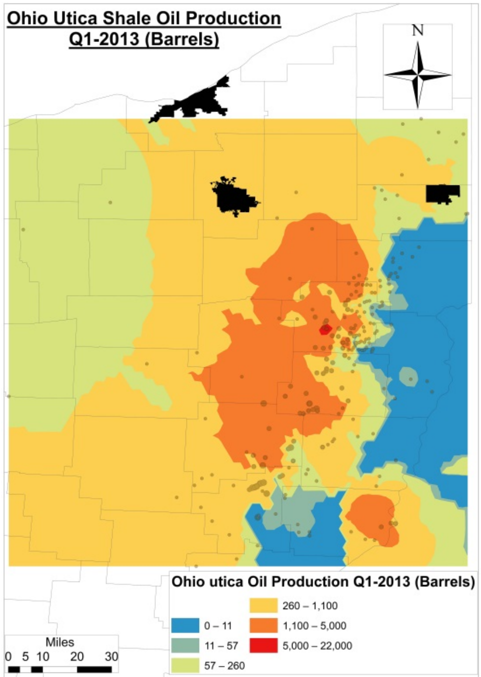
Production

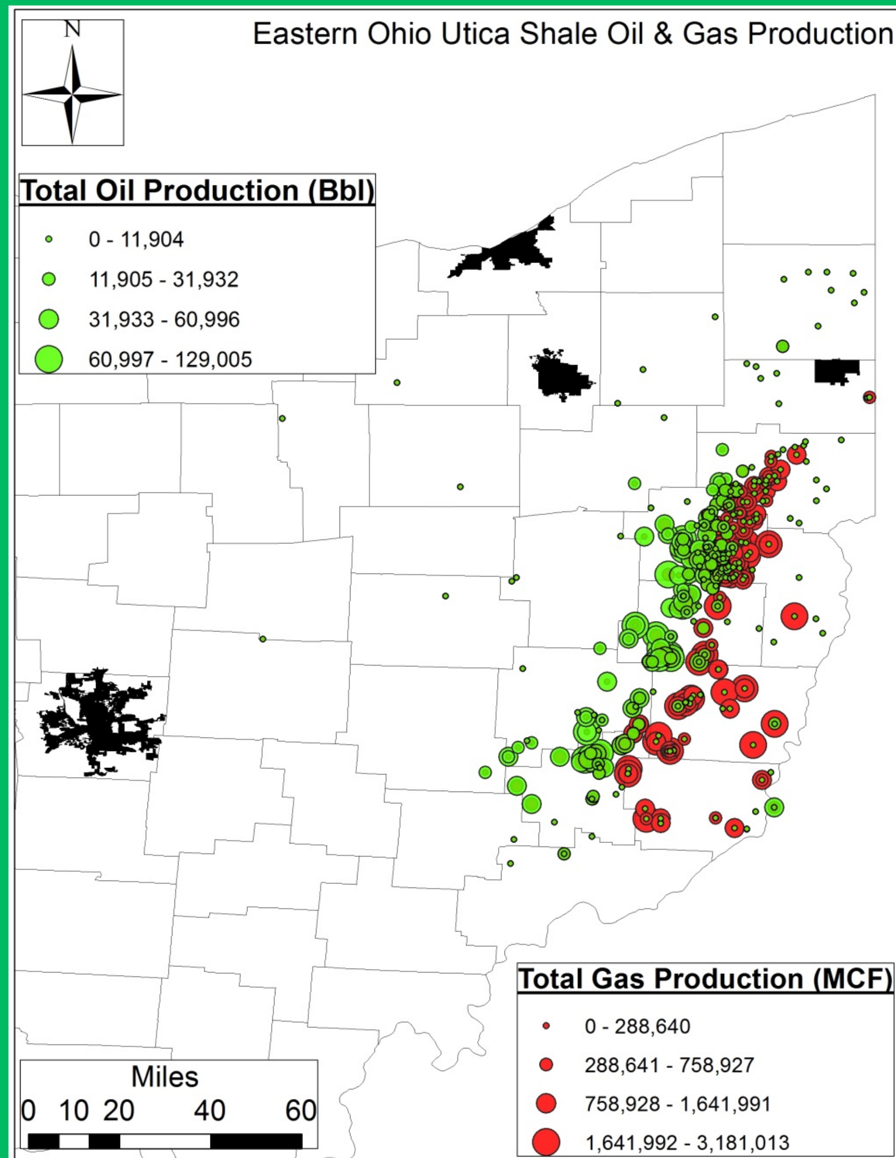
- As laterals get longer (i.e., 50-55 feet per lateral per quarter) water, sand, and chemical needs expand in parallel
  - Total Production Increasing But Per Well Production Decreasing



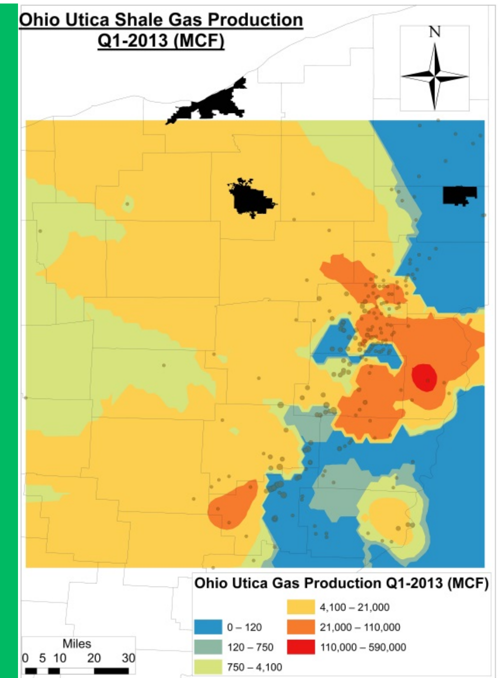
Production



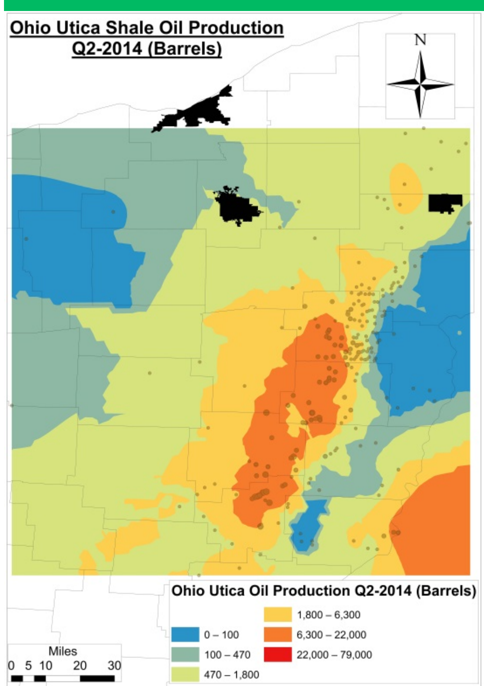
Ohio Utica Shale Oil Production
Q1-2013 (Barrels)
N
Ohio utica Oil Production Q1-2013 (Barrels)
0 – 11
11 – 57
57 – 260
260 – 1,100
1,100 – 5,000
5,000 – 22,000
Miles
0 5 10 20 30



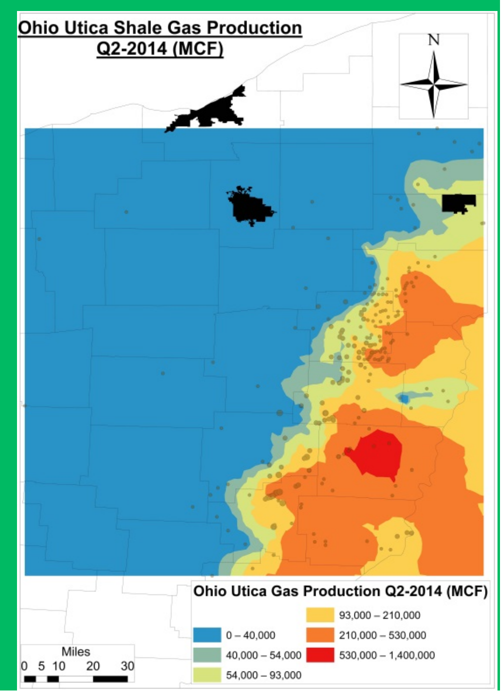
Eastern Ohio Utica Shale Oil & Gas Production
N
Total Oil Production (Bbl)
0 - 11,904
11,905 - 31,932
31,933 - 60,996
60,997 - 129,005
Total Gas Production (MCF)
0 - 288,640
288,641 - 758,927
758,928 - 1,641,991
1,641,992 - 3,181,013
Miles
0 10 20 40 60



Ohio Utica Shale Gas Production
Q1-2013 (MCF)
N
Ohio Utica Gas Production Q1-2013 (MCF)
0 – 120
120 – 750
750 – 4,100
4,100 – 21,000
21,000 – 110,000
110,000 – 590,000
Miles
0 5 10 20 30



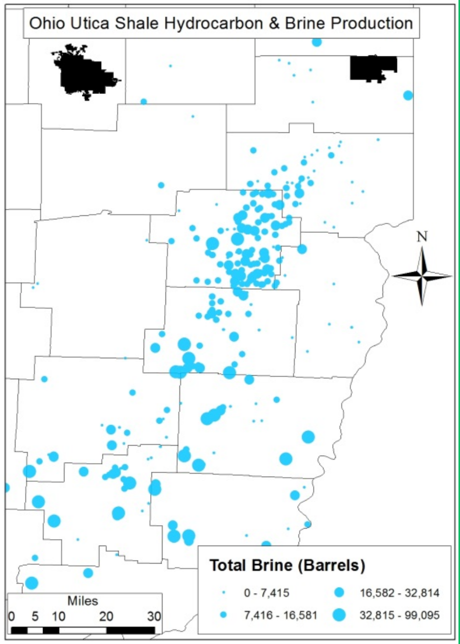
Ohio Utica Shale Oil Production
Q2-2014 (Barrels)
N
Ohio Utica Oil Production Q2-2014 (Barrels)
0 – 100
100 – 470
470 – 1,800
1,800 – 6,300
6,300 – 22,000
22,000 – 79,000
Miles
0 5 10 20 30

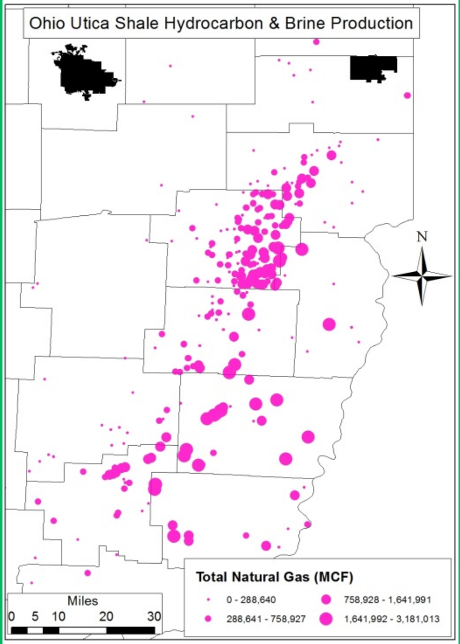


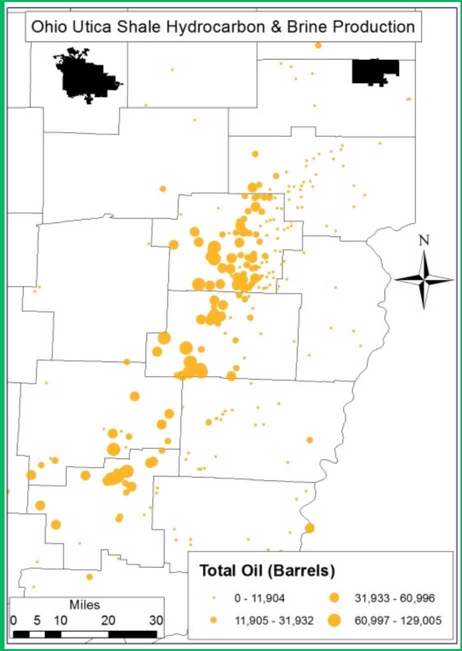
Ohio Utica Shale Gas Production
Q2-2014 (MCF)
N
Ohio Utica Gas Production Q2-2014 (MCF)
0 – 40,000
40,000 – 54,000
54,000 – 93,000
93,000 – 210,000
210,000 – 530,000
530,000 – 1,400,000
Miles
0 5 10 20 30

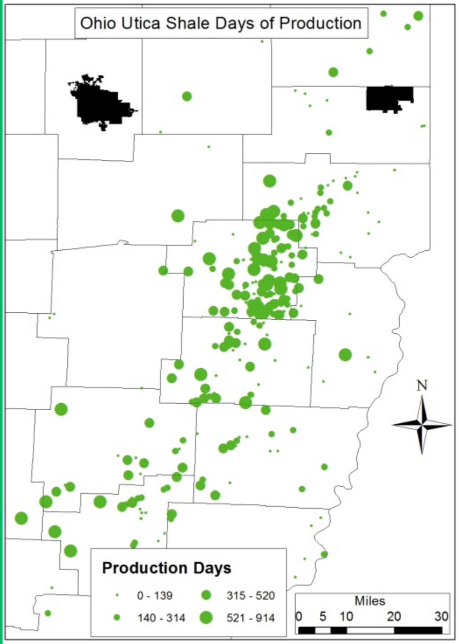
Production

- As laterals get longer (i.e., 50-55 feet per lateral per quarter) water, sand, and chemical needs expand in parallel
  - Total Production Increasing But Per Well Production Decreasing





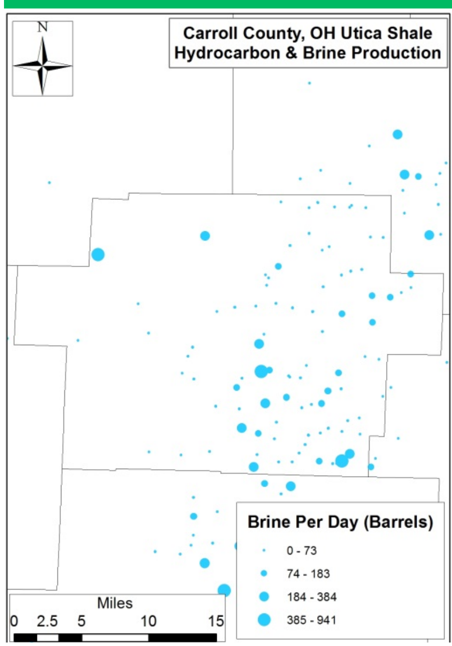


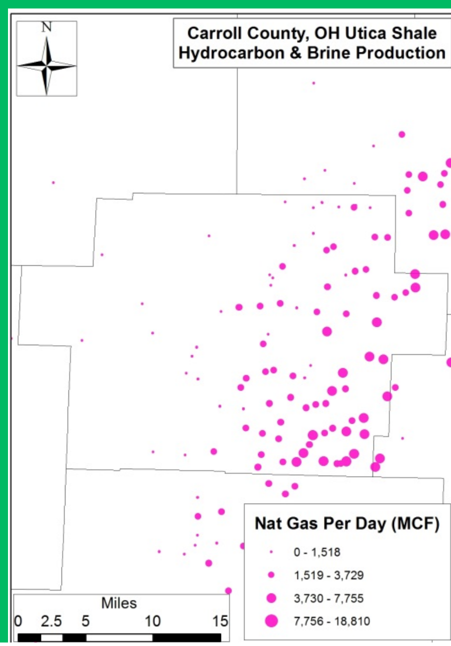


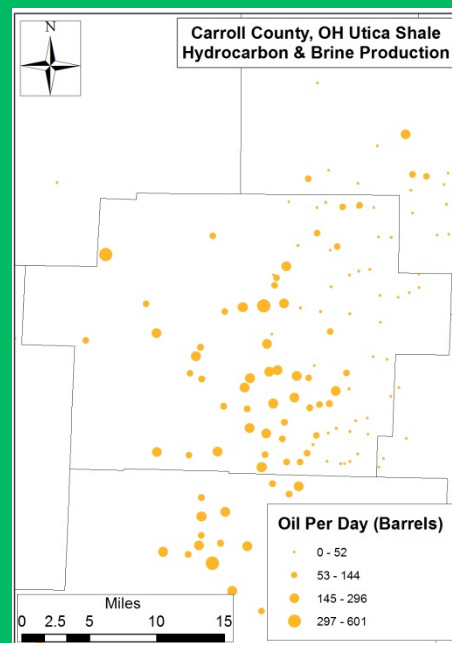
- 1st to 2nd Year Declines of 84% on a per day basis
  - Followed by 27% declines for oil and 10% for gas
    - Freshwater usage is increasing by 3.6 gallons of water per gallon of oil
- 2011 Vs Present
  - Oil – 2011 declines by 2.63 BPD Vs Present 21-48 BPD
  - Nat Gas – 2011 declines by 118 MCF Vs Present 125-251 MCF (Note: 2011 wells 3,158)

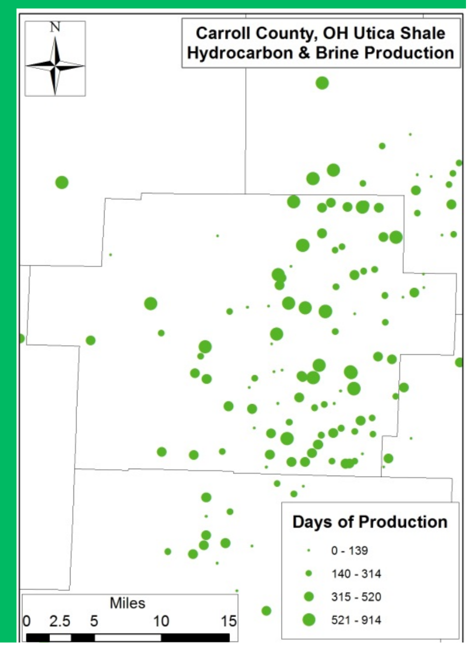
Carroll County Production

	----------Carroll (312)----------			----------Rest of State (409)----------		
Variable	Max	Sum	Mean	Max	Sum	Mean
Total Days	914	91,193	**292±188**	898	78,430	192±177
Oil (Barrels)						
Per Day	453	23,190	74±73	601	39,109	**96±122**
Total	83,098	4,838,147	15,507	129,005	6,523,185	**15,949**
Gas (MCF)						
Per Day	6,774	672,391	2,155±1,264	18,810	1,360,923	**3,327±3,477**
Total	2,196,240	168,739,064	**540,830**	3,181,013	215,706,401	527,400
Brine (Barrels)						
Per Day	941	18,516	59±87	810	40,839	**100±120**
Total	36,917	3,105,260	9,953	99,095	4,669,870	**11,418**



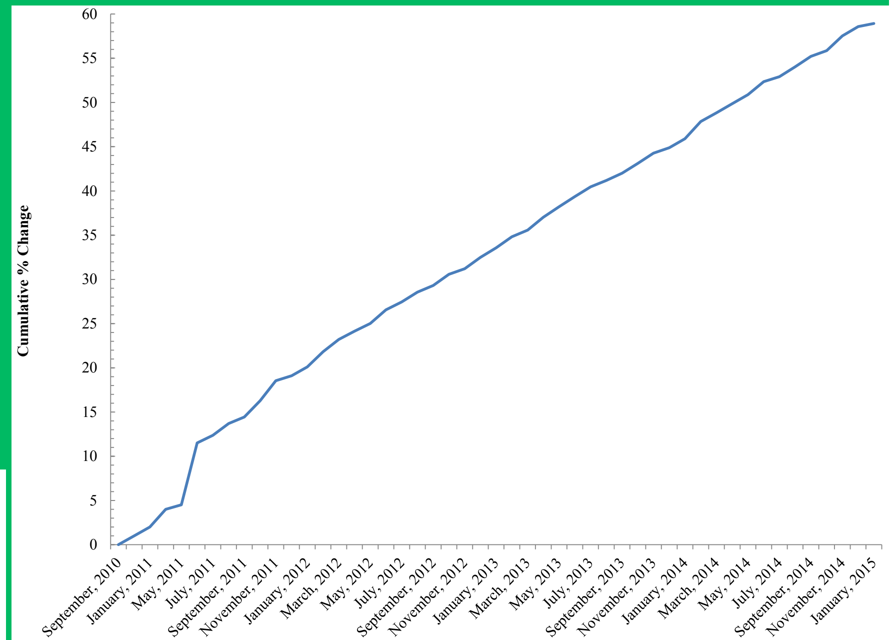


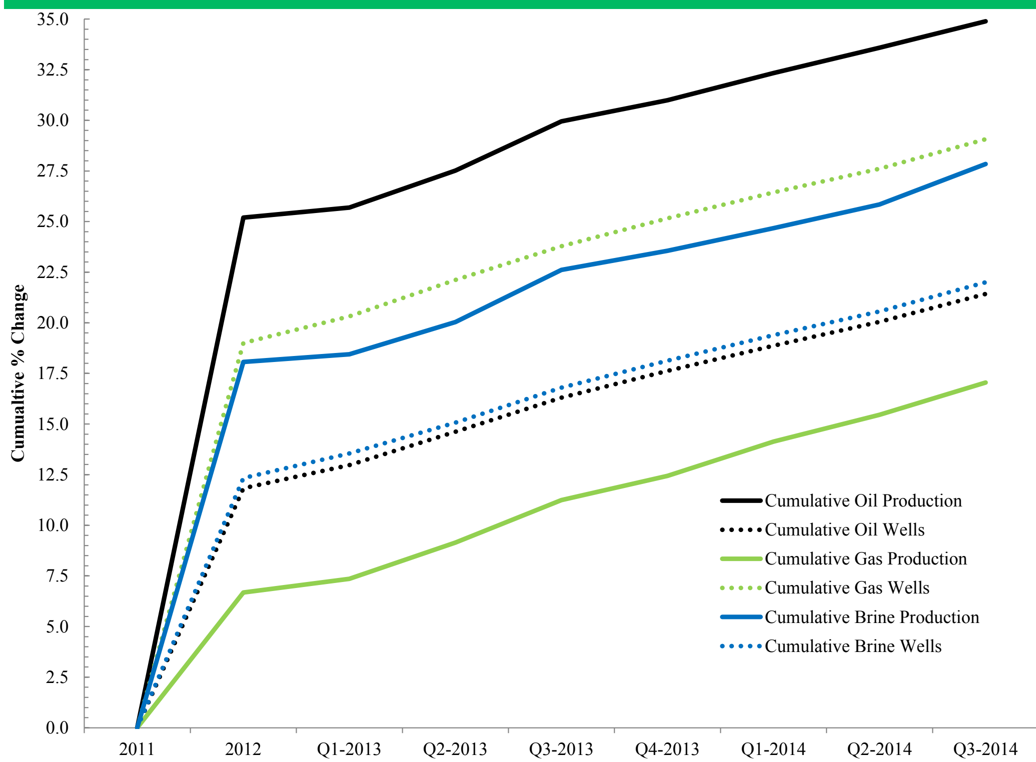




Production

- Total Production Increasing But Per Well Production Decreasing
    - Red Queen Hypothesis
  - Oil Production = 349%
  - Gas = 171%
  - Brine = 278%
  - Permitting = 589%
    - Producing roughly 88% of drilled/drilling wells

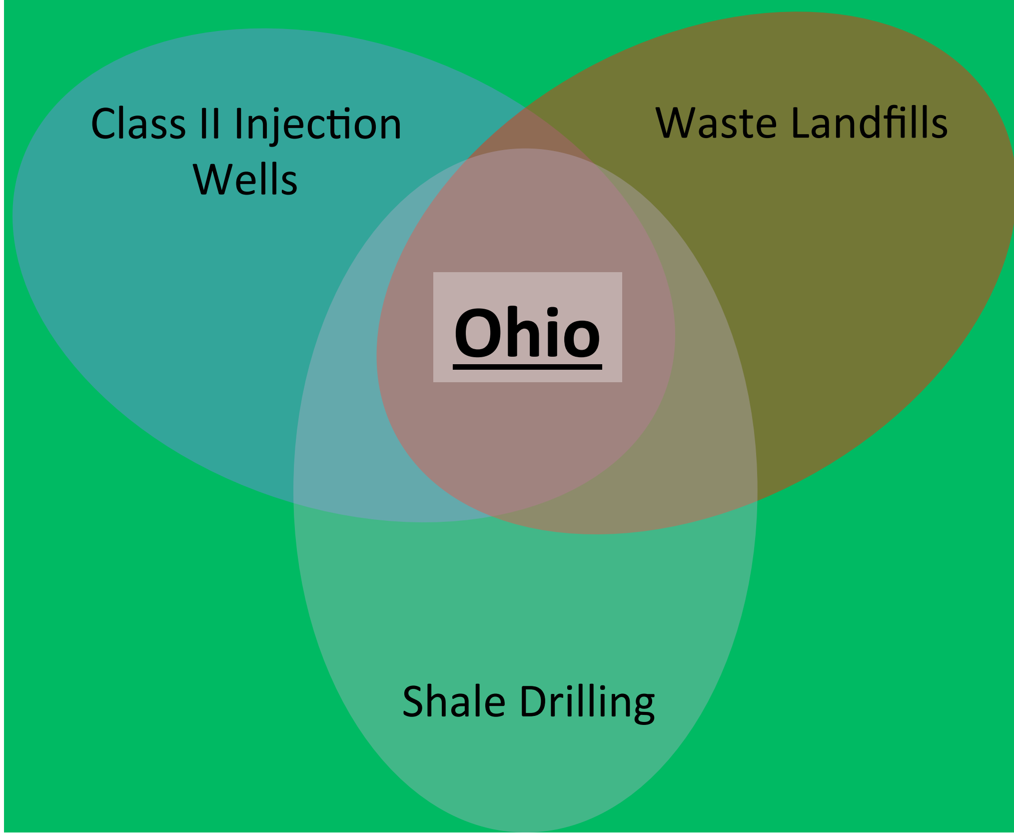


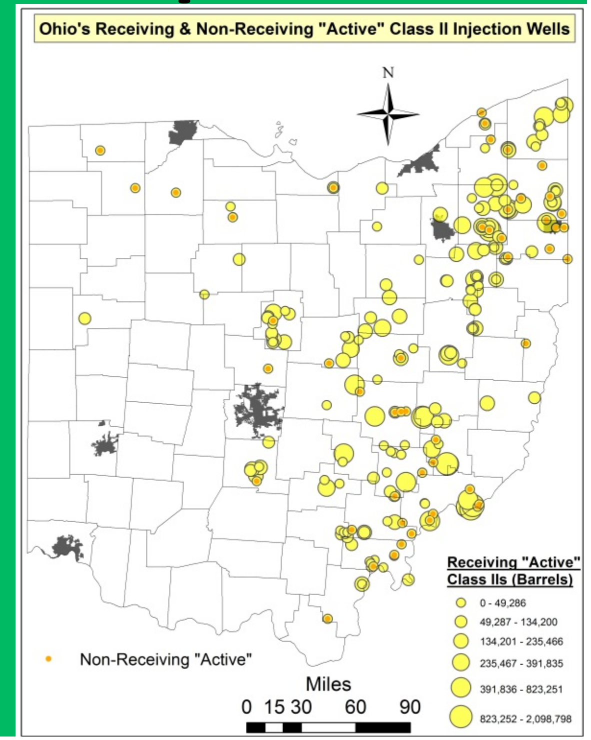


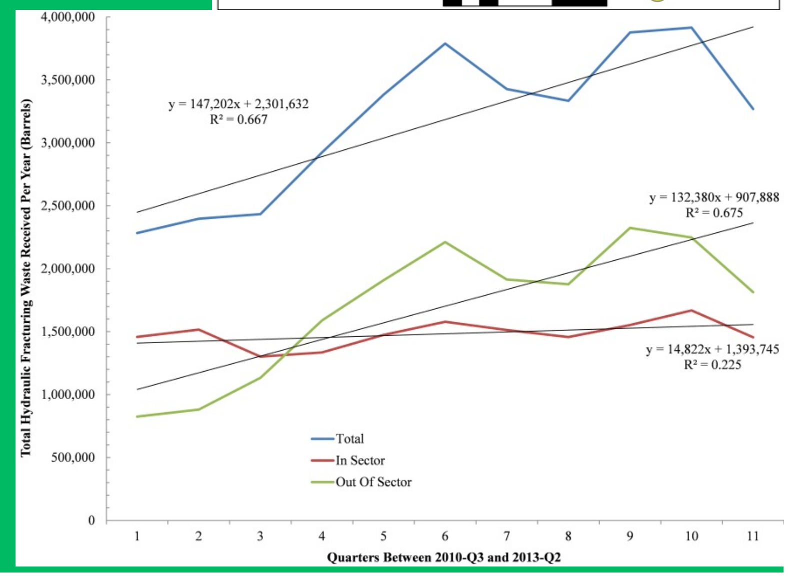
- Tax Revenue Potential
  - 0.5-0.8% = 35 years to $4.6 billion proposed for 2020
  - 1-4% = 21 years....
  - 5-7% = 11 years
- 11-25% required to generate 2020 tax revenue

Where waste is going & Ohio's Uniqueness

- Ohio at unique point in the middle of the Shale Drilling Venn Diagram
    - Plus Proximity to Pennsylvania and West Virginia

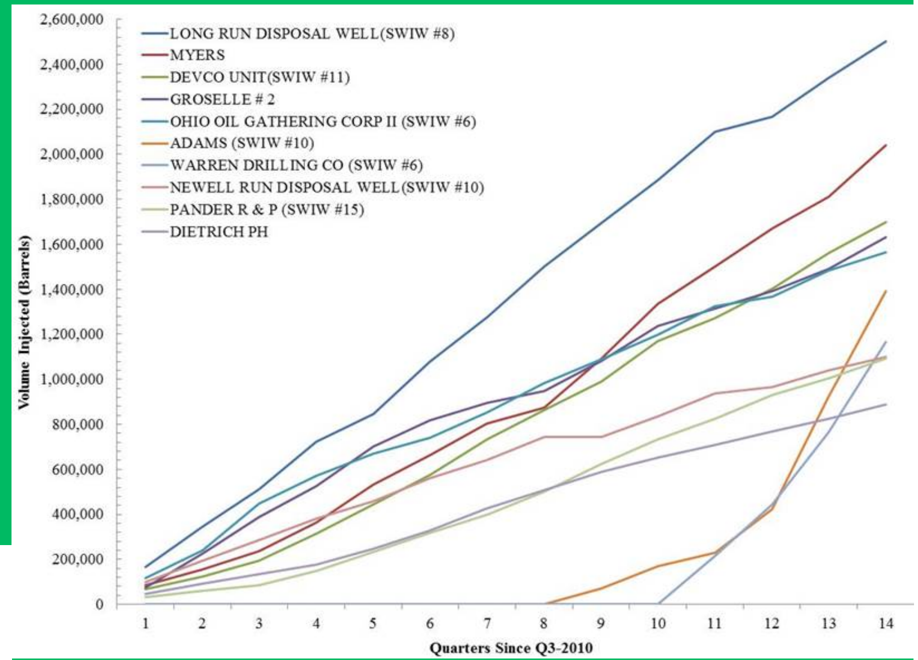


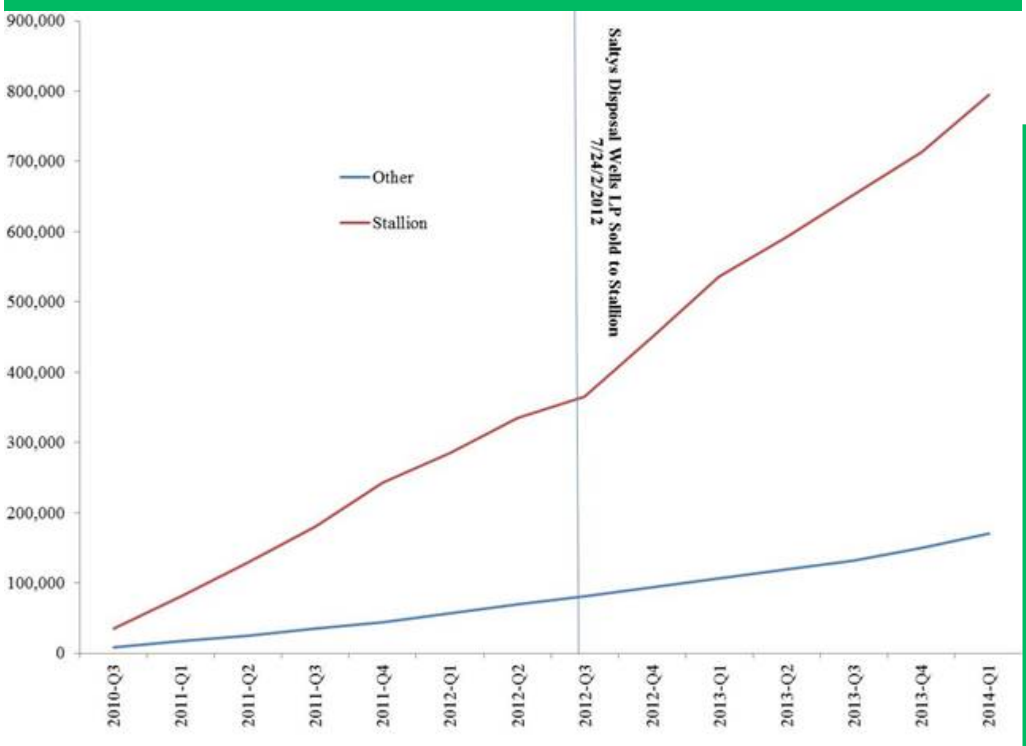




Where waste is going & Ohio's Uniqueness

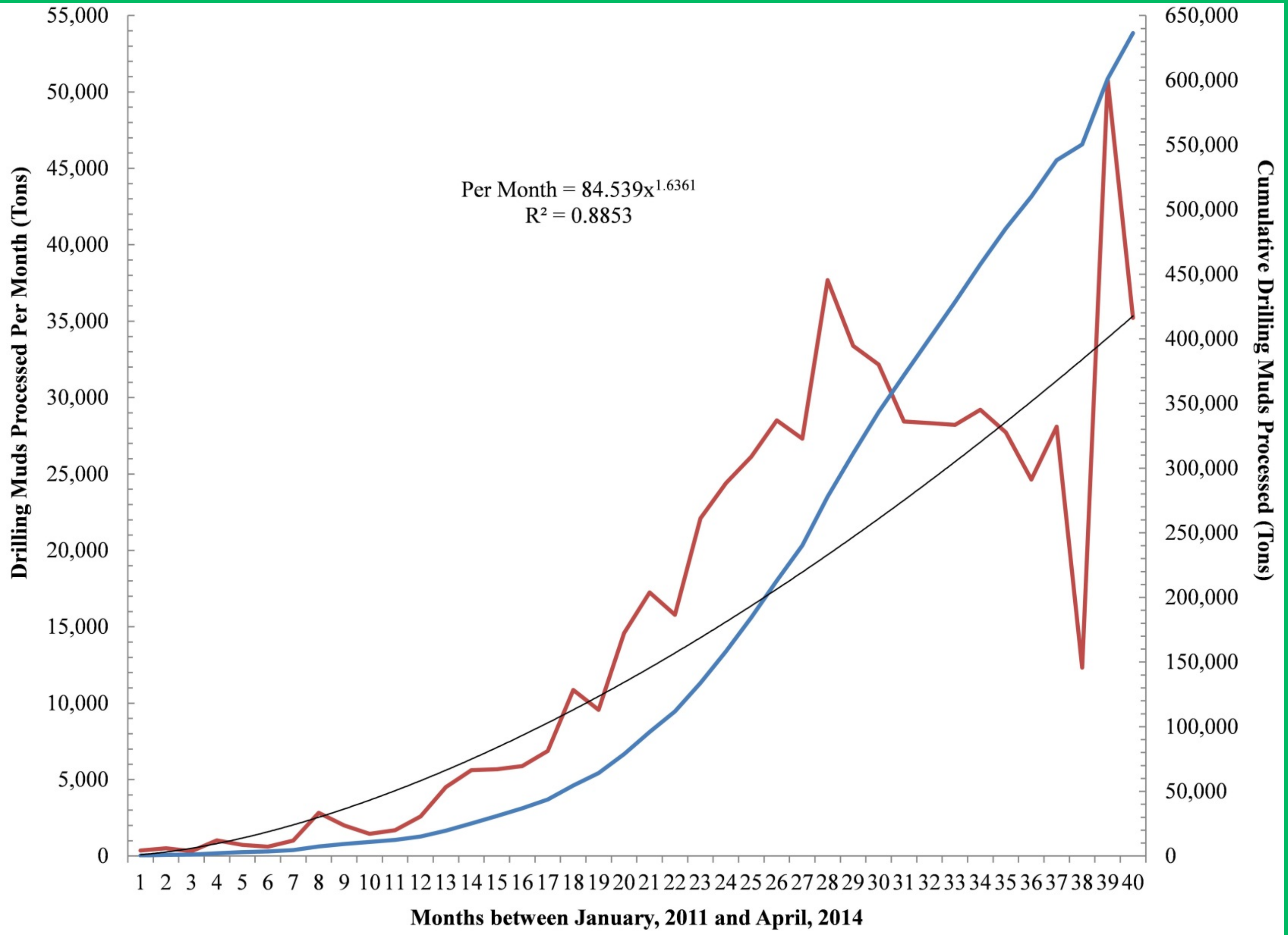
- Class II Injection Wells
  - Significantly varies by area and ownership
  - 117 Million Gallons Per Well; +5.4 Million Gallons Per Well





Where waste is going & Ohio's Uniqueness

- Drill Cuttings and Southeast Ohio
  - Very little data to work with but for Columbiana-Carroll-Harrison SWD and Barb Walton
  - 28,098 Tons Per Facility; +15,319 Tons Per Facility
  - Drill Cuttings averaging 600-720 tons per lateral; + 4.7-5.2 tons per lateral per quarter



What the data says

Variable	Avg	Increase Per Quarter
Lateral Length (ft)	6,440-6,380	+ 50-55 feet
Drill Cuttings (Tons)	608	4.7-5.2
Landfill Drilling Muds (Tons Per Facility)	28,098	15,319
Water Usage (Gallons)*		
OH**	6.2-7.0 MGs	405-410K
% of Residential Demand	11-18%	
% of "Available Water"	5-8% (11% w/in 1 year)	
Gallons Water Per Gallon Oil	16-38	3.6
WV	6.9 MGs	450K
Silica Sand (Tons)	4,303	86
Injection Waste (Gallons Per Quarter)	117 MGs	5.4 MGs
	Total	
Midwest Pipeline Proposals (Miles)	22,127	
Disturbance (mi^2)	118	
Forest (acres)	17,132	
Crops (acres)	30,730	
Hay/Pasture (acres)	20,742	
Grasslands	6,837	

* Encana/Marathon Oil proposing 23-25 MGs laterals in Michigan

** 7-9% returns to surface as brine waste; OH wells producing 1.1-1.3 units of oil per unit of oil

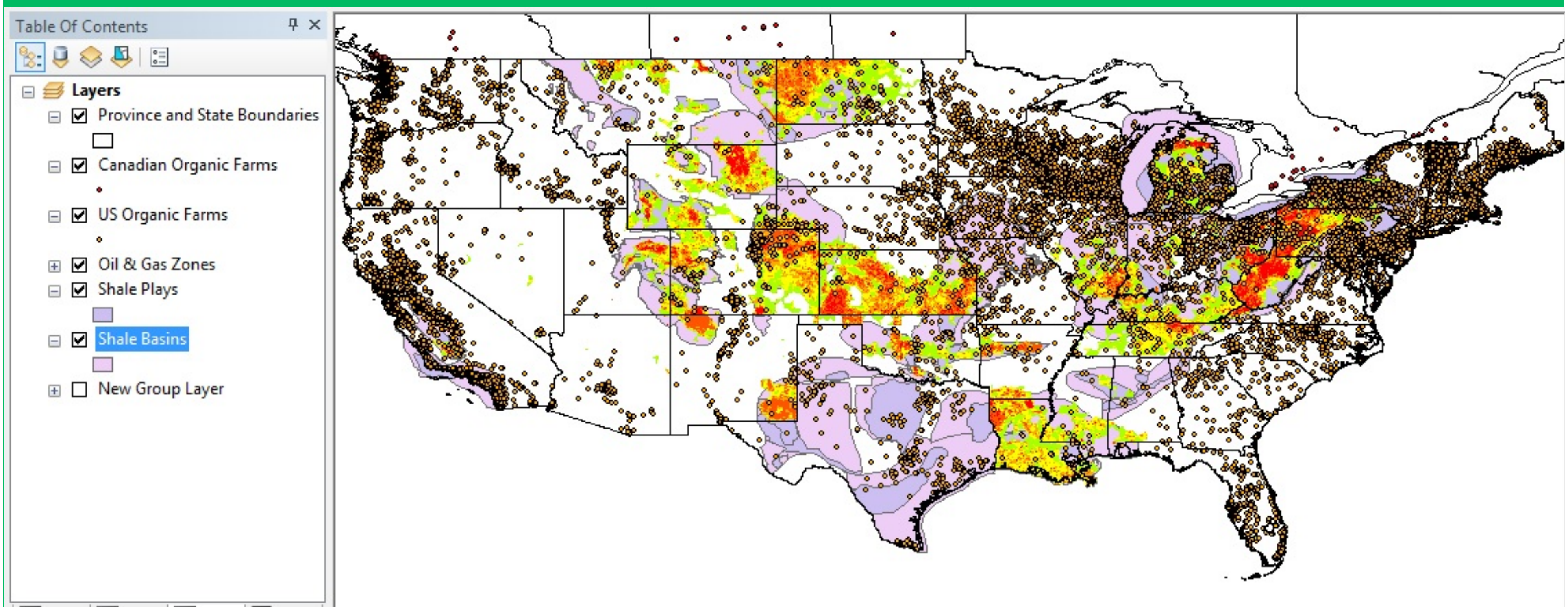
MWCD selling "excess" water to industry for $4.25 per 1,000 gallons; $00.10-00.12 per gallon of injection waste disposed; $3.50 per ton of drilling mud disposed in landfills

Organic Farming-Shale Gas Nexus

- 19,662 Organic Farms in the US and Canada (703 in Ohio (3.6% of Total))
  - 25 in Utica Core (<1 mile)
  - 103 Within Utica Intermediate (1-3 miles)
  - 195 Within Extended Periphery (3-5 miles)
    - 36 within 1 Mile of Injection Wells
    - 96 within 3 Miles of Injection Wells
- Nationally
  - 455 in Shale Gas Core (< 2.5 Miles)
  - 752 in Shale Gas Intermediate (2.5-5 miles)
  - 2,140 in Shale Gas Periphery (5-20 miles) or 11% of North American Organic Farms

Organic Farming-Shale Gas Nexus

- 19,662 Organic Farms in the US and Canada
- Nationally
  - 2,912 Organic Farms in the US Shale Gas Plays (15%)
  - 6,179 Organic Farms in the US Shale Gas Basins (31%)
    - California, 1,334; Colorado 297; Illinois 286; **Indiana 334;** Iowa 239; **Michigan 504;** Missouri 118; **New York 834; Ohio 510; Pennsylvania 449;** Texas 394; Wisconsin 271

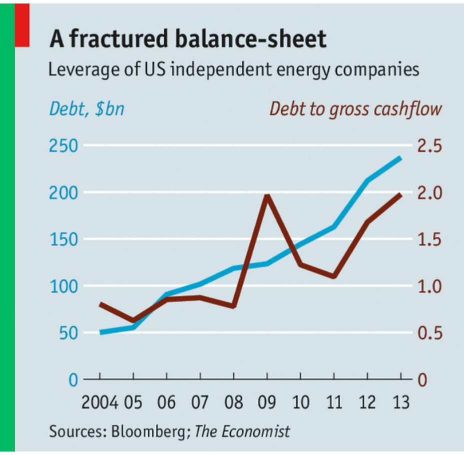


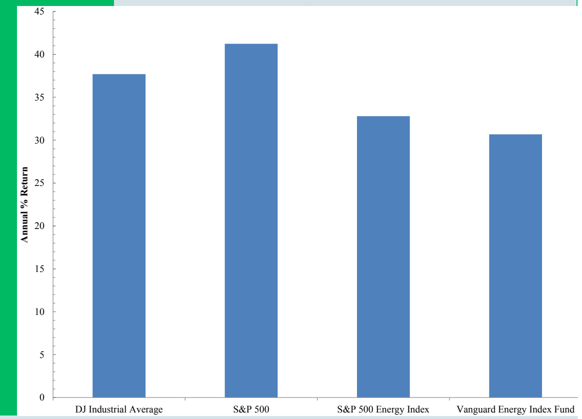
Regional Conclusions

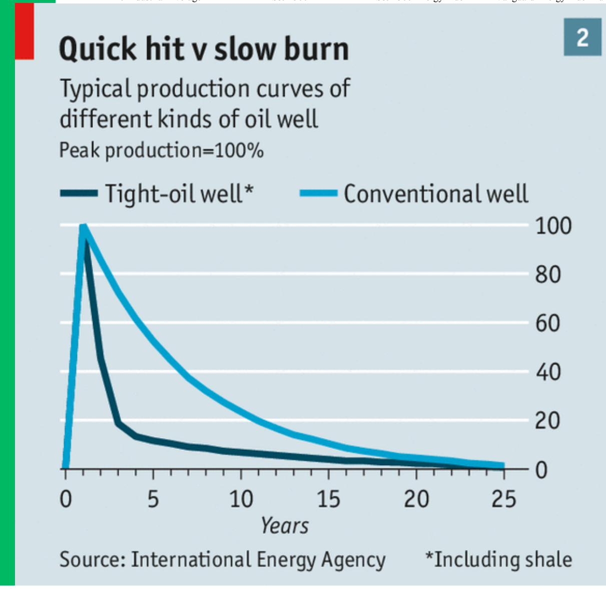
- Build-out of Shale Infrastructure & Resource Utilization:
  - Increases likelihood that "energy independence" was just cover for arbitrage and global export
  - Proposal/Permitting trend dwarfs current inventory and production
  - Increases likelihood of many small environmental/health events many of which will go undocumented
    - Increased environmental/health risk connectivity (Ex. Bradford County)
  - Further fragments landscape and dwarfs land-use/land-cover (LULC) associated with well pads
  - The potential loss of ecosystem services and watershed resilience is nontrivial
    - 1.7 Million Ohioans worth of CO_2 emissions (1.3-3.3 million)
    - Muskingum Watershed rapidly approaching "available water" tipping point with industry requiring more water and sand
      - Mining in northern Great Lakes has hit inflection point
  - Jobs and Economic Boost Ephemeral Vs Landscape Change and Watershed Resilience are permanent

Macro Conclusions

- Leverage – Resolute Energy, American Eagle Energy, Quicksilver Resources
- Shareholder Returns
  - 15 publicly traded Ohio firms have experienced a -4.33% decline in share price since DFP and -1.53% annually
  - Credit ratings plummeting and access to credit non-existent
- Geopolitics – Sheikhs Vs Shale
  - “Geopolitics, Shale Gas, and Pipelines”
- Water Scarcity/Security
- Resource Utilization (i.e. sand mining)

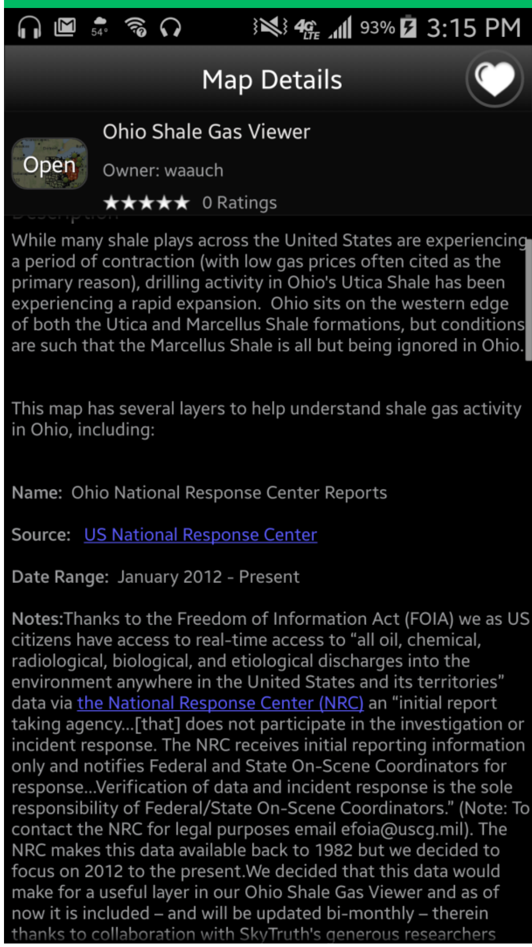


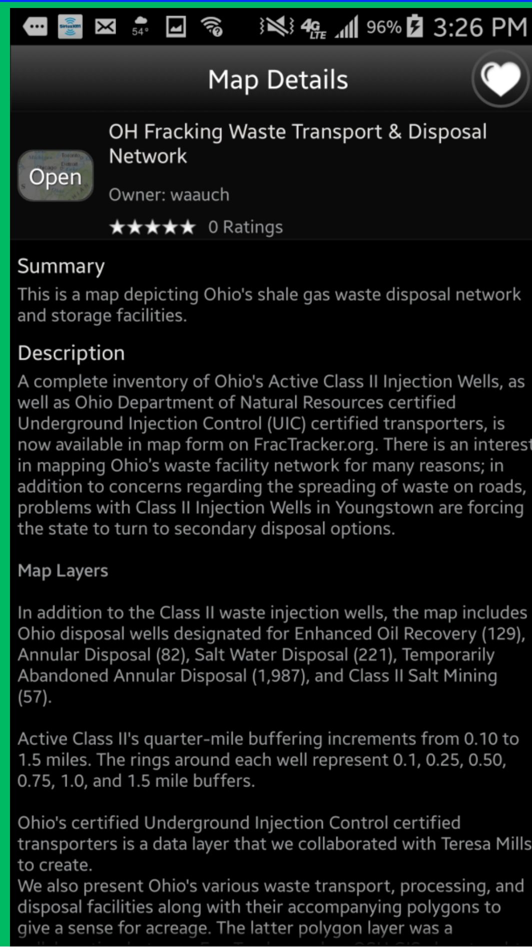


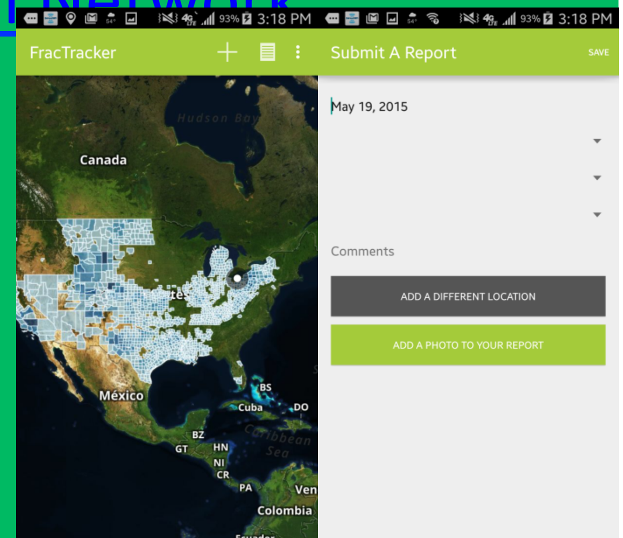


Conclusions

- A couple Shameless Plugs
  - Our [“US Organic Farms and Oil & Gas Activity”]() and [“Ohio Shale Gas Viewer”](), and [“Fracking Waste Transport & Disposal Network”]()







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Data inconsistencies from states with unconventional oil and gas activity

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The quality and availability of unconventional oil and gas (O&G) data in the United States have never been compared methodically state-to-state. By conducting such an assessment, this study seeks to better understand private and publicly sourced data variability and to identify data availability gaps. We developed an exploratory data-grading tool - Data Accessibility and Usability Index (DAUI) - to guide the review of O&G data quality. Between July and October 2013, we requested, collected, and assessed 5 categories of unconventional O&G data (wells drilled, violations, production, waste, and Class II disposal wells) from 10 states with active drilling activity. We based our assessment on eight data quality parameters (accessibility, usability, point location, completeness, metadata, agency responsiveness, accuracy, and cost). Using the DAUI, two authors graded the 10 states and then averaged their scores. The average score received across all states, data categories, and parameters was 67.1 out of 100, largely insufficient for proper data transparency. By state, Pennsylvania received the highest average ($\bar{x} = 93.5$) and ranked first in all but one data category. The lowest scoring state was Texas ($\bar{x} = 44$) largely due to its policy of charging for certain data. This article discusses the various reasons for scores received, as well as methodological limitations of the assessment metrics. We argue that the significant variability of unconventional O&G data—and its availability to the public—is a barrier to regulatory and industry transparency. The lack of transparency also impacts public education and broader participation in industry governance. This study supports the need to develop a set of data best management practices (BMPs) for state regulatory agencies and the O&G industry, and suggests potential BMPs for this purpose.

Keywords: Data transparency, environmental governance.oil and gas extraction, public participation, unconventional drilling.