

Quantifying Habitat Disturbance by Marcellus Shale Drilling Activities in Pennsylvania

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MUG Presentation

- Introduction and Problem Statement
- GIS Methods
 - Data Acquisition and sources
 - Geoprocessing
 - Geovisualization
- Results
- Future Work

Introduction

- Concept
 - Developed by Dr. Chad Freed in Spring 2012
 - Funded by a grant from the Clinton Global Initiative awarded to Elisabeth Powell in Summer 2013
- To use geographic information systems (GIS) technology to quantify the land area disturbed by construction activities associated with natural gas mining of the Marcellus Shale Formation in Pennsylvania



Previous Work

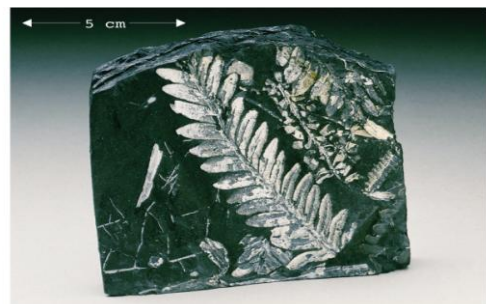
- Sloenecker, E.T., Milheim, L.E., Roig-Silva, C.M., Malizia, A.R., Marr, D.A., and Fisher, G.B., 2012, "Landscape consequences of natural gas extraction in Bradford and Washington Counties, Pennsylvania, 2004-2010": U.S. Geological Survey Open-File Report 2012-1154, 36p.

Introduction

Marcellus Shale Play

- Shale – rock composed of consolidated clay and silt (mud) with a high porosity but very low permeability. Black organic-rich shale is the source rock.
- Mined for natural gas
- Other Formations being mined in the US
 - Barnett in Texas
 - Bakken in South Dakota
 - Utica in New York

Shale



Introduction

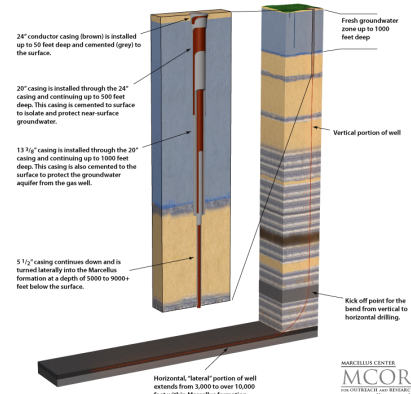
Benefits of Natural Gas Extraction

- Cleaner source of energy than coal
- Increase in local economies
- Decrease in unemployment
- Revenue from taxing the extracted gas
- Extensive reserves in the United States
 - Energy independence?

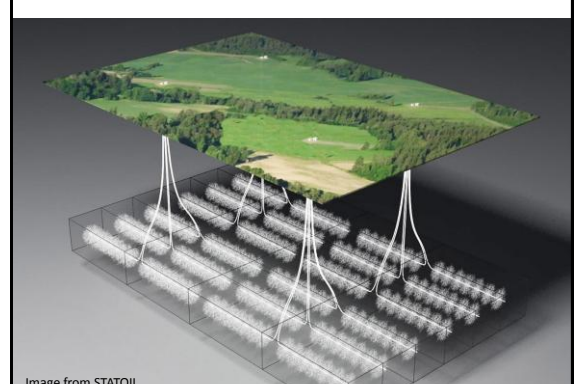


Introduction

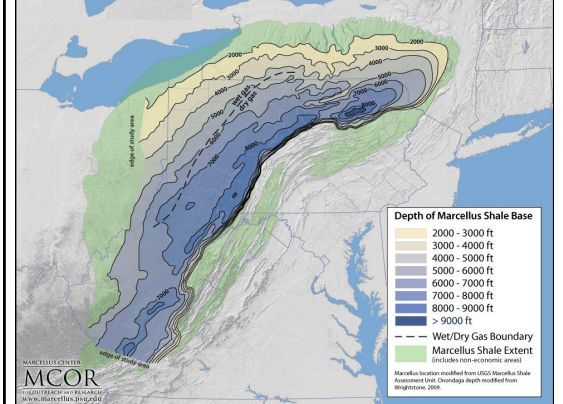
Cross-Section of Typical Horizontal Marcellus Well



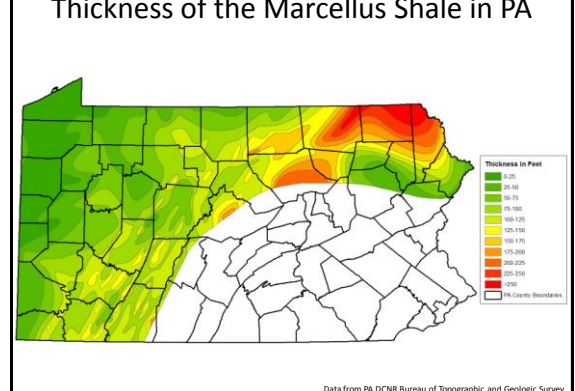
Land Surface and Subsurface Spatial Relationships



Introduction



Thickness of the Marcellus Shale in PA

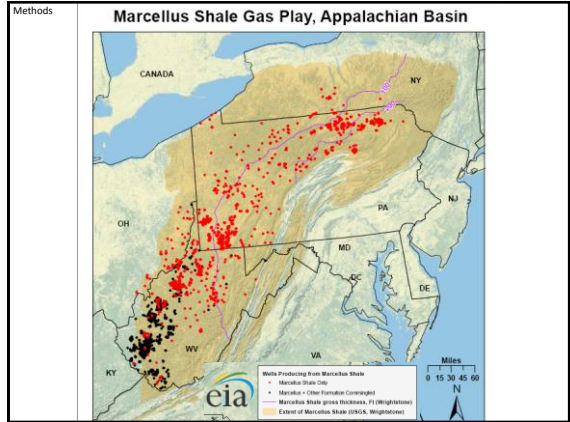


Introduction

Problems with Natural Gas Extraction in Shale Formations

- Ground Water Contamination
- Surface Water Contamination
- Fresh water requirements
- Introducing chemicals to the subsurface called fracking fluids
- Increased traffic (trucks)
- Stress on infrastructure
- Housing limitations
- STD's
- Landscape Footprint

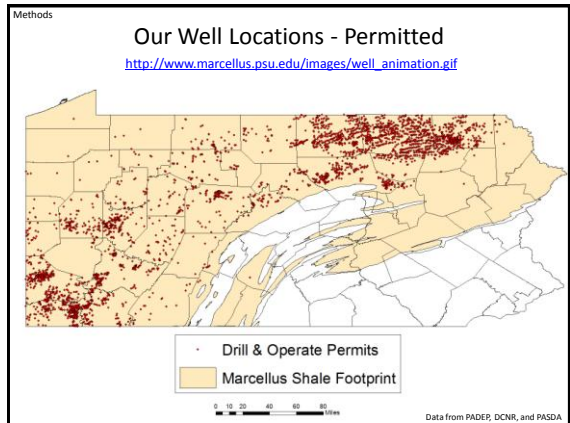
Methods



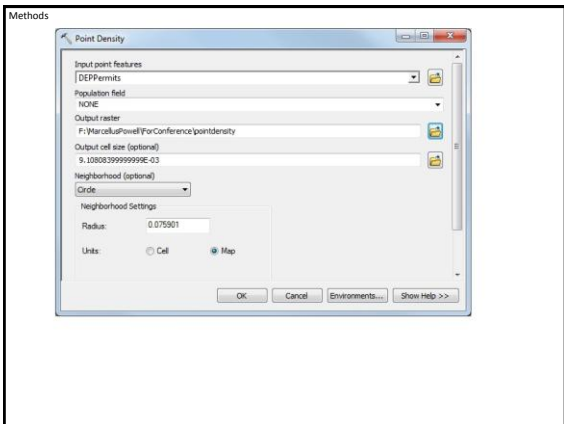
Well Data from Pennsylvania Department of Environmental Protection (PADEP)

WELL_ID	DATE	OP	CO	REG	COUNTY	MUNICIPALITY	FARM_NAME	WELL_CODE	DECK	WELL_STATUS	LATITUDE	LONGITUDE	CONFORMATION	UNCONVENTIONAL
4/26/2008	128	20376	000	99233	WYOMING	EP DOGO	Wheaton/Herringfield Top	SCHWEDZ	18M GAS	Active	40.12789	-79.4683	Vertical Well	Yes
4/26/2008	128	20376	000	99233	WYOMING	EP DOGO	Wheaton/Herringfield Top	SCHWEDZ	2 GAS	Regulatory Inac	40.12850	-79.3668	Vertical Well	Yes
4/26/2008	128	20376	000	99233	WYOMING	EP DOGO	Wheaton/Herringfield Top	SCHWEDZ	3 GAS	Active	40.20902	-80.292	Vertical Well	Yes
5/13/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	1 GAS	Active	40.27891	-80.2661	Vertical Well	Yes
5/22/2008	128	22222	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	2 COMB. OIL/GAS	Flugged Oil Well	40.27266	-80.3079	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	3 COMB. OIL/GAS	Regulatory Inac	40.27266	-80.3079	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	4 COMB. OIL/GAS	Active	40.27272	-80.3048	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	5 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	6 COMB. OIL/GAS	Flugged Oil Well	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	7 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	8 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	9 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	10 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	11 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	12 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	13 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	14 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	15 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	16 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	17 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	18 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	19 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	20 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	21 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	22 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	23 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	24 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	25 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	26 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
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12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	28 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes
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12/27/2008	128	22228	000	40913	RANGE RECK	EP DOGO	Washington/Mount Pleasant	DESERTER1	30 COMB. OIL/GAS	Active	40.28447	-80.2923	Vertical Well	Yes

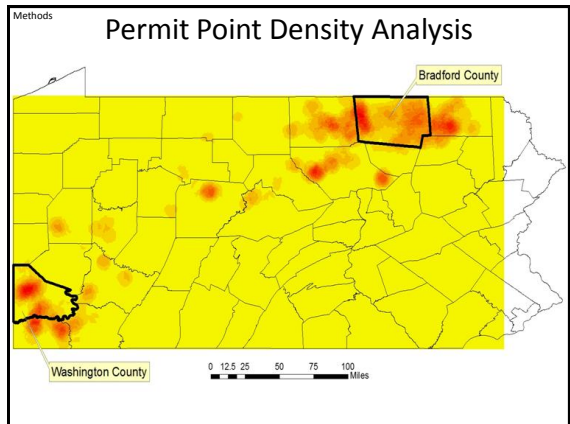
Methods

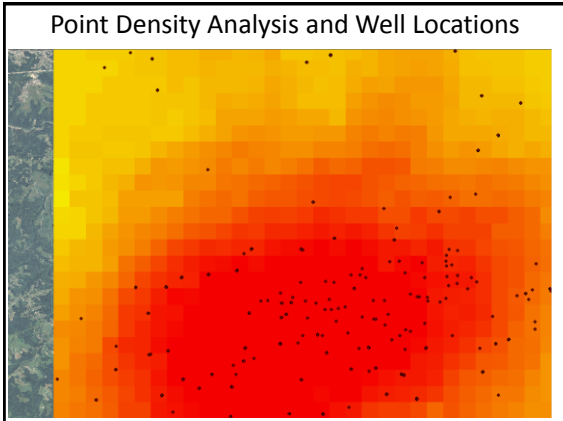
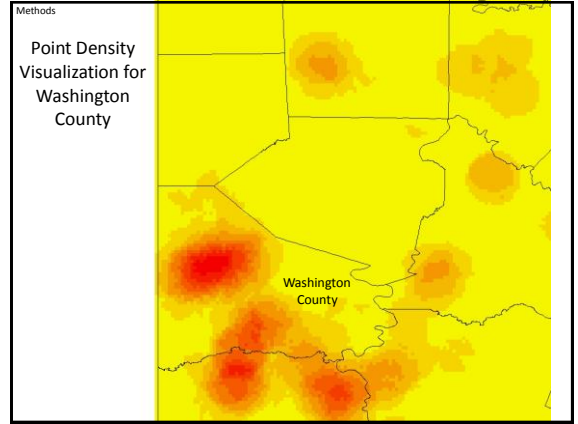
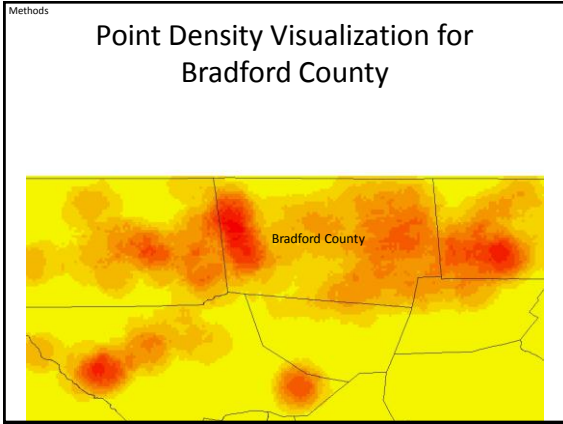


Methods



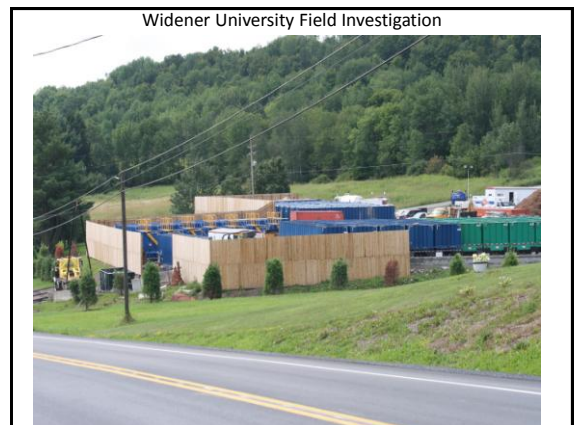
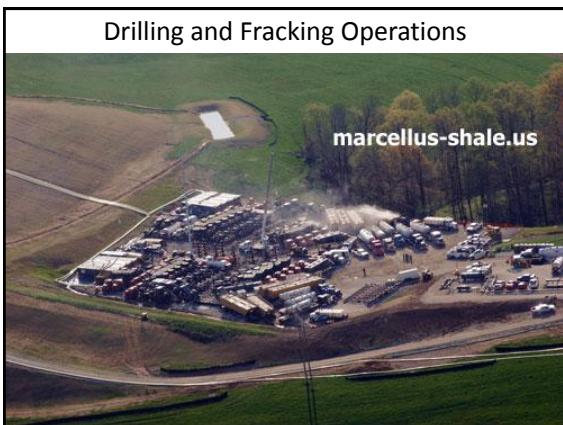
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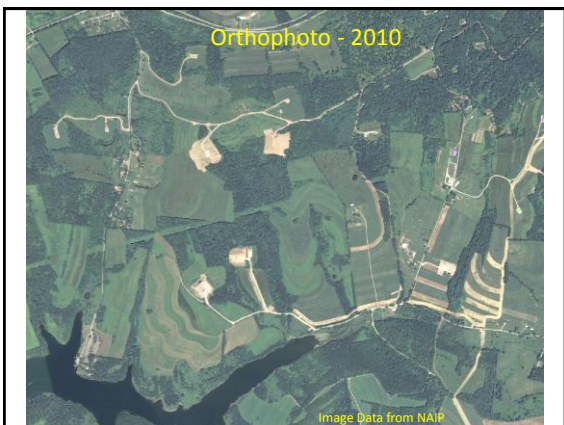
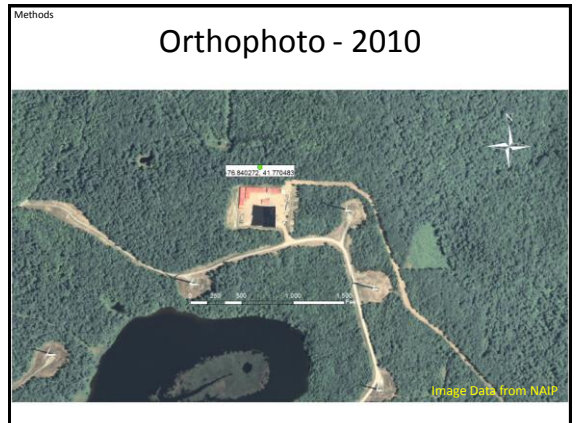
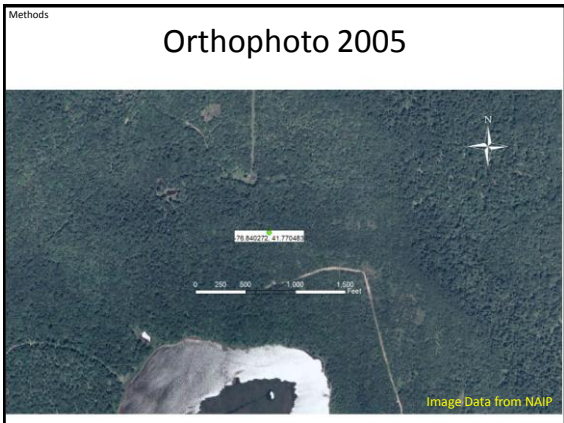


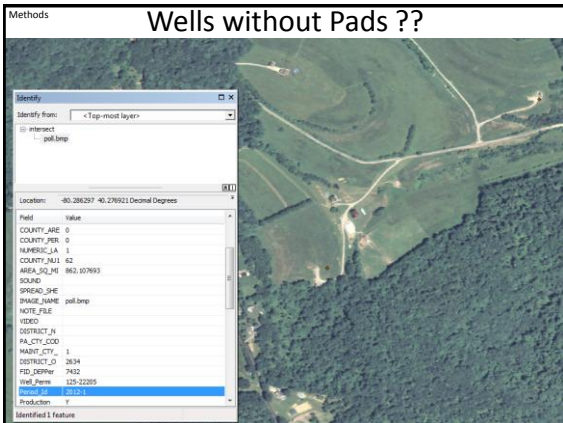
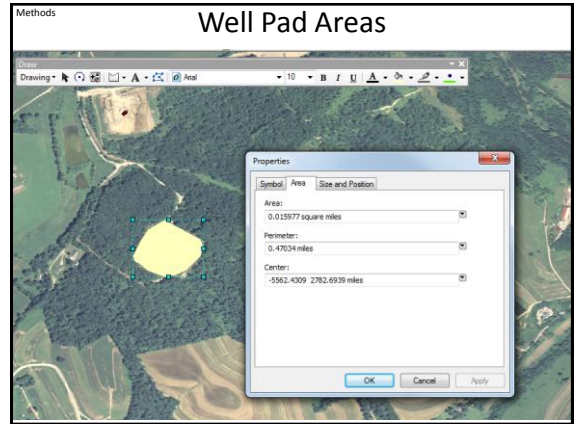
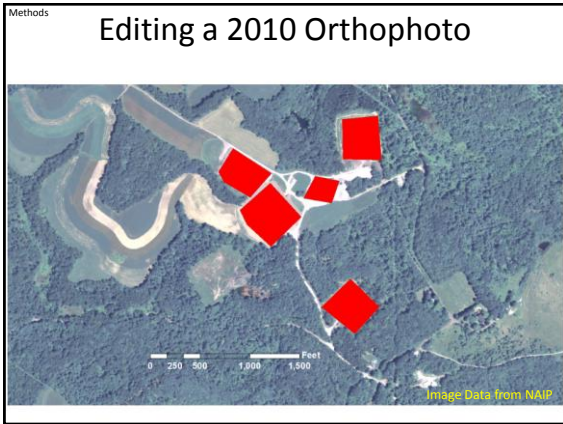


- Methods
- ### Number of Wells in each County
- Bradford County
 - 1786 wells in county
 - Area of Bradford County is 1161 square miles
 - *1.5 wells per square mile*

 - Washington County
 - 880 wells in county
 - Area of Washington is 862 square miles
 - *1.0 wells per square mile*

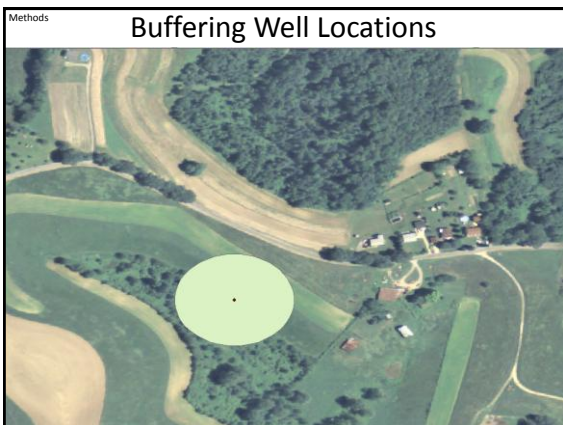






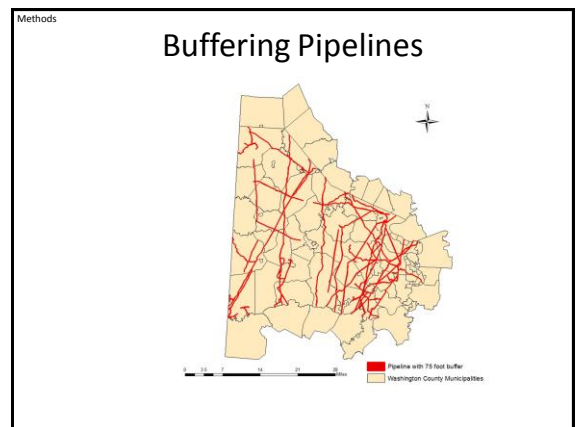
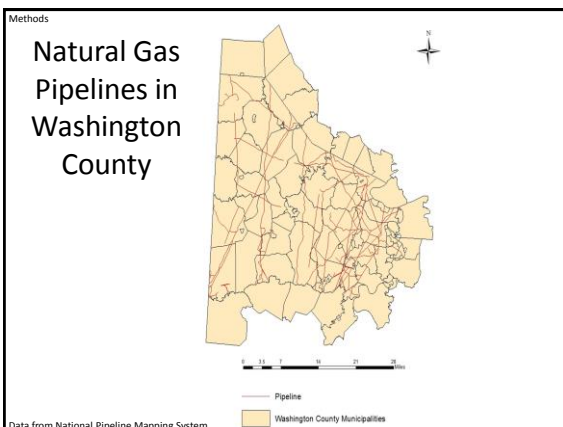
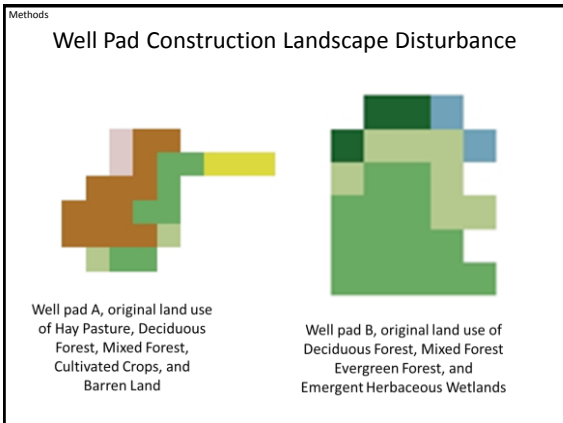
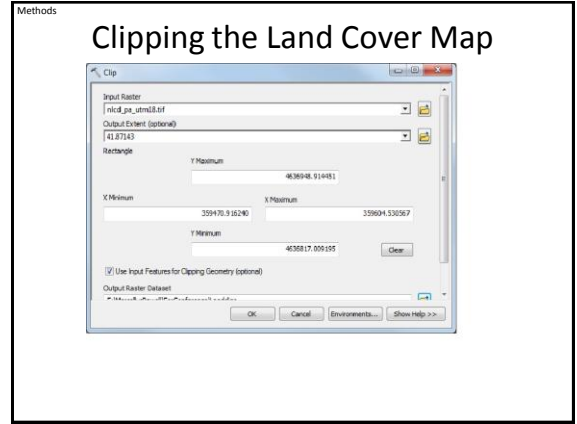
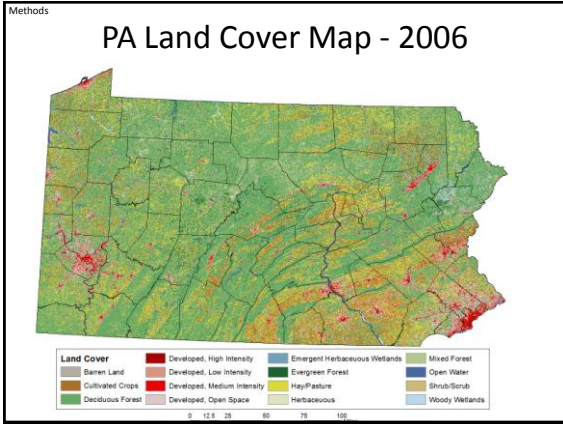
Geoprocessing Wells without Pads

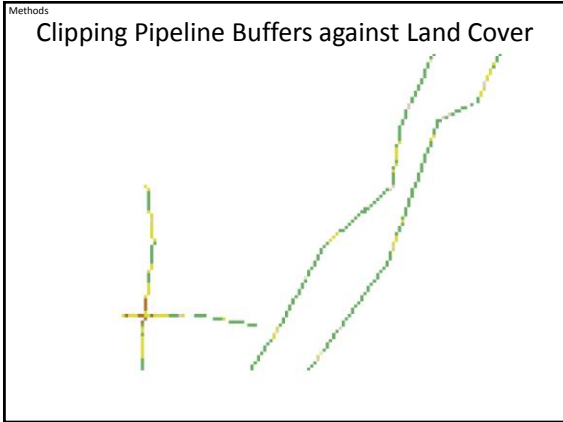
- Average well pad areas from constructed pads
 - Bradford County is 3.08 acres
 - Washington County is 3.42 acres
- Using the area of a circle buffer the “unconstructed” well locations by each respective average for the county.



At this point ...

- We have polygons of all the constructed well pads to 2010.
- We have polygons of all the “unconstructed” well pads for active wells as of 2013.
- We have the total area of landscape disturbance.
- We have an average well pad area for each county.





Constructed Well Pad Disturbances in Bradford County through 2010

Land Cover Class	Pixal Count	Meters Squared	Acres
Developed, Open Space	28	25200	6
Developed, Low Intensity	2	1800	0
Deciduous Forest	1134	1020600	252
Evergreen Forest	100	90000	22
Mixed Forest	438	394200	97
Shrub/Scrub	92	82800	20
Herbaceous	12	10800	3
Hay/Pasture	2434	2190600	541
Cultivated Crops	1456	1310400	324
		Total	1267

Projected Well Pad Disturbances in Bradford County

Land Cover Class	Pixal Count	Meters Squared	Acres
Developed, Open Space	39	35100	9
Barren Land	8	7200	2
Deciduous Forest	879	791100	195
Evergreen Forest	70	63000	16
Mixed Forest	194	174600	43
Shrub/Scrub	118	106200	26
Herbaceous	1	900	0
Hay/Pasture	1290	1161000	287
Cultivated Crops	1211	1089900	269
Emergent Herbaceous Wetlands	1	900	0
		Total	848

Constructed Pipeline Disturbance in Bradford County

Land Cover Class	Pixal Count	Square Meters	Acres
Open Water	20	18000	4
Developed, Open Space	229	206100	51
Developed, Low Intensity	22	19800	5
Developed, Medium Intensity	1	900	0
Deciduous Forest	1588	1429200	353
Evergreen Forest	350	315000	78
Mixed Forest	816	734400	181
Shrub/Scrub	52	46800	12
Herbaceous	4	3600	1
Hay/Pasture	1402	1261800	312
Cultivated Crops	675	607500	150
Woody Wetlands	1	900	0
Emergent Herbaceous Wetlands	17	15300	4
		Total	1151

Constructed Well Pad Disturbances in Washington County through 2010

Land Cover Class	Pixal Count	Meters Squared	Acres
Developed, Open Space	18	16200	4
Barren Land	39	35100	9
Deciduous Forest	1086	977400	242
Evergreen Forest	9	8100	2
Herbaceous	34	30600	8
Hay/Pasture	669	602100	149
Cultivated Crops	463	416700	103
		Total	516

Projected Well Pad Disturbances in Washington County

Land Cover Class	Pixel Count	Meters Squared	Acres
Developed, Open Space	11	9900	2
Developed, Low Intensity	2	1800	0
Barren Land	5	4500	1
Deciduous Forest	1050	945000	234
Evergreen Forest	9	8100	2
Herbaceous	36	32400	8
Hay/Pasture	887	798300	197
Cultivated Crops	386	347400	86
		Total	531

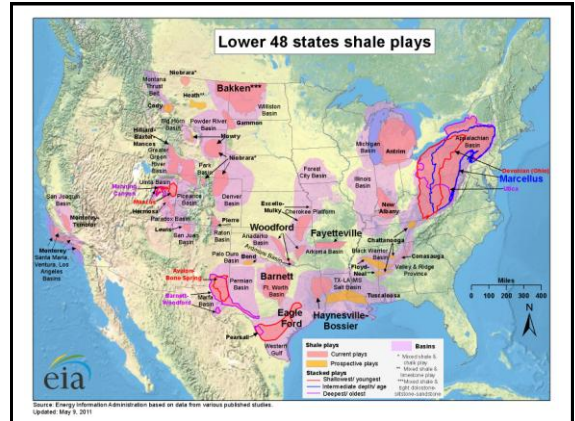
Constructed Pipeline Disturbance in Washington County

Land Cover Class	Pixel Count	Meters Squared	Acres
Open Water	13	11700	3
Developed, Open Space	347	312300	77
Developed, Low Intensity	82	73800	18
Developed, Medium Intensity	25	22500	6
Developed, High Intensity	8	7200	2
Barren Land	26	23400	6
Deciduous Forest	2724	2451600	606
Evergreen Forest	19	17100	4
Mixed Forest	3	2700	1
Herbaceous	34	30600	8
Hay/Pasture	1190	1071000	265
Cultivated Crops	565	508500	126
		Total	1120

Results

Total Landscape Disturbances

- Bradford County
 - 3,266 acres
 - 1.2 acres per well
- Washington County
 - 2,167 acres
 - 2.4 acres per well



Future Work

- Include Roads
- Scale Dependency
- 2010 – 2013 Editing and quantification
- Develop Model to facilitate geoprocessing
- Remote sensing techniques to discriminate well pads
- Edit and quantify waste lagoons

Questions ???

