

DISPROPORTIONALITIES IN FACILITY PRODUCTION OF AND COMMUNITY EXPOSURE TO OIL AND GAS VENTING AND FLARING

KATHERINE ANN (KATE) WILLYARD

PHD CANDIDATE, DEPARTMENT OF SOCIOLOGY, TEXAS A&M UNIVERSITY

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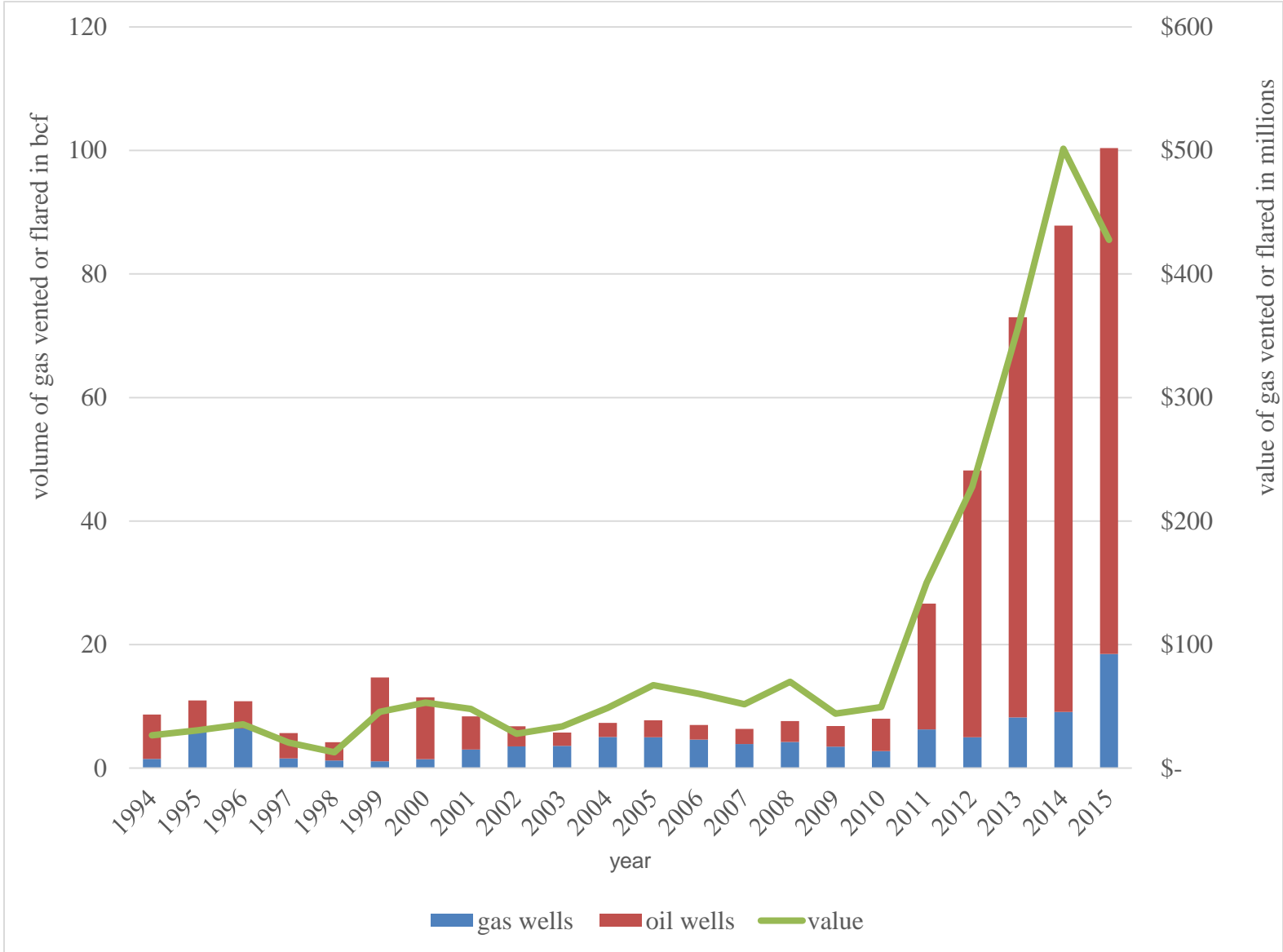


Oil and gas extraction industry venting and flaring

PROBLEMS PRODUCED BY VENTING AND FLARING

- **Produces greenhouse gas emissions**
 - Emits carbon dioxide
 - Largest source of methane emissions by the oil and gas extraction industry
- **Produces health hazards**
 - Largest industrial source of volatile organic compounds that cause increased hematological, breathing and skin problems to surrounding communities
- **Wastes a finite natural resource**

The Growing Problem of Venting and Flaring in Texas



Source: Texas Railroad Commission Production Data Query, Energy Information Administration Natural Gas Prices

RESOURCE BASED ENVIRONMENTAL INEQUALITY RESEARCH

- **Ecological sacrifice zones** (National Academy of Sciences 1973)
- **Communities closer to these zones tend to have:**
 - Higher rates of poverty and unemployment (Greenberg 2017)
 - Higher immigrant populations (Grineski et al. 2010; Viel et al. 2011)
 - Lower education levels (Ogneva-Himmelberger and Huang 2015)
- **Traditionally, research is conducted at the community-level** (Bullard 1990; Mohai and Bryant 1992; Mohai and Saha 2007)
- **A new line of research conducts analysis at the facility-level** (Collins et al. 2016; Grant et al. 2010)

GAP IN KNOWLEDGE

- **We do not know where most venting and flaring occurs and which communities are most affected**
 - Why? Limitations of federal data
 - I overcome data limitations by using state records
- **Community and facility analysis has yet to be compared**

RESEARCH GOALS

- **Research Question:** What are the characteristics of communities (if any) that were disproportionately exposed to Texas oil and gas venting and flaring practices in 2012?
- **Objectives**
 - Visualize disproportionalities
 - Quantify the relationship between venting and flaring volumes at facilities within one mile of the block group and block group community characteristics
 - Quantify the relationship between facility venting and flaring volumes and the characteristics of communities living in block groups within one mile of the facility
 - Compare facility and community level analysis

HYPOTHESIS

- **Community economic status relates to venting and flaring volumes**
 - Income
 - Home Value
 - + Portion in Poverty
- **Community organizational capacity relates to venting and flaring volumes**
 - + Portion Uneducated
 - + Portion Non-English Speaking
 - Population Density
 - Nonprofit Organizations
- **Community racial status relates to venting and flaring volumes**
 - + Portion Black
 - + Portion Hispanic

DESIGN

- **Quantitative Cross Sectional Analysis of Texas Oil and Gas Venting and Flaring Practices in 2012**
- **Why Texas?**
 - Limited to single state in order to eliminate between-state variation in regulation and reporting of venting and flaring
 - Texas produces more than any other state
- **Why 2012?**
 - Year of heavy development in the middle of the recent shale oil boom

SAMPLE

- **Community-Level**

- Sample: Texas block groups with publicly released American Community Survey estimates
- Sample Size: 15,771
- Note: 39 Texas block groups were not included because no publicly released American Community Survey estimates are available (due to sample size and confidentiality reasons)

- **Facility-Level:**

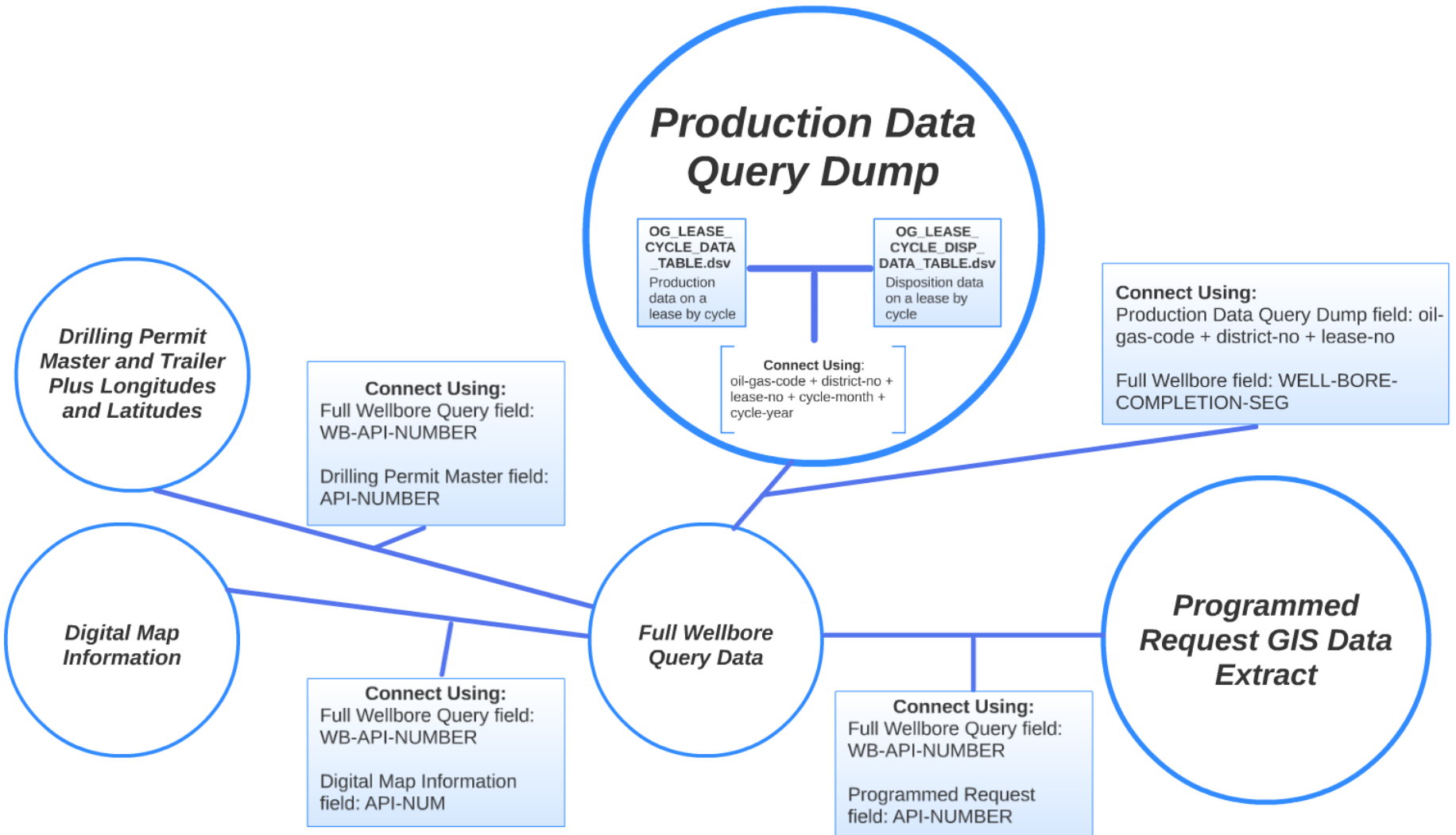
- Sample: Producing Texas oil and gas extraction facilities within one mile of Texas block groups with publicly released American Community Survey estimates
- Sample Size: 126,862
- Note: 35,282 producing Texas oil and gas extraction facilities were not included because they were not within one mile of publicly released American Community Survey block group estimates (because they are not near residential areas)

DATA

- **Texas Railroad Commission Datasets**
 - Programmed Request Data Extract
 - Production Data Query Dump
 - Full Wellbore Query Data
 - Drilling Permit Master and Trailer Plus Longitudes and Latitudes
 - Digital Map Information
- **American Community Survey, Five-Year (2010-2014) Population Estimates, Geodatabase Format**
- **The National Center for Charitable Statistics Database**
- **Texas Statewide Imagery Political Boundaries Shapefiles**

Variable	Facility-Level Measure	Community-Level Measure
DEPENDENT VARIABLE		
Venting and Flaring Magnitude	Volume (in mcf) of gas vented or flared at facility	Volume (in mcf) of gas vented or flared at facilities within one mile
ECONOMIC STATUS VARIABLES		
Income	Median ACS income category of households in block groups within one mile of facility	Median ACS household income category of block group
Home Value	Median ACS home value category of households	Median ACS home value category of block group
Portion in Poverty	100 * Households living at or below the poverty that live in block groups within one mile of the facility / Households	100 * Household living at or below the poverty line in block group / Households
ORGANIZATIONAL CAPACITY VARIABLES		
Portion Uneducated	100 * Individuals 25 and older without a high school diploma living in a block group within one mile of the facility / Individuals	100 * Individuals 25 and older without a high school diploma living in block group / Individuals 25 and older residing in block group
Portion Non-English Speaking	100 * Households with limited English fluency in block groups within one mile of the facility / Households	100 * Households with limited English fluency in block group / Households
Population Density	Individuals living in block groups within one mile of the facility / Land area of block groups within a mile of the facility (in square miles)	Individuals living in block group / Landed area of block group (in square miles)
Nonprofit Organizations	Registered nonprofits in the county in which the facility is located	Registered nonprofits in the county in which the block group is located
RACIAL STATUS VARIABLES		
Portion Black	100 * Non-Hispanic black individuals residing in block groups within one mile of the facility / Individuals	100 * Non-Hispanic black individuals living in block group / Individuals
Portion Hispanic	100 * Hispanic individuals residing in block groups within one mile of the facility / Individuals	100 * Number of Hispanic individuals living in block group / Individuals

DATA MANAGEMENT: CONNECTING RRC DATASETS



DATA MANAGEMENT: CREATING THE GIS

- 1. Load all data tables into a geodatabase**
- 2. Make X Y Event Layer using facility longitude/latitude coordinates**
- 3. Project all shapefiles**
- 4. Match county boundary file with National Center for Charitable Statistics data table using county name**
- 5. Overlay linked county data with facilities and block groups**
- 6. Create a one mile buffer around county-linked facility points**
- 7. Overlay facility buffers with American Community Survey block group shapefile**
- 8. Match facility/block group data tables using unique identifier**
- 9. Dissolve by facility/block group unique identifier**

NEGATIVE BINOMIAL REGRESSION

Negative Binomial Regression Model:

$$\mu_i = \exp(\ln(t_i) + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \dots + \beta_k x_{ki})$$

$$\Pr(Y=y_i | \mu_i, \alpha) = \frac{\Gamma(y_i + \alpha^{-1})}{\Gamma(\alpha^{-1})\Gamma(y_i + 1)} \left(\frac{1}{1 + \alpha\mu_i}\right)^{\alpha^{-1}} \left(\frac{\alpha\mu_i}{1 + \alpha\mu_i}\right)^{y_i}$$

Where μ_i is the mean incidence rate of y per unit of exposure t (i.e., risk of new occurrence during period t). β_1 is the intercept. $\beta_2, \beta_3, \dots, \beta_k$ are the estimated unknown regression parameters. Γ is a gamma noise variable which has a mean of 1 and a scale of v . α is $1 / v$. And the model is estimated using maximum likelihood estimation (MLE) techniques.

Used to model over-dispersion in count data

Assumptions:

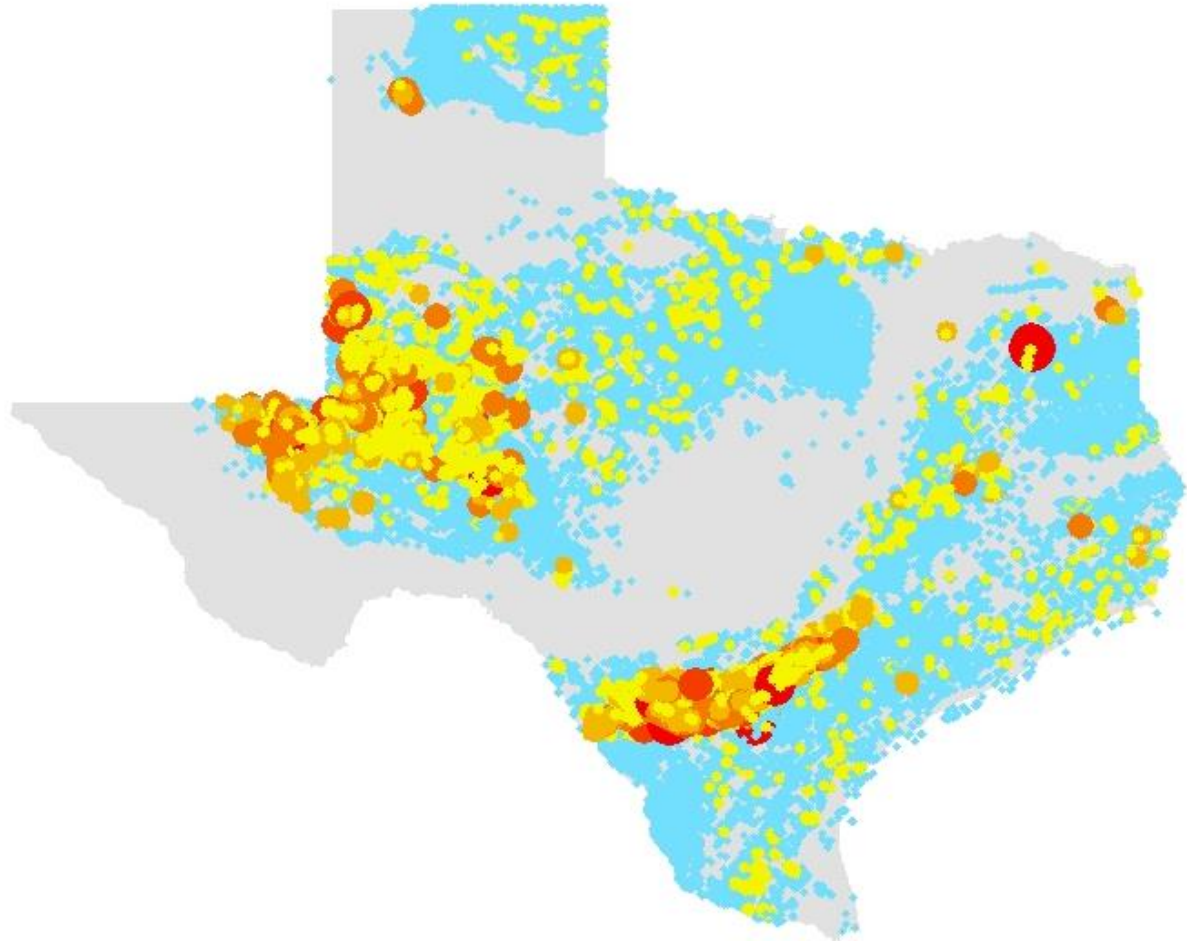
- Linearity of parameters
- Independent variables not strongly collinear
- Has Poisson regression mean structure and an extra parameter to model over-dispersion, so homoskedasticity is not assumed

RESULTS- THE CODE AND MAP

<https://tinyurl.com/vf12code>

<https://tinyurl.com/vf12map>

RESULTS- MAP



Legend

gas vented or flared (in mcf)

- 0
- 1 - 15,000
- 15,001 - 50,000
- 50,001 - 150,000
- 150,001 - 300,000
- 300,001 - 812,179



0 40 80 160 240 320 Miles

Source: Texas Railroad Commission Databases
Datum: NAD 83
Cartographer: Katherine Ann Calle Willyard

RESULTS- REGRESSION MODELS

	Variable	Hypothesized Relationship	Observed:	Facility Level	Community Level
Economic Status Variables	Income	-		-	+
	Home Value	-		+***	-***
	Portion in Poverty	+		-***	-***
Organizational Capacity Variables	Portion Uneducated	+		-	+
	Portion Non-English Speaking	+		-	+
	Population Density	-		-***	-***
	Nonprofit Organizations	+		+	-
Racial Status Variables	% Black	+		+***	-
	% Hispanic	+		+***	-

*** p<0.001 ** p<0.01 * p<0.05 (two-tailed significance tests)

FINDINGS

- **Venting and flaring volumes are consistently associated with:**
 - **portion in poverty**
 - **population density**
- **There is an inconsistent relationship between home values and venting and flaring volumes**
 - Communities with higher home values experience lower venting and flaring volumes in general
 - Facilities that vent and flare more are located in communities with higher home values in general
- **There is a positive relationship between minority communities and venting and flaring volumes, but only at the facility level**

DISCUSSION

- **Both community and facility level analysis is important to understand how environmental inequality is produced**
- **Results consistently show venting and flaring is associated with less resistant communities, suggesting a political action explanation of environmental inequality**
- **Racial disparities are more prevalent when examining facility-level analysis results**
- **Future research should use restricted community data needed to better quantify the rural communities surrounding oil and gas extraction facilities**

POLICY RECOMMENDATIONS

Federal

- **Implement Obama-Era “Flare Bans” on Federal Lands**

State

- **Revoke Texas Statewide Rule 32 Section f.2.D.**
- **Increase funding to the Texas Railroad Commission**
- **Increase accessibility of Texas Railroad Commission venting/flaring data**

QUESTIONS?

CONTACT ME:

KATE.WILLYARD @ TAMU.EDU



RESULTS- SUMMARY STATISTICS

	Facility-Level Descriptive Statistics					Community-Level Descriptive Statistics				
	N	Mean	Sd	Min	Max	N	Mean	Sd	Min	Max
DEPENDENT VARIABLE										
Venting/Flaring	126,862	374.825	6206.392	0	812179	15,771	105421.8	0.224	0	9,357,806
ECONOMIC STATUS VARIABLES										
Income	126,862	9.652	1.944	1	15	15,771	8.712	3.116	1	16
Home Value	126,862	12.815	2.726	1	21	15,771	13.016	4.271	1	24
Portion in Poverty	126,862	13.990	9.431	0	100	15,737	18.703	16.042	0	100
ORGANIZATIONAL CAPACITY VARIABLES										
Portion Less Educated	126,862	19.740	10.836	0	78.553	15,769	20.1236	16.900	0	93
Portion Non-English Speaking	126,861	4.914	7.471	0	44.860	15,729	8.626	11.829	0	100
Population Density	126,862	38.905	156.712	.007	6,707.434	15,771	3,883.46	4,564.5	.007	97,154.52
NGOs	126,862	268.978	826.143	0	14,502	15,771	4,770.59	5,242.9	0	14,502
RACIAL STATUS VARIABLES										
Portion Black	126,862	4.210796	7.436	0	88.075	15,771	11.423	17.984	0	100
Portion Hispanic	126,862	25.70266	23.534	0	100	15,771	37.637	30.240	0	100

	Facility-Level Model		Community-Level Model	
	b	SE	b	SE
ECONOMIC STATUS VARIABLES				
Income	-0.0240194	.0262581	0.121653	.0810912
Home Value	0.0884666***	.0194512	-0.2927679***	.0596402
Portion in Poverty	-0.0514166***	.0062121	-0.0745143***	.0128536
ORGANIZATIONAL CAPACITY VARIABLES				
Portion Uneducated	-0.0018903	.0057317	0.0084704	.018643
Portion Non-English Speaking	-0.022331	.0113807	0.0198733	.0264484
Population Density	-0.0025975***	.0004765	-0.0004095***	.000056
Nonprofit Organizations	0.00000929	.0000612	-0.0000735	.0000417
RACIAL STATUS VARIABLES				
Portion Black	0.0191236**	.0060571	-0.0188988	.0148769
Portion Hispanic	0.0683608***	.0040138	-0.0058969	.0089561
Constant	3.443548***	.382711	12.47004***	1.270354
Ln Alpha	5.265375	.0129144	5.358954	.0362877
Alpha	193.5188	2.499173	212.5026	7.71124
N	126,861		15,729	
Pseudo R ²	0.0054		0.0123	
Chi ² (9)	894.34		282.92	
AIC	1.287		1.441	
AIC*n	163,299.630		22,672.995	

*** p<0.001

** p<0.01

* p<0.05

(two-tailed significance tests)