Pollution Sources and Mortality Rates across Rural-Urban Areas in the United States

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INTRODUCTION

Rural populations are potentially exposed to a variety of serious environmental risks from point and non-point pollution sources including industrial facilities, animal containment facilities, mining operations, logging and timber activities, petroleum refineries, agricultural activities, incinerators, land fills, sewage treatment facilities, and transportation routes.(1-5) However, a comprehensive assessment of rural environmental pollution sources and impacts has not yet been undertaken. We report here the number and types of potential pollution sources present in rural counties using data from a variety of secondary sources. We also examine associations between pollution sources and Centers for Disease Control and Prevention (CDC) age-adjusted mortality rates.

STUDY DESIGN AND METHODS

We gathered together a set of existing databases to create a new linked county-level database of potential pollution sources and corresponding health outcomes, with particular attention to sources in rural settings. The text box below describes the rural definitions that we used.

RURAL DEFINITIONS AND ANALYSES

1. Noncore counties (codes 4, 6, 7, 9-12) versus micropolitan counties (codes 3, 5, and 8) versus metropolitan counties (codes 1 and 2) from the urban-influences codes; used for Table 1.
2. Non-metropolitan counties (codes 4-9) versus metropolitan counties (codes 1-3) from rural-urban continuum codes; used for Table 2 and for Figures 1 through 3.

Data were drawn several public, national datasets. These are described in the two text Boxes below. All data were compiled at the county level (N=3,141). We created spatial versions of these databases, checked for errors and then utilized spatial software to describe at the county level the types of potential pollution sources present in rural and urban areas. Next, we examined the statistical associations between potential pollution sources and CDC age-

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adjusted mortality rates, including all-cause mortality and mortality from cardiovascular disease, respiratory disease, and cancer.

DATA SOURCES
Environmental Protection Agency (EPA);
Centers for Disease Control and Prevention (CDC);
Department of Energy's Energy Information Administration (EIA);
US Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS);
Multi-Resolution Land Characteristics Consortium's National Land Cover Dataset (NLCD);
Health Resources and Services Administration's Area Resource File (ARF);
Appalachian Regional Commission (ARC);
U.S. Census Bureau

FINDINGS

Rural areas had fewer EPA-monitored pollution sites per county, and fewer fossil fuel plants, relative to urban counties. Metropolitan sites have greater average number and concentration of pollution sites per county than micropolitan areas, which in turn have higher number and concentration per county than noncore areas. Exceptions to this pattern are that micropolitan areas have the highest percent of land committed to agriculture, and the highest concentration of agricultural animals per acre.

EPA SPECIFIC DATA SOURCES
Aerometric Information Retrieval System (AIRS): air pollution from stationary sources such as factories and power plants;
Permit Compliance System (PCS): waste water discharges from stationary sources;
Toxics Release Inventory (TRI): locations where toxic chemicals are used, manufactured, treated, transported, or released;
Emissions and Generation Resource Integrated Database (eGRID): locations of electrical power plants, grouped into type (coal, oil, natural gas, wind, solar, nuclear, hydropower, geothermal, biofuel).

Non-core counties had 30,658 EPA-monitored pollution discharge sites, and micropolitan counties had 34,397 sites (the sum of AIRS, PCS, and TRI sites shown in Table 1). Micropolitan and non-core counties contained 1,065 fossil-fuel power plants. Coal mining activity is concentrated in non-metropolitan counties. As expected, rural counties had greater exposure to potential agriculture-related pollution. Results are summarized in Table1.

Table 1: Summary of potential pollution sources for non-core (N=1,376), micropolitan, (675), and metropolitan (N=1,090) counties.

	NON-CORE		MICROPOLITAN		METROPOLITAN		P< [7]
	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	
TRI sites [1]	4.2 (5.7)	5,811	15.9 (16.0)	10,763	50.2 (111.6)	54,742	.0001
AIRS sites [1]	5.2 (11.4)	7,182	10.5 (17.8)	7,085	35.1 (129.0)	38,255	.0001
PCS sites [1]	12.8 (29.0)	17,665	24.5 (36.8)	16,549	44.3 (80.2)	48,284	.0001

Coal plants	.07 (.30)	96	.20 (.52)	137	.33 (.65)	355	.0001
Oil plants	.20 (.62)	281	.24 (.63)	163	.32 (.94)	353	.0004
Natural gas plants	.13 (.42)	182	.31 (.65)	206	.92 (2.5)	1,008	.0001
Fossil fuel power plants [2]	.41 (.83)	559	.75 (1.1)	506	1.57 (3.0)	1,716	.0001
Hydropower plants	.23 (.85)	322	.56 (2.0)	380	.59 (1.87)	641	.0001
Wind plants	.06 (.76)	85	.05 (.34)	36	.09 (1.3)	94	.71
Nuclear plants	.005 (.07)	7	.01 (.10)	7	.04 (.21)	46	.0001
Total power plants [3]	.76 (1.5)	1,051	1.5 (2.5)	1,010	2.67 (5.1)	2,913	.0001
TCL – TRI [4]	.01 (.07)	--	.03 (.09)	--	.11 (.26)	--	.0001
TCL – AIRS [4]	.02 (.16)	--	.02 (.10)	--	.14 (.90)	--	.0001
TCL – PCS [4]	.02 (.06)	--	.04 (.05)	--	.08 (.14)	--	.0001
TCL – Fossil fuel power plants	.0008 (.002)	--	.001 (.003)	--	.0035 (.02)	--	.0001
Coal mining counties	--	67	--	32	--	40	.32
Percent developed land	1.1 (2.6)	--	2.2 (2.9)	--	8.6 (13.5)	--	.0001
Percent acres in cropland [5]	22.2 (23.8)	--	25.5 (25.0)	--	19.4 (21.0)	--	.0001
Animals per acre [6]	7.6 (32.0)	--	9.0 (33.3)	--	7.9 (30.8)	--	.64

1. TRI, AIRS and PCS refer, respectively, to the EPA's Toxics Release Inventory Sites, the Aerometric Information Retrieval System on air pollution discharge sites, and the Permit Compliance System on water pollution discharge sites.
2. Fossil fuel power plants is the sum of coal, oil, and natural gas plants.
3. Total power plants include those listed plus geothermal, solar, biofuel and other.
4. TCL refers to Total Cumulative Load, which is equal to the number of sites per county square land mile.
5. Crops include corn, barley, wheat, hay, beans, cotton, tobacco, and multiple other types of grains, fruits and vegetables.
6. Animals include beef and dairy cows, pigs and hogs, chickens (broilers and layers), sheep and goats.
7. Significant difference among the three counties groups.

Table 2 shows associations between potential pollution sources and age-adjusted mortality rates for non-metropolitan counties after controlling statistically for other risk variables. Air pollution sites were associated with higher cancer mortality, and water pollution sites were associated with higher total and cancer mortality rates. Greater levels of coal mining were associated with higher total and respiratory mortality rates. Cancer mortality rates were positively associated with greater percent of developed land (including land developed for residential, commercial, industrial, or transportation purposes). These associations suggest but do not prove causal relationships, and further research will be necessary to understand causal relationships among the associations found.

Table 2: Regression results for *non-metropolitan* counties (N=2,051).[1] Cells are unstandardized regression coefficients with standard errors in parentheses. Independent variables of interest are industrial pollution sources.

MORTALITY:	TOTAL		CANCER		CARDIOVASCULAR		RESPIRATORY	
Model 1	Estimate (SE)	P<	Estimate (SE)	P<	Estimate (SE)	P<	Estimate (SE)	P<
TCL- AIRS	6.01 (19.00)	.75	12.56 (6.38)	.05	2.68 (12.57)	.83	6.29 (5.54)	.26
TCL – PCS	76.31 (32.14)	.02	26.43 (10.79)	.02	13.35 (21.27)	.53	7.39 (9.37)	.43
TCL – TRI	17.20 (34.60)	.62	-22.90 (11.62)	.05	-12.29 (22.90)	.59	-1.70 (10.09)	.87
Model 2								
Low coal mining	10.64 (8.63)	.22	5.17 (2.91)	.08	.81 (5.72)	.89	1.24 (2.51)	.62
High coal mining	22.84 (7.95)	.004	3.52 (2.67)	.19	1.17 (5.26)	.82	8.76 (2.31)	.0002
Model 3								
Percent developed land	120.6 (77.0)	.12	62.45 (20.63)	.003	13.18 (39.78)	.74	2.26 (17.90)	.90

1. Covariates included are: smoking rate, percent male population, primary care physicians per 1,000 population, poverty rate, rural-urban continuum code, percent race/ethnicity groups (African American, Native American, Asian American, Hispanic), high school education rate, college education rate, Appalachian county.

A sample of national maps showing the distribution of potential pollution sources are also provided at the end of this report. Air pollution sites are higher in the area stretching from central Appalachia through Washington DC (Figure 1). Coal mining is concentrated in central and northern Appalachia, and in selected locations in the Midwest and West (Figure 2). Water pollution sites are higher in areas of southern Louisiana, north Alabama, and in an area stretching from Ohio and North Carolina up to New York (Figure 3.) Additional maps are available in the WVRHRC Final Report #1 and on the WVRHRC's website. The website also has state-level maps with more visible county detail.

Figure 1: Aerometric Information Retrieval System (AIRS) sites per square mile.

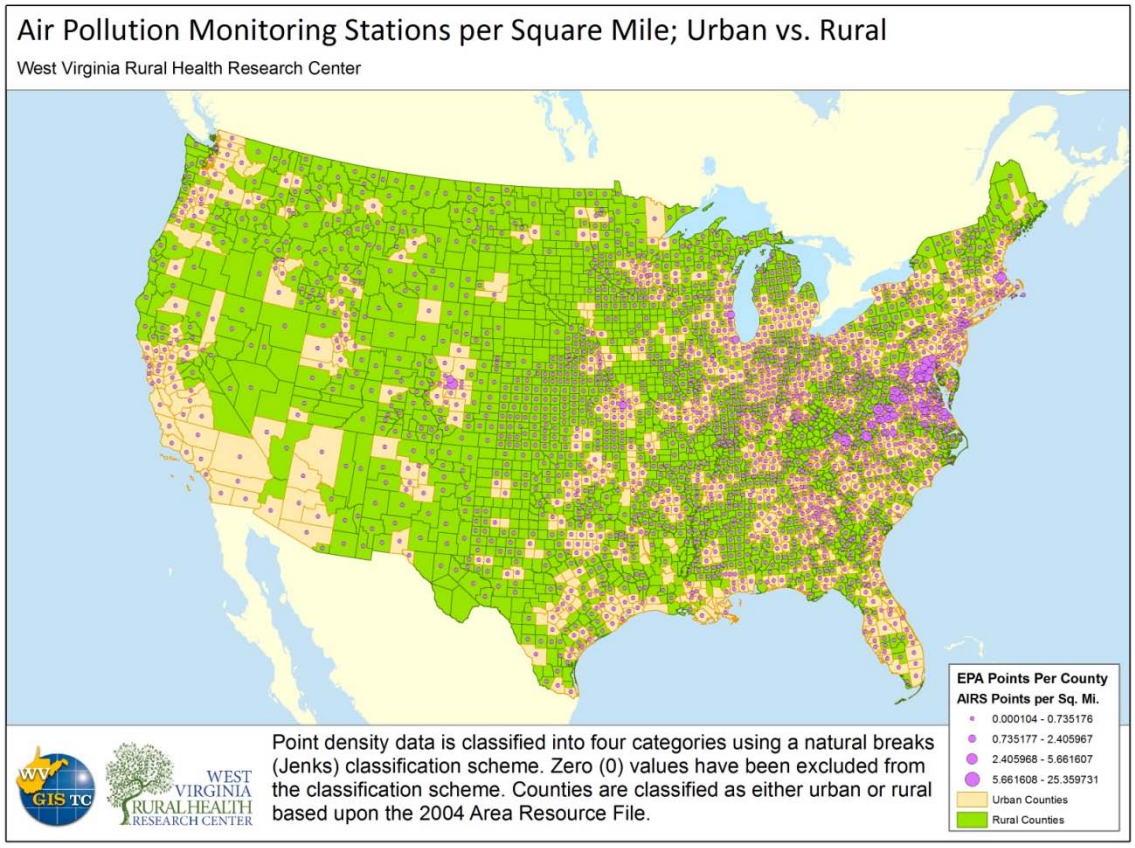


Figure 2: Coal production by county.

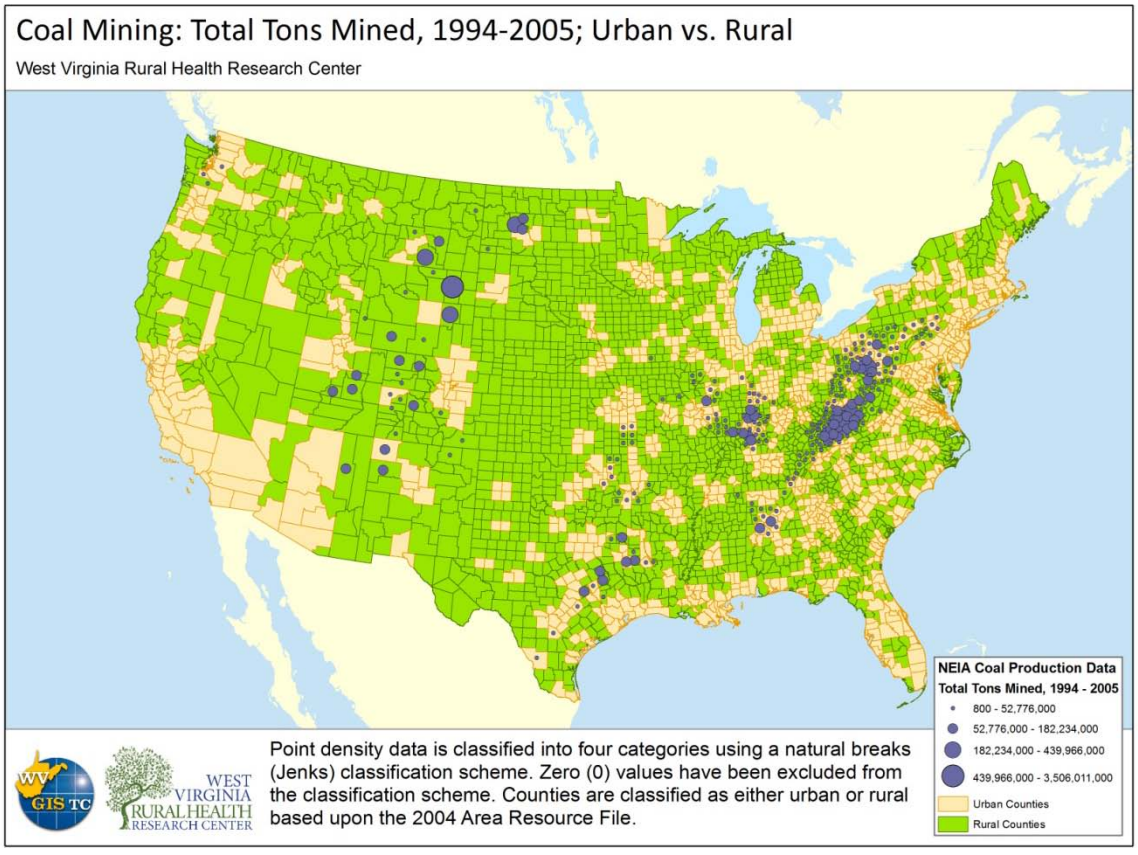
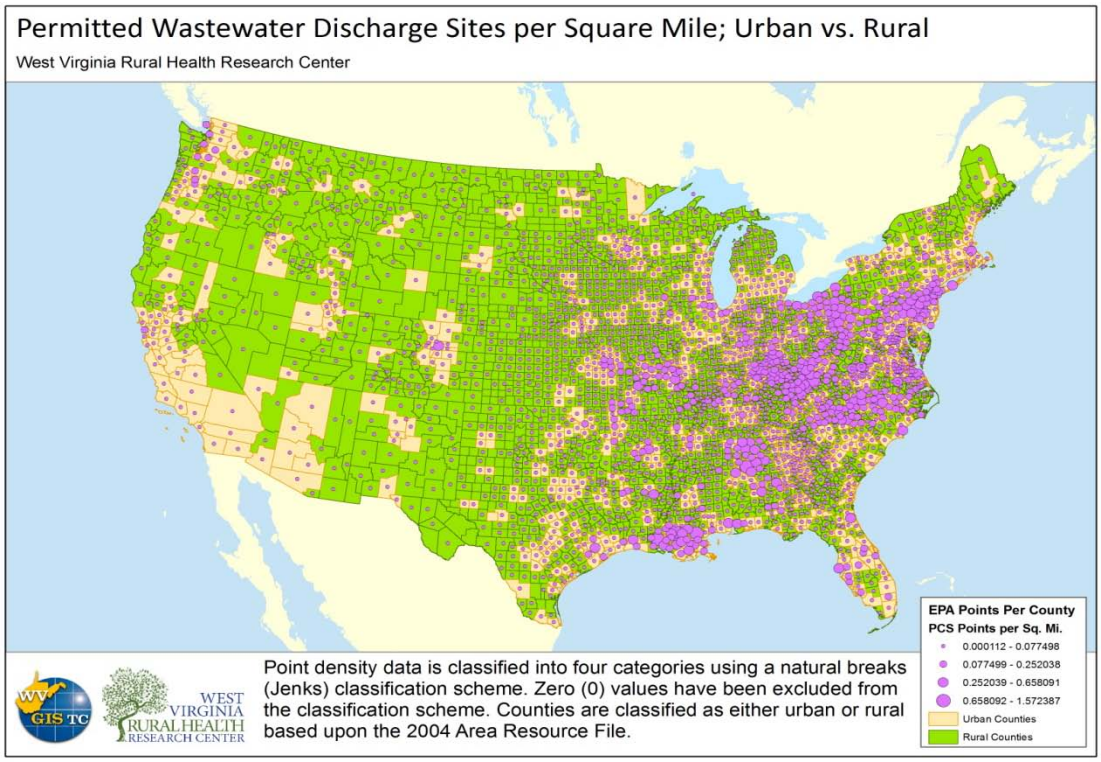


Figure 3: Permit Compliance System (PCS) sites per square mile.



CONCLUSIONS AND POLICY IMPLICATIONS

Pollution sources that may impact human health are present in large numbers in rural counties of the United States. The common presence of these pollution sources suggests the need for careful environmental monitoring in rural areas. Further research is needed to better understand the types and distributions of pollution in rural areas, and the health consequences that result. Health care professionals who work in rural settings will need to have the appropriate training and resources to diagnose and treat environmentally-instigated or mediated disease. Improved coordination between the health care community and the public health community in rural settings may improve the capacity of rural health care providers to deliver environmentally-sensitive services.

REFERENCES

1. Hendryx M, Ahern M. Relations between health indicators and residential proximity to coal mining in West Virginia. American Journal of Public Health 2008;98:669-671.
2. Hanchette CL. The political ecology of lead poisoning in eastern North Carolina. Health and Place 2008;14:209-216.
3. Khudar S, Milz SA, Bisesi M, Vincent R, McNulty W, Czajkowski K. Health survey of residents living near farm fields permitted to receive biosolids. Archives of Environmental and Occupational Health 2007;62:5-11.
4. Malcoe LH, Lynch RA, Kegler MC, Skaggs VJ. Lead sources, behaviors, and socioeconomic factors in relation to blood lead of Native American and White children: a community-based assessment of a former mining area. Environmental Health Perspectives 2002;110 (Suppl 2):221-231.
5. Garry VF, Harkins M, Lyubimov A, Erickson L, Long L. Reproductive outcomes in the women of the Red River Valley of the north. I. The spouses of pesticide applicators: pregnancy loss, age at menarche, and exposures to pesticides. Journal of Toxicology and Environmental Health A 2002;65:786.

Additional Information

See the Full Report that corresponds to this Brief for more detailed methods and findings from this study at: http://wvrhrc.hsc.wvu.edu/projects/2009/hendryx/