Environmental Inequity in the Phoenix Metropolitan Statistical Area, 1990 and 2000

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ABSTRACT

In this research, we explore the spatial distribution of toxic facilities and decadal change in environmental inequities in the Phoenix, Arizona metropolitan area. A Geographic Information System (GIS) is used to map Toxics Release Inventory (TRI) facilities and socio-demographic indicators in 1990 and 2000. We employ both traditional and novel techniques to assess change in the pattern of environmental inequity. Statistical comparisons between host/non-host Census Tracts and Tracts with our Hazards Density Index (HDI) score provides an introductory analysis. We complement the analysis by examining the relationship of HDI scores to race and class through Geographically Weighted Regression (GWR), a spatial regression technique.

Sources: EPA Toxics Release Inventory data for 1990 and 2000
U.S. Census Bureau 1990 and 2000
EPA Toxics Release Inventory data for 1987-2000 high-level summary downloaded from www.rtk.net

RESEARCH QUESTIONS

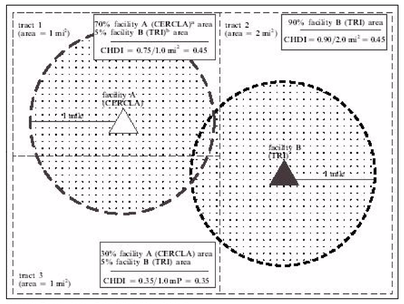
1. Are there environmental inequities in the distribution of large industrial facilities and their hazardous emissions in the Phoenix metropolitan area?

2. Do patterns of inequities change with the methods used to allocate risk across the metro area?

3. Do patterns of environmental inequities in Phoenix change as locations and amounts of industrial emissions shift in the decade between 1990 and 2000?

METHODOLOGY

We begin our analysis by calculating a ***Hazards Density Index*** (HDI) for each Census Tract in the Phoenix Metropolitan Statistical Area for 1990 and 2000.



Hazards Density Index Calculation (Unweighted)

Our Hazards Density Index (HDI) is constructed by calculating what portion of 1-mile radial buffers around TRI facilities falls inside each Census Tract. By slicing each buffer into overlapping wedges, we can account for the spillover effect of toxic emissions into neighboring Census Tracts. The cumulative area occupied by all buffer wedges in a tract is used both to calculate hazard by facility encroachement and by volume of air emissions in a tract.

Accordingly, we weigh the HDI score by emissions volume to obtain an HDI score that takes into account air emissions. In this research we only map TRI facilities because these data allow us to determine which facilities were in operation in 1990 and in 2000. Through GIS mapping we uncover the spatial distribution of HDI in the study area. High HDI values indicate high concentrations of hazardous facilities and toxic air emissions in a tract.

We then look at the sociodemographic characteristics and difference of t-tests of HDI and host/non-host Census Tracts.

Going beyond traditional statistical analysis, we apply **Geographically Weighted Regression** to examine the spatial manifestation of the relationship between race and class to HDI.

We illustrate the results by mapping sociodemographic indicators (percent Hispanics, Blacks, renter) and the local r-squared statistics of the GWR analysis.

WHAT IS GWR?

The application of statistical regression techniques is limited for analysis of spatial data because it assumes that the process examined is constant over space, that is, it presupposes that *"the regression parameters are 'whole-map' statistics"* (Fotheringham *et al.* 2006).

Conventional regression generates a single regression equation to describe the relationship between variables. GWR generates spatial data about the spatial variation in the relationship between variables.

Geographically Weighted Regression accounts for the spatial non-stationarity of events by estimating local --as opposed to global--parameters for each mapped relationship, in this case HDI against each demographic.

Local parameters are estimated by assigning more weight to observations that are closer to the location of the desired parameter than those farther away.

A local r-squared statistic (for each observation point) generated by GWR can be mapped to discover what fraction of the local variance is explained by the regression.

FINDINGS

The total volume of reported TRI emissions in the Phoenix MSA decreased from 6,066,903 pounds in 1990 to 2,146,546 pounds in 2000, a 64.6 percent decrease. Offsite transfers, however, increased dramatically during the period. The number of TRI facilities also increased from 165 to 189.

The difference of means test between tracts with HDI scores of zero and greater than zero shows that in both 1990 and 2000, average percentages of the Black, Latino, and Native American population were higher for tracts with positive HDIs than for zero-value HDI tracts, with the exception of the Native American population in year 2000, which experienced a small reduction in its presence within larger-than-zero HDI tracts. Both percentage White and the number of persons of median income are higher in tracts with zero-value HDIs.

Similarly, TRI host/non-host difference of means analysis suggests that both percentage White and the number of persons of median income are higher in census tracts without TRI facilities than in those that host TRI sites.

The higher-intensity colors in the R^2 maps indicate in what parts of the Phoenix MSA each associated sociodemographic variable becomes a strong predictor of high HDI values.

In 1990, high predictability by percent Latino and Black is highly concentrated in a few clusters, the largest one located in central Phoenix.

The spatial relationship between these two ethnicity indicators is very similar. The relationship between HDI and percent renters is weaker, although a similar concentration pattern is present.

The pattern in 2000 appears much more diffuse, with much weaker relationships (compared to 1990) across all three sociodemographic indicators. Percent Latino,however, emerges as the strongest predictor of HDI during this period.

The differences between 1990 and 2000 are possibly due to the large reduction in emissions during the period. A large influx of Latinos to the area in the years since 1990 may also account for the shift.

Our findings suggest that the relationship between race and class and proximity to hazardous industrial facilities is marked. The GWR analysis contributes to a spatially-aware understanding of environmental injustice by demonstrating local variations within a study area.

Statistical Analysis

	1990		2000	
%White				
HDI>0 (sd)	67.07	(27.3061)	49.51	(27.3863)
HDI=0 (sd)	82.26	(18.2799)	71.32	(22.4797)
t (significance)	6.48	(0.0000)	8.27	(0.0000)
%Latino/a				
HDI>0 (sd)	23.18	(15.1423)	38.34	(26.1654)
HDI=0 (sd)	12.69	(22.3949)	21.01	(20.1863)
t (significance)	-5.44	(0.0000)	-6.97	(0.0000)
%Black				
HDI>0 (sd)	5.21	(9.1019)	5.30	(7.0437)
HDI=0 (sd)	2.65	(5.2123)	3.01	(3.3120)
t (significance)	-3.37	(0 .0004)	-3.70	(0.0001)
%Native				
HDI>0 (sd)	2.78	(8.4629)	1.21	(8.2617)
HDI=0 (sd)	0.84	(1.2008)	2.52	(1.7711)
t (significance)	-2.97	(0.0017)	-1.87	(0.0315)
Median Income				
HDI>0 (sd)	39,379	(19,427)	40,486	(19,007)
HDI=0 (sd)	48,028	(20,996)	48,403	(18,991)
t (significance)	4.50	(0.0000)	4.12	(0.0000)

Mean sociodemographic characteristics and difference of means t-test for census tracts with zero and nonzero Hazard Density Index Scores

TRI facility in tract	1990		2000	
% White				
With (sd)	63.3	(30.3572)	47.0	(28.5260)
Without (sd)	78.8	(21.1543)	67.3	(24.6376)
t (significance)	3.90	(0.0001)	5.18	(0.0000)
% Latino/a				
With (sd)	26.8	(26.0649)	40.7	(26.9667)
Without (sd)	14.9	(16.8994)	24.1	(22.2186)
t (significance)	-3.51	(0.0004)	-4.51	(0.0000)
Percent Black				
With (sd)	5.4	(9.5508)	5.4	(6.2369)
Without (sd)	3.3	(6.4855)	3.4	(4.5843)
t (significance)	-1.65	(0.0519)	-2.30	(0.0123)
% Native				
With (sd)	2.9	(10.6659)	3.0	(10.9782)
Without (sd)	1.3	(3.8064)	1.4	(2.9592)
t (significance)	-1.17	(0.1224)	-1.12	(0.1342)
Median Income				
With (sd)	38,935	(20,030)	40,005	(20,299)
Without (sd)	45,780	(20,831)	46,893	(19,043)
t (significance)	2.58	(0.0007)	2.45	(0.0082)

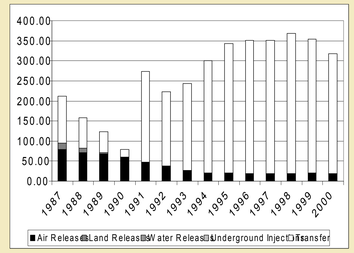
Mean sociodemographic characteristics and difference of means t-tests for census tracts with and without TRI sites

	1990		2000	
	Unstandardized	Standardized	Unstandardized	Standardized
Air Releases	60.82	51.32	17.81	13.38
Off-site Transfers	18.46	8.58	299.81	214.53
Total	79.27	59.90	318.05	228.28
Inhalation Toxicity Weight (100,000 lbs)*				
	1990		2000	
	Unstandardized	Standardized	Unstandardized	Standardized
Air Releases	2,900.11	2,491.67	6,152.01	3,212.74
Off-site Transfers	16,798.27	15,002.06	1,373,898.70	681,382.08
Total	19,698.52	17,493.72	1,387,368.25	691,912.23

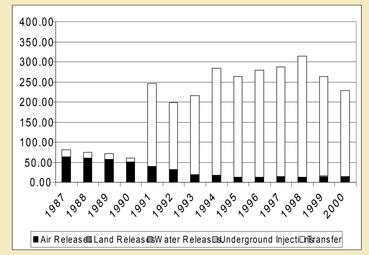
Phoenix TRI Releases by Medium and Inhalation Toxicity Weight, 1990 and 2000

Year	Number of TRI sites	Number of tracts with at least one site	Number of tracts with no sites	Number of tracts with HDI>0	Number of tracts with HDI=0
1990	143	63	403	171	295
2000	126	59	407	140	326

Distribution of Metro Phoenix TRI sites with stack and fugitive air emissions by census tract, 1990 and 2000

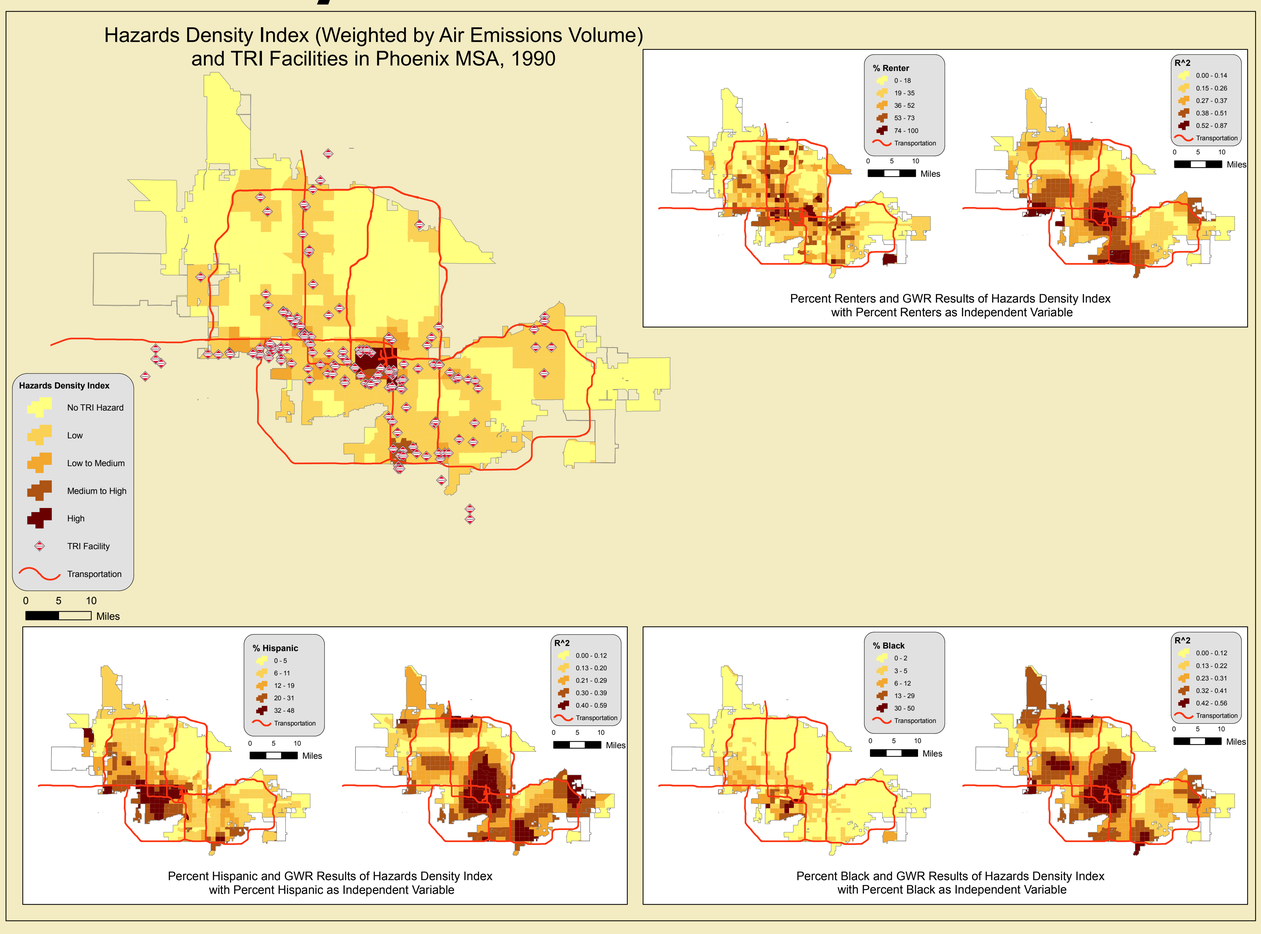


TRI Releases by Medium (100,000 lbs), 1987-2000
Data Sources: EPA TRI, 1987-2000 high-level summary downloaded from www.rtk.net



TRI Releases by Medium (100,000 lbs): Standardized to original chemical list 1987-2000
Data Sources: EPA TRI, 1987-2000 high-level summary downloaded from www.rtk.net

GWR Analysis 1990

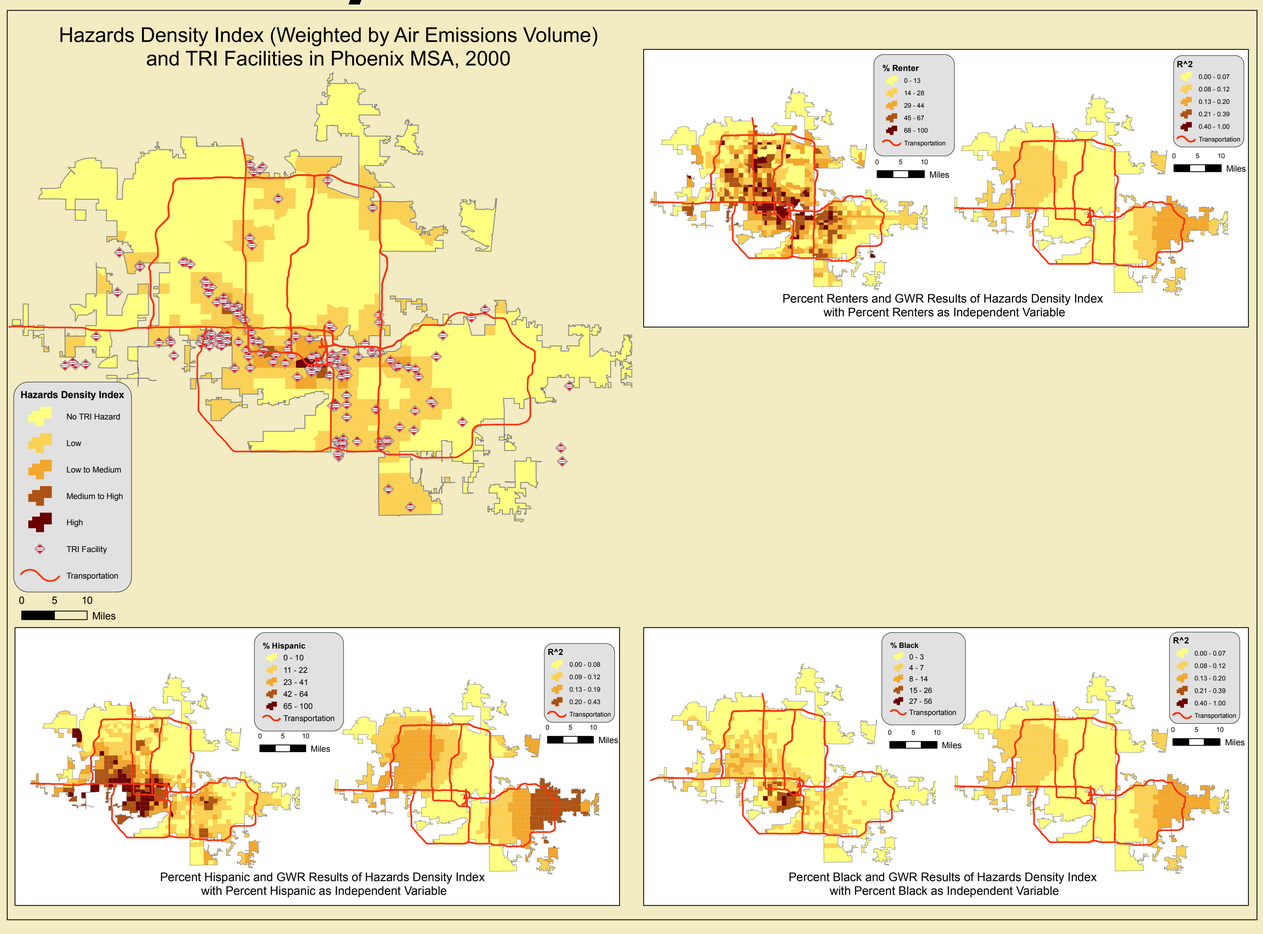


Percent Renters and GWR Results of Hazards Density Index with Percent Renters as Independent Variable

Percent Hispanic and GWR Results of Hazards Density Index with Percent Hispanic as Independent Variable

Percent Black and GWR Results of Hazards Density Index with Percent Black as Independent Variable

GWR Analysis 2000



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