Risk Analysis, Vol. 16, No. 4, 1996

The Role of Geographic Scale in Monitoring Environmental Justice

Susan L. Cutter,[1,3] Danika Holm,[2] and Lloyd Clark[1]

Received July 19, 1995; revised December 2, 1995

Utilizing the concept of environmental justice, this paper examines the differential burdens of toxic and hazardous waste facilities locations in low income minority communities. The association between the presence of facilities and socioeconomic characteristics of places are examined for the state of South Carolina at three different spatial scales: counties, census tracts, and census block groups. Three different types of hazardous waste/toxic facilities are also examined: Toxic Release Inventory (TRI) sites, Treatment, Storage, and Disposal sites (TSD), and inactive hazardous waste sites. At the county level, there was some association between the presence of toxic/hazardous waste facilities and race and income. In South Carolina, this translates to a disproportionate burden on White, more affluent communities in metropolitan areas, rather than low income minority communities. At both the census tract and block group levels, there is no association between race and the location of toxic/hazardous waste facilities. There are slight differences in the income levels between tracts and block groups with facilities and those without. This localized ecology of hazard sources must be expanded to include emission/discharge data in order to adequately address environmental justice issues on who bears the burdens of environmental contamination.

KEY WORDS: Environmental justice; toxic hazards; hazardous waste; spatial scale.

1. INTRODUCTION

The issue of fairness in the distribution and impact of environmental risks and hazards continues to generate headlines. Concern about the disproportionate impact of environmental hazards on people of color and economically-disadvantaged groups led to the formation of the environmental justice movement—a coalition of environmental, civil rights, and social equality activitists. In 1987, the United Church of Christ's Commission on Racial Justice published their landmark study on toxic waste and race, offering some empirical support for environmental discrimination claims.[1] On February 11, 1994, President Clinton signed Executive Order Number 12898, requiring each federal agency to adopt the principle of environmental justice in programmatic decisions. Yet, 2 years after this new directive, there still is little consensus on the definition, classification, and measurement of inequity.

Most of the social science literature on environmental equity either examines the spatial and/or temporal distribution of benefits and burdens (called outcome equity) or identifies the causal mechanisms that give rise to these differences in the first place (process equity). As suggested elsewhere[2–4] inequity originates from three major sources of dissimilarities: social, generational, and procedural. To test for outcome equity, one examines the disproportionate effect of environmental degradation on places or people arising from these dissimilarities.[5]

To fully examine equity issues we need a more systematic analyses of what constitutes an equity problem

[1] Department of Geography, University of South Carolina, Columbia, South Carolina 29208.
[2] Agency for Toxic Substances and Disease Registry, 1600 Clifton Road NE, Mailstop E-56, Atlanta, Georgia 30333.
[3] To whom all correspondence should be addressed.

0272-4332/96/0800-0517$09.50/1

(what parameter do we measure), what is the appropriate scale for examining equity (which spatial unit of measurement), and what time-frame should be considered in looking at causes of equity or its spatial consequences.[3,6,7] Two of these considerations (parameter measured and scale) are addressed in this paper. Using 1992 hazards and 1990 social data, three different risk sources and three different spatial units are used to test the following hypothesis: hazardous waste or toxic facilities are disproportionately located in economically disadvantaged and minority communities within South Carolina.

South Carolina is one of the primary dumping grounds for hazardous and radioactive waste for the entire nation.[8-10] It is a poor, rural state with a relatively high percentage of residents who are people of color. Given that South Carolina is ''dumped on'' in the national context, are the facilities within the state also dumping on minority, poor, and disempowered communities? A number of specific questions guide our analysis. First, what is the nature of the distribution of hazardous waste and toxic facilities/sites throughout the state and what is the relationship between race, economic status, and location of these facilities? Second, do these associations differ when varying spatial scales are employed as the unit of analysis? Third, are the relationships between race, economic status, and location of facilities consistent between different types of hazardous facilities/sites?

2. THE SOCIAL BURDENS OF ENVIRONMENTAL POLLUTION

The suggestion that the poor residents of inner city neighborhoods bear the greatest burden of environmental contamination is nothing new. As early as 1971, the USEPA commissioned a number of studies on the topic.[11-14] Currently, research on the social burdens of pollution is being addressed within the environmental justice framework.

2.1. Environmental Justice

Most people consider the environmental justice movement began in Warren County, North Carolina, in 1982.[15-19] Civil rights activists and political leaders joined area residents to block unsuccessfully, the construction of the PCB landfill. An investigation of hazardous landfill siting practices followed which found a strong relationship between the siting of four hazardous waste landfills in the Southeast and the race and socioeconomic status of the surrounding communities.[20] The accumulating evidence and increasing public awareness prompted the United Church of Christ's Commission for Racial Justice to initiate a national study of toxic waste sites and race.[1] Communities with commercial hazardous waste facilities had greater numbers of minority residents living in close proximity to hazardous waste facilities than other communities in the same county without facilities. Race, more than any other demographic variable, most strongly correlated with the location of waste facilities, prompting many activists to claim ''environmental racism'' in describing the inequality resulting from corporate economic and governmental regulatory decisions.[21]

2.2. Do Inequities Exist?

Despite the fact that environmental justice is a major social issue, the empirical support for inequity remains mixed.[3,22] There is little consistency in the research findings as to the source of the inequity (e.g., the specific environmental threat), the spatial scale, targeted subpopulations (people of color, elderly, children), or time frame (longitudinal or snapshot approaches). For example, the United Church of Christ study[1] compared demographic patterns and the location of hazardous waste sites using zip code areas as the unit of analysis. In a 1993 update,[23] the initial UCC results were reaffirmed and the strength of the associations increased. For example, the concentration of people of color living in communities with commercial hazardous waste facilities increased from 25% in 1987 to 31% in 1993. This was largely due to manipulating statistical averaging procedures, not necessarily as a consequence of demographic shifts. In the 1987 report, unweighted statistics were utilized while the 1993 update used weighted averages based on the total population in each zip code area. When controlling for regional variations, income, not race turns out to be the key determinant of differences in the locations of facilities.

As a consequence of different units of analysis (zip codes, census tracts, etc.), and the use of different sources of environmental threats (NPL sites, TSD facilities), the findings on differential burdens cannot be compared and thus do not offer definitive proof of environmental justice claims one way or the other (Table I). Clearly, the methodological units employed directly impact the conclusions. For example, proponents of zip codes as the unit of measurement[1,23,24] claim zip codes offer more detailed analyses for national comparisons

Table I. Empirical Support for Environmental Justice Claims

Reference number	Coverage	Spatial unit	Environmental threat
32	national	county	NPL sites
7	national	county	TRI emissions
1	national	zip codes	hazardous waste landfills
23	national	zip codes	hazardous waste landfills and facilities
24	national	zip codes	TSD facilities
5	national	towns	waste-to-energy facilities
33	national	minor civil div.	NPL
25	25 SMSAs	census tract	TSD facilities
26	25 SMSAs	census tract	TSD facilities
14	13 SMSAs	census tract	air and water pollution, noise, solid waste
32	state/SC	county	TSD facilities
31	state/SC	county	toxic emissions
34	state/NJ	minor civil div.	NPL
28	state/SC	census tract	TSD facilities
22	SMSA/Detroit	1.5 mile zones	commercial hazardous waste facilities
27	SMSA/Pittsburgh	census tract	TRI, extremely hazardous substance facilities
17	SMSA/Houston	neighborhood	incinerators and landfills
35	SMSA/Baton Rouge	entire area	environmental hazards
29	county/Los Angeles	census tract	TRI emissions
20	Southeast/four locales	zip codes	hazardous waste landfills
44	Southeast/four locales	census tract	hazardous waste landfills
	SMSA/Houston	census tract	incinerators and landfills

than county coverages. There are about 3100 counties nationwide vs. 30,000 5-digit zip codes, and the areal coverage of zip codes is less. Zip codes are more inclusive than census tracts, for example, which do not always cover rural areas. Furthermore, for national comparisons, census tract data are more expensive to acquire for the entire U.S., a consideration that might limit comparative assessments for the entire U.S. Studies using census tract divisions[25–29] offer more detailed localized analyses. Census tracts are relatively homogeneous in terms of populations size (around 4000) while zip code populations are highly variable thus necessitating standardization when computing percentages, a problem addressed by Goldman and Fitton[23] in their use of weighted averages. Also, census tracts are a better approximation for "neighborhood" than zip codes because of their smaller areal coverage. Other spatial units used in previous empirical studies include counties,[7,30–32] minor civil divisions (MCDs),[33,34] and undifferentiated metropolitan areas.[35,36]

The discrepancy in the choice of areal units affects the comparability of studies and ultimately the strength of the statistical associations. Within geography, this is known as the modifiable areal unit (MAU) problem.[37] Scale differences or the variation in results obtained when data are aggregated into fewer and larger units is one manifestation of the MAU problem. The ecological fallacy, ascribing aggregate data (such as percent minority) to all individuals who form that aggregate, is another example of the MAU problem. Correlation coefficients tend to increase with aggregation.[37] Thus, it should be no surprise that different spatial units of analysis will produce different correlations, and that the larger the unit of measurement, the stronger the correlation. Unfortunately, these methodological issues have not been adequately addressed in the literature as Zimmerman and others point out.[3,6,7] To illustrate these methodological concerns, we will test the robustness of the equity hypothesis using three different spatial scales and three different environmental parameters.

3. SOUTH CAROLINA'S SOCIAL GEOGRAPHY

South Carolina is a relatively small state with a diverse physical and human landscape.[38] It is characterized by its poor and rural populace. The state is below the national and regional averages for median household income and educational attainment, and above the national average for percentage of residents living in poverty. Less than 55% of the state's population is defined as urban, and only 16 of the state's 46 counties are labeled metropolitan according to the U.S. Census.

The state's four major regions represent a different settlement history that typifies the social mosaic found within the state. The Upstate region is the historical center of manufacturing and has the smallest percentage of both African American residents and persons below the poverty line (Fig. 1a, b). The Upstate has more than a third (1.3 million) of the state's population, yet has moderate population densities (50 persons per square mile). More than 70% of the population is White and more than 85% live above the poverty line with median household incomes greater than $24,000.[39]

The Midlands region is more densely populated than the Upstate (61 people per square mile), yet has fewer people (.6 million). With the exception of the Columbia metro area, most of the Midlands is rural. The population is generally more affluent and more educated than statewide averages (Fig. 1b).

The Inner Coastal Plain is rural with average densities of 28 persons per square mile. The population is poor (25% below the state average for median household income), African American (53%), and less educated than the rest of the state. More than one-quarter of the population lives below the poverty line and the region has the highest unemployment rate in the state (averaging more than 8%) (Fig. 1c). The regional economy is dominated by agriculture.

The Low country, South Carolina's coastal region, contains some of the steepest socioeconomic gradients within the state. For example, one of the wealthiest communities in the state (Hilton Head with a median household income of $42,995) as well as some of the poorest (Ridgeland with a median household income of $16,029) are found within close proximity. The Low Country has one-quarter of the state's population, mostly concentrated in the Charleston metropolitan area and in Myrtle Beach, yet the rest of the Low country is very rural. Population densities mirror the statewide average. Median household income is below the state average, while the percentage of non-White residents is slightly above (35%). Tourism and forestry dominate the regional economy, with the exception of an industrialized core in metropolitan Charleston.

4. RISK MOSAIC

Three parameters were used to measure inequities in hazardous waste/toxic burdens on state residents: hazardous waste treatment, storage, and disposal (TSD) facilities; Toxic Release Inventory facilities (TRI); and inactive hazardous waste sites (CERCLIS). The state has 79 treatment, disposal, and storage (TSD) sites that are concentrated in the three largest metropolitan complexes—Spartanburg-Greenville, Charleston, and Columbia—although more than half the counties in the state (26 of 46) are sites for these permitted hazardous waste facilities (Fig. 1d). In 1992, 46 states sent hazardous waste to South Carolina,[40] and the majority of this out-of-state waste was sent to seven facilities: two hazardous waste incinerators (Rock Hill, Roebuck), a commercial hazardous waste land disposal facility (GSX-Laidlaw) in Pinewood, two cement kiln incinerators (Harleyville, Holly Hill), and two recycling facilities in Greer and Sumter.[41]

The second risk indicator is Toxics Release Inventory (TRI) sites. TRI is a national database of industrial facilities that release toxic and hazardous chemicals. The current reporting threshold is for facilities generating more than 25,000 pounds of toxics in manufacturing and processing uses, and 100,000 pounds for other uses. The TRI includes on-site releases (air, water, land, underground injection), and off-site transfers (to treatment or disposal facilities). In 1991, the TRI was expanded to include new data on off-site transfers of wastes for recycling and energy recovery as well as on-site recycling, energy recovery, and treatment as mandated by the Pollution Prevention Act of 1990. In 1992 there were 436 TRI-reporting facilities in South Carolina[42,43] (Fig. 1e). These were concentrated primarily in the Upstate, especially in Greenville and Spartanburg counties. Outliers are found in the Midlands metro counties and in the Charleston metropolitan region.

The last indicator of toxic hazards is the location of inactive hazardous waste sites that are candidates for remediation. These abandoned hazardous waste sites litter the South Carolina landscape, as they do elsewhere. In 1992, there were 23 South Carolina sites on the National Priority List (NPL) in the process of being cleaned up, and another 424 were identified by the state for priority cleanup under the Superfund program. The 23 NPL sites were located predominately in Greenville, Lexington, Richland, and Beaufort counties. The remaining CERCLIS sites (identified by the state and listed for eventual remediation under the national Superfund program) are more evenly distributed, although some clustering occurs in the Greenville-Spartanburg area and in the Columbia and Charleston metro regions (Fig. 1f).

5. SCALE DIFFERENCES IN MEASURING INEQUITY

To begin our analysis, we examined the relationship between the location of hazardous/toxic facilities and the social profiles of counties. There are strong and statistically significant associations between the number of facilities per county and a number of our social indica-

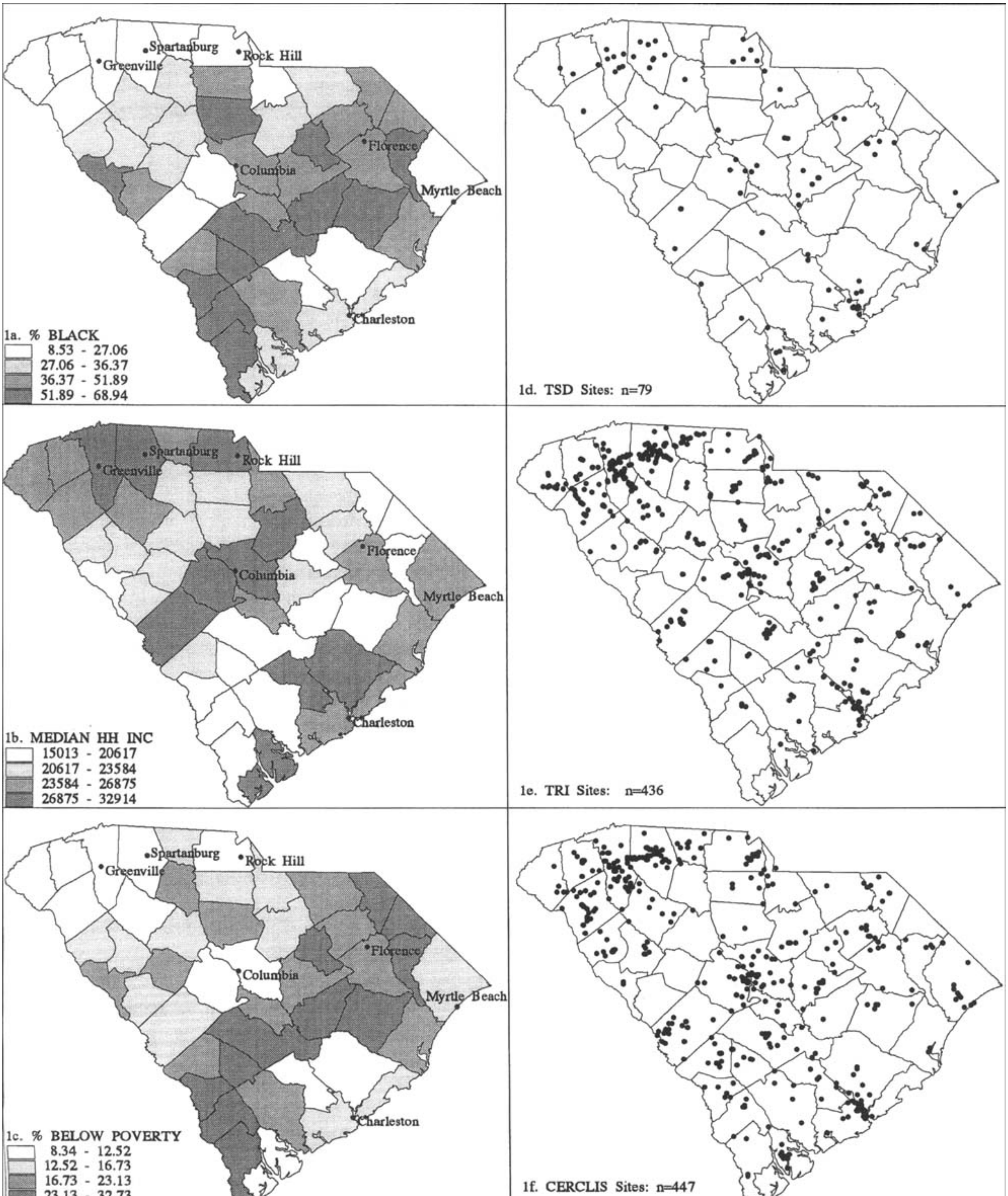

Fig. 1. The distribution of hazardous sites and sociodemographic characteristics in South Carolina.

Table II. County Comparisons of the Frequency of Sources of Environmental Threats (r)

Social indicator	TSD	CERCLIS	TRI	Total
Population	.81***	.90***	.83***	.90***
Population density	.78**	.86***	.83***	.88***
Black (%)	−.39**	−.42**	−.43**	−.44***
Below poverty (%)	−.45**	−.46**	−.45**	−.48***
Med HH income	.57***	.55***	.47***	.54***
Under 18 (%)	−.33*	−.42**	−.38*	−.41**
Over 55 (%)	−.41**	−.26	−.17	−.24
LT 12 yrs. educ. (%)	−.61***	−.54***	−.38**	−.50***
College degree (%)	.63***	.64***	.51***	.61***
Mfg. employ (%)	.63***	.66***	.51**	.61***
Laborers (%)	−.58***	−.51***	−.29*	−.43**
Unemployed (%)	−.47***	−.44**	−.41**	−.45**
Total N	79	447	436	962
Counties (%)	56.5	95.6	93.5	97.8

* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table III. Correlations Between Frequency of Facilities and Spatial Unit (r)

Social indicator	County	Tract	Block group
Population	.90***	.20***	.10***
Population density	.88***	−.20***	−.14***
Black (%)	−.44**	.00	.03
Below poverty (%)	−.48***	−.00	.02
Med HH income	.54***	−.05	−.06**
Under 18 (%)	−.41**	.11***	.06***
Over 55 (%)	−.24	−.10**	−.07***
LT 12 yrs. educ. (%)	−.50***	.12***	.07***
College degree (%)	.61***	−.17***	−.11***
Mfg. employ (%)	.61***	−.16***	−.11***
Laborers (%)	−.43**	.18***	.10***
Unemployed (%)	−.45**	.05	−.06***
Total N	46	832	3185
With sites (%)	97.8	46.9	18.8
Mean no. sites	20.56	1.15	0.29
Range	0–106	0–13	0–7

* $p < .05$.
** $p < .01$.
*** $p < .001$.

tors (Table II). For example, the strongest correlation was with population and population density. Counties with larger populations and higher population densities were associated with greater numbers of these facilities. More surprising was the negative association with percentage black and the percentage below poverty levels. Higher frequencies of facilities per county were associated with higher income ($r = .54$, $p = .001$), White ($r = .45$, $p = .01$), college-educated residents ($r = .58$, $p = .001$). There is no significant difference between each risk indicator (TSD, CERCLIS, or TRI) and direction of the social indicators correlations (positive or negative), but there were minor differences in the relative strength of the associations.

Based on this initial statistical test, we conclude that inequities do exist within South Carolina, but they do not involve counties that one thought were the most obvious, (i.e., low income counties with high percentages of minority residents). Rather, it appears from this county-level analysis that it is the more urbanized, White, middle-income counties that bear a disproportionate burden of hazardous waste/toxic facilities.

Because of the state's developmental history, South Carolina counties are not homogeneous and exhibit wide variations in social characteristics within each county. The rural nature of much of the state and the lack of localized zoning means that socioeconomic gradients within and between counties are quite steep. To test whether hazardous waste facilities are located in the economically disadvantaged or minority sections within counties required an examination of the state's subcounty geography. There are 821 Census tracts in South Carolina, each containing approximately 4000 people. In replicating the county correlation analysis we found little or no correlation between frequency of sites and social indicators at the tract level (Table III). Race and income had no association with the presence or absence of hazardous waste/toxic facilities at this spatial scale. Even when controlling for the effect of population and population density, there was no association between race and income and the number of facilities. This can be partially explained by the lack of any facility in 53% of all tracts. It is also partially explained by the disaggregation of the data.

We also used this statistical procedure at the block group Census level. Here, even fewer block groups contained sites (only 19% contained one or more facilities). Again, there was no association between the number of facilities, race, or income at the block group unit of analysis. Even when controlling for population density and populations, the income or racial composition of block groups had no bearing on the presence or absence of facilities.

Because of the high correlations with population and population density discovered in our first test, we ran a sensitivity analysis on the data to see if there was an urban bias. Only MSA-designated counties were selected ($N = 16$), and the Pearson correlation analysis was repeated at the county, tract, and block group levels. There are no statistically significant associations between race or income and the presence of hazardous waste/toxic facilities in urban counties. This conclusion also holds true for tracts and block groups within urban counties as well.

As a result of the weak associations in the correlation test, we ran a *t*-test procedure to examine socioeconomic differences between tracts with and without a hazardous waste/toxic facilities. Census tracts with toxic/hazardous waste facilities averaged 2.5 sites per tract (ranging from 1 to a high of 13). There are no significant differences in the racial composition of tracts that host and those that do not host a hazardous waste/toxic producing facility (Table IV). With respect to economic indicators, there are no differences based on our poverty indicator, but there is a distinction between tracts with sites and those without when one looks at median household income. In other words, the median income for tracts with a site is 5% lower ($1320) than those without a site. Tracts hosting hazardous waste/toxic facilities generally are more populated but have lower population densities. Census tracts with facilities also have a higher percentage of residents under 18, residents who are less educated, and a higher percentage of residents employed as laborers than tracts without facilities. Similar findings were found when the block group spatial unit was used (Table IV). At this level, race was also insignificant. Median household income discrepancies were slightly greater (7% or around $1801). Block groups hosting facilities are characterized by higher populations, higher percentages of children, poorer educational levels (36% do not even have a high school diploma), and higher percentages of residents working in laboring professions.

Since we found differences in the social profile of tracts and block groups with and without hazardous/toxic sites, our final test of the equity hypothesis involved a classification procedure. A discriminant analysis was run first for tracts (dichotomized as those with and those without sites) to see if we could predict membership in either category based on the social profile of the tract. In the first procedure, the discriminant analysis correctly classified only 60% of the tracts using these social indicators. Type of employment (labor, manufacturing) and educational levels were the most significant variables in differentiating tracts and block groups with toxic facilities from those without. In the second procedure, block groups were used, and we were able to correctly classify 81% of the block groups using these social indicators. We can conclude that neither race nor economic status, in and of themselves, predict whether or not a community hosts a hazardous waste or toxic facility. In South Carolina, those social indicators best able to differentiate are percentage employed in labor occupations, percentage of residents with college degrees, and percentage employed in manufacturing occupations. There is no spatial pattern to those census tracts or block groups that were correctly or incorrectly classified.

6. PROVING ENVIRONMENTAL INJUSTICE

There are a number of important findings of this research. First, the distribution of hazardous facilities within South Carolina is clustered in the Upstate industrial core and in the metropolitan complexes of Charleston and Columbia. Second, there is general consensus on the relationship between race, income, and the locations of our three different risk indicators (TSD, TRI, and CERCLIS sites). Where correlations differed it was due to minor variations in the strength of correlations not the direction (Table V). Third, in using three different spatial units (county, census tract, block group), we found conflicting evidence in support of our inequity hypothesis. At the county level, there was an association between race and economic status and the presence of hazardous waste/toxic facilities. In South Carolina, this association meant that White, relatively affluent residents in metropolitan areas were disproportionately affected more than rural, low-income minority residents. When these patterns are examined at the census tract and block group levels, there is no discernible difference in the racial composition of tracts (or block groups) that have or do not have one or more of these facilities. There are only slight differences in economic levels.

These results challenge the conclusions reached by Goldman and Fitton for the South.[23] This suggests that aggregation at regional scales masks both interstate and intrastate variations. In South Carolina, the bulk of the state's industrial sector is located in the upper Piedmont, a region that has a relatively low African American population. This may help explain why race is not associated with the presence of these facilities. Manufacturing plants produce a range of toxic substances in varying amounts with different toxicity levels, yet our analysis grouped them all together. For example, one of the region's largest and most toxic hazardous waste facility (GSX-Laidlaw in Pinewood) is, in fact, located in one of the poorest communities in the state. If we were to look at those facilities that generated the most toxic of emissions (in both quantity and toxicity) we may find a very different pattern of inequity than the one presented here.

Table IV. Difference of Means Test Between Areas With and Without Sites

Social indicator	Tracts[a] W/sites (N = 385)	Tracts[a] W/O sites (N = 436)	Difference	Block group[b] W/sites (N = 600)	Block group[b] W/O sites (N = 2585)	Difference
Population	4725	3808	917***	1256	1053	203***
Population density	255	560	305***	255	599	344***
Non-White (%)	33.5	32.4	1.1	33.6	31.4	2.2
Below poverty (%)	16.2	15.9	0.3	16.5	15.9	0.6
Med HH income ($)	25324	26644	1320*	25137	26938	1801***
Under 18 (%)	26.8	25.1	1.7***	26.9	25.3	1.6***
Over 55 (%)	19.8	21.7	1.9***	20.4	22.5	2.1***
LT 12 yrs. educ. (%)	34.2	30.1	4.1	36.2	32.0	4.2
College degree (%)	12.4	16.9	4.5***	11.3	15.7	4.4
Mfg. employ (%)	17.8	21.7	3.9***	16.7	20.8	4.1***
Laborers (%)	22.7	18.6	4.1	24.1	19.8	4.3
Unemployed (%)	6.3	5.8	0.5	6.6	5.9	0.7

[a] DF 435, 384.
[b] DF 2584, 599.
* $p < .05$.
*** $p < .001$.

Table V. Correlation Coefficients (r) of Race and Income by Spatial Scale and Source of Environmental Risk[a]

	RCRA		CERCLIS		TRI	
	With sites	All	With sites	All	With sites	All
County						
Black (%)	−.39**	−.39**	−.42**	−.42**	−.43**	−.42***
Below poverty (%)	−.45**	−.46**	−.46*	−.48**	−.45**	−.46**
Median income	.57**	.57**	.55**	.56**	.47**	.47**
Tract						
Non-White (%)	−.04	−.01	.02	.02	−.05	−.01
Below poverty (%)	−.09	−.05	.02	.02	−.02	−.00
Median income	.09	.03	−.04	−.06	−.00	−.04
Block group						
Non-White (%)	−.03	−.00	−.05	−.04*	−.02	−.02
Below poverty	−.06	−.02	.06	.03	.01	.01
Median income	.05	−.00	−.03	−.05**	−.02	−.02

[a] County n = 46 for all, n = 45 with sites only; tract n = 821 for all, n = 385 with sites only; block group n = 3185 for all, n = 600 for sites only.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Whether or not this current analysis provides conclusive support of the inequity hypothesis is difficult to say. Because our analysis focused on political divisions (e.g., Census-defined areas) there are some caveats to our conclusions. The geographic area may not be representative of the impact area, which might extend beyond the boundary of the census unit. Second, the facility may not be located in the center of the spatial unit, and thus the representativeness of the sociodemographic data may be questionable as pointed out earlier in the paper. This edge effect is a consistent problem in census geography and one that could easily be remedied using the analytical capabilities in a GIS. While not the focus of this current study, this is a direction for future research.

We also chose to examine associations between the presence or absence of sites and socioeconomic characteristics. This was deliberate as we wanted to compare our findings to others in the literature. Again, a more robust analysis could take a linear, predictive approach using probit or regression analyses, or a nonlinear approach utilizing neural network analysis. Both methodologies, however, are beyond the scope of this paper and the questions we posed.

The next step is to focus on potential exposures to hazardous substances from these facilities (as mentioned above), not simply their presence or absence in the community. From our perspective, this is the most important consideration for environmental justice research, as communities of color might have greater potential exposure levels to environmental contaminants even though the number of hazardous waste/toxic sites is relatively small. This type of analysis moves the debate from a static dimension (e.g., the original siting decision and the current demographic composition of communities) to a more dynamic system involving both qualitative and quantitative estimates on the amount of contaminants discharged from facilities and the potential pathways of exposure. These can then be generalized to estimate which communities might be most affected, by what type of contamination, and thus determine the appropriate mitigation or policy responses. This localized ecology of hazards and potential exposures could be expanded to include other non-industrial sources of risk such as those from agricultural use of pesticides or the transportation of hazardous substances. A secondary line of research should focus on the historical development of the toxic landscape, and the need to identify which came first (the facility or the people) as we track the original siting of facilities and changes in community composition over time. Both are needed as we focus on the hazards of places and the implementation of environmental justice principles.

Finally, our results suggest that tracts and block groups are the most appropriate spatial scale for assessing inequities because of wide intra-county and intra-zip code variations in risks and socioeconomic indicators. Empirical verification of environmental justice must be conducted on a state-by-state basis to ensure the robustness of the findings thus building the evidentiary support from the local context to the national pattern. County-level analyses are useful as a first cut to provide a comparative assessment at the national or regional level, but to adequately measure and monitor environmental justice concerns, we must look to our own backyards and our knowledge of the local setting. It may be that the most appropriate scale lies beyond our ability to manipulate statistical information (e.g., local neighborhoods or blocks). Specific site-level visits may be required to determine whether locational decisions, do, in fact, lead to greater potential exposures for people of color. In moving beyond the activist rhetoric, we must have a better social scientific understanding of the complexities of environmental threats, locational patterns, spatial scale, and the social geography of local places. A geographical understanding of all these dimensions is absolutely critical in the implementation of environmentally-just public policies.

ACKNOWLEDGMENTS

We wish to thank Minhe Ji for his assistance in the preparation of the graphics for this article. This research was partially supported by grants from the South Carolina Universities Research and Education Foundation (#30-95, #62-95).

REFERENCES

1. United Church of Christ, Commission for Racial Justice, *Toxic Wastes and Race: A National Report on the Racial and Socioeconomic Characteristics of Communities with Hazardous Waste Sites* (United Church of Christ, New York, 1987).
2. R. D. Bullard, "Overcoming Racism in Environmental Decision-making," *Environment* **36**(4), 10–20, 39–44 (1994).
3. S. L. Cutter, "Race, Class, and Environmental Justice," *Progr. Hum. Geog.* **19**(1), 111–122 (1995).
4. R. E. Kasperson, "Global Environmental Hazards: Political Issues in Societal Responses," in G. J. Demko and W. B. Wood (eds)., *Reordering the World: Geopolitical Perspectives on the 21st Century* (Westview Press, Boulder, 1994) pp. 141–166.
5. M. R. Greenberg, "Proving Environmental Inequity in Siting Locally Unwanted Land Uses," *Risk—Issues Health Safety* **235** (Summer), 235–252 (1993).
6. R. Zimmerman, "Issues of Classification in Environmental Equity: How We Manage Is How We Measure," *Fordham Urban Law J.* **21**, 633–669 (1994).
7. S. A. Perlin, R. W. Setzer, J. Creason, and K. Sexton, "Distribution of Industrial Air Emissions by Income and Race in the United States: An Approach Using the Toxic Release Inventory," *Environ. Sci. Technol.* **29**(1), 69–80 (1995).
8. B. Hall and M. L. Kerr, *1991–1992 Green Index: A State-by-State Guide to the Nation's Environmental Health* (Island Press, Washington, D.C., 1991).
9. B. Hall, "Gold and Green," *South. Exp.* Fall, 3–24 (1994).
10. R. D. Bullard, *Dumping in Dixie: Race, Class, and Environmental Quality* (Westview Press, Boulder, 1990).
11. U.S. Environmental Protection Agency (EPA), *Improving the Inner City Environment* (USEPA, Washington, D.C., 1971).
12. USEPA, *Our Urban Environment* (USEPA, Washington, D.C., 1971).
13. W. Kruvant, *Incidence of Pollution Where People Live in Washington* (Center for Metropolitan Studies, Washington, D.C., 1974).
14. B. J. L. Berry (ed.), *The Social Burdens of Environmental Pollution: A Comparative Metropolitan Data Source* (Ballinger, Cambridge, 1977).
15. K. Geiser and G. Waneck, "PCBs and Warren County," *Sci. People* July/August: 13–17 (1983).
16. B. Bryant and P. Mohai (eds.), *Race and the Incidence of Environmental Hazards: A Time for Discourse* (Westview Press, Boulder, 1992).

17. R. D. Bullard and B. H. Wright, "Mobilizing the Black Community for Environmental Justice," *J. Intergroup Rel.* **17**(1), 33–43 (1990).
18. R. D. Bullard (ed.), *Confronting Environmental Racism: Voices from the Grassroots* (South End Press, Boston, 1993).
19. R. D. Bullard, *Unequal Protection: Environmental Justice and Communities of Color* (Sierra Club Books, San Francisco, 1994).
20. U.S. General Accounting Office, *Siting of Hazardous Waste Landfills and Their Correlation with Racial and Economic Status of Surrounding Communities* (Government Printing Office, Washington, D.C. 1983).
21. B. A. Goldman, "Polluting the Poor," *Nation*, October 5: 348–349 (1992).
22. P. Mohai and B. Bryant, "Environmental Racism: Reviewing the Evidence," in B. Bryant and Paul Mohai (eds.), *Race and the Incidence of Environmental Hazards: A Time for Discourse* (Westview Press, Boulder, 1992), pp. 163–176.
23. B. A. Goldman and L. Fitton, *Toxic Wastes and Race Revisited* (Center for Policy Alternatives, New York, 1994).
24. J. T. Hamilton, "Testing for Environmental Racism: Prejudice, Profits, Political Power?" *J. Policy Anal. Management* **14**(1), 107–132 (1995).
25. D. L. Anderton, A. B. Anderson, P. H. Rossi, J. M. Oakes, M. R. Fraser, E. W. Weber, and E. J. Calabrese, "Hazardous Waste Facilities: 'Environmental Equity' Issues in Metropolitan Areas," *Eval. Rev.* **18**(2), 123–140 (1994).
26. D. L. Anderton, A. B. Anderson, J. M. Oakes, and M. R. Fraser. "Environmental Equity: The Demographics of Dumping," *Demography* **31**(2), 229–248 (1994).
27. T. S. Glickman, "Measuring Environmental Equity with Geographical Information Systems," *Renewable Res. J.* **12**(3), 17–21 (1994).
28. D. M. Holm. "Environmental Inequities in South Carolina: The Distribution of Hazardous Waste Facilities," Unpublished Master's thesis, Department of Geography, University of South Carolina (1994).
29. L. M. Burke, "Race and Environmental Equity: A Geographic Analysis in Los Angeles," *Geo Info Syst.* October, 44–50 (1993).
30. J. A. Hird, "Environmental Policy and Equity: The Case of Superfund," *J. Policy Anal. Management* **12**(2), 323–343 (1993).
31. S. L. Cutter, "The Burdens of Toxic Risks: Are They Fair?" *South Carolina Business Econ. Rev.* **41**(1), 3–7 (1994).
32. K. Crew-Meyer, "Hazardous Waste and Race in South Carolina," *South Carolina Policy Forum* **5**(3), 25–28 (1994).
33. R. Zimmerman, "Social Equity and Environmental Risk," *Risk Anal.* **13**(6), 649–666 (1993).
34. M. R. Greenberg, "Separate and Not Equal: Health-Environmental Risk and Economic-Social Impacts in Remediating Hazardous Waste Sites," in S. K. Majumdar, F. J. Brenner, E. W. Miller, and L. M. Rosenfeld (eds.), *Environmental Contaminants and Health* (Pennsylvania Academy of Sciences, Philadelphia, 1994).
35. F. O. Adeola, "Environmental Hazards, Health, and Racial Inequity in Hazardous Waste Distribution," *Environ. Behav.* **26**(1), 99–126 (1994).
36. R. D. Bullard, "Solid Waste Sites and the Black Houston Community," *Sociol. Inequity* **53** (Spring), 273–288 (1983).
37. S. Openshaw, "The Modifiable Areal Unit Problem," in *Concepts and Techniques in Modern Geography 38* (Geo Books, Norwich, England, no date).
38. C. F. Kovacik and J. J. Winberry, *South Carolina: The Making of a Landscape* (University of South Carolina Press, Columbia, 1987).
39. State of South Carolina, *South Carolina Statistical Abstract* (SC State Budget Control Board, Columbia, 1993).
40. South Carolina DHEC, *Hazardous Waste Activities Reported in South Carolina for 1992* (SC Department of Health and Environmental Control, Columbia, 1993).
41. L. B. Lynn, "Environmental Equity in South Carolina: Hazardous Waste Issues Impacting the African American Community," in K. Campbell (ed.), *The State of Black South Carolina—An Action Agenda for the Future*, Chap. 6 (The Columbia Urban League, Columbia, 1993).
42. U.S. Environmental Protection Agency, *1991 Toxics Release Inventory* (USEPA, EPA745-R-92-003, Washington, D.C., 1993).
43. U.S. Environmental Protection Agency, *1992 Toxics Release Inventory State Fact Sheets* (USEPA, EPA 745-F-94-001, Washington, D.C., 1994).
44. V. Been, "Locally Undesirable Land Uses in Minority Neighborhoods: Disproportionate Siting or Market Dynamics," *The Yale Law Journal* **103**(6), 1383–1422 (1994).