# The Distribution and Enforcement of Air Polluting Facilities in New Jersey

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This study examines the spatial distribution and enforcement of air polluting facilities in the state of New Jersey, as listed in the U.S. Environmental Protection Agency's Aerometric Information Retrieval System. Results show that air-polluting facilities tend to concentrate near minority neighborhoods, although this relationship is partially explained by factors of population density, manufacturing employment, and land use. Other results suggest that facilities in areas with a relatively high percentage of minority population tend to have a weaker record of environmental enforcement as compared to other facilities. Of the socioeconomic variables considered, employment in manufacturing appears to be the most strongly related to environmental enforcement.
**Key Words: environmental justice, air pollution, race.**

## Introduction

The principle of environmental justice plays a key role in guiding environmental policy in the United States through Executive Order 12898 (Clinton 1994), which instructs federal agencies to adopt environmental policies that do not discriminate against groups of people based on race and applies to both the distribution of environmental risk and the ability to participate in environmental decision making. Environmental justice has also emerged as an activist movement, combining elements of both the environmental and civil rights movements, in which minority communities have sought to block hazardous facility development through litigation against hazardous facility developers and environmental regulatory agencies (Fisher 1995). Many of these environmental justice lawsuits have been based on evidence of environmental inequity, defined as where poor and/or minority communities bear a disproportionate burden of environmental risk as compared to other communities (Hill 2002).

Many studies have found evidence for environmental inequity at the national level (UCC 1987; Goldman and Fitton 1994; Ringquist 1997). Other studies, however, have noted that the question of environmental justice hinges not on environmental inequity but on the role and motivations of developers, regulators, or policy makers in creating patterns of environmental inequity ( for discussion, see Bullard 1996; Szasz and Meuser 1997; Helfand and Peyton 1999). This latter viewpoint is particularly relevant given that a number of studies have shown that factors of income, employment, and land use may explain patterns of hazardous facility location better than race (Anderton et al. 1994; Been 1994). In addition, a handful of longitudinal studies have found no evidence of racial inequity in the initial siting of hazardous facilities (Oakes, Anderton, and Anderson 1996; Yandle and Burton 1996; Mitchell, Thomas, and Cutter 1999), casting doubt on whether evidence of environmental inequity indicates a causal relationship between the presence of minorities and hazardous facility location.

Most environmental justice analyses have been limited to the comparison of socioeconomic character among areas that host or do not host hazardous facilities or among areas that differ in their degree of environmental risk. I argue here that these "conventional" studies of environmental equity can be enriched by a complementary analysis of racial equity in environmental regulation and enforcement. Analyses of environmental enforcement can potentially provide information that ties environmental inequity directly to decision making by environmental enforcement agencies. The present research demonstrates an environmental justice analysis that combines environmental equity

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and environmental enforcement studies. This analysis focuses on the spatial distribution and environmental enforcement of air polluting facilities in the state of New Jersey. The study of environmental equity investigates the relationship among variables indicating socioeconomic character and land use with the density for air polluting facilities, as maintained by the U.S. Environmental Protection Agency (EPA). The study of environmental enforcement investigates socioeconomic inequity in the New Jersey Department of Environmental Protection's (NJDEP) record of violation, compliance, penalties, and enforcement actions for air polluting facilities.

I focus on New Jersey for this case study because of its sizable minority population (34 percent), relatively large number of air polluting facilities, and mix of urban and rural land uses. In addition, the state is the subject of an ongoing environmental justice case (*South Camden Citizens in Action v. New Jersey Department of Environmental Protection*) in which the NJDEP is accused of violating Title VI of the Civil Rights Act. The research presented here is associated with an analysis originally undertaken for the plaintiff in this case.

## Explanations of Environmental Inequity

There is broad statistical evidence for racial and other socioeconomic inequity in the spatial distribution of a variety of types of hazardous facilities, including treatment, storage, and disposal facilities (TSDFs), facilities listed in the EPA's Toxic Release Inventory (TRI), and superfund sites (UCC 1987; Mohai and Bryant 1992; Hird 1993; Ringquist 1997; Daniels and Friedman 1999; Sadd et al. 1999). Szasz and Meuser (1997) provide a helpful typology of explanations for environmental inequity. The typology distinguishes between a situation in which a hazardous facility location is chosen because of demographics and a situation in which a facility location is chosen for reasons other than demographics. In the former case, a location for a facility may be chosen because of the economic benefits associated with facility development, because of political disempowerment of the targeted community, or because of outright racial prejudice on the part of facility developers or policy makers. In the case where a facility is sited for reasons other than demographics, the choice of facility location may be based on the availability of inexpensive, industrial land that (coincidentally or not) coincides with socioeconomic disadvantage. Additionally, a facility may be initially located in a community that is not socioeconomically disadvantaged or in a relatively uninhabited area, and socioeconomic disadvantage proximate to the facility increases subsequent to the facility being built.

Most studies that have explicitly addressed the causes of environmental inequity have undertaken significant archival research into the social, political, and economic history of industrial development and settlement patterns. Boone and Modarres (1999), for example, investigate the historical causes of the concentration of hazardous facilities in the Hispanic-dominated city of Commerce, California, in Los Angeles County. These authors find that although there is considerable evidence for environmental inequity in Commerce, the direct causes of this inequity concern zoning decisions made prior to World War II that were not racially motivated. In another analysis of hazardous facility location in Los Angeles, Pulido, Sidawi, and Vos (1996) examine the historical development of residential and hazardous facility location patterns in two neighborhoods where concentrations of minorities coincide with industrial pollution. These authors find that currently observed patterns of environmental inequity are the result of intentional discrimination on the part of city planners (in one case) and racial divisions of labor associated with certain industries.

Other studies have looked at the issue of the causes of environmental inequity in the context of political empowerment. Lake (1996) argues that environmental justice encompasses equity not only in environmental risk but also in the ability to participate in the environmental decision-making process. In a nationwide analysis of the expansion of commercial hazardous waste facilities, Hamilton (1995) tests three causal theories of race-related distributions of environmental hazards: (1) intentional discrimination by companies or regulators, (2) differences among communities in their willingness to pay for environmental amenities, and (3) differences among communities in political empowerment and propensity for opposition to facility siting. Hamilton (1995) finds that political empowerment is the most important factor in predicting which areas are targeted for increases in waste treatment capacity.

A number of authors have also asserted that because observed patterns of environmental risk are intimately tied to the history of the economic and political impacts of racism and discrimination, one cannot neatly separate issues of environmental equity and intent to discriminate. For instance, although Boone and Modarres (1999, 182–83), state that they found historical zoning laws to be the primary determinant of hazardous facility location in Commerce, California, they also note that "considering the prevailing racist notions regarding Mexicans in the 1920s, it is difficult to believe the planning commission would treat the wishes of [a white community] the same as those of Latinos." In a review of urban environmental justice issues, Gelobter (1994) also emphasizes the interaction of race, class, and land-use change in creating environmental inequity, pointing out that politicians and hazardous facility developers often share goals of land development even when those goals may be in opposition to those of the community in which the development is targeted. Pulido (2000) demonstrates how white privilege has played a role in creating environmental inequity in Los Angeles through the interrelated historical processes of industrial development in the urban core and the migration of whites to the suburbs. She argues that white privilege, operating through the process of suburbanization, has allowed whites to obtain residences in areas of less environmental risk as compared to minorities.

While the issue of environmental enforcement is to some extent implied in these studies due to the permitting process required to build and operate facilities that release toxins into the environment, particularly for commercial TSDFs, such studies do not directly address the issue of equity in the enforcement of environmental regulations. There have, in fact, been only a handful of environmental equity studies focusing on enforcement. Hird (1993), for example, analyzed the pace of cleanup for EPA Superfund sites and found that although there is environmental inequity in Superfund location, the pace of cleanup depended on the degree of hazard and not on socioeconomic factors or political representation.

Combining equity analyses of hazardous facility location and environmental enforcement can play an important role in the interpretation of the causes of environmental inequity. While it can be argued that poverty, land use, and other nonracial factors may lead to racial inequity in hazardous facility location, environmental enforcement is wholly dependent upon the actions of enforcement agencies. Findings of inequity in environmental enforcement may be particularly noteworthy in the context of environmental justice litigation, which often revolves around charges that environmental regulation agencies are not equitably enforcing environmental law with regard to race. These cases have typically been based on federal discrimination laws, such as the Equal Protection Clause of the Fourteenth Amendment or Title VI of the Civil Rights Act of 1964 (Fisher 1995; Liu 2001). Generally, however, U.S. courts have been reluctant to find violations of federal discrimination laws in the absence of evidence of intentional discrimination, even when there is ample evidence of racial inequity in environmental risk (Hill 2002). It has been suggested, however, that environmental equity studies may be used as part of a much more convincing legal strategy for environmental justice advocates when combined with other evidence of racial discrimination related to environmental risk (Cole 1994), such as racial inequity in environmental enforcement (Hill 2002).

## Data

Data concerning air polluting facilities in New Jersey were acquired from the AIRS Facility Subsystem (AFS; EPA 1999), a component of the EPA's Protection Agency's (EPA) Aerometric Information Retrieval System (AIRS). Hereafter, the air polluting facilities addressed in this article are referred to as AFS facilities. The present study included only those AFS facilities that are currently in operation and that are classified as "major" or "synthetic minor," classes of facilities for which the NJDEP maintains data. There are a total of 1,467 major or synthetic minor AFS facilities in operation in New Jersey. However, 251 of these facilities were geocoded by the EPA outside the boundary of New Jersey, or not geocoded at all, and were therefore excluded from this study. Figure 1 shows the locations of the 1,216 AFS facilities considered in this study.

Data describing a number of socioeconomic and land-use factors that have been shown to be significant predictors of hazardous facility location in previous research were used in the present study. U.S. Bureau of the Census tract-level data from the 2000 Census provided information on race, educational attainment, and employment. There are 1,944 tracts in New Jersey, nine of which have zero population. This research therefore focuses on the 1,935 tracts with people living in them.

Note that the appropriate unit of analysis, for example, the use of tracts versus ZIP codes, has been an ongoing issue in environmental equity research because different analytical results may result using the same socioeconomic variables aggregated to different spatial units (Cutter et al. 1996; Williams 1999), a problem known as the modifiable areal unit problem (MAUP; Fotheringham and Wong 1991). While it may appear that the use of the finest resolution spatial unit available is optimal for statistical analyses of environmental equity, previous research suggests that in many cases of environmental inequity, minority communities are not directly adjacent to hazardous facilities but are rather relatively proximal to them (Mennis 2002). For example, minorities may tend to cluster within three kilometers of a hazardous facility but not within one kilometer. This may be the case, say, in cases where a hazardous facility is located within an urban industrial area or where the industrial area itself is sparsely populated but occurs at the edge of a residential minority community. Thus, even though much tract level Census data are also available at the block group level, a finer resolution than tract, the larger size of tracts may be better able to capture the spatial relationship of minorities with AFS facilities. This is particularly the case in urban areas where block groups are very small.

Data on land cover for New Jersey were acquired from the U.S. Geological Survey in order to incorporate the influence of land use on the spatial distribution of hazardous facilities. These data, part of the National Land Cover Data (NLCD) program, were generated from early to middle 1990s Landsat Thematic Mapper (TM) satellite imagery and are made available as a thirty-meter resolution grid data set. These Census and land-cover data were used to generate the following tract-level socioeconomic and land-use variables, for which descriptive statistics and maps are provided in Table 1 and Figure 1, respectively.

- Percent minority — Percentage of persons who identify as nonwhite or Hispanic, or both
- Population density — Persons/square kilometer
- Educational attainment — Percentage of the population over the age of twenty-five who have graduated from high school (or obtained high school equivalency)
- Poverty rate — Percentage of the population living below the poverty line for whom poverty level was measured
- Manufacturing employment — Percentage of the population over the age of sixteen who are employed in the manufacturing industry
- Percent industrial — Percentage of land area used for commercial, industrial, or transportation purposes (extracted from the NLCD data)

## Analysis of Environmental Equity

The first part of the analysis compares the percent minority of tracts that are located nearby AFS facilities with those that are not. Percent minority was calculated for tracts that host (contain) an AFS facility and for those tracts located within one kilometer, two kilometers, and three kilometers of an AFS facility. Note that percent minority was calculated by dividing the total number of minorities by the total population of all the tracts in the group; it is not an

***Table 1*** *Descriptive Statistics for Variables Used in the Analysis*

| | Min | Max | Mean | SD |
|---|---|---|---|---|
| Percent minority | 0 | 100 | 35 | 31 |
| Population density (persons/km$^2$) | 2 | 44,243 | 3,143 | 4,487 |
| Educational attainment (%) | 0 | 100 | 81 | 13 |
| Poverty rate (%) | 0 | 100 | 10 | 10 |
| Manufacturing employment (%) | 0 | 68 | 12 | 5 |
| Percent industrial | 0 | 70 | 7 | 10 |

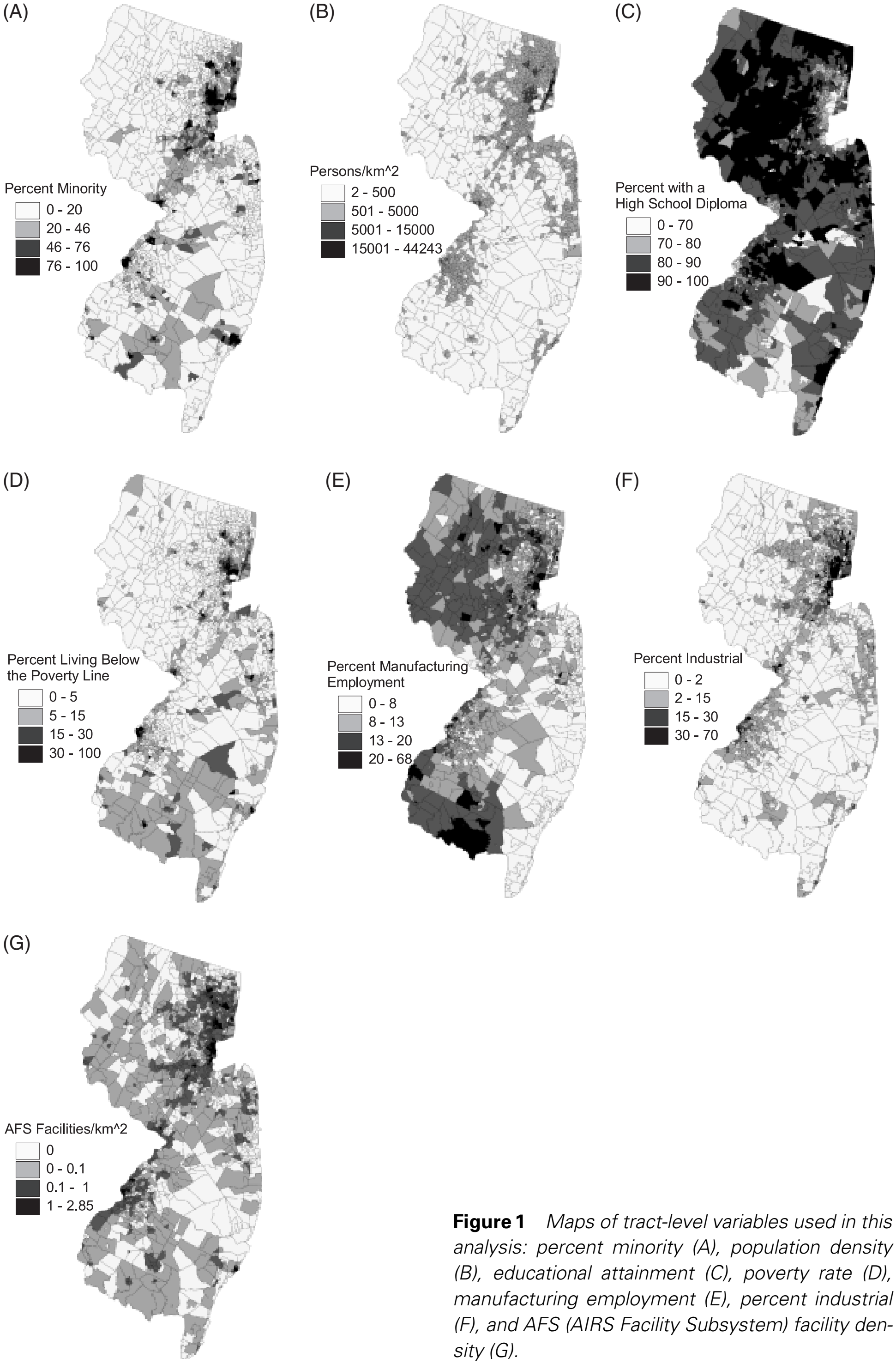


**Figure 1** *Maps of tract-level variables used in this analysis: percent minority (A), population density (B), educational attainment (C), poverty rate (D), manufacturing employment (E), percent industrial (F), and AFS (AIRS Facility Subsystem) facility density (G).*

average of the percent minority values of all the tracts in each group. A tract is considered within, say, one kilometer of an AFS facility if its centroid (geometric center) is contained within a one-kilometer buffer drawn around a facility. Previous research has demonstrated that although minorities in urban areas are often concentrated near hazardous facilities, this pattern may not be captured by looking only at the host tract (Anderton et al. 1994; Sadd et al. 1999). One reason for this is that tracts vary greatly in size, typically being much larger in rural areas and smaller in urban areas. In addition, hazardous facilities may be located on the borders of tracts (Zimmerman 1994). For these reasons, measurement of proximity to AFS facilities affords a more accurate metric of the racial character of the communities that surround AFS facilities than that derived by simply looking at the tracts that host facilities.

Table 2 shows that tracts that host AFS facilities and those that do not have approximately the same percent minority (33 percent and 35 percent, respectively). However, those tracts located within one kilometer of an AFS facility have nearly double the percent minority (50 percent) compared to those located farther away (26 percent). This difference in percent minority increases when tracts located within two kilometers of an AFS facility are compared to those tracts that are located farther away and then holds when the proximity threshold is increased to three kilometers. The percent minority of tracts that are located within three kilometers of an AFS facility is nearly three times higher than the percent minority of tracts that are not.

***Table 2*** *Percent Minority of Tracts Near and Far from AFS (AIRS Facility Subsystem) Facilities*

| | # Tracts | Population | % Minority |
|---|---|---|---|
| All tracts in New Jersey | 1,944 | 8,414,350 | 34 |
| Tracts hosting facilities | 613 | 2,820,755 | 33 |
| Tracts not hosting facilities | 1,331 | 5,593,595 | 35 |
| Tracts w/in one kilometer of facilities | 685 | 2,825,789 | 50 |
| Tracts w/out one kilometer of facilities | 1,259 | 5,588,561 | 26 |
| Tracts w/in two kilometers of facilities | 1,292 | 6,490,918 | 43 |
| Tracts w/out two kilometers of facilities | 652 | 2,923,432 | 17 |
| Tracts w/in three kilometers of facilities | 1,565 | 6,742,457 | 39 |
| Tracts w/out three kilometers of facilities | 379 | 1,671,893 | 14 |

Kendall's tau-b correlation was then used to assess the relationship among socioeconomic variables with the density of AFS facilities. AFS facility density was calculated using a simple density function with a one-kilometer search radius. The result of this function is a thirty-meter resolution grid in which each grid cell's value is the facility density (facilities/km$^2$) at that grid cell location, calculated by dividing the number of facilities found within one kilometer of the center of that grid cell by the area of search. This approach for calculating point density across a space is a well-established point pattern analysis technique (Bailey and Gatrell 1995) and was previously demonstrated for environmental justice analysis by Mennis (2002). The tract-level facility density value was calculated by taking the mean of all the grid cell facility density values contained within the tract (Figure 1).

Note that this density-based method for representing hazardous facility location is an improvement over those methods that encode whether a tract hosts, or is within a certain distance of, a hazardous facility. The calculation of facility density incorporates the fact that hazardous facilities may cluster near, but not within, particular tracts and is also sensitive to whether a tract is near only one, versus many, facilities.

Correlation results indicate that each of the explanatory variables is significantly correlated with AFS density (Table 3). As the density of AFS facilities increases, population density, percent minority, poverty rate, manufacturing employment, and percent industrial all increase. Educational attainment, on the other hand,

***Table 3*** *Kendall Tau-b Correlation of AFS (AIRS Facility Subsystem) Facility Density*

| Variable | Correlation |
|---|---|
| Percent minority | 0.336* |
| Population density | 0.284* |
| Educational attainment | −0.329* |
| Poverty rate | 0.274* |
| Manufacturing employment | 0.178* |
| Percent industrial | 0.333* |

*$p < 0.0005$

decreases with increasing AFS density. The strongest relationships with AFS density are maintained by percent minority, educational attainment, and percent industrial.

Mulitivariate regression was used to analyze the interaction of the socioeconomic variables and their relationship with AFS facility density. The natural log of the population density and the square root of the facility density were entered into the regression, in order to better approach a normal distribution of the residuals. Note also that percent minority, poverty rate, and educational attainment are all highly correlated with each other (|Spearman's r| > 0.7 for each variable pair). All three variables are included in the analysis because understanding the relationship of race with other aspects of socioeconomic character, such as educational attainment and poverty, is an important component of environmental justice research (Downey 1998). However, the presence of multicollinearity prohibits any two of these variables from being entered into the same regression model. The postregression diagnostic variance inflation factor (VIF) test was used to ensure that multicollinearity did not unduly bias the regression results.

Table 4 reports the results of the regression of facility density. Model 1 shows that a portion of the relationship between percent minority and facility density is explained by population density, and the two variables together account for 24 percent of the variation in facility density. Model 2 shows that manufacturing employment is significant but increases the goodness of fit of the model only slightly. The further addition of percent industrial in Model 4 increases the $R^2$ to 0.40 and further reduces the influence of percent minority, although it remains significant. The replacement of percent minority with educational attainment and poverty rate in Models 4 and 5, respectively, does not significantly alter the nature of the variable relationships presented in Model 3.

***Table 4*** *Standardized Coefficients for Regression of Density of AFS (AIRS Facility Subsystem) Facilities (sqrt)*

| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| Percent Minority | 0.347* | 0.310* | 0.189* | | |
| Population Density (ln) | 0.198* | 0.202* | 0.208* | 0.216* | 0.253* |
| Educational Attainment | | | | −0.244* | |
| Poverty Rate | | | | | 0.153* |
| Manufacturing Employment | | 0.180* | 0.139* | 0.103* | 0.158* |
| Percent Industrial | | | 0.379* | 0.352* | 0.376* |
| Adjusted $R^2$ | 0.242 | 0.275 | 0.401 | 0.418 | 0.398 |
| *N* | 1,935 | 1,933 | 1,933 | 1,933 | 1,933 |

*$^*p < 0.0005$*

## Analysis of Environmental Enforcement

The analysis of environmental enforcement investigates whether there is racial inequity in the compliance, significant violations, and penalties among AFS facilities. The AFS database provided data describing a number of indicators of environmental enforcement used in this analysis. These data included: (1) information on whether a facility has, or had in the past, a significant violation of their permit agreement or federal environmental law and which agency (EPA or the state) has lead enforcement; (2) information on whether a facility is in or out of compliance with regard to state or federal air pollution regulations or a permit application, or if the compliance status is unknown; and (3) the total civil penalty amount in U.S. dollars that a facility has been assessed by an enforcement agency.

The AFS database also yielded data concerning which, if any, of eighty-three possible enforcement actions have been taken against a facility in response to issues of noncompliance and significant violation status. Of these eighty-three, I focused on the twelve enforcement actions that were taken by the state, or jointly between the state and the EPA. However, there were zero of any of these types of actions, with the exception of those actions coded 7A (Notice of Non-Compliance), 7C (state NOV [Notice of Violation] issued), and 8C (state administrative order issued). There were only six total actions of type 7A, and a preliminary review demonstrated that these did not exhibit any clear pattern with regard to socioeconomic character. Therefore, the analysis of enforcement actions focuses solely on action types 7C and 8C.

Using these AFS database data, the following enforcement variables were derived and recorded for each AFS facility:

- Out of compliance — A binary variable indicating if the facility is out of compliance
- Unknown compliance — A binary variable indicating if the facility has unknown compliance
- Significant violation — A binary variable indicating if the facility has a significant violation and where lead enforcement is by either the state, state/EPA combined, or is undetermined
- Penalty amount — Total amount of penalty assessed in U.S. dollars
- Number of 7C actions
- Number of 8C actions

The socioeconomic character associated with each AFS facility was determined by using areal weighting (Goodchild, Anselin, and Deichmann 1993) to calculate the value for each of the socioeconomic variables within a one-kilometer radius of each facility. Areal weighting assumes a homogenous distribution of population and population character within each tract. The total population of a given tract that is assigned to a facility is calculated in direct proportion to the percentage of that tract's area falling within the facility's one-kilometer radius. Each socioeconomic variable was calculated for each facility in this manner. Note that this areal weighting approach is a more accurate measure of the socioeconomic character surrounding a facility than the standard approach, which simply records the socioeconomic character of the facility's host tract.

A comparison of means was used to investigate the relationships of the socioeconomic variables with the three nonbinary environmental enforcement variables. Because of the nonnormal distribution of the enforcement data, the Mann-Whitney U test was used to compare the mean rank of each of the enforcement variables between the top and bottom classes of a five-class quantile classification scheme for each socioeconomic and land use variable. In quantile classification, each class has an approximately equal number of cases (i.e., AFS facilities).

***Table 5*** *Mann-Whitney U Tests of Non-Binary Environmental Enforcement Variables Comparing Top and Bottom Quantile Classes of Socioeconomic and Land Use Variables (N= 1,216)*

| | **Number of 7C Actions** | **Number of 8C Actions** | **Penalty Amount** |
|---|---|---|---|
| Population | 29,264.5 | 26,423.0 | 26,914.5 |
| Density | (0.895) | (0.031)* | (0.068) |
| Percent | 28,617.5 | 25485.5 | 25,323.0 |
| Minority | (0.968) | (0.025)* | (0.018)** |
| Educational | 29,403.5 | 29,994.0 | 31,022.0 |
| Attainment | (0.046)* | (0.109) | (0.345) |
| Poverty Rate | 27662.5 | 29181.0 | 29917.5 |
| | (0.005)** | (0.077) | (0.195) |
| Manufacturing | 21681.0 | 19783.0 | 19704.0 |
| Employment | (0.001)*** | (0.000)*** | (0.000)*** |
| Percent | 21890.5 | 21570.5 | 22157.0 |
| Industrial | (0.065) | (0.041)* | (0.110) |

*$*p<0.05$, $**p<0.01$, $***p<0.005$*
*Note: Significance reported in parentheses.*

Results of the Mann-Whitney U test are shown in Table 5. For percent minority, the results indicate a significant difference in the mean rank of the penalty amount and number of 8C actions. Facilities in high-percent minority areas are associated with significantly less 8C actions and lower penalty amounts as compared to facilities in low-percent minority areas. Also of note is the result for manufacturing employment, which has significantly different mean ranks for all three enforcement variables tested. Facilities in high-percent manufacturing employment areas are associated with significantly higher penalty amounts and more 7C and 8C

***Table 6*** *Mann-Whitney U Tests of Socioeconomic and Land Use Variables Comparing Binary Environmental Enforcement Variables (N= 1,216)*

| | **Significant Violation** | **Out of Compliance** | **Unknown Compliance** |
|---|---|---|---|
| Population | 136917.0 | 26692.5 | 61593.0 |
| Density | (0.411) | (0.014)* | (0.379) |
| Percent | 124457.0 | 28143.0 | 57894.5 |
| Minority | (0.002)*** | (0.059) | (0.057) |
| Educational | 116181.5 | 31253.0 | 64172.5 |
| Attainment | (0.000)*** | (0.491) | (0.866) |
| Poverty Rate | 118759.0 | 30974.5 | 60737.5 |
| | (0.000)*** | (0.426) | (0.263) |
| Manufacturing | 118778.0 | 21515.5 | 52213.5 |
| Employment | (0.000)*** | (0.000)*** | (0.001)*** |
| Percent | 115644.0 | 28629.5 | 63472.0 |
| Industrial | (0.000)*** | (0.089) | (0.718) |

*$*p<0.05$, $**p<0.01$, $***p<0.005$*
*Note: Significance reported in parentheses.*

actions as compared to facilities in low-percent manufacturing employment areas.

Three additional Mann-Whitney U tests were also used to determine if there is a significant difference in the mean ranks of all the socioeconomic and land-use variables for each of the binary enforcement variables: significant violation, out of compliance, and unknown compliance. The results are reported in Table 6. Of note is the result for significant violation. Facilities with a significant violation are associated with higher percent minority, poverty rate, and manufacturing employment, and with lower educational attainment, as compared to those facilities without a significant violation. The manufacturing employment variable again stands out for being significantly higher for facilities that are out of compliance, and for which compliance is unknown, as compared to those facilities in compliance.

## Discussion

The analysis of environmental equity indicates that AFS facilities tend to locate in areas that have a particular socioeconomic and land-use character. Regarding race, AFS facilities are located disproportionately in high-percent minority areas. The results presented in Table 2 suggest something of a bull's eye pattern where minorities are not concentrated immediately surrounding hazardous facilities but at a slightly further, though still proximate, distance. Much of the variation in AFS facility location with regard to race is also reflected in other variables that capture related aspects of socioeconomic character, such as educational attainment and poverty rate. This study also agrees with Anderton et al. (1994) in finding that employment in manufacturing is associated with hazardous facility location. The variable with the greatest degree of explanation in AFS facility location is industrial land use. This study therefore agrees with studies by Boer et al. (1997) and Sadd et al. (1999) who find land use to be an important predictor of hazardous facility location.

Given the relationship of percent minority to these other variables, it is perhaps surprising that percent minority retains its significance in predicting the density of AFS facilities even after the influence of factors of population density, land use, and employment have been removed. Regardless of these geographic and employment characteristics, AFS facilities tend to concentrate nearby high-percent minority tracts. The transformation of facility density is also important, indicating that AFS facilities tend to cluster in tracts with very high values of population density, percent minority, manufacturing employment, and percent industrial. As these variables decrease in value, the density of hazardous facilities tends to decrease very rapidly.

This research also indicates that there is variation in environmental enforcement with regard to race. AFS facilities in areas with high minority concentrations are associated with higher rates of significant violation, lower rates of state administrative orders issued, and lower penalty amounts assessed as compared to those facilities in areas with lower minority concentrations. We can conclude that whereas facilities in high-percent minority areas tend to violate regulations more often, they receive relatively few notices from the state, and their fines tend to be relatively low. This is counterintuitive to what one would generally expect—more significant violations should be associated with more notices and higher fines. Among all the categories of socioeconomic and land use variables (i.e., low- and high-percent categories in the quantile classifications), the high-percent minority category is unique for having the combination of high significant violation and low penalty amount.

Manufacturing employment appears to be the socioeconomic variable with the greatest overall relationship to enforcement. Recall that the correlation of manufacturing employment with AFS facility density was found to be significant, but the relationship was weak compared with the other socioeconomic variables. It is perhaps surprising, then, that manufacturing employment is associated more strongly with measures of enforcement than any of the other socioeconomic and land-use variables. Higher rates of manufacturing employment are associated with higher rates of out-of-compliance status, unknown compliance status, state administrative orders issued, significant violation, and penalty amounts.

These results suggest socioeconomic inequity in the degree of enforcement and monetary penalties for significant violations. As with environmental inequity in hazardous facility location, however, there may be a myriad of reasons for the inequity in enforcement agency decision making. The association between manufacturing employment and environmental enforcement perhaps reflects the fact that when many people who work at a hazardous facility also live in the immediate area of that facility, there is a greater investment (whether monetary or in simply in terms of vigilance) in the facility's adherence to environmental regulations. It is also possible that those facilities with a large number of employees, and hence a larger percentage of manufacturing employment in the immediate area, are also subject to a greater degree of attention from the NJDEP regarding enforcement.

A related explanation for the more general socioeconomic variation in environmental enforcement concerns political empowerment. Hamilton (1995) has demonstrated that environmental inequity can be linked to the probability that a particular community will engage in political action to resist hazardous facility expansion. Political empowerment is also cited as a factor by Boone and Modarres (1999) in their historical analysis of environmental inequity in Los Angeles. If politically empowered communities can influence the siting of hazardous facilities more effectively than their non-politically empowered counterparts, it follows that these same communities may also be better at influencing facilities' adherence to regulation (i.e., significant violation) and severity of enforcement actions (i.e., penalty amounts) by environmental regulatory agencies.

Another factor that may contribute to the degree of environmental enforcement for a particular AFS facility is the facility type. For instance, a certain type of AFS facility may vary with regard to enforcement measures and may be spatially distributed in a particular way, say, in the urban core or in rural areas. The spatial distribution of a certain type of facility may also be correlated with certain socioeconomic characteristics. In this case, socioeconomic differences among AFS facilities in environmental enforcement would be a byproduct of AFS facility location.

This study suggests that minorities are disproportionately exposed to environmental risk in New Jersey. This inequity in environmental risk is manifested not only in the disproportionate locations of air polluting facilities in minority neighborhoods but also in the tendency of regulation and environmental enforcement to be less rigorous in minority neighborhoods. These arguments may be of use in environmental justice litigation, where evidence of discrimination beyond the spatial distribution of hazardous facilities can play an important role. In addition, these findings may be of use to environmental enforcement agencies in ensuring compliance with federal standards of nondiscrimination.

## Conclusion

This study demonstrates how a conventional environmental justice analysis that focuses solely on environmental equity may be enhanced through an analysis of environmental enforcement. Evidence of racial inequity in hazardous facility location can often be explained by non-racial factors, such as land use. Environmental enforcement, however, is a direct result of decisions made by environmental enforcement agencies. Combined evidence of racial inequity in hazardous facility location and enforcement can provide a richer portrait of environmental injustice than an analysis of facility location in isolation.

While this study cannot pinpoint the causes of the racial inequity in AFS facility location and enforcement, it provides important evidence for environmental injustice in New Jersey. First, this study shows that while factors of population density, land use, and employment are important, they do not fully explain the disproportionate siting of hazardous facilities in minority areas. Second, this study suggests that there is socioeconomic inequity not only in AFS facility location but also in environmental enforcement. High-percent minority areas tend to have a weaker record of environmental enforcement as compared to low-percent minority areas. It should be noted, however, that percent employed in manufacturing appears to be a more influential factor in environmental enforcement than race.

This research has focused on a small subset of the rich enforcement data provided by the EPA. Other relevant EPA enforcement data include historic records on compliance status and the length of time facilities have taken to address regulatory violations. These enforcement data may be combined with toxic release data to examine the relationship among socioeconomic character, violations of environmental regulations, the risk associated with those violations, and the enforcement actions associated with those violations. Future environmental justice research in environmental enforcement should also focus on examining socioeconomic variation among facility types, for instance by classifying facilities by NAIC (North American Industrial Classification) code, in order to investigate whether certain types of facilities may be subject to different enforcement regimes. It would also be of interest to investigate how the relationship of socioeconomic status with environmental enforcement varies from state to state, or among different regions of the United States that are relatively homogeneous with regard to types of industrial activity. Such a study would allow for the comparison of environmental equity and enforcement among different enforcement and industrial regimes.

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