ENVIRONMENTAL JUSTICE AND WATER POLLUTION CONTROL
The Clean Water Act Construction Grants Program

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This study examines the third goal of the Environmental Protection Agency Office of Water's Environmental Justice Strategy that focuses on providing equal access to environmental infrastructure for all citizens, including those located in disadvantaged communities. One way to ensure equal access is through the equitable distribution of funding pursuant to the Clean Water Act. This article examines whether disadvantaged communities received a disproportionately low share of the funding or had a lower probability of obtaining construction grants. The article also examines 9,854 grant awards in the 48 contiguous states at the county level during the period 1983 to 1992. The results indicate that counties with relatively small populations had more difficulty obtaining construction grants. The effect of income and minority composition was more pronounced in small communities. High-income communities did better than poor communities in terms of both the share of awards and the probability of receiving grants. The results also indicate that a county's minority composition was inversely related to the probability of obtaining a grant but positively related to the share of grant awards.

Since 1972, state and local efforts to address point source pollution have been influenced by federal requirements contained in the Clean Water Act (CWA). The CWA required municipal treatment plants to achieve secondary treatment by July 1, 1988. To help municipalities achieve these goals, the CWA's Construction Grant Program (CGP) provided over $60 billion to assist in building and upgrading publicly owned treatment works (POTWs) (Environmental Protection Agency [EPA], 1997). Grants were allocated on a competitive basis and states were given some latitude in establishing their priority lists. The decision to place projects on priority lists was typically based on whether the facilities were in compliance with CWA requirements, the financial needs associated with construction, and whether facility improvements were needed to improve water quality. There were no specific requirements to consider community

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> student for the multi-discipline teams encountered in institutions, architectural-engineering firms, government agencies, boards, and review commissions, or multi-disciplined design teams. (p. 52)

In the area of business skills,

> The committee concluded that most architectural and engineering students leave school with little knowledge of business, economics, and management and this adversely affects their ability to serve their clients, to understand the concerns of their employers, to manage projects effectively, to operate a design practice, and to qualify for more responsible positions. (p. 53)

The committee that prepared the report also agreed that good communication skills are vital to both engineers and architects and that the writing, speaking, and graphic communications skills of most graduates are poor. At the same time, the report noted that it may not be completely realistic to expect new graduates to function as professionals immediately upon graduation.

Conversations and correspondence with many notable engineering educators over the past few years have emphasized the difficulty of expanding the existing engineering curriculum. There is even an increased emphasis for condensed programs. In light of this, it may be necessary to establish a new degree discipline within colleges of engineering or structure a multidisciplinary degree program in a nonengineering department. This article does not suggest a solution. However, the issue is believed to be sufficiently critical to warrant focused discussion on curriculum. A proposed activity would be a forum for open discussion of the educational needs of infrastructure professionals and the adequacy of existing university curricula at the undergraduate and graduate levels for the training of those professionals. At a minimum, this activity should assess and attempt to build consensus for

1. The knowledge base necessary for engineers and other professionals to successfully manage complex infrastructure systems.
2. The basic curriculum elements and level of instruction necessary to develop a core competence, requisite to the desired knowledge base, that will produce better trained and more capable infrastructure professionals.
3. The means by which truly interdisciplinary thinking and communication skills can be developed and applied by a broad range of professionals to infrastructure problems.
4. The adequacy of available university-level programs.

Infrastructure is a serious business that is vital to our continued prosperity and quality of life. It is too important to be left to well-meaning but ill-prepared managers.

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demographics (e.g., population, minority population, community wealth, etc.) when establishing state priority lists.

In an effort to shift responsibility for financing wastewater treatment to state and local governments, the CGP was replaced by state revolving loan programs (SRLPs).[1] The policy change appears to have had the greatest financial impact on disadvantaged communities, which are defined by the EPA as small, rural, low-income, and minority communities. The EPA has long suspected that disadvantaged communities have had trouble affording the local share of project costs, and often they did not apply for federal construction grants (Jondrow & Levy, 1984; O'Toole, 1996; Reeves, 1984; EPA, 1991, 1993). Compounding the problem is a trend toward growing financial needs in disadvantaged communities. Approximately 67% of communities reporting needs have populations smaller than 10,000. The total documented needs for these communities is currently $13.8 billion and represents 11% of the total needs that are currently estimated to be approximately $139.5 billion (EPA, 1997). Thus, an important question is whether disadvantaged communities have had equal access to environmental infrastructure funding.

These concerns were officially recognized when the EPA's Office of Water released its *Environmental Justice Strategy* (hereafter referred to as the EPA's Strategy) on November 8, 1994 (EPA, 1994). The Strategy was prepared in response to President Clinton's directive to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations in the United States (§1-1-101, E.O. 12898, February 11, 1994). Three goals form the basis of the EPA's Strategy: (a) provide equal environmental protection for all citizens, (b) enhance access of disadvantaged citizens to environmental decision makers, and (c) provide equal access to environmental infrastructure for all citizens, including those who live in disadvantaged communities (EPA, 1994). Many of the Strategy's recommendations focus on enhancing data collection and conducting pilot projects to examine whether disproportionate human health or environmental effects exist. The Strategy also recommends process-oriented actions that focus on addressing environmental justice concerns in appropriate EPA programs.

Objectives of the Study

This study examined the Strategy's third goal of providing equal access to environmental infrastructure (e.g., sewage treatment plants and water supply systems) for all citizens, including those in disadvantaged communities. Although the Strategy is unclear on a precise definition of disadvantaged communities, it is clear that the EPA considers the definition to include small, rural, low-income, and minority communities. Though environmental justice research has expanded considerably in the past few years (e.g., Been, 1993, 1994; Goldman, 1994; Hamilton, 1993, 1995; Hird, 1993; General Accounting Office [GAO], 1995; Yandle & Burton, 1996), little attention has focused on water quality issues (e.g., Goldman, 1994; Mohai & Bryant, 1992).[2] A few studies examined toxic fish consumption (e.g., West, Fly, Larkin, & Marans, 1992). One study suggested that EPA's enforcement efforts under the CWA are more aggressive in low-income states (Hunter & Waterman, 1996). Two studies also examined the progressivity associated with the implementation of the CWA's requirements (Gianessi & Peskin, 1980; Lake, Hanneman, & Oster, 1979).

Questions related to investments in and access to environmental infrastructure have largely been ignored. Consequently, this study was designed to be exploratory in nature. It examines some of the propositions put forward in the Strategy and attempts to operationalize EPA's use of the term *disadvantaged community*. As a result, this article demonstrates one methodological approach for examining the distribution of environmental infrastructure funding.

One way to measure access to environmental infrastructure in the water quality arena is to examine the distribution of the federal funding to construct POTWs.[3] Even though the CGP has been replaced by the SRLP, the question of whether $60 billion in funding was distributed in a manner that systematically favored some communities over others is an important public policy

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Even though the CGP has been replaced by the SRLP, the question of whether $60 billion in funding was distributed in a manner that systematically favored some communities over others is an important public policy question. . . . If the funding distribution was biased in favor of certain types of communities, then other types of communities were left to finance the construction of POTWs themselves or rely on the more expensive SRLP to comply with the CWA requirements.

question. All communities are required to meet the same set of water pollution control requirements. If the funding distribution was biased in favor of certain types of communities, then other types of communities were left to finance the construction of POTWs themselves or rely on the more expensive SRLP to comply with the CWA requirements. Accordingly, this study is interested in the answers to two interrelated questions:

- Did disadvantaged communities receive a proportional share of the aggregate total of environmental infrastructure funding?
- Did disadvantaged communities have a lower probability of receiving environmental infrastructure funding?

The distinction is important because, whereas there might be little discrepancy in the size of funding awards, it is possible that disadvantaged communities simply failed to compete well for available funding.

Underlying both questions is the concept of equity—the impartial distribution of environmental benefits and costs to individuals or communities regardless of race, ethnicity, or economic status. Two concepts are useful to consider when examining environmental equity: horizontal and vertical. Horizontal equity implies the equal treatment of relative equals (Berne & Stiefel, 1984). The EPA's Strategy implies that all communities should have an equal opportunity to receive federal funds. Accordingly, observed disparities should not be a function of characteristics considered to be illegitimate in the EPA's Strategy (e.g., wealth, size, or racial characteristics). Horizontal equity is typically examined using measures that capture the dispersion within a distribution (e.g., correlations, regressions, etc.). Perfect horizontal equity would be when federal funding was dispersed randomly among communities with similar characteristics (Berne & Stiefel, 1984).

It is also important to consider issues related to vertical equity. Vertical equity can be defined as the unequal treatment of unequals; in other words, the relative degree of progressivity or regressivity associated with a distributional policy (Berne & Stiefel, 1984). For example, it might be desirable to target federal funds to communities with greater infrastructure needs, low-income communities that cannot afford infrastructure, or communities with greater environmental problems. Though not a distinct concern within the EPA's Strategy, the final section of this article considers whether these distributional questions are better viewed in terms of vertical equity.

The study examined the distribution of 9,854 grant awards made during the last 10 years of the CGP. Over the last 25 years, the CWA has served as a major source of environmental infrastructure funding. There are four reasons why this program was selected. First, the federal government spent nearly $60 billion under the CGP and it is unclear whether it led to inequities in the availability of environmental infrastructure. Second, the policy shift to SRLPs is likely to have exacerbated any inequities present in the CGP. Third, conducting a cross-state comparison of the SRLP is more difficult due to differences across the states in the implementation of their SRLPs (Johnson, 1995; O'Toole, 1996).[4] Finally, it is important to know if the CGP created historical inequities that may need to be addressed by the SRLP. Accordingly, it was prudent to first examine the CGP to identify issues that could be examined in subsequent studies of the SRLP.

Data and Hypotheses

The unit of analysis consisted of all counties in the 48 contiguous states ($N = 3,110$). Alaska and Hawaii were excluded, as were the trust territories, the Commonwealth of Puerto Rico, and the District of Columbia. Their exclusion made the data set more homogenous and decreased the possibility of having geographic differences confound the results. Because county level data were used, a fundamental assumption was that every county had at least one treatment or collection facility eligible for funding or had a need for funding to construct a facility. This assumption appears reasonable when one considers that there are over five times as many POTWs as there are counties, and nearly 67% of POTWs serve small communities with populations of less than 10,000 people and process less than 1 million gallons per day.

Although environmental justice research often uses smaller units of analysis (e.g., census blocks, zip codes, etc.), county level data were more appropriate in this study for two reasons. First, POTWs are regional in nature and often transcend political boundaries. Many times, POTWs are operated as special districts and serve more than one municipality. They may also serve unincorporated areas of a county. This regional aspect of POTWs makes it difficult to use municipal (place) level census data.[5] Second, a substantial proportion of the data set would be assigned zeros with respect to funding if place-level data were used. This would make the statistical analyses problematic.

Dependent Variables

Our analysis examined 9,854 grant awards between 1983 and 1992. The data were obtained from the *Consolidated Federal Funds Report* (Bureau of the Census, 1993). It is important to note that these were grant awards, not expenditures. In some cases, a municipality may have received a grant but never spent the money. Grant recipients also may have spent less or more than the amount of an award. It is also possible that the EPA withdrew the initial award. Therefore, an assumption underlying the analysis is that these minor adjustments occurred randomly within the data set and that they did not bias the results.

Two dependent variables were constructed from the data. The first examined each county's share of the grant awards. Even though the EPA made the actual awards, they routinely concurred with state decisions concerning the awards. Thus, each POTW competed against other POTWs in the same state for funding. To examine how well POTWs in each county competed for funding, a dependent variable was constructed by summing the total grant awards within a county during the period and the aggregate amount was divided by the total of the state's awards during the time period. Using this measure had the added advantage of minimizing other problems with the data. First, state-funding awards varied over time based on different allocation formulas and congressional appropriation levels. Second, construction projects often spanned several years, so multiple awards for the same or related projects were often made in sequential years. Finally, in any given year there were too few awards to conduct a proper statistical analysis. Using this funding share measure helped minimize these potential problems. In addition to this measure, the traditional grants per capita measure for each county was also examined. This measure of the dependent variable did not change the results of the hypotheses tests reported in the following section.

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The second dependent variable examined the probability that at least one POTW in a county received a grant award pursuant to the CGP during the time period. A binary dependent variable was constructed and coded as 1 if a county received a grant award and a 0 if it did not.

Independent Variables: Population, Community Wealth, and Minority Composition

The EPA's Strategy is concerned with the question of whether disadvantaged communities have trouble obtaining federal water pollution control funding (EPA, 1994). Although they are not well defined by the EPA in their Strategy, disadvantaged communities appear to include small, low-income, and minority communities.[6] Previous environmental policy and environmental justice research also suggests that these community attributes could lead to unequal access to environmental infrastructure. The following sections discuss the hypotheses that emerge from this research. Data for the measures used to test the hypotheses were obtained from the 1990 Census.

POPULATION

The EPA's Strategy (1994), other EPA reports (1991, 1993), and other research (e.g., O'Toole, 1996) suggests that small (i.e., low population) and rural communities have trouble obtaining grant and loan funding. This is an important concern because approximately 67% of communities reporting financial needs were located in small communities serving less than 10,000 people (EPA, 1997). A central challenge for environmental justice research examining distributional questions is to effectively control for the effects of population. Many environmental problems have an intrinsic population-based component. For example, hazardous waste facilities and toxic releases are more likely to be located in and around population centers. This study flips the distributional question on its head and looks at whether population leads to more of a good thing—increased environmental infrastructure funding.

A central challenge for environmental justice research examining distributional questions is to effectively control for the effects of population. Many environmental problems have an intrinsic population-based component.

There are two reasons to suspect that population is likely to be an important factor that should be controlled for in the analysis. First, the amount of funding needed to construct or upgrade a POTW is likely to increase with increasing population. As population increases, the probability that there are multiple facilities serving a community also increases. This should increase the probability that the community received a grant award. Second, larger communities are more likely to have the political capital necessary to elevate their position on state priority lists and compete effectively for grants. The CGP is a little different than many competitive grant programs. To receive funding, projects must first get on state priority lists. EPA and state officials are more likely to take an interest in heavily populated communities and encourage them to apply for grants. They are also more likely to be subject to EPA and state enforcement efforts, which can help elevate their position on state priority lists (Hunter & Waterman, 1996). Moreover, heavily populated communities are more likely to have the administrative capacity and skills necessary to apply for federal grants. This leads to the following hypothesis:

> *Hypothesis 1:* It is hypothesized that a county's population size, density, and increasing population is positively related to its share of construction grants and the probability of receiving at least one grant award.

Three independent variables were used to test this hypothesis: (a) population size, (b) population density, and (c) population change. Population size was measured as a county's share of a state's population in 1990. This measure was calculated by dividing the county's population by the state's population. Population density was measured as the 1990 population per square mile. Population change was measured as the percentage change in a county's population between 1980 and 1990.

COMMUNITY WEALTH

Previous environmental policy research suggests that states with greater financial resources spend more on environmental protection (Lester & Lombard, 1990). It is reasonable to assume that counties with greater financial resources also spend more on environmental protection. This argument is consistent with the EPA's (1991, 1993) observation that low-income communities often have trouble financing local matching requirements as well as the project costs that are not eligible for funding under the CGP. It is also likely that low-income communities lack the administrative capacity necessary to compete effectively for federal grants. Moreover, previous environmental justice research suggests that low-income communities are discriminated against during state and local government decision making (e.g., Goldman, 1994; Hamilton, 1995). Accordingly, it is reasonable to assume that some low-income communities are discriminated against during the prioritization process used to award construction grants. This leads to the following hypothesis:

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> *Hypothesis 2:* It is hypothesized that a county's wealth is positively related to the county's share of construction grants and the probability of receiving at least one grant award.

Two measures of community wealth were used in the analysis: (a) percentage of the population below the poverty level in 1989 and (b) median household income in 1990. The percentage of the population below the poverty level gives a measure of the relative proportion of a county's population that is poor. As poverty level increases, it is expected that the share of grant funds and the probability of obtaining single grant awards will decline. Median household income measures the relative income levels across counties. Both measures provide some indication of whether low-income communities are discriminated against and of their ability to finance these projects. The analysis also examined whether median household income should be modeled as a nonlinear function, where the effect of income begins to increase at a decreasing rate after it reaches a certain point. Two factors could contribute to the presence of a nonlinear relationship. Extremely wealthy communities could also be discriminated against in the grant allocation process. Wealthy communities may also wish to avoid grant conditions imposed by the EPA and decide to fund projects on their own. To model this nonlinear effect, the square of median household income was included as an additional independent variable.

A third possible measure of community wealth would be a county's median home value. It would provide a relative indicator of a county's property tax base. However, given the high correlation between median home value and median household income ($r = .741$), only one variable was included in the statistical analysis. Because user fees and sewer taxes are not typically based on property value, median household income was considered to be the more appropriate measure.

MINORITY COMPOSITION

Previous environmental justice research suggests that minority communities often experience disproportionate environmental impacts or are discriminated against during governing decision making (e.g., Goldman, 1994; Hamilton, 1995). Accordingly, it is reasonable to conclude that counties with relatively high concentrations of minority residents may be discriminated against during the allocation of construction grants. This leads to the following hypothesis:

> *Hypothesis 3:* It is hypothesized that a county's minority composition is inversely related to its share of construction grants and the probability of receiving at least one grant award.

Minority composition was measured in terms of a county's share of the state's minority population in 1990. This was calculated by dividing a county's total minority population by the number of minority residents in the state. This provided a relative measure of a county's minority population compared to other counties in the same state with which it was competing for federal funding. This helped control for differences in the minority population concentrations across the states, thus providing a better comparative measure. The statistical analysis was repeated using the more traditional measure of the percentage of a county's population that was classified as non-White. The results of the hypotheses tests using this measure were consistent with those reported for the county's share of minority residents.

Controlling for Differences Across States

Previous environmental policy research suggests that there are often differences in state environmental policy implementation (e.g., Davis & Lester, 1989; Lester, 1990; Lester & Lombard, 1990). Therefore, it is reasonable to assume that there are differences among the states with respect to the process used to prioritize and allocate construction grants.[7] To control for state-level differences, dummy variables for each state were included as independent variables in the tobit analysis. Though only a few state dummy variables were statistically significant at the $p < .05$ level, the estimates are more conservative with the dummy variables included. State dummy variables were not included in the logit analysis because the model would not converge when they were included.

Data Analysis

Ordinary least squares (OLS) regression analysis is a common statistical technique that can be used to examine distributional effects. If grant awards were distributed equitably, their distribution should not be a function of the factors considered to be illegitimate by the EPA.

It is important to note that this research design does not determine causal relationships. Rather, it uses statistical models to test hypotheses about potential relationships and suggest explanations that are consistent with the data. Ordinary least squares (OLS) regression analysis is a common statistical technique that can be used to examine distributional effects. If grant awards were distributed equitably, their distribution should not be a function of the factors considered to be illegitimate by the EPA. Because it is likely that some minimum thresholds (e.g., population level, density, wealth, etc.) were required to be eligible for funding, the data were considered to be censored. In the presence of censoring, OLS can be a biased and inconsistent estimator (Long, 1997). Accordingly, maximum likelihood estimation (MLE) for the tobit model (censored regression model) was used to examine the funding distribution. An OLS regression on only those counties obtaining grant awards produced similar results (see the appendix).

The probability of receiving a grant award during the 10-year period was modeled using logistic regression (i.e., logit model). Because the coefficients of the logit model are not directly interpretable, discrete changes in probability were examined using the techniques recommended by Long (1997). All statistical calculations were completed using the MARKOV module for GAUSS (Long, 1993). A sensitivity analysis was conducted to ensure that extreme values (e.g., counties with very high and low populations) did not bias the reported results.

Results

Table 1 contains the descriptive statistics for all counties. Approximately 66.8% of the counties received at least one construction grant during the period. This percentage remains relatively stable even when counties with populations in the top and bottom 5%, 15%, and 25% of the data set were removed. On average, counties receiving construction grant awards had a larger share of both a state's total and minority population. Moreover, the correlation between a county's share of total population and minority population was quite high (r = .889) and the importance of this relationship is discussed in more detail later in the article (see Table 2). Counties receiving grant awards also appeared to be better off financially—they had lower percentages of the population in poverty and higher median household incomes.

Table 2 displays the correlation matrix of the variables used in the analysis. Two results merit attention. First, the relationships were all in the hypothesized direction with the exception of a county's share of minority population, which was positively related to a county's share of grant awards (r = .692). An explanation for the result is that counties with a large share of minority population were also the ones with a large share of a state's population (e.g., major cities and urbanized areas). Therefore, they may have fared well when competing for construction grants. Second, there is a lot of colinearity between several of the independent variables. In particular, there is a high negative correlation between median household income and poverty rates (r = −.766) and a moderate correlation between population change and median household income (r = .454). This colinearity may be one reason that a few of the hypothesized relationships were not identified.

POPULATION

The results of the tobit analysis indicate that we should reject the hypothesis that an increase in a county's population results in an increase in a county's share of grant awards (see Table 3).

Table 1: Descriptive Statistics for All Counties in the 48 Contiguous States Based on 1990 Census Data

	All Counties		*Funding*		*No Funding*	
	M	SD	M	SD	M	SD
Dependent variable						
County share of grants (%)	1.54	5.25	2.31	6.29	0	0
Independent variables						
County share of population (%)	1.54	3.8	2.01	4.49	0.61	1.25
Population change (%)	4.12	16.64	4.42	15.60	3.50	18.60
Density (population/square mile)	221.40	1,425.50	239.10	1,369.30	185.90	1,532.70
Population in poverty (%)	16.70	7.93	15.79	7.28	18.54	8.84
Median household income ($)	23,845	6,469	24,572	6,517	22,383	6,116
County share of minorities (%)	1.54	5.33	2.04	6.35	0.55	1.71
Sample size	3,110 (100%)		2,079 (66.8%)		1,031 (33.2%)	

Table 2: Correlations Among Variables Used in the Study

Variables	*1*	*2*	*3*	*4*	*5*	*6*
1. County's share of grants	—	—	—	—	—	—
2. County's share of population	.692	—	—	—	—	—
3. Population change (%)	.346	.141	—	—	—	—
4. Density (population/square mile)	.274	.214	.026	—	—	—
5. Population in poverty (%)	–.111	–.176	–.258	–.041	—	—
6. Median household income	.199	.326	.454	.167	–.766	—
7. County's share of minorities	.688	.889	.069	.291	–.052	.206

A Wald test was used to confirm this result. A test that the coefficient was equal to zero in the tobit analysis ($\chi^2 = 1.423, p = .233$) was statistically insignificant. There are two possible explanations for the result. First, the colinearity between population change and median household income may confound the results. Second, it is possible that perceived population change (rather than the actual population change) had the stronger influence during the grant allocation process.

However, the results do suggest that we should accept the hypotheses that an increase in a county's share of population and its density was positively related to a county's share of grant awards. The results contained in Table 3 suggest that a 1% increase in a county's share of population is expected to increase a county's share of grant awards by .61%, holding all other variables constant. For a unit change (100 people) in population density, a county's share of grant awards is expected to increase by .04%. The results using grants per capita as a dependent variable suggest that it is not the aggregate population size that is important, but rather the density of a county's population that is the significant factor.

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The results of the logit analysis suggest that we should reject the hypothesis that a county's population density and population change are positively related to the probability of receiving a construction grant (see Table 4). Contrary to our expectations, the results suggest that there is an inverse relationship. However, the results do indicate that a county's share of population is positively related to the probability of receiving a grant. Counties with a larger share of population consistently have a higher probability of obtaining construction grants. All else being equal, a unit change (1%) in the county's share of population centered around the mean is expected to increase the probability of receiving a construction grant by 12.3%. Figures 1, 2, and 3 also suggest that population plays an important role in a county's ability to obtain construction grants. Moreover, as population increases, it quickly becomes the dominant factor. Figures 2 and 3 indicate that counties with large shares of a state's population have a high probability of obtaining construction grants, regardless of income level or minority concentration.

Table 3: Results of the Tobit Regression on a County's Share of Funding and the Logit Analysis of a County's Probability of Receiving a Grant

	Tobit		*Logit*	
	β	t	β	t
Constant	-7.861	-6.30***	-2.168	-5.15***
County share of population (%)	0.611	10.93***	0.638	9.10***
Population change (%)	—	—	-0.008	-3.21**
Density (100/square mile)	0.042	6.55***	-0.014	-3.17**
Median household income ($1,000)	0.535	6.65***	0.169	5.36***
Median household income ($1,000)^2	-0.008	-6.44***	-0.002	-4.63***
County share of minorities (%)	0.279	7.61***	-0.091	-2.51*
$LR\chi^2$	1,827.68***		319.717***	
Sample size	3,110		3,110	

NOTE: Results with the state dummy variables are contained in the appendix. Logit analyses do not include state dummy variables.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 4: Discrete Change in a County's Probability of Receiving a Grant

	Range[a]	*Unit Change*[b]	*Standard Deviation*[c]
County share of population (%)	.49	.123	.230
Population change (%)	.37	-.002	-.029
Density (100/square mile)	.74	.003	-.040
Median household income ($1,000)	.92	.008	.051
Median household income ($1,000)^2	—	—	—
County share of minorities (%)	.76	-.018	-.104

NOTE: All probabilities were calculated with all other variables held constant at their means.
a. Range from the minimum to maximum value in the data set.
b. Unit change centered around the mean.
c. Increase of 1 standard deviation above the mean.

COMMUNITY WEALTH

The results of the tobit and logit analyses lead us to reject the hypothesis that a county's poverty level is inversely related to the county's share of construction grant awards and the probability of receiving a construction grant. Wald tests were used to confirm the result. Tests that the coefficient was equal to zero in the tobit analysis ($\chi^2 = .002$, $p = .963$) and logit analysis ($\chi^2 = 2.096$, $p = .148$) were both statistically insignificant. One possible explanation for this result is the colinearity between poverty level and median household income. However, the results for the variable median household income are consistent with the hypothesized relationships and suggest the presence of a nonlinear relationship.

Table 3 indicates that a $1,000 increase in median household income is expected to result in approximately a .53% increase in a county's share of construction grant awards, holding all other variables constant. The results of the logit analysis contained in Table 4 also indicate that, all else being equal, a unit change ($1,000) centered around the mean and a standard deviation increase from the mean is expected to increase the probability of obtaining a construction grant by .8% and 5.1%, respectively. Figures 1, 2, and 3 illustrate that high-income communities consistently have a higher probability of obtaining construction grants than poor communities.

The effect of income is also more pronounced when a county's share of population is low (see Figure 1) and its share of minority population is high (see Figure 3). Figure 2 also illustrates the nonlinear nature of the income effect. The probability of obtaining a construction grant increases until median household income reaches approximately $32,000, and then it begins to

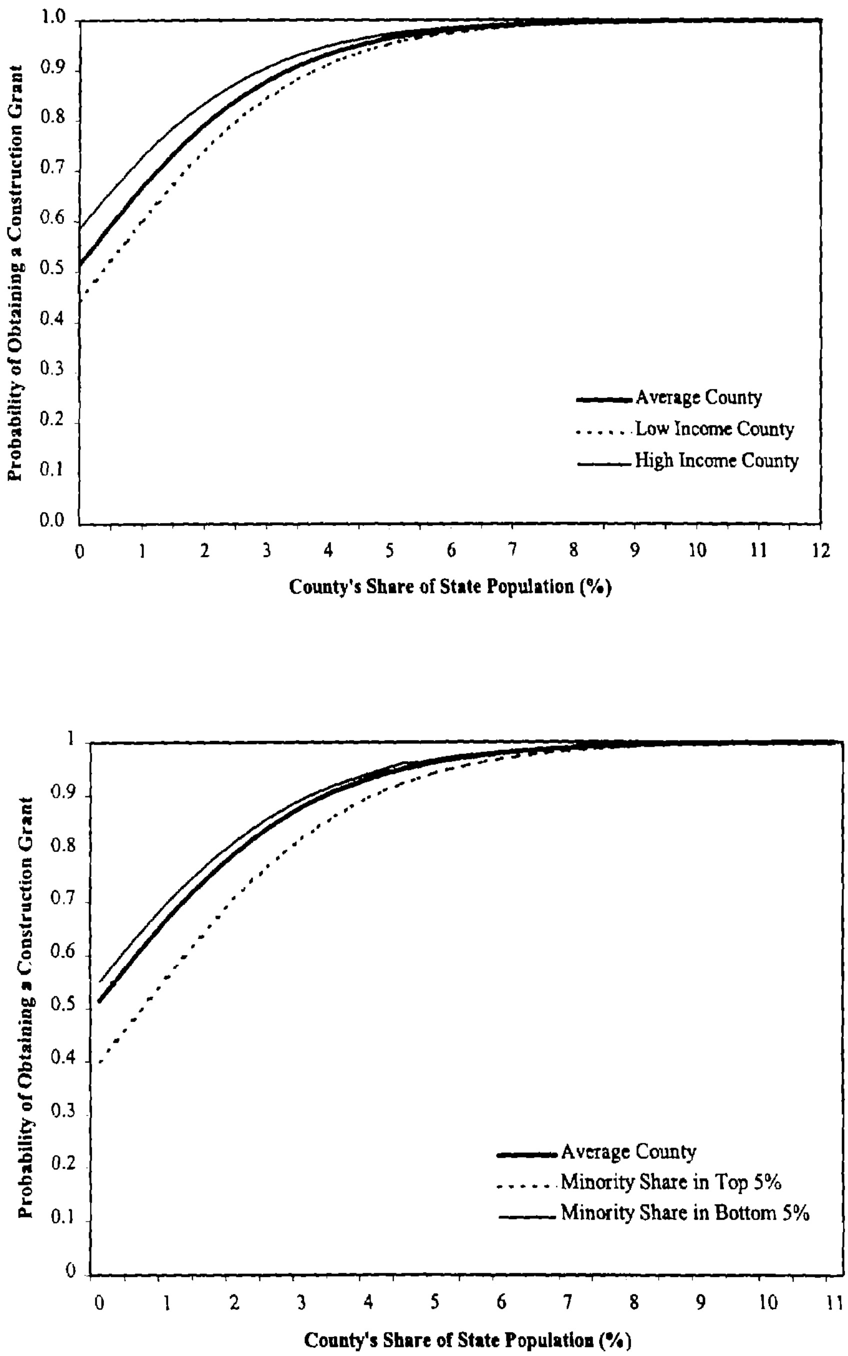


Figure 1: Discrete Change in Probability for a Change in Share of Population

NOTE: High-income and low-income counties have income fixed at 1 standard deviation below the mean, respectively. All other variables were held at their means.

decrease. Other nonlinearities were also examined. The square root and the natural log of income, when substituted for income and income squared, also produced statistically significant relationships in the hypothesized direction in both the logit and tobit analysis. These results suggest that either wealthy communities are discriminated against when applying for construction grants or they tend to choose instead to finance projects themselves.

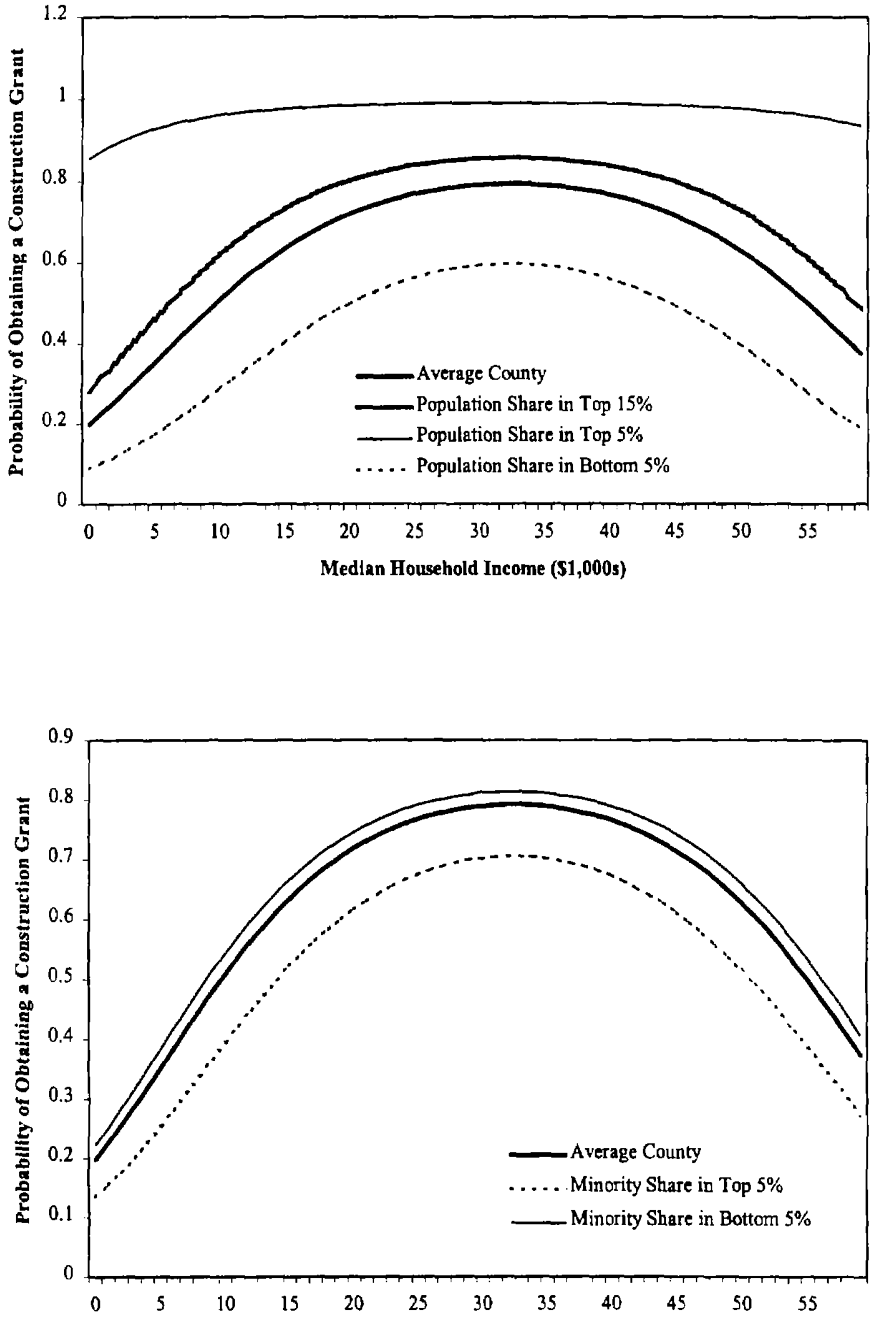
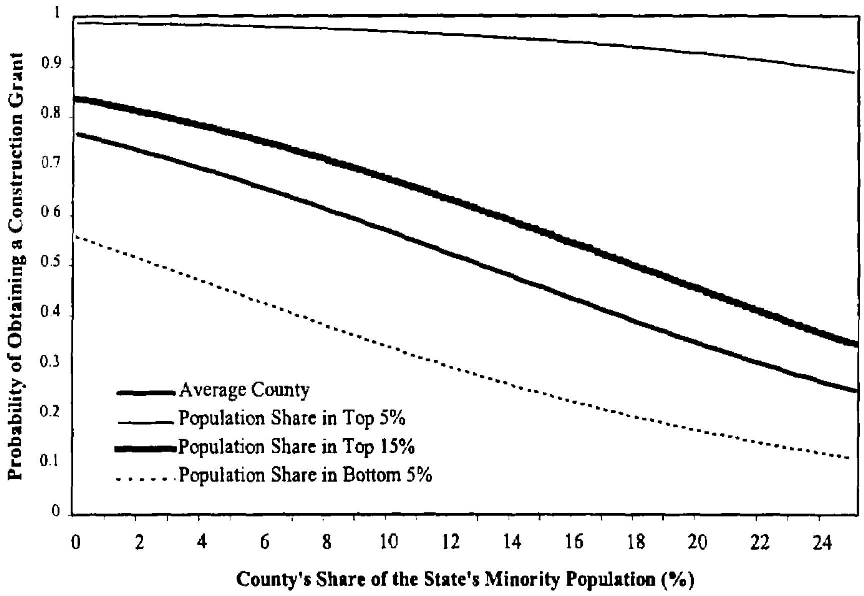


Figure 2: Discrete Change in Probability for a Change in Median Household Income

MINORITY COMPOSITION

The results of the tobit analysis contained in Table 3 indicate that we should reject the hypothesis that a county's minority composition is inversely related to its share of construction grant awards. The results indicate that the relationship is actually in the opposite direction. All else being equal, a unit change (1%) in a county's share of the minority population is expected to increase the county's share of grant awards by approximately .28%. Accordingly, counties with high concentrations of a state's minority populations are likely to have higher shares of a state's



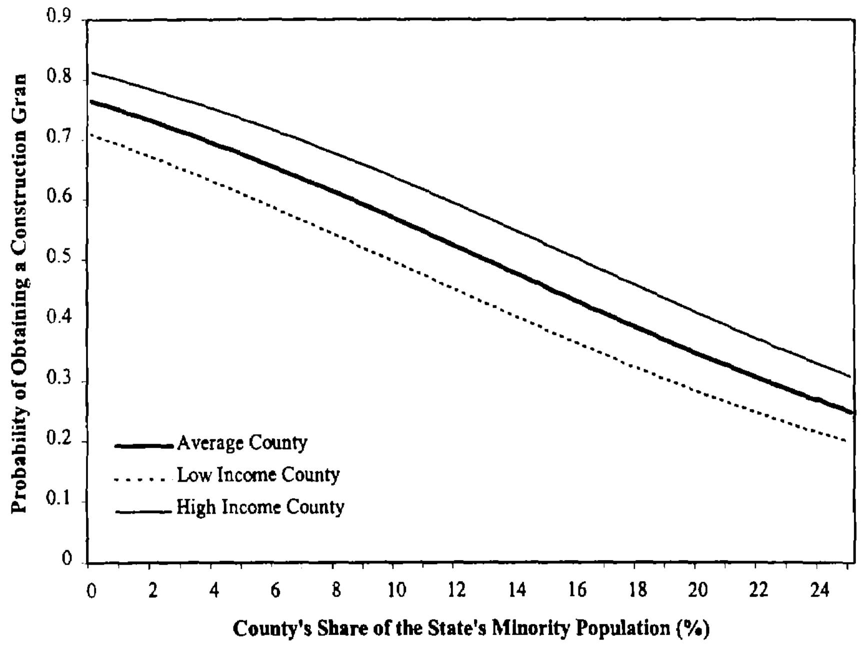


Figure 3: Discrete Change in Probability for a Change in Share of Minorities

NOTE: High-income and low-income counties have income fixed at 1 standard deviation above and below the mean, respectively. All other variables were held constant at their means.

total grant awards. The analysis was repeated, substituting a county's percentage of minority residents as the independent variable. These results were not statistically significant, which confirms the finding that minority composition appears to have no statistically significant influence on the aggregate amount of funding awards.

However, the results of the logit analysis contained in Table 3 are consistent with the study's hypothesis that a county's share of the minority population is inversely related to the probability of receiving a construction grant. All else being equal, a 1% change and a standard deviation increase in a county's share of minorities is expected to decrease the probability of receiving a construction grant by 1.8% and 10.4%, respectively. Substituting the variable percentage of the county's population classified as non-White yields a similar result. This confirms the finding that as a county's minority concentration increases, the probability of receiving a grant award decreases. Figures 1, 2, and 3 all illustrate that counties with a large share of a state's minority population consistently had a lower probability of obtaining construction grants. Accordingly, the probability of receiving a grant decreases as the county's share of a state's minority population increases, and poor minority communities consistently had a lower probability of receiving construction grants than wealthy minority communities.

Discussion

The results suggest that counties with a small share of a state's population (i.e., rural counties) received a smaller share of a state's total grant awards. It appears that the amount of funding is primarily a function of the size and density of the population. Counties with a smaller share of the state's population also had a lower probability of receiving grants. More important, as a county's share of population decreases, the effects of income and minority composition become more pronounced. However, as population increases, it quickly becomes the dominant factor. Large cities and other urbanized areas are likely to receive grants regardless of income or minority composition. These findings support the EPA's and others' (e.g., O'Toole, 1996) contention that smaller communities have more trouble competing for and obtaining construction grants and loans.

Counties with a smaller share of the state's population also had a lower probability of receiving grants. More important, as a county's share of population decreases, the effects of income and minority composition become more pronounced.

Another important result is that, all else being equal, wealthy communities did better than poor communities in terms of the share of grant funding awarded and the probability of receiving grants. These results are consistent with the EPA's assertion that low-income communities had more difficulty obtaining grants. This raises the possibility that the communities lack the political capital and administrative capacity necessary to effectively compete for grants. The effect of income also appears to be nonlinear. This result raises two possibilities: Extremely wealthy communities avoided applying for construction grants to avoid the EPA or a state EPA's oversight and funded projects on their own or they were also discriminated against. Both of these possibilities are ignored in the EPA's Strategy (1994) and merit further research.

Finally, the results suggest that a county's share of the state's minority population is inversely related to the probability of obtaining construction grants but positively related to the share of grant awards. The results are consistent with the EPA's assertion that minority communities have trouble obtaining grants and the problem appears to be compounded in small and low-income communities. This raises the possibility that minority communities are discriminated against during the development of priority lists. As previously stated, it is also possible that the communities lack the political capital and administrative capacity necessary to effectively compete for grants. These problems are likely to be more pronounced in the SRLP, which is a more complicated program when viewed from a public finance perspective. However, though minority communities had a lower probability of obtaining construction grants, when they did receive grants the size of the award appears to be primarily a function of the size of the population served. Moreover, the results suggest that many urbanized areas were effective in competing for construction grants even though they often have a large share of a state's minority population.

Implications for Future Research

The study also demonstrates three methodological challenges confronting environmental justice researchers. First, the study demonstrates the importance of distinguishing between inequalities associated with a public decision-making process and the policy outcomes stemming from that process. One set of inequities does not necessarily imply the other. Therefore, it is important to consider them as separate questions. Second, the available data rarely correspond to the desirable unit of analysis. Thus, the selection of a unit of analysis often involves making compromises. Although the trend in environmental justice has been toward using an ever-smaller unit of analysis, it is not always the desirable course of action. Zip codes, census blocks and tracts, and place-level and county-level data all have strengths and weaknesses. The important thing is to consider the merits of various measures and choose a unit of analysis that best captures the phenomena being examined.

Third, the study illustrates how difficult it can be to separate the effects of race from those associated with the overall distribution of a population. Environmental justice researchers should note the high positive correlation between a county's share of population and its share of minority residents ($r = .889$). This relationship holds even when high- and low-population counties are removed from the data set. Accordingly, when environmental justice research uses county-level data to examine the relationship between the location of an environmental problem (e.g., land fills, hazardous waste disposal sites, incinerators, air pollution, water pollution, etc.) and a community's minority composition, they may be likely to find statistically significant relationships when there is a strong population-based component to a problem. For example, Hird (1993) examined the distribution of National Priority List (NPL) superfund sites at the county level and found a statistically significant relationship with a county's minority composition. This result could be due to discrimination against minority communities during the siting process. It could also be the result of having NPL sites being located near population centers that also tend to have a high proportion of a state's minority population. Because most environmental problems have a strong population-based component, a major challenge for environmental justice research is to separate the effect of population distribution from the factors of interest (e.g., race, income, etc.).

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The results also suggest that additional research on environmental infrastructure programs is warranted. State- and local-level expenditures on environmental infrastructure should be examined. Further statistical analysis at the state level, along with qualitative case studies aimed at understanding the grant allocation process, would also be beneficial. For example, it is unclear whether the disparities increased as the CGP moved from a 75% to a 55% matching requirement. Moreover, whereas the results suggest that small, low-income, and minority communities had trouble obtaining construction grants, the extent to which this disparity translates into unequal access to infrastructure remains unclear and subject to further investigation.

It is also unclear whether these disparities increased when the CGP was phased out and replaced by the SRLP. There is reason to believe that this is the case (O'Toole, 1996). State revolving loans (SRLs) generally provide a smaller subsidy than grants, and this increases the capital costs for municipalities. For example, the EPA estimates that an SRL issued at 4% will result in user fees approximately 20% higher than projects financed with 55% construction grants (EPA, 1991). Disadvantaged communities may also have poor credit ratings and encounter problems qualifying for and repaying SRLs, even with low interest rates (EPA, 1991, 1993). Because the financial burdens have increased, it is logical to assume that any inequities in the CGP are likely to be exacerbated in the SRLP. Understanding the distributional effects of the CWA SRLPs is important because $20 billion in federal capitalization costs have already been incurred. Moreover, SRLPs are also being created pursuant to the Safe Drinking Water Act to help upgrade community drinking water systems. There is even talk in Congress of moving to revolving loan programs in other policy areas (e.g., transportation). If we had a better understanding of the distributional questions surrounding SRLPs, it would become possible to take better advantage of the cross-subsidization options resulting from this public financing arrangement.

The study also raises important public policy questions about how environmental infrastructure funding should be allocated. Though the Strategy's third goal is to ensure that all citizens have equal access to environmental infrastructure, little guidance is offered on how to ensure that the goal is achieved. Most of the Strategy's recommendations amount to token technical assistance efforts. It is doubtful that any of the recommendations would make significant progress toward accomplishing the Strategy's third goal. It also seems unlikely that significant progress can be made until EPA and state officials confront the question of where limited federal infrastructure funding should be spent. For example, infrastructure spending for POTWs could be targeted toward

1. Population centers (arguably the approach of the CGP and SRLP),
2. Small and low-income communities (where most of the POTWs are located), or
3. Areas where the greatest environmental benefits would result (arguably the approach that would best achieve the goals of the CWA).

There are several reasons why it might be desirable to target investments in areas with large populations. First, financial needs are greater in communities with high populations. Second, sewage treatment options are more limited because in densely populated communities it is often inappropriate to rely on onsite sewage disposal systems (OSDSs). Third, allocating large grants and loans to population centers reduces the transaction costs associated with administering the programs. Finally, targeting federal funding in areas with larger populations lets a larger proportion of the total population benefit from the expenditures.

A second option would be to target infrastructure funding in small and low-income communities. A variation on this option would be to ensure that a portion of available funding is allocated to these communities. Although approximately 67% of sewage treatment facilities are located in small communities, they account for only 11% of financial needs. Targeting limited funding in these communities could benefit a larger proportion of existing POTWs. It could also be argued that communities with large populations are in a better position to self-finance construction costs with user fees or bonds.

Although approximately 67% of sewage treatment facilities are located in small communities, they account for only 11% of financial needs. Targeting limited funding in these communities could benefit a larger proportion of existing POTWs.

The final option argues that population and income are not relevant factors. Instead, investments should be based on the magnitude of environmental benefits associated with the expenditures. If investments are targeted in urbanized areas, the expenditures may be inadequate to ensure that surface water quality meets the CWA's fishable and swimable standards. Conversely, targeting funding in small or rural communities may result in public expenditures in areas where water quality, for the most part, already meets CWA standards. The problem with basing funding decisions on the magnitude of associated environmental improvements is that all communities are required to meet similar CWA requirements. Moreover, the information costs associated with administering this type of program would be high.

Each option is based on different normative judgments about what is the most efficient policy. Each option is fair in its own right but is inconsistent with the others. The first option, which appears to be the current Strategy, is to maximize the number of people benefiting from public expenditures. The second maximizes the number of POTWs that benefit, whereas the third optimizes the environmental improvements resulting from public expenditures. The three options illustrate the central problem with the EPA Strategy's third goal. It is based exclusively on the notion of horizontal equity and assumes that the distribution of funding should not be a function of the characteristics of disadvantaged communities. However, the Strategy is silent on the question of what community characteristics should drive decisions related to investments in environmental infrastructure. Consequently, it fails to consider important questions related to vertical equity or how communities are unequal. Because it makes little sense to distribute limited environmental infrastructure resources in a random fashion, the Strategy should be revised to indicate how limited funding should be spent.

The Strategy also fails to consider one of the important consequences of the shift from a CGP to an SRLP, the role of EPA oversight in infrastructure investment decisions. Under the old CGP, the EPA exercised much greater control over investment decisions. As a consequence of the move to an SRLP, state officials now have control over investment decisions. There are also significant differences across the states in terms of their implementation of the SRLPs (O'Toole, 1996). This will dramatically increase the costs for the EPA to perform oversight. It will also make it harder for the EPA to ensure that the Strategy's third goal will be achieved. Because the Strategy is silent on how limited environmental infrastructure funding should be invested, it is unclear how the EPA will monitor state investment decisions and assess whether disadvantaged communities are being treated fairly in the allocation of state revolving loans. These are issues that the EPA should consider if they revise their Strategy.

Conclusion

This study provides a foundation that environmental justice research can build on when examining questions related to environmental infrastructure. Continued population growth and redistribution, deterioration of existing infrastructure, and more stringent environmental standards are all likely to increase financial needs (EPA, 1993, 1997). There is also the growing recognition that additional capital investment is necessary to address water quality problems resulting from nonpoint source runoff, combined sewer overflows, excessive nitrogen and phosphorous loadings to surface waters, and groundwater contamination resulting from excessive loadings from OSDSs. Because federal and state environmental infrastructure funding is not increasing in a corresponding manner, competition for limited funding is likely to increase in the foreseeable future. There is also a trend toward the increased reliance on SRLPs to finance public expenditures in environmental infrastructure. Given these trends, it is reasonable to conclude that it will be increasingly difficult for disadvantaged communities to finance environmental infrastructure. This raises a number of important public policy questions and suggests that this should be an important area for future environmental justice research.

Appendix

Complete Results of the Tobit Analysis and an Ordinary Least Squares (OLS) Regression on a County's Share of Funding for All Counties Receiving Funding

	Tobit		*OLS*	
	β	t	β	t
Constant (Alabama)	-7.861	-6.30***	-4.062	-3.27**
County share of population (%)	0.611	10.93***	0.474	8.81***
Density (100/square mile)	0.042	6.55***	0.093	12.64***
County share of minorities	0.279	7.61***	0.295	8.46***
Median household income ($1,000)	0.535	6.65***	0.365	4.47***
Median household income ($1,000)^2	-0.009	-6.44***	-0.007	-4.70***
Arizona	1.207	0.88	0.785	0.63
Arkansas	-0.585	-0.68	0.724	0.82
California	-0.440	-0.48	-0.740	-0.84
Colorado	-1.944	-2.11*	0.411	0.41
Connecticut	1.875	1.04	3.297	1.86
Delaware	3.510	1.23	6.480	2.44*
Florida	1.250	-1.41	-0.526	-0.59
Georgia	2.510	-3.28**	-0.191	-0.23
Idaho	-0.605	-0.62	0.134	0.14
Illinois	-0.413	-0.52	-0.663	-0.87
Indiana	-0.550	-0.67	-0.734	-0.94
Iowa	-0.960	-1.19	-0.469	-0.59
Kansas	1.498	-1.86	-0.317	-0.39
Kentucky	-0.568	-0.73	-0.120	-0.16
Louisiana	-0.789	-0.88	0.405	0.44
Maine	-0.877	-0.65	3.820	2.35*
Maryland	0.809	0.68	0.702	0.63
Massachusetts	0.244	0.17	-0.031	-0.02
Michigan	-0.243	-0.29	-0.590	-0.75
Minnesota	0.055	0.07	-0.572	-0.75
Mississippi	-0.660	-0.78	0.694	0.78
Missouri	0.264	0.34	-0.428	-0.59
Montana	-0.986	-1.08	0.331	0.35
Nebraska	-0.984	-1.20	-0.145	-0.18
Nevada	-1.895	-1.35	2.973	1.71

(continued)

Appendix Continued

	Tobit		OLS	
	β	t	β	t
New Hampshire	0.623	0.39	2.940	1.80
New Jersey	0.880	0.69	−0.329	−0.28
New Mexico	−0.739	−0.69	1.500	1.26
New York	−0.813	−0.88	−0.697	−0.82
North Carolina	−0.758	−0.95	−0.567	−0.73
North Dakota	0.052	0.06	0.003	0.00
Ohio	−0.243	−0.29	−0.857	−1.11
Oklahoma	0.034	0.04	−0.107	−0.13
Oregon	−0.843	−0.81	0.177	0.17
Pennsylvania	−0.577	−0.66	−0.843	−1.01
Rhode Island	1.484	0.68	5.507	2.44*
South Carolina	0.060	0.06	−0.266	−0.30
South Dakota	0.396	0.46	0.023	0.03
Tennessee	−0.015	−0.02	−0.440	−0.58
Texas	−2.089	−2.94**	−0.523	−0.73
Utah	−0.656	−0.59	1.280	1.12
Vermont	−0.329	−0.23	3.042	1.97*
Virginia	−2.772	−3.48***	0.202	0.24
Washington	−1.231	−1.20	0.110	0.10
West Virginia	0.225	0.25	−0.020	−0.02
Wisconsin	−1.036	−1.19	−0.370	−0.43
Wyoming	0.291	0.25	0.266	0.24
$LR\chi^2$	1,827.68***		847.43***	
Adjusted R^2	—		0.546	
Sample size	3,110		2,079	

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

Notes

1. Many critics charged that plants were overbuilt, that states used federal construction grant funds as a substitute for their own, and that Environmental Protection Agency (EPA) oversight led to long construction delays and escalating project costs. These complaints, combined with budget-cutting pressures at the national level and Reagan's new federalism, helped lead to a state revolving loan program (SRLP) that gave state officials significantly more control over investment decisions (O'Toole, 1996).

2. Environmental justice is a relatively new field of social environmental policy research that examines the distribution of environmental benefits and harms within a population. Because of the possible disparate impacts borne by minority populations, many researchers use the term *environmental racism*. According to Bullard (1991), "Environmental racism is a combination of prejudice and the power to implement decisions and policies that defend, protect, and enhance the social positions of whites at the expense of peoples of color" (p. 25). It includes disproportional environmental outcomes that impact minorities as a result of low incomes, low education levels, or restricted mobility and is a narrower concept (Hamilton, 1995, p. 109).

Previous environmental justice research consists of case studies (e.g., Bailey & Faupel, 1992; Bullard, 1983, 1990, 1993, 1994; Edelstein, 1988; Mohai & Bryant, 1992), comparative analyses (e.g., Been, 1994; Berry, 1977; Hamilton, 1993, 1995; Hird, 1993; United Church of Christ Commission for Racial Justice & Public Data Access, Inc. [UCC & PDA], 1987), economic analyses (e.g., Gelobter, 1992; Gianessi & Peskin, 1980; Kohlhase, 1991; Lake, Hanneman, & Oster, 1979; Reed & Young, 1983), and legal analyses (e.g., Been, 1993; Cole, 1992; Colquette & Robertson, 1991; Godsil, 1991). A great deal of research also focuses on hazardous and toxic waste facilities (Hamilton, 1993, 1995; Hird, 1993; Kohlhase, 1991; Lee, 1992; Mohai & Bryant, 1992; UCC & PDA, 1987; General Accounting Office GAO, 1995; Yandle & Burton, 1996), air pollution (e.g., Asch & Seneca, 1978; Gelobter, 1992), regulatory costs and benefits (e.g., Gianessi & Peskin, 1980; Lake et al., 1979; Reed & Young, 1983), and pesticide exposures (e.g., Bullard, 1983; West, Fly, Larkin, & Marans, 1992).

3. Clearly there are many different types of environmental infrastructure and different ways to measure access to these facilities. Unfortunately, this data is not readily available in a form that would permit the type of national-level analysis put forth in this article. It nonetheless is an important area for future research.

4. The major differences in the structure of state programs include different configurations of the service delivery networks, different interest rates and financing methods, and differences in the cross-subsidization process associated with a SRLP (Johnson, 1995; O'Toole, 1996).

5. The service areas of POTWs can also cross county boundaries. But given the choice between the county- and place-level data available, county-level data was determined to better fit the questions asked. Whereas county-level data will certainly smooth many of the demographic differences, this will make the analysis more conservative.

6. Although many small communities will include wealthy, predominantly White communities, it is important to note that these communities will also face higher user fees and finance charges than larger communities. This could make it difficult for them to compete for construction grants or state revolving loans as well.

7. The differences across the states are even more pronounced in the SRLPs (Johnson, 1995; O'Toole, 1996).

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