WHICH CAME FIRST? TOXIC FACILITIES, MINORITY MOVE-IN, AND ENVIRONMENTAL JUSTICE

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ABSTRACT: *Previous research suggests that minority residential areas have a disproportionate likelihood of hosting various environmental hazards. Some critics have responded that the contemporary correlation of race and hazards may reflect post-siting minority move-in, perhaps because of a risk effect on housing costs, rather than discrimination in siting. This article examines the disproportionate siting and minority move-in hypotheses in Los Angeles County by reconciling tract geography and data over three decades with firm-level information on the initial siting dates for toxic storage and disposal facilities. Using simple t-tests, logit analysis, and a novel simultaneous model, we find that disproportionate siting matters more than disproportionate minority move-in in the sample area. Racial transition is also an important predictor of siting, suggesting a role for multiracial organizing in resisting new facilities.*

In recent years, policy makers have become increasingly responsive to the perception of racially inequitable exposure to various environmental hazards concerns. As early as 1994, a Presidential Executive Order directed all federal agencies to take into account the potentially disproportionate burdens of pollution or hazards existing in US minority communities. In 1998, the Southern California Air Quality Management District—charged with cleaning up the country's dirtiest air—decided, under pressure from grassroots activists, to create its own task force on environmental justice. One year later, the California legislature adopted a law directing the state's Office of Policy Research to develop environmental justice guidelines for California's

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various agencies, forcing a scramble among policy makers to better define both the problem and appropriate remedies.

Despite the ongoing response at the policy level, the research on disproportionate exposure by race has yielded mixed results. Making use of simple cross-tabulations, basic correlation analysis, and case studies, the earliest work in this field found that minority neighborhoods hosted a disproportionate share of the environmental hazards and toxins produced by an industrialized society (Bullard, 1990; UCC, 1987). Subsequently, some researchers found that race was not a significant factor when controlling for income, employee proximity, and other reasonable variables (Anderton, Anderson, Oakes, & Fraser, 1994; Anderton, Anderson, Rossi, et al., 1994). However, a more recent wave of research, also controlling for other explanatory factors, has tended to confirm the racial disproportionality hypothesis (see, for example, Been, 1995).

Virtually all of this research has amounted to a "snapshot in time" of the distribution of environmental hazards. Recognizing where hazards are and whom they might affect is of immediate utility to those public officials calculating health risks, planning emergency measures, or seeking to redevelop contaminated land. But such a cross-section analysis does not fully address a question of central concern to policy makers: Were the hazards disproportionately sited in minority communities or did minority residents move in after hazards were sited?

The debate between the "disproportionate siting" and "minority move-in" hypotheses matters greatly for urban and environmental policy. If the problem of disproportionate exposure by race is due to siting, then it would be appropriate for policy makers to revise zoning and permitting procedures to eliminate any elements of discrimination. But suppose the pattern emerges because the siting of hazards detracts from neighborhood livability and thereby diminishes land values, inducing an exodus of middle-class (often Anglo) homeowners and an influx of lower-class (often minority) residents. While health precautions would still call for buffers between industrial and residential uses as well as other safeguards, the notion that the process is market-driven may lead some to suggest that individuals are simply choosing to trade increased neighborhood health risks for slightly larger or better (in other ways) housing.

The role for policy in this view might be confined to: (1) ensuring access to data about neighborhood health risks so that individuals who choose to trade risk for affordable housing are not acting on incomplete information (see Burby & Strong, 1997), and (2) continuing the enforcement of existing statutes that limit the steering of minority house-seekers to particular neighborhoods. Indeed, if information is complete and housing discrimination is limited, then some might argue that there is little reason to be concerned about a contemporary pattern of disproportionate exposure; after all, market dynamics suggest that those neighborhoods with hazards will eventually become predominantly minority anyway.

Is the current pattern of environmental inequity a field of bad dreams: Build it and minorities will come? This article contributes to disentangling the role of disproportionate siting and minority move-in with a study of the temporal dynamics in Los Angeles County, a region where there is clear evidence of disproportionate contemporary exposure to toxic storage and disposal facilities (TSDFs), toxic air releases, and other environmental negatives (Boer, Pastor, Sadd, & Snyder, 1997; Burke, 1993; Sadd, Pastor, Boer, & Snyder 1999; Szasz, Meuser, Aronson, & Fukurai, 1993). We focus on TSDFs, facilities that operate under a U.S. EPA permit to store hazardous wastes (any non-petroleum substance which is ignitable, corrosive, reactive, or toxic) as defined in the Resource Conservation and Recovery Act of 1976. Most TSDFs are private, for-profit businesses that accept waste from other generating facilities.

We link the siting dates and addresses of Los Angeles' high-capacity TSDFs (those which handle more than 50 tons a year) to a database that tracks changes in selected socio-economic variables through the period 1970 to 1990, with all data geographically indexed to the 1990

census tract shapes. We subject the resulting data to a variety of tests, including logistic regressions to predict future siting and a simultaneous model that accounts for both minority move-in and disproportionate siting. The results indicate that disproportionate siting matters more than minority move-in within the sample area. The results also suggest that areas undergoing ethnic transition may be as vulnerable to siting as areas with older or more established minority populations. This finding reinforces the activist argument that residents should organize on a multiracial basis to resist increased exposure to environmental hazards.

The article proceeds as follows. The first section reviews previous studies and outlines our approach. The second section discusses basic trends in the data. The third section offers logit-style regressions that attempt to predict the likelihood that a hazardous site will be located in a particular area. The fourth section tests for the possibility of minority-move-in, both after the siting and during the period of siting. The final section concludes with possible lessons for both policy makers and activists.

LITERATURE REVIEW AND METHODOLOGY

There is now a burgeoning literature examining the pattern of contemporary location of environmental hazards (see the extensive review in Szasz & Meuser, 1997). While the evidence is often more mixed than many activists have believed, the bulk of the research does seem to point to disproportionate exposure to hazards in minority communities. The most recent work about California is strongly supportive of disproportionality in the Golden State. Morello-Frosch (1997), for example, focuses on hazardous air pollutants (HAP) at the county and census tract level and finds a consistent association between the percentage of minorities and both HAP concentrations and estimated likelihoods of pollutant-related cancer risk. Our own previous work (Boer et al., 1997; Sadd et al., 1999) explores the distribution of hazardous waste storage and disposal facilities (TSDF) and toxic air releases in Southern California and finds strong evidence of a racial pattern, even when controlling for reasonable variables such as land use, manufacturing employment, and income.

Many have assumed that contemporary inequity is the result of discriminatory siting practices. The general argument is that low levels of political power in minority communities may induce polluters to locate hazards in these areas (Hamilton, 1995). Such a political argument is often implicitly based on notions of social capital and community efficacy: Where residents have more ability to organize and affect policy, perhaps because of their income or racial status in a stratified society, they will be more able to resist the placement of a hazardous facility. Of course, social capital may in fact be affected by other factors, such as the level of education of residents or the ability to bridge differences between minority groups, a topic we explore below (see also Briggs, 1998; Temkin & Rohe, 1998).

An alternative argument suggests that disproportionate exposure simply reflects the market: Both minorities and undesirable land uses will be attracted to areas with lower housing values, and in fact, minorities may move in after the arrival of a new locally undesirable land use (Been & Gupta, 1997). In our view, this market-based account of minority move-in is unlikely, at least in Southern California; after all, if race still matters when income is held constant in a cross-section regression, then any disproportionate move-in of ethnic residents would seem to reflect different consumer tastes for exposure to this type of risk. In fact, however, one survey suggests that minority residents may be even more concerned about environmental risk, particularly in the contemporary period in which environmental justice has become a key organizing buzzword in selected communities (Burby & Strong, 1997). Still, the minority move-in argument persists and a more sophisticated version can incorporate the potential role of housing discrimination in limiting the locational opportunities for minorities.

Despite the importance of the issue, there is very little solid research on the dynamics of disproportionate siting versus minority move-in. Yandle and Burton (1996) provided an early longitudinal look at hazardous landfills in metropolitan areas in Texas but their work has been sharply criticized on methodological grounds (see, for example, Anderton, 1996; Mohai, 1996). More recently, Shaikh and Loomis (1999) looked at the decadal percentage change in minorities in Denver neighborhoods after the siting of a stationary source of air pollution. Not only did they find no evidence of minority move-in but they also found some evidence suggesting that communities without polluting sites experienced larger increases in the percentage of minorities; however, the areal units in their study are zip codes, a less uniform geography which has largely been eschewed in favor of census tracts in most recent research efforts.

Thus, the two most significant and reputable longitudinal studies are Oakes, Anderton, & Anderson (1996) and Been & Gupta (1997). The Oakes, et al. (1996) study uses the 1992 Environmental Services Directory to determine beginning dates for commercial TSDFs nationwide. Comparing tracts that received TSDFs over the 1970 to 1990 period to the rest of the county, the authors found no evidence of either disproportionate siting by race—or of a subsequent move-in of minorities that exceeds the pattern for areas with similar industrial characteristics. They then conducted a more formal multivariate regression analysis on the TSDF tracts and a stratified sample of non-TSDF tracts: neither race nor poverty was significant and the only variable with real predictive power was the percentage of local residents involved in industrial employment. As for post-siting changes, a TSDF tends to have a negative (not positive) impact on African American or Latino in-migration, albeit at an insignificant level. Thus, in both the simple comparisons and the multivariate setting, neither disproportionate siting nor minority move-in are shown to exist.

In a similar nationwide longitudinal study, Been and Gupta (1997) arrived at slightly different results. Like Oakes et al. (1996), they used a national sample and conducted multivariate regressions on tracts that received TSDFs and a stratified sample of tracts that did not. They also found no evidence for a market dynamics story of minority move-in subsequent to the siting of a TSDF. However, they did find that the percentage of Latinos had a significant impact on the likelihood of receiving a TSDF (as did the percentage of local industrial employees and population density). While this overall pattern of results tends to offer some weak support to the usual claims of environmental justice proponents, there is no evidence that the percentage of African American residents has an impact on siting and the percentage of residents in poverty is actually found to have a negative impact on 1980s sitings.

Our own approach involves several modifications from the previous studies. First, we look only at one region, Los Angeles County. This limited geographic scope is partly due to our view that the nature of hazards is related to the industrial clusters of a region—Los Angeles's furniture making and metal plating industries are not likely to drift north to Seattle, and Microsoft is not likely to move south to Los Angeles—so it is the distribution of hazards within a region that matters. Logistically, this regional focus also allowed us to obtain siting information from original business records and permit applications, as well as to accurately locate and verify each TSDF by conducting visits to actual facility locations. Focusing on one region also allowed us to employ a California Department of Finance (DOF) database that allocates certain variables from the 1970 and 1980 censuses, including ethnicity, to the 1990s tract boundaries. Therefore, we could consider all host and non-host tracts rather than a stratified sample as in earlier work.

A second difference is our use of geocoded site location and GIS procedures to determine affected tracts. Both Been and Gupta (1997) and Oakes, et al. (1996) focused on the demographic characteristics of tracts that contained TSDFs. Yet as Anderton, Anderson, Rossi, et al. (1994) and Anderton, Anderson, Oakes, et al. (1994) pointed out, TSDFs are often located

near a tract boundary and a simple tagging of only the host tract will ignore the impact on immediately adjacent neighborhoods. Therefore we pinpointed the actual facility and used a circular buffer distance of one-quarter mile and one mile to define the potentially affected tracts and residential population. As a result of this procedure, there are slightly more affected tracts than there are TSDFs at the one-quarter mile level and, of course, even more affected tracts when we extend out to the one-mile circle.

Third, we go beyond previous work in considering the post-siting dynamics. With little theoretical justification, other researchers have tended to employ the same variable set to predict move-in as they did to predict siting; we instead nest our analysis of post-siting effects in a simple model of neighborhood demographic change. We also advance the field by constructing and testing a simultaneous (or two-stage least squares) model. After all, disproportionate siting and minority move-in often occur at the same time and a regression strategy that accounts for this may be the best way to estimate the separate effects.

Fourth, we focus on the effects of a new dimension of ethnic change. Previous work has stressed the percentage of minorities. But while a 40% increase in Latinos that is matched by a corresponding 40% decrease in African Americans may leave the percentage of minorities unchanged, the neighborhood will in fact be transformed. Such ethnic transitions may weaken the usual social bonds constituted by race and make an area more susceptible to siting. We investigate this "social capital" effect below, finding that it does indeed have an effect on the likelihood of receiving a TSDF.

Before presenting the methods and results, we should acknowledge several clear limits to our work and that of others. One is that we are testing for effects at the neighborhood level. Such a focus on the social ecology of an area does not mean that particular subpopulations or individuals are necessarily exposed in the same rate as their census tract; actual exposure can vary depending on a variety of factors. This neighborhood effects approach, however, is characteristic of almost all environmental justice studies, primarily for reasons of data collection (for an exception based on an original survey, see Burby, 1999; Burby & Strong, 1997). In addition, some epidemiological studies have demonstrated a significant relationship between residential proximity to hazardous waste storage facilities and increased health risk and disease, especially among pregnant mothers and infants (Berry & Bove 1997; Croen, Shaw, Sanbonmatsu, Selvin, & Buffler, 1997; Goldman, Paigen, Magnant, & Highland, 1985; Knox & Gilman 1997; see also Shaw, Schulman, Frisch, Cummins, & Harris, 1992).

A second related limit is that we do not really establish the actual risk associated with living near a TSDF. Once again, there are few efforts in the environmental justice literature that tackle actual risk; an exception is Morello-Frosch's effort to use public health methodologies to transform cumulative exposure to hazardous air pollutants into estimated cancer risk. However, few people believe that living near a TSDF enhances their quality of life and, as Burby and Strong (1997) argue, proximity to environmental negatives does seem to have a significant impact on perceptions of neighborhood quality. People are more likely to be alarmed about hazards when their sense is that they are being exposed involuntarily or that exposure is unfair. In short, the distribution of perceived risk and perceived fairness also matters.

Finally, while this study was conducted with as much rigor as possible, it still requires all the qualifications necessarily associated with the statistical work in this field. Most specifically, associating race with siting decisions, even in multivariate exercises, may establish pattern but it does not establish intent. The real rationales for location will need to be uncovered by specific case studies, of which there are a few excellent examples (see Boone & Modarres, 1999; Pulido, 1996). This study simply offers a framework of plausibility for the more detailed and qualitative work ahead for other researchers.

DATA SET AND BASIC TRENDS

The data set we use merges selected variables from the 1970, 1980, and 1990 censuses, all recalculated to the 1990 tract shapes, with information on the location and siting dates of TSDFs in Los Angeles County. Because many facilities obtained permits long after siting (partly because they were sited prior to current regulations or operated with interim permits), the recorded permit dates used in many studies are often inaccurate. To correct this, we filed a series of public records act requests to obtain the original forms identifying when any particular facility began operation. We focused on the high-capacity TSDFs—those that process or store at least 50 tons of hazardous substances annually. Although slightly less than half (39 of 83) of the TSDFs in the study area are classified as high capacity, these facilities handle nearly all of the hazardous waste among TSDFs in the region (644,136 of 644,511 total tons). Of these 39, our records search proved unable to identify the siting date of one of these facilities. Given the circular buffers, we ultimately examined 55 tracts in the quarter mile radius (for which there was at least 50 tons allocated to the tract when casting a circle of effect around the facility), and 245 tracts in the one-mile radius as of 1990, all within a county with 1,652 tracts.

Figure 1 shows all TSDFs in the county; Figures 2 and 3 plot two possible date-location combinations for the high capacity TSDFs (existed prior to 1970, or was placed 1970 to 1990) against median household income and percentage of minorities in 1990. There is a definite visual correlation between these socio-economic variables and the contemporary location of high-capacity TSDFs. This association is confirmed in the t-tests shown in Table 1. The focus in this article is on the high-capacity TSDFs so all references in the statistical tables and the following discussion are to the high-capacity variety only.

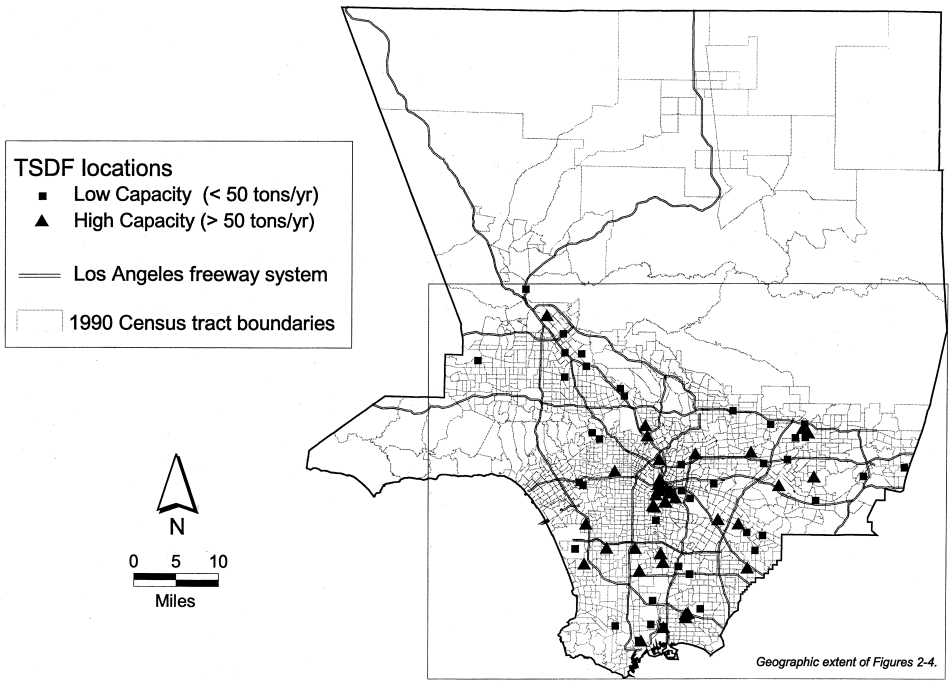

FIGURE 1
Locations of Hazardous Waste TSDFs in Los Angeles County, California (1993).

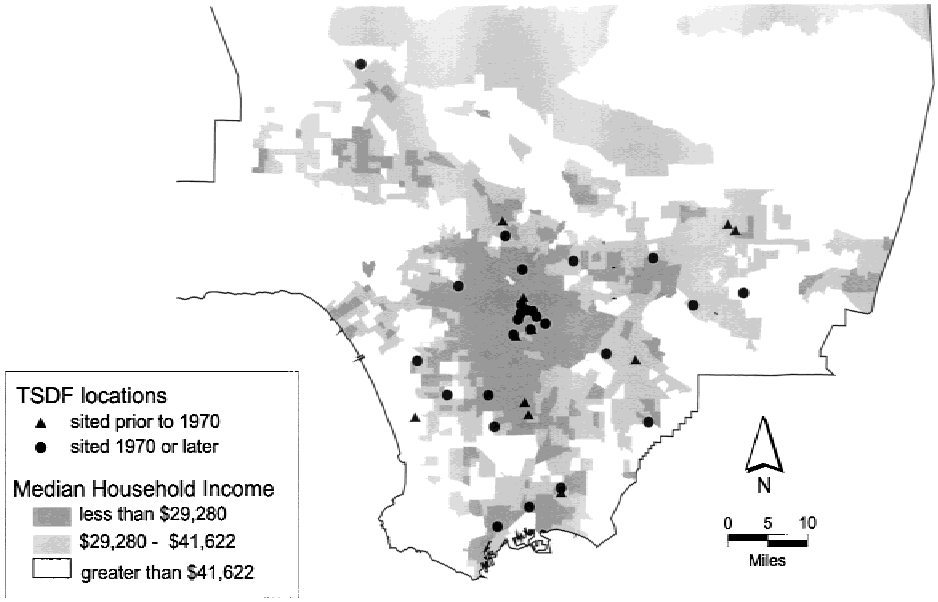

FIGURE 2

High Capacity Hazardous Waste TSDFs and Median Household Income, 1990, Los Angeles County, California

Note: Each category contains one-third of all Los Angeles County census tracts.

Note that Table 1 first offers the county average for the examined variables, then the difference between the values of those variables in affected and non-affected tracts, with significance levels for the differences immediately to the right; Tables 2 through 4 use a similar structure to present results. In 1990, tracts that contained or were proximate to TSDFs tended

TABLE 1

Comparing Tracts With and Without TSDFs in Los Angeles County as of 1990

Variable	Average	Within 1/4 mile of TSDF, 1980 (Difference)	Within 1 mile of TSDF, 1990 (Difference)
% Minority	56.3	25.5***	27.2***
% African American	11.0	7.6**	7.8***
% Latino	34.7	18.6***	18.5***
Household Income	$38,369	−$11,379***	−$9,796***
Home Value	$243,257	−$73,559***	−$70,571***
Median Rent	$629	−$137***	−$113***
% College Educated	22.0	−11.8***	−11.2***
% Single Family Housing	59.8	−6.9*	−2.8
Population Density	11,031.3	−2,192.4*	1,083.2*
% Blue Collar	40.7	15.3***	13.4***
% Manufacturing Emp.	20.4	5.7***	6.2***
N (depends on variable)	1636–1641	54–55	252–253

*p < .10. **p < .05. ***p < .01.

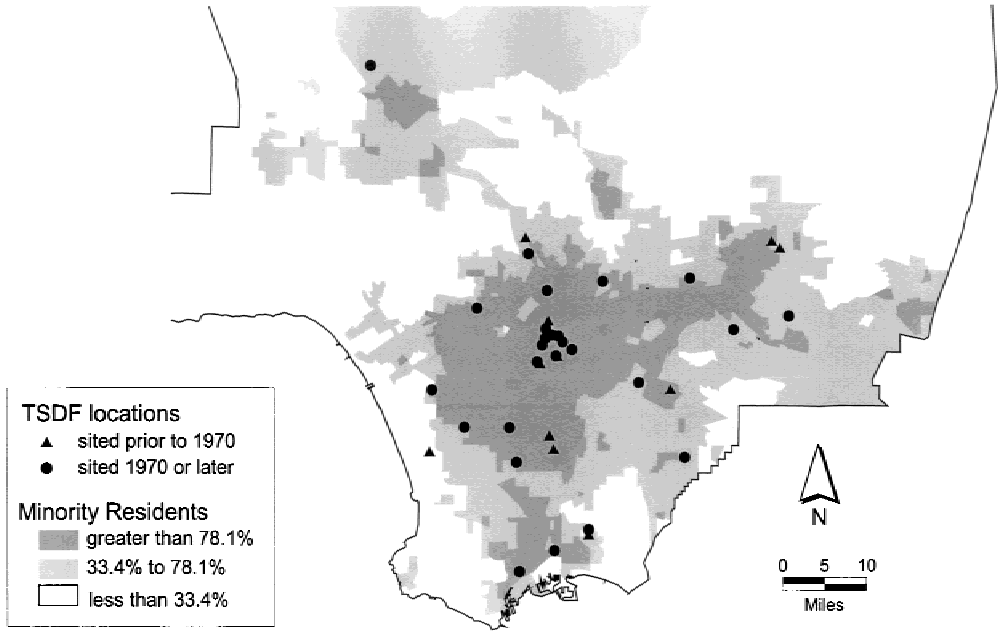

FIGURE 3

High Capacity Hazardous Waste TSDFs and Presence of Minority Residents, 1990, Los Angeles County, California

Note: Reported as percentage of African American, Asian-American, and Latino. Each category contains one-third of all Los Angeles County census tracts.

TABLE 2

Comparison of the Characteristics of Tracts That Would Receive a TSDF in 1970–90 With All Other Tracts in Los Angeles County in 1970

Variable	1970 Average	TSDF Sited Within 1/4 Mile Between 1970–90 (Difference)	TSDF Sited Within 1 Mile Between 1970–90 (Difference)
% Minority	31.8	22.2***	22.2***
% African American	10.8	15.4**	11.0***
% Latino	18.0	4.3	9.0***
Household Income	$10,032	−$1,908***	−$1,603***
Home Value	$26,042	−$4,621***	−$4,270***
Median Rent	$138	−23.0***	−21.3***
% College Educated	12.6	−4.9***	−5.2***
% Single Family Housing	64.4	−9.2**	−1.4
Population Density	8,724.1	−1933.9*	446.0
% Blue Collar	46.1	9.8***	9.4***
N (depends on variable)	1604–1640	34–35	161–164

*p < .10. **p < .05. ***p < .01.

TABLE 3

Demographic Changes in Tracts Following a TSDF Siting Versus Tracts Without a TSDF (over two decades following a siting)

		Received a TSDF between 1960–70	
Change from 1970–90	Average	Within 1/4 mile (Difference)	Within 1-mile (Difference)
Change in % Minority	24.6	0.2	−0.9
Change in % African American	0.2	−5.9	−3.9*
Change in % Latino	16.7	8.1	2.4
Increase in Household Income	275.5%	−9.5%	3.0%
Increase in Home Value	817.7%	−102.2%	−9.8%
Increase in Median Rent	361.9%	16.3%	11.8%
Change in % College Educated	9.4	−3.9**	0.1
Change in % Single Family Housing	−4.7	3.0	1.0
Change in % Blue Collar	−5.3	0.3	−3.0*
N (depends on variable)	1604–1640	10	46–47

*p < .10. **p < .05. ***p < .01.

to contain a higher percentage of minority and poor residents. They also had lower rents and house values. The proximate areas also were less educated and more blue-collar. The percentage of single-family housing units—used as a proxy for home ownership, a measure unavailable in the DOF database—is negatively correlated with TSDFs at the one-quarter mile radius. Population density is negative and significant in the quarter mile sample but is actually positive and significant in the one-mile sample; the finding is not consistent with the common sense notion that TSDFs might best be placed in less populous areas.

Of course, the real issue is whether the tracts were significantly different prior to TSDF siting. Table 2 uses the tract characteristics of 1970 to show that the areas that were to receive TSDFs over the 20 years contained more minority, poor, and blue-collar residents; note that the percentage of Latino residents was not significant at the one-quarter mile, achieving a significance level close to but not within the usual .10 cut-off. Receiving tracts were also less likely to have homeowners, at least in the one-quarter mile buffer. These areas also had lower initial home values and rents along with a lower percentage of college-educated residents, suggesting the important role that educational skills might play in resisting hazards. Population density was negative and significant for the one-quarter mile zone but positive (albeit insignificant) at the one-mile level. In short, many of the patterns reflected in the 1990 snapshot were present in the soon-to-be-affected 1970 tracts, a result consistent with a story of disproportionate siting.

What happened in tracts after a hazard arrived? Using our dating scheme, we looked at the changes from 1970 to 1990 in tracts that received or were near hazardous sites located in the 1960 to 1970 period, benchmarking against areas that did not receive such sites. As seen in Table 3, there is virtually no evidence of move-in: using the standard .10 cutoff, the only significant changes were a less rapid increase in the percentage of college educated residents in the one-quarter mile buffer, a decline in the percentage of African Americans, and a sharper fall in the percentage of blue-collar workers in the one-mile radius. While generally insignificant, the sign pattern does suggest that Latinos may have been replacing African Americans in these newly toxic areas.

However, since one might expect these and any other shifts to emerge rapidly, Table 4 examines changes in the next decade, first for those areas receiving sites in the 1960s and then

TABLE 4

Demographic Changes in Tracts Following a TSDF Siting Versus Tracts Without a TSDF (over decade following a siting)

		Received a TSDF between 1960–70	
Change from 1970–80	Average	Within 1/4 mile (Difference)	Within 1-mile (Difference)
Change in % Minority	14.2	3.1	2.5
Change in % African American	2.0	−1.0	1.4
Change in % Latino	8.1	4.0	0.2
Increase in Household Income	91.6%	−8.3%	−2.2%
Increase in Home Value	254.0%	−34.5%*	−16.9%*
Increase in Median Rent	99.7%	−10.26	−6.0%
Change in % College Educated	5.1	−3.0*	−0.6
Change in % Single Family Housing	−2.4	−0.9	0.7
Change in % Blue Collar	−1.8	1.8	−2.2*
N (depends on variable)	1604–1639	18	46–47
		Received a TSDF between 1970–80	
Change from 1980–90	Average	Within 1/4 mile (Difference)	Within 1-mile (Difference)
Change in % Minority	10.3	0.6	1.7**
Change in % African American	−1.8	0.1	0.2
Change in % Latino	8.6	1.2	0.6
Increase in Household Income	96.9%	−9.8%*	−3.2%
Increase in Home Value	159.1%	15.9%	8.1%**
Increase in Median Rent	133.7%	−0.1%	3.6%
Change in % College Educated	4.3	−2.6**	−2.4***
Change in % Single Family Housing	−2.3	−4.8	−0.6
Change in % Blue Collar	−3.5	0.6	0.8
N (depends on variable)	1616–1640	28–30	128–132

*p < .10. **p < .05. ***p < .01.

for those receiving sites in the 1970s. For the first group, there are a few moderately significant changes in the next decade at the one-mile level: Housing values did rise less rapidly for both radii while the percentages of college educated and blue-collar workers fell in relative terms for the one-quarter mile and one-mile buffers respectively. In the tracts that received hazardous sites in the 1970s, the next decade brought less rapid increases in household income at the one-quarter mile, declines in the relative presence of college-educated in both buffers, and a relative increase in the percentage of minorities at the one-mile level. Strikingly, however, household values actually rose more rapidly for those homes falling in the one-mile zone.

As suggested above, a focus on the percentage increase in minorities can ignore interethnic shifts. Black to Brown shifts have been especially prevalent in South Los Angeles, an area laden with hazardous or toxic facilities and air pollution. The sign pattern in the 20-year profile (positive for Latinos, negative for African Americans) suggests that some of these changes may have been occurring in tracts closer to high-capacity TSDFs. Such shifting neighborhood patterns can cause tensions between minority groups, weakening neighborhood social capital and increasing the area's vulnerability to siting locally undesirable land uses. To avoid missing this important phenomenon, we devised a measure that calculates the absolute sum of eth-

nic changes—for example, an increase in Latinos of 20% of the total population and a decrease in African Americans by the same amount yields a value of 40% rather than the zero obtained when calculating the percentage increase in minorities. We label this measure of dynamics within a census tract "ethnic churning."

We only have measures for such churning for the 1970s and the 1980s. Starting with the one-quarter mile sites, we find that there is significant ethnic churning during the decade of a TSDF siting (in the 1970s or the 1980s) but no significant evidence of churning in either the decade before or the decade after. A more interesting pattern emerges when we utilize a one-mile radius. We find a significant degree of ethnic churning in the soon-to-be affected tracts in the decade before the siting (for 1980s sites, as this is the only group for which we have ethnic change data for the previous decade). In the decade of the siting, the one-mile tracts have more ethnic churning than the unaffected tracts. By the decade after the siting, the difference between affected and unaffected tracts has fallen in value and is significant only for sitings in the 1970s. By the second decade after the siting (for facilities placed in the 1960s) there is virtually no difference in the ethnic churning occurring between affected and unaffected tracts. The overall pattern seems to indicate that such demographic transition actually begins in the decade prior to the siting and then slowly fades as the tract transforms ethnically to a new character, a finding that is consistent with our presumption that such transitions may make areas politically weak and hence vulnerable to the siting of TSDFs. To address this possibility, we explore the issue more formally in the multivariate regressions below.

To sum, while there is some evidence for the move-in hypotheses—a significant increase in minorities in one of the ten-year periods, a slower increase in housing values in another of the time periods examined, and some degree of ethnic churning—both the general pattern of insignificance and certain contradictory results (including a relative decrease in blue collar workers, a relative increase in housing values in one period, and a move-out of African Americans over the 20-year period) suggest problems with the market dynamics story. In general, the disproportionate siting hypothesis holds up much better in these simple t-tests, lending more credence to the proponents of environmental justice than to the market dynamic doubters.

MULTIVARIATE ANALYSIS OF SITING

While the bivariate analyses are suggestive, the fact that areas that received TSDFs were both poor and minority makes it difficult to determine whether race had an independent effect. To estimate this separate effect, we need a multivariate procedure in which various characteristics of a tract in 1970 are used to jointly predict the arrival of a hazard in a subsequent period. Building on a model developed by Boer et al. (1997) to test for contemporaneous correlation, we performed a logit regression in which the dependent variable took the value of one if a tract was to receive a nearby TSDF in the 1970 to 1990 period. We considered only areas that were not yet hosting TSDFs at the beginning of the period, implying that the sample is reduced further for the one-mile radius (as we must exclude tracts that were within one mile of existing TSDFs). An alternative strategy of considering all tracts yields nearly identical results and is used, for example, when we attempt to determine if the preexistence of a hazard has a positive effect on attracting another hazard.

The independent or explanatory variables were drawn from the 1970 census material. To avoid collinearity, we pared down the explanatory variables to the percentage of single family housing, population density, median household income, and the percentage of minorities. The first variable is a proxy for home ownership, with our hypothesis that homeowners, having made financial and social investments in a neighborhood, are more likely to resist the siting of a TSDF; as such, it is an indirect measure of one dimension of social capital. Population

density is expected to have a negative effect, both because reasonable public health strategies would suggest that dense areas should be avoided and because density can be a (negatively correlated) stand-in for industrial land use, a variable unavailable to us in the 1970 sample. As for income, we expected a U-shaped function: Often, the lowest income areas lack pollution because they lack economic activity, the wealthiest areas avoid pollution because of political power, and the burden falls most heavily on working-class areas (Been, 1995; Szasz & Meuser, 1997). Finally, the percentage of minorities is, according to environmental justice advocates, expected to have a positive impact.

As seen in Table 5, all of our variables were appropriately signed and reasonably significant (although the income variables attained only a .20 significance level at the one-quarter mile radius, a fact not indicated in the table as the standard cut-off for significance is .10). The percentages of African Americans and Latinos were significant when entered separately (as noted in the columns marked Model 2). To check whether a location that had already been polluted by previous siting was more attractive (or offered less resistance to) future sites, we also conducted regressions in which we entered a dummy variable for the pre-existence of another TSDF. To economize on space the results are not shown in the table. Previous presence was significant but this produced only modest shifts in coefficient values and had no effect on the pattern of significance for the other variables, including the percentage of minorities. The overall pattern seems to support those who have contended that siting may have been disproportionately concentrated in minority areas.

We also experimented with a quadratic specification for African Americans and Latinos, in which, consistent with our specification of income, the ethnic variables assume a curvilinear relationship with a peak value. In logit regressions using 1970 data to predict siting in the next 20 years, the Latino quadratic specification was always significant but the African American attained mixed significance. At the one-quarter mile radii, peak vulnerability during the 1970s occurred when a tract was 44% African American and 48% Latino. This is consistent with homophily hypothesis of sociology, which predicts that ties are most likely to form among individuals with similar characteristics (Blau, 1977). In historically or uniformly ethnic areas, this particular social capital can be deployed to resist siting; in areas where minority presence

TABLE 5

Logit Results Predicting Siting of a TSDF

Variables (as of 1970):	TSDF placed Within 1/4 mile 1970–90 (Model 1)	TSDF placed Within 1/4 mile 1970–90 (Model 2)	TSDF placed Within one mile 1970–90 (Model 1)	TSDF placed Within one mile 1970–90 (Model 2)
% Single Family Housing	−0.0292***	−0.0307***	−0.0092**	−0.0109**
Population Density	−0.0002***	−0.0002***	−0.00006***	−0.00006***
Household Income	0.0588	0.0606	0.0812***	0.0810***
Household Income squared	−0.0003	−0.0003	−0.0004***	−0.0004***
% Minority	0.0327***		0.0295***	
% African Americans		0.0332**		0.0274***
% Latinos		0.0270*		0.0340***
Observations	1610	1610	1540	1540
Log Likelihood	293.2	295.1	939.7	947.6
Nagelkerke R^2	0.164	0.158	0.129	0.119

*p < .10. **p < .05. ***p < .01.

is high but split and changing between African American and Latino groups, there may be little communication and more vulnerability.

Minority Move-In versus Disproportionate Siting

What about the effects of siting on minority move-in? To determine the pattern, we first devised a simple model of tract-level increases in the percentage of minorities. For right-hand side variables, we included the Anglo percentage of the population and a quadratic for Anglo population. The curvilinear relationship arises because tracts with few Anglos have little room left to add minorities; tracts highly populated by Anglos tend to resist minority move-in through various mechanisms, and peak minority movement occurs somewhere between these two extremes (Massey & Denton, 1993). We also included home value and median rent, expecting lower values of each of these to attract minority movers, partly because such movers have low income and partly because lower values might reflect the impacts of housing discrimination. We also included a measure of residential stability (proxied by those residing in the same house five years previously), expecting a negative relationship because areas with more stability will generate fewer vacancies.

Table 6 indicates that the basic model performs quite well, yielding a reasonable R^2 and high significance for all the variables. We then added an independent variable that takes a value of one if the tracts received a TSDF before 1970, and zero otherwise (within one-quarter or one-mile radii as appropriate; see Models 2 and 3 in Table 6). At the one-quarter level, the variable enters negatively, albeit insignificantly: Controlling for other factors, the existence of a TSDF seemed to lead to some modest minority move-out, a result similar to Oakes, et al. (1996). The variable is actually positive but insignificant at the one-mile level.

Consistent with the earlier t-tests, we then looked at the effects in the decade immediately following siting on the presumption that effects might show up rapidly. For the 1970s, the sign for 1960s siting is insignificant and, therefore, is not reported. In the 1980s, receiving a TSDF within one-quarter mile during the 1970s had a negative and insignificant impact while receiving a TSDF within one mile had a positive but insignificant effect on minority move-in (see Table 7). When we control for the previous decade's change in the percentage of minor-

TABLE 6

Regression Results Predicting Minority Move-In from 1970–90

Variable	Change in Minorities 1970–90 (Model 1)	Change in Minorities 1970–90 (Model 2)	Change in Minorities 1970–90 (Model 3)
% Anglo population-beginning of decade	1.425***	1.426***	1.425***
Anglo population squared-beginning of decade	−0.011***	−0.011***	−0.011***
Median Home Value-beginning of decade	−0.135***	−0.135***	−0.134***
Median Rent-beginning of decade	−0.096***	−0.096***	−0.096***
% Reside Same House-end of previous decade	−0.179***	−0.180***	−0.179***
TSDF within 1/4 mile in 1970		−1.578	
TSDF within one mile in 1970			0.237
Observations	1584	1584	1584
F-Test	219.607***	182.943***	182.895***
Adjusted R^2	0.408	0.408	0.408

*p < .10. **p < .05. ***p < .01.

TABLE 7

Regression Results Predicting Minority Move-In from 1980–1990

Variable	Change in Minorities 1980–90 (Model 1)	Change in Minorities 1980–90 (Model 2)	Change in Minorities 1980–90 (Model 3)	Change in Minorities 1980–90 (Model 4)
% Anglo population-beginning of decade	0.764***	0.760***	0.597***	0.596***
Anglo population squared-beginning of decade	−0.007***	−0.007***	−0.005***	−0.005***
Median Home Value-beginning of decade	−0.051***	−0.052***	−0.058***	−0.059***
Median Rent-beginning of decade	−0.010	−0.009	−0.017**	−0.017**
% Reside Same House-end of previous decade	−0.035***	−0.035***	0.002	0.002
TSDF siting within 1/4 mile during 1970's	−0.288		0.039	
TSDF siting within one mile during 1970's		0.859		0.499
Change in minorities-previous decade			0.195***	0.195***
Observations	1618	1618	1617	1617
F-Test	227.193***	227.772***	235.214***	235.419***
Adjusted R^2	0.456	0.457	0.504	0.504

*p < .10. **p < .05. ***p < .01.

ities, siting has a positive effect but the coefficient values are quite small while the change in minority percentage in the previous decade is quite significant, a pattern which suggests that neighborhoods may become more open to minority house seekers as a result of an earlier move-in—or that the prior processes of disproportionate siting and demographic transition were simultaneous.

To estimate such a simultaneous model involves two-stage least squares regressions. Because our predictive equation for the effects of minorities on siting was a binomial logit, we first calculated it as a linear probability model to determine whether the relationship would be amenable to the two-stage approach; as expected, the adjusted R^2 fell since the linear probability fit is much less exact but the variables were signed correctly and the minority variables were actually stronger. We then estimated the determinants of TSDF siting over the 20-year period, including as a factor the change in the percentage of minorities over that same period; we simultaneously estimated minority move-in, adding in a variable indicating the siting of a TSDF over the same period. We ran variants of this model, including one in which the prior siting of a TSDF was allowed to influence the future siting of a TSDF, and one in which we considered only those tracts receiving a TSDF for the first time. As the results were broadly similar, we focus on the latter results to maintain consistency with the previous tables.

Table 8 presents the results of this exercise. Note that we now use the pre-existing percentage minority and percentage minority squared in the move-in regression (rather than Anglo percentage) to maintain consistency with the siting regression. As evident in Table 8, an increase in percentage minority tends to attract a TSDF in both the one-quarter and one-mile radius (again, the R^2s are low because we have moved from a binomial to a linear probability model) while the siting of a TSDF, holding other factors constant, actually tends to lead to minority move-out not move-in. Given the earlier t-test comparisons on Latinos, we also estimated a model in which the key variable was the change in percentage Latino and non-Latino; the results also did not indicate move-in in the context of controlling for other factors. The overall pattern is not supportive of the market dynamics account of the contemporary location of TSDFs.

To see whether a change in the ethnic composition of an area—even if it remains minority—weakens social capital and makes areas more vulnerable to disproportionate siting, we re-estimated the model by using ethnic churning during the 1970s and 1980s and TSDF siting over the same period. Table 9 shows the results parallel those reported earlier for the change in the percentage of minorities: Ethnic churning during these two decades is a strong predictor of a concurrent siting of a TSDF, with the one-quarter mile effect of ethnic change on siting only narrowly missing significance (it is significant at the .104 level) while the income specification is significant at the .20 level (not shown in Table 9 because of the standard .10 cut-off). The churning variable is highly significant at predicting TSDF siting at the one-mile level while TSDF siting has a negative effect on ethnic churning for both radii. The representation of this can be seen in a map of Los Angeles County (Figure 4) which overlays the location of TSDFs over the 1970s and 1980s with a breakdown of tracts by their degree of ethnic churning. There is a remarkable visual correlation between the two.

POLICY IMPLICATIONS

This study examined the issue of whether the pattern of disproportionate exposure of minorities to toxic storage and disposal facilities (TSDFs) reflects the disproportionate siting of such TSDFs or whether the contemporary situation results from a subsequent move-in of minority residents, at least in Los Angeles County. Initial t-tests suggest that areas that were soon to receive TSDFs were low-income, minority, and disproportionately renters; after they received these hazards, their gain in minority residents did not generally outpace that of the rest

TABLE 8

Inflow of Minorities and Siting of TSDFs in a Simultaneous Model

Variables (beginning of period)	TSDF siting w/in 1/4 mile 1970–90	Change in % Minorities 1970–90	TSDF siting w/in 1/4 mile 1970–90	Change in % Minorities 1970–90
% Single Family Housing	−0.0007***		−0.0008**	
Population Density	−0.000004***		−0.000005***	
Household Income	0.0006		0.0025***	
Household Income Squared	−0.000001		−0.000006***	
Median Home Value		−0.1337***		−0.1289***
Median Rent		−0.0958***		−0.1020***
Reside Same House Past 5 years		−0.1792***		−0.1202**
% Minority	0.0011***	0.8895***	0.0042***	1.0852***
Minorities squared		−0.0118***		−0.0131***
Change in % minorities, 1970–90	0.0008*		0.0034***	
Siting of a TSDF, 1/4 mile, 1970–90		−85.704***		
Siting of a TSDF, 1 mile, 1970–90				−51.039**
Observations	1566	1566	1499	1499
Adjusted R^2	0.027	0.290	0.068	0.219
F-Value	8.297***	107.652***	19.190***	70.979***

*p < .10. **p < .05. ***p < .01.

TABLE 9

Ethnic Churning and Siting of TSDFs in a Simultaneous Model

Variables (beginning of period)	TSDF siting within 1/4 mile 1970–90	Ethnic Churning 1970–90	TSDF siting within 1/4 mile 1970–90	Ethnic Churning 1970–90
% Single Family Housing	−0.0007***		−0.0007***	
Population Density	−0.000004***		−0.000005***	
Household Income	0.0008		0.0033***	
Household Income Squared	−0.000002		−0.000008***	
Median Home Value		−0.3026***		−0.2850***
Median Rent		−0.1855***		−0.2008***
Reside Same House Past 5 years		−0.5166***		−0.3772***
% Minority	0.0009***	1.1067***	0.0035***	1.6932***
Minorities squared		−0.0115***		−0.0157***
Dynamic Variables				
Change in ethnic comp., 1970–90	0.0006***		0.0023***	
Siting of a TSDF, 1/4 mile, 1970–90		−148.686***		
Siting of a TSDF, 1 mile, 1970–90				−117.041***
Observations	1566	1566	1499	1499
Adjusted R^2	0.027	0.178	0.064	0.112
F-Value	8.100***	57.502***	18.211***	32.531***

*p < .10. **p < .05. ***p < .01.

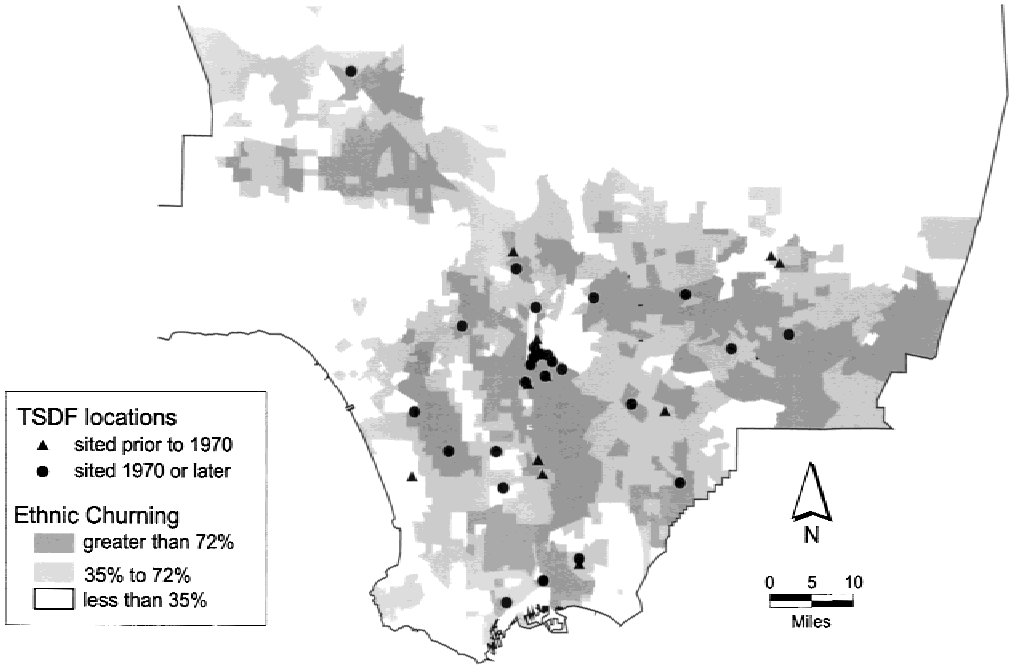

FIGURE 4

High Capacity Hazardous Waste TSDFs and Ethnic Churning, 1970–1990, Los Angeles County, CA
Note: Derived from 1970, 1980, and 1990 census data. Each category contains one-third of all Los Angeles County census tracts.

of the sample. Logit regressions confirmed that demographic variables seemed to matter in the future siting of a TSDF; linear regressions on the changing demographics of census tracts suggest that TSDFs do not generally tend to induce minority move-in. Finally, a simultaneous model that tries to account for the contemporary siting of a hazard and the move-in of minorities also suggests that demographics matter in siting while siting generally has an unexpected effect on demographics, disproportionately repelling rather than attracting minority residents.

The central lesson from our various statistical tests is consistent: Controlling for other factors, minorities attract TSDFs but TSDFs do not generally attract minorities. Of course, even if minority move-in is not the primary determinant of the current pattern of hazards in Los Angeles, we see little harm in ensuring that full information about toxic or potentially hazardous sites is provided to homeowners (perhaps as part of real estate disclosure forms that are required by law to indicate flood zones in most states, and on-site environmental hazards in California) so that their decisions are fully informed. There is obviously also a need to combat housing discrimination and the steering of minority homebuyers and renters.

However, to the extent that other studies confirm disproportionate siting as a causal factor, it may be useful to re-examine zoning and other practices along several different dimensions. The first is simply public participation in the siting process. While one leading critic of the environmental justice movement has suggested that community participation can lead to "theatrics" (Foreman 1998, p. 45), Cole (1992) argues that it can be effective at generating compromises and ensuring that an informed community can monitor post-siting environmental hazards.

In California, there is a mechanism for participation in siting TSDFs under the 1986 Tanner Act that mandated that governments develop local assessment committees reflecting the makeup of the community that would interact with facility proponents early in the siting approval process (Schwartz & Wolfe, 1999). However, critics argue that such committees are often unrepresentative of the immediately affected population, in part because committee selection is determined by a larger government unit (for example the county) which may be poised to capture the economic benefits even though the costs will be concentrated in particular neighborhoods (Cole, 1999).

Schwartz and Wolfe (1999), therefore, recommend changing the process to ensure that more members come from the immediately adjacent neighborhood. We concur but also stress that public participation presents a conundrum: Expecting the currently unorganized communities most likely to receive hazards to be able to conduct an effective public campaign to protect their interests is optimistic. Moreover, hazard-by-hazard organizing is time-consuming and can put communities in a reactive rather than proactive mode. This suggests the need to develop some baseline standards that can protect those least able to defend their own interests.

Suppose, for example, that new TSDFs were disallowed in any location where the effect would be to worsen the existing distribution of hazards by race or income. This is a minimal standard. Since 1990, the census tracts within one-quarter mile of a TSDF had, on average, a population about 25% more minority than in the rest of the county. By this standard, therefore, the only areas greenlined should be those that were more than 25% above the rest of the county. Thus, such a rule would not significantly reverse existing inequities but simply prevent them from getting worse.

To explore the impacts of this greenlining rule, we took the average income and percentage of minorities for the tracts with existing TSDFs in 1970 and designated tracts with either a lower income or more minorities as areas to be avoided during the 1970s. We then did the same calculation for 1980 to arrive at the greenlined areas for that decade. By this standard, just over half of the TSDFs sited in the two decades were in avoidance areas and might have been disallowed.

Given the current strict regulatory environment and increased public opposition to such perceived hazards, whether real, potential, or perceived, no new high-capacity TSDFs have been sited in southern California since 1988. This essentially locks in the current disproportionate pattern of location of these potential hazards. The emphasis now is on clean up and rehabilitation, with brownfields efforts receiving support from federal, state, and local governments. In these efforts, special attention could be paid to the greenlined areas as a way to remedy a past pattern of disproportionate siting. In a similar vein, Burby and Strong (1997) recommend targeting information to those who may most need it, such as communities that are the most distrustful because of a past experience with disproportionate siting.

This study offers a lesson consistent with the experience many environmental justice advocates: Demographics reflecting political weakness—including a higher presence of minorities, a lower presence of home owners, or a significant degree of ethnic churning—seem to be the real attractors of TSDFs. A special challenge is posed by the fact that areas undergoing transition and unable to lay claim to pre-existing racially based social capital may be especially vulnerable. If this is so, then the current strategy of most of the environmental justice movement—building social capital across ethnic lines by an explicit commitment to a people of color movement—may be an effective way to combat the environmental degradation often found in urban minority communities.

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