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Not so Black and White: environmental justice and cumulative impact assessments

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Abstract

A growing number of scientific studies in recent years have investigated disparate exposure to ecological hazards in American society. Working from an environmental justice perspective, this body of research consistently reveals that poor communities of color are most likely to bear a disproportionate burden of negative externalities. These studies utilize a wide range of research methodologies, including various indicators of ecological hazards (e.g., proximity to waste sites, industrial emissions, ambient air quality), but few, if any, utilize composite measures to approximate cumulative environmental impact. Consequently, the environmental justice (EJ) literature is characterized by a failure to effectively measure overall impact from an extensive range of ecological hazards. Limitations on available data make this a serious problem for present and future studies. We argue that cumulative measures of environmental impact can play an important role in furthering our understanding of environmental injustices in the United States. In this study of Massachusetts, we develop and implement such a cumulative measure of negative environmental impacts. By controlling for the density and severity of ecological hazardous sites and facilities within every community in the state, we demonstrate that exposure patterns take a generally linear distribution when analyzed by race and class. So, while our results reaffirm previous findings that low-income communities and communities of color bear significantly greater ecological burdens than predominantly White and more affluent communities, our findings also suggest that environmental injustices exist on a remarkably consistent continuum for nearly all communities. In other words, as the minority population and lower-income composition of a community increases, correspondingly, so does

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cumulative exposure to environmental hazards. In this respect, communities which are more racially mixed and of moderate income status that are not typically identified as meeting EJ criteria (in demographic terms) also face more significant ecological hazards. Thus, the strict bifurcation of communities into categories of Environmental Justice and Non-Environmental Justice is problematic, and poses a serious dilemma for policy makers, public health officials, and community activists. To overcome this challenge requires the adoption of a cumulative environmental justice impact assessment (CEJIA), which in addition to the demographic characteristics of a community, also takes into account the total environmental burden and related health impacts upon residents. Furthermore, through the adoption of the precautionary principle, source reduction, and alternative forms of "cleaner" production, environmental justice advocates must work for policies which reduce the environmental threat for the full range of communities, as well as their own.

Keywords: Environmental justice; Impact assessment; Public health; Race; Class; Inequality

1. Introduction

Environmental Impact Assessments (EIAs) of human activities on local environments can take different approaches. One approach is to identify and document the effects of hazards on human health. This is referred to as Human Health Impact Analysis (HHIA) and is a characteristic of epidemiology, toxicology, and related medical fields. In this approach, demonstration of risk is based on statistical probability of associations between hazards and health impacts. HHIAs are often critiqued on the basis of shortcomings in causal reasoning. To scientifically demonstrate that environmental hazards cause measurable declines in human health requires meeting three criteria: (1) that the hazard precedes the health impact, (2) that the health impact is not the result of other causes, and (3) that the health impact occurs "often enough" to warrant statistical association and statistical significance.

Given the kinds of data available to researchers, demonstrating causal associations of environmental indicators with human health indicators is extremely difficult. Steinemann (2000) identifies multiple causes, multiple effects, lag times, interactive effects, individual outcomes, and individual susceptibilities as obstacles to drawing causal associations in HHIAs. A recent report by the Center for Disease Control recognizes many of these same issues claiming that,

> The measurement of an environmental chemical in a person's blood or urine does not by itself mean that the chemical causes disease (Center for Disease Control, 2003: 7).

And a report by U.S. PIRG claims,

> . . . for any particular community, understanding the potential health threats that could result from toxic releases is a nearly impossible task. Public health officials often lack sufficient understanding of how citizens have been exposed to toxic substances, how those substances work within the body, and how many people have contracted chronic disease. . . (U.S. PIRG, 2003: 9).

A second approach that EIAs can take is to focus on *potential* health threats and risks. This approach is more characteristic of social science and is typically grounded in risk assessment and cost–benefit analysis. Much of the current literature on environmental justice (EJ) is based on comparisons of exposure and risk between different populations, rather than on the toxicological and biological impacts of those exposures (Bryant, 1995). These analyses often describe patterns of unequal exposure to risks between communities, but do not always attempt to prove associations between environmental hazards and human health outcomes. The analysis of risk is ripe with methodological debate.

The dialogue on environmental justice increasingly addresses questions regarding: (1) the methodological approaches used to generate statistical evidence of disproportionate impact; and (2) the social processes that lead to disparate exposures (Pellow, 2000). It is important for researchers to address these issues for the following reasons. First, understanding the various dimensions of environmental justice is in the interest of general scientific inquiry. Second, it is in the interest of public health to effectively direct resources toward those communities in greatest need of assistance. Third, it is in the interest of all citizens and communities to move environmental and health politics toward a more inclusive and effective agenda that can more successfully improve overall public health by reducing risks for all communities. Achieving these goals is dependent upon a comprehensive understanding of the distribution of risk across communities. For example, the association of environmental hazards with non-White populations is statistically demonstrated in several studies (U.S. General Accounting Office, 1983; United Church of Christ, Commission for Racial Justice, 1987; Mohai and Bryant, 1992; Hird, 1993; White, 1992; Zimmerman, 1993; Goldman and Fitton, 1994; Krieg, 1995); yet it remains unclear whether these studies would generate similar results if they operationalized measures of cumulative impact.

In this article, we develop and utilize an indicator of Cumulative Environmental Justice Impact Assessment (CEJIA)—an innovative measure for identifying and comparing the disparate siting of ecologically hazardous sites and facilities in low-income communities and communities of color (Table 1). We do so by developing a cumulative measure of ecological hazards at the community level and a composite measure of social conditions at the community level. The manner in which these variables are associated supports previous claims of environmental injustice and provides a framework in which to understand the politics of public health. We begin with a review of methodological concerns and previous findings.

2. Improving environmental justice research

Valid and reliable measures are the foundation of sound scientific research. Research in EJ must address the methods by which *community* and *hazards* are

Table 1
Categorical distribution of communities by income ($N = 368$)

Valid $0 to 29,999	Frequency	Percentage	Valid percent	Cumulative percent
$30,000 to 39,999	137	37.2	37.2	50.8
$40,000 to 49,999	114	31.0	31.0	81.8
$50,000 and greater	67	18.2	18.2	100.0
Total	368	100.0	100.0	

measured. In a nationwide analysis of census tracts in SMSAs, Anderton (1994) finds no evidence of racial/ethnic bias to the location of treatment, storage, and disposal facilities (TSDFs) (Table 2). However, when his data are reaggregated to include the surrounding areas, patterns of environmental racism become evident. This would indicate that in many cases, impacted populations and ecological hazards share census borders, but exist in different geographic communities. Mohai and Saha (2003) expose some of the effects that census-defined communities have on environmental justice research by comparing statistical results from different measures of affected communities. Their results indicate that how a community is defined in relation to its ecological hazards has a substantial impact on statistical claims of environmental racism. While these findings are a major contribution to the field, it would be useful to know if similar results could be generalized beyond the use of treatment, storage, and disposal facilities (TSDFs).

The lack of a full range of environmental indicators brings into question the *content validity* of much research. Content validity can be defined as the degree to which a measure covers the range of meanings included within a concept (Babbie, 2001:144). For example, Krieg (1998b) finds that the degrees of racial and/or class-based environmental inequities vary by ecological indicator. Only the inclusion of multiple indicators of environmental hazards could help answer this question. Cumulative measures could show how methodological variations and data manipulation are capable of influencing statistical evidence of environmental injustices. The problem of limited indicators poses a challenge to those in the field and implies that debates over the social conditions that generate environmental injustice are far from being resolved.

Another methodological issue pertinent to the study of ecological hazards concerns variations in the degree of risk posed by hazardous waste sites. As Bullard (1994) claims, all hazardous waste landfills are not created equal. This is

Table 2
Categorical distribution of communities by race ($N = 368$): percent non-White

Valid less than 5%	Frequency	Percent age	Valid percent	Cumulative percent
5–14.99%	49	13.3	13.3	94.6
15–24.99%	9	2.4	2.4	97.0
25% and greater	11	3.0	3.0	100.0
Total	368	100.0	100.0	

true for all types of ecological hazards. While some ecological hazards pose tremendous risks to the health of the surrounding population, others may be considered relatively harmless. An ecological hazard does not exist in isolation from physical and social conditions. Identical hazards may pose radically different risks to local populations depending on the social context in which they exist. For example, a leaking incinerator ash landfill poses little immediate risk in an isolated environment, but a considerable risk when soccer fields are built on top of it. Similarly, the risks posed by ground water contamination vary from one community to the next. It may pose a considerable health risk in communities that use groundwater as a source of drinking water; however, in a community that has water piped in from a non-contaminated source, the local groundwater contamination may pose a much smaller health risk. These differences are not addressed in quantitative studies of environmental justice and it is common for all sites tend to be viewed as equal. Data are generally unavailable to help control for these factors.

Methodological problems of this sort directly impact the generalizability, or external validity, of a study. What constitutes a risk in one community may not constitute a similar risk in another community. Even empirical evidence of environmental injustices from the most rigorous of research designs, including claims of racial and class bias, can be challenged as "methodological productions" that generate statistical aberrations.

Discerning disproportionate impacts have another methodological dimension. As stated by Eady (2003) "even more confounding than how one defines the limits of communities is how one develops a standard methodology for defining the term 'disproportionate'." (p.173) In other words, how extensive a comparison of the impacted community with other communities is necessary, and how much worse does this disproportionate impact upon the community have to be, before we can claim "environmental injustice?" She concludes, "environmental justice science is inexact at best...there is a clear subjectivity to environmental justice that is not easily overcome by policy or any science than can predict scientific or legal outcomes with certainty" (p.174) (Eady, 2003). Resolving these methodological issues is not so "Black and White."

Our study of Massachusetts (Faber and Krieg, 2003) attempts to address some of these concerns by assessing the overall distribution of ecological hazards across *all* communities in the state by utilizing a Cumulative Environmental Justice Impact Assessment (CEJIA). Cumulative measures of ecological hazards are a new addition to environmental justice research. Most studies are based on single environmental indicators such as lead, PCBs, Superfund sites, industrial toxic waste releases, or treatment, storage, and disposal facilities (TSDF). With few exceptions, such studies generally do not operationalize multiple indicators of environmental hazards. We are aware of no studies that operationalize a complete assessment of the total environmental hazards characteristic of communities across an entire state. We feel that this research is a step in that direction. Before describing the development of this measure, let us review the extent and distribution of ecological hazards in Massachusetts from our earlier study (Faber and Krieg, 2001).

3. The extent of ecological hazards produced in Massachusetts

- There are over 21,030 Department of Environmental Protection (DEP) hazardous waste sites in the state (based on data collected in 2000). Some 3389 of these sites are considered to pose serious environmental and human health threats, and include 32 sites on the Environmental Protection Agency's National Priorities List (NPL) or Superfund list.
- Between 1990 and 1998, some 1029 large industrial facilities produced some 164,385,598 pounds of toxic chemical waste which was *released* on-site directly into the environment (discharged into the air, ground, underground, or adjacent bodies of water) of the communities in which they were located—an amount equivalent to 2055 tractor-trailer trucks each loaded with 80,000 pounds of toxic waste.
- Coal and oil-burning power plants, specifically those plants built prior to 1977, are also a major source of air pollution in the state. In fact, utilities in Massachusetts are responsible for over 60% of the state's soot-forming sulfur dioxide emissions, 15% of the state's smog—causing nitrogen oxide emissions and 30% of the state's heat-trapping carbon dioxide emissions. Sulfur dioxide (SO2) emissions are the main precursor to the creation of soot—tiny particles of soot can penetrate deep into the throat and lungs (and cause an estimated 1500 premature deaths each year in the northeastern region of the U.S., according to the American Lung Association).
- Fossil-fuel power plants are also responsible for more than 800 pounds of airborne mercury emissions every year. Mercury causes severe damage to the neurological system and has developmental effects on fetuses and small children.
- Every county in Massachusetts has levels of air-borne toxic chemicals in the form of volatile organic compounds (VOCs) that exceed health-based state levels. Concentrations of benzene, 1,3-butadiene, formaldehyde, and acrolein—chemicals which are known to cause numerous adverse health effects, including neurological disorders, birth defects, reproductive disorders, and respiratory diseases—exceed the health-based risk standards in all counties *by up to 80 times*. As a result, air pollution kills 1300 people in the state each year.

4. Patterns of disproportionate impact of ecological hazards in Massachusetts

This study utilizes demographic data from the 1990 U.S. Census and environmental data collected in the year 2000 from the Massachusetts Department of Environmental Protection (DEP), U.S. Environmental Protection Agency (U.S. EPA), and the Massachusetts Toxics Use Reduction Institute. Although 2000 Census data was available at the level of Minor Civil Division, the city of Boston and the town of Barnstable were not yet available at the neighborhood levels. These data are used to analyze exposure to ecological hazards in all 351 cities and towns (minor civil divisions, or MCDs) across the state. In addition to these 351 cities and towns in Massachusetts, we also included seven subtowns or neighborhoods within the larger town of Barnstable: Barnstable, Centerville, Cotuit, Hyannis, Marstons Mills, Osterville, and West Barnstable. We also include 12 subtowns or neighborhoods within the larger city of Boston: Allston/Brighton, Charlestown, Dorchester, East Boston, Hyde Park, Jamaica Plain, Mattapan, Roslindale, Roxbury, South Boston, West Roxbury, and Downtown Boston (for the purposes of the report, Downtown Boston encompasses Central Boston and Chinatown, Back Bay and Beacon Hill, the South End, and the Fenway/Kenmore neighborhoods). Because these more specific neighborhoods making up all of Boston and Barnstable are included, summary data for Boston and Barnstable (as cases in the data) are excluded from the totals (otherwise the data from these areas would be reported twice). As a result, a total of 368 communities are analyzed.

Seventeen different indicators of ecological hazards are used to assess the cumulative environmental impacts for each community. These indicators are shown in Table 3 (although the table has only 16 rows, the second row “DEP Hazardous Waste Site (Tier I–II) is considered two indicators). Data representing Massachusetts Department of Environmental Protection (DEP) general

Table 3
List of ecological hazards used to assess cumulative impact

Type of hazardous facility or site	Points for rating severity of each facility or site
DEP hazardous waste site (general)	1
DEP hazardous waste site (Tier I–II)	5
EPA-NPL (Superfund) waste site	25
Large power plant—top five polluter	25
Small power plant	10
Proposed power plant	5
TURA industrial facility	5
Municipal incinerator	20
Resource recovery facility	10
Incinerator ash landfill	5
Demolition landfill	3
Illegal site	5
Sludge landfill	5
Tire pile	5
Municipal solid waste landfill	5
Trash transfer station	5

* The assignment of points is identical to that used in an earlier study (Faber and Krieg, 2003).

sites, Tier I sites, Tier II sites, and Federal Superfund sites are provided by the DEP web site (March, 2000). Data representing resource recovery facilities, incinerator ash landfills, demolition landfills, illegal sites, sludge landfills, tire piles, municipal solid waste landfills, and trash transfer stations are provided by the Massachusetts DEP (April, 2000). Data representing TURA industrial facilities are provided by the Massachusetts Toxic Use Reduction Institute and represent the cumulative total for any facility that reported releases at any time between 1990 and 1998 (1029 distinct facilities). Data representing power plants (large, small, and proposed) are from the U.S. EPA (March 2000). Finally, data representing municipal incinerators are from the Massachusetts DEP (April 2000). Although TRI data reported in pounds of releases are not included in this analysis, they were used in a previous study (Faber and Krieg, 2001) and are referred to as *Chemical Emissions* in the figures that follow. These chemical emissions represent the sum total of TRI releases between 1990 and 1998. TRI emissions are not included in the cumulative measure used here.

An analysis of the social and geographic distribution of these ecological hazards across the Commonwealth of Massachusetts (Faber and Krieg, 2001) shows that they disproportionately impact communities of color and low income communities. A summary of major findings from Faber and Krieg (2001) is presented below.

4.1. Income-based unequal exposure

Ô Communities with median household incomes of less than \$30,000 average nearly two-and-a-half times more hazardous waste sites than communities with median household incomes of \$40,000 and higher. They also average over four times as many waste sites per square mile.

Ô Communities with median household incomes of less than \$30,000 average nearly seven times as many pounds of chemical emissions from polluting industrial facilities per square mile (during the period 1990–1998) as compared to communities with median household incomes of over \$40,000.

Ô On average, communities with median household incomes of less than \$30,000 face a cumulative exposure rate to all environmentally hazardous sites and facilities which is more than three times greater than all other communities in the state. In fact, 14 of the 15 most intensively overburdened communities in Massachusetts (measured as density of hazardous facilities and sites) are of lower-income status (median household income of \$39,999 or less).

4.2. Racially based unequal exposure

Ô Communities where people of color make up 15% or more of the total population average over four times the number of waste sites as communities with less than 5% people of color. Furthermore, communities where people of color make up 25% or more of the total population average nine times more hazardous waste sites per square mile than communities where less than 5% of the population are people of color.

Ô Communities where people of color make up 25% or more of the total population average nearly five times as many pounds of chemical emissions from polluting industrial facilities per square mile as compared to communities where less than 5% of the population are people of color.

Ô On average, communities where people of color make up 25% or more of the population face a cumulative exposure rate to all environmentally hazardous sites and facilities which is nearly nine times greater than communities where less than 5% of the population are people of color.

Ô Nine of the 15 most intensively overburdened communities in the state are communities of color (defined as a town with 15%>minority). There are only 20 communities of color in the state.

The figures below offer a visual summary of the patterns of disproportionate impact in the Commonwealth of Massachusetts (Faber and Krieg, 2001).

The data presented in Figs. 1–4 are based on single indicators of ecological hazards, either hazardous sites or chemical emissions are reported in Toxic

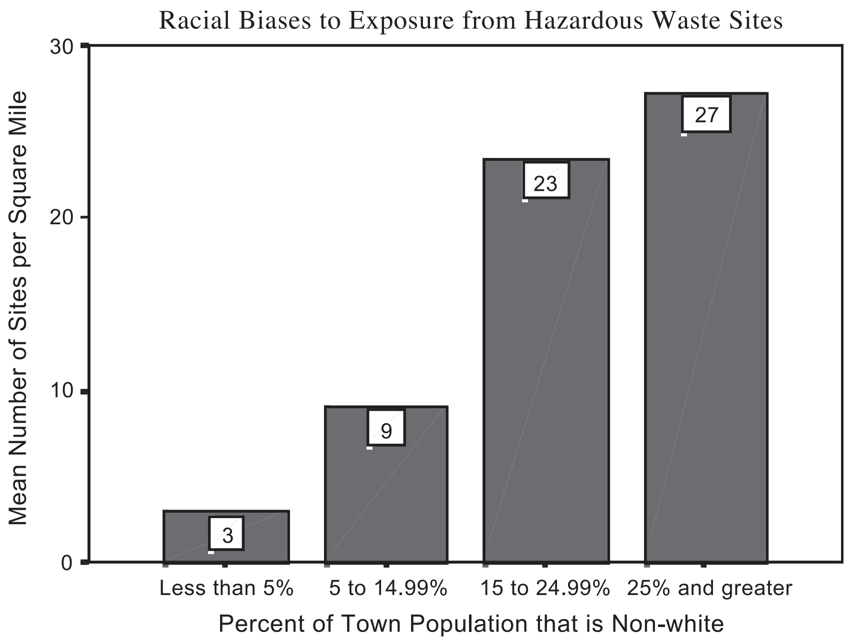

Fig. 1. Unequal exposure to hazardous waste sites by race. Average of 4.94 sites per square mile for 368 Massachusetts communities.

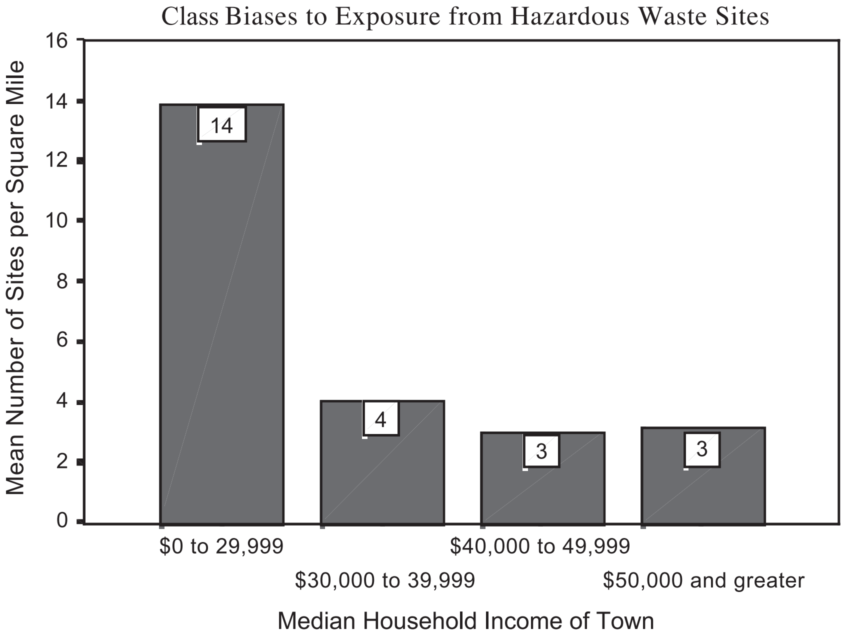

Fig. 2. Unequal exposure to hazardous waste sites by income. Average of 4.94 sites per square mile for 368 Massachusetts communities.

Release Inventories. Although the chemical emissions data are cumulative over a period of 9 years, the ecological indicators themselves do not constitute cumulative measures. It therefore remains unclear whether similar racial and class-based environmental inequities exist when multiple indicators of ecological hazards are analyzed. It also remains unclear whether similar patterns exist when race and class are treated as continuous rather than categorical variables. To increase the content validity of our indicator, we have created a measure of cumulative impact to more fully assess the risks posed by the 17 different ecological hazards described earlier. Each type of hazard is assigned points based on the relative risks it imposes upon the host community. The point system is similar to that used in scaling, in which a panel of experts independently assigns relative weights to each of the items included in the composite measure. The relative weights of each ecological hazard are summed for each community, providing a relative measure of the overall risks. Officials at the Massachusetts Department of Environmental Protection and several researchers familiar with environmental justice literature reacted favorably to the ranking system shown in Table 3.

Increasing the range of ecological hazards raises the content validity of indicators of total risk, but still does not yield a complete measure of health risks. To better assess the potential threat ecological hazards impose upon

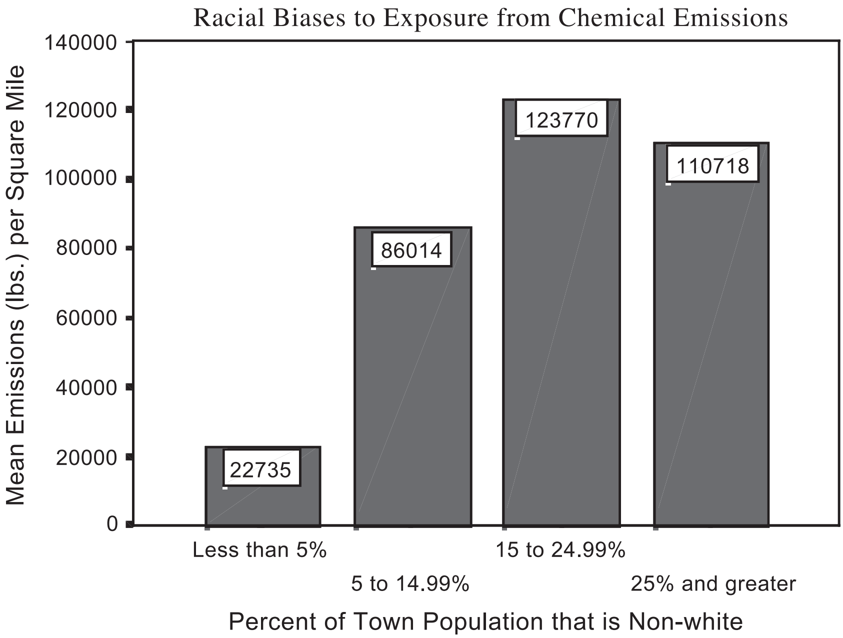

Fig. 3. Unequal exposure to pollution from industrial facilities by race. Average of 36, 262 lbs. of chemical emissions per square mile during 1990-98 for 368 Massachusetts communities.

communities, it is necessary to determine the spatial density of ecological hazard points (EHP) across each community. This is accomplished by dividing the sum of ecological hazard points by the number of square miles of land area in each community. The result is an average number of points per square mile. Figs. 5 and 6 are consistent with the previous (single indicator) results, showing that patterns of racial- and class-based environmental inequalities persist when analyzed using a cumulative measure.

As these data show, low-income communities and communities of color in Massachusetts are historically the hardest hit by environmental problems. In this way, environmental injustices manifest themselves in the tendency for lower income communities and communities of color to bear a greater burden of ecological hazards relative to upper income communities and White communities. Many of these problems are the result of the siting of a disproportionate number of unwanted activities such as bus depots, landfills, industrial facilities, incinerators, toxic waste sites, and sewage treatment plants in low-income neighborhoods and communities of color. Yet, these neighborhoods have had the fewest resources to confront or prevent these threats. The Executive Office of Environmental Affairs (EOEA) in Massachusetts, while sensitive to the need for environmental justice, failed to adopt a set of environmental health indicators to help identify environmental justice commu-

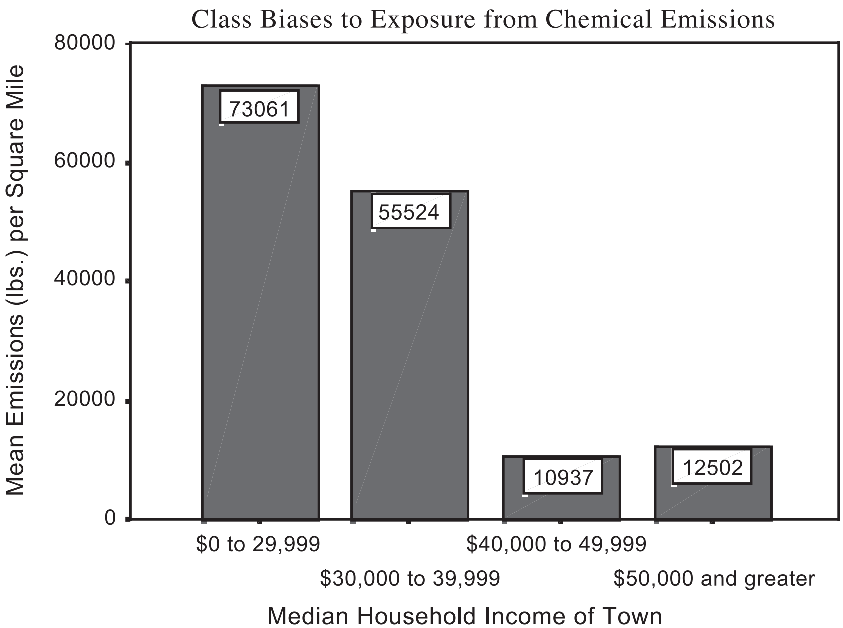

Fig. 4. Unequal exposure to pollution from industrial facilities by income. Average of 36, 262 lbs. of chemical emissions per square mile during 1990-98 for 368 Massachusetts communities.

nities at risk. In an otherwise excellent environmental justice policy, this decision disproportionately impacts communities where the Massachusetts Department of Public Health has identified elevated incidence of low birth weight, cancer, or hospital discharges associated with asthma and respiratory disease.

For instance, Roxbury residents are exposed to a number of different environmental hazards that have resulted in a asthma hospitalization rate five times the state average. Similarly, there is considerable concern for the high incidence of asthma, lupus and other auto immune diseases in Dorchester, Mattapan, and Roxbury. Certain populations are more at risk of certain illnesses than other populations. Because local environmental contaminants are believed to be a contributing cause to contraction of the disease, and given that communities of color and lower-income communities in Massachusetts experience much higher levels of environmental pollutants, the incidence rates of asthma, cancer, and other health problems are related to the interplay of race, social class, and gender (Gouveia-Vigeant and Tickner, 2003). In other words, these illnesses should be thought of as environmental justice issues.

Even though communities of color and low-income communities are typically exposed to a disproportionate environmental burden, and therefore are likely to suffer more from toxic-induced or -aggravated diseases, people of color and low-

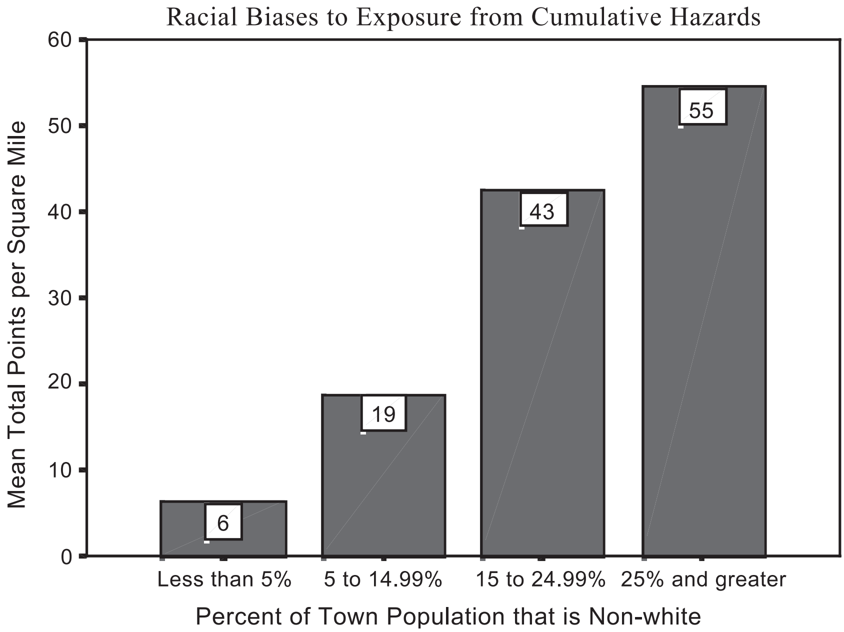

Fig. 5. Unequal exposure to all hazardous facilities and sites combined by race. Average of 10.4 points per square mile cumulative exposure rate for 368 Massachusetts communities.

income families often lack adequate health care insurance, receive substandard medical care and services, and spend higher proportions of their income on health care. Why do the environmental justice aspects of these elevated health problems receive so little public attention?

5. Framing issues of environmental health

Not all environmental problems are identified as "social problems". As Shibley and Prosterman (1998) claim, "whether an environmental issue becomes a social problem..."—the perception, for example, that lead paint contamination is pervasive and harmful rather than a minimal threat—"is related to how social events are framed". Frames, according to Goffman (1974), are schemata of interpretation that allow people to locate, perceive, identify, and label events taking place around them. Collective behavior occurs only after existing strains are identified and defined as social problems. As Blumer (1971) claims, "...a social problem exists primarily in terms of how it is defined and conceived in a society instead of being an objective condition with a definitive objective makeup." In effect, social problems may exist in an objective reality, but until they are recognized as a social problem, collective action to address the causes

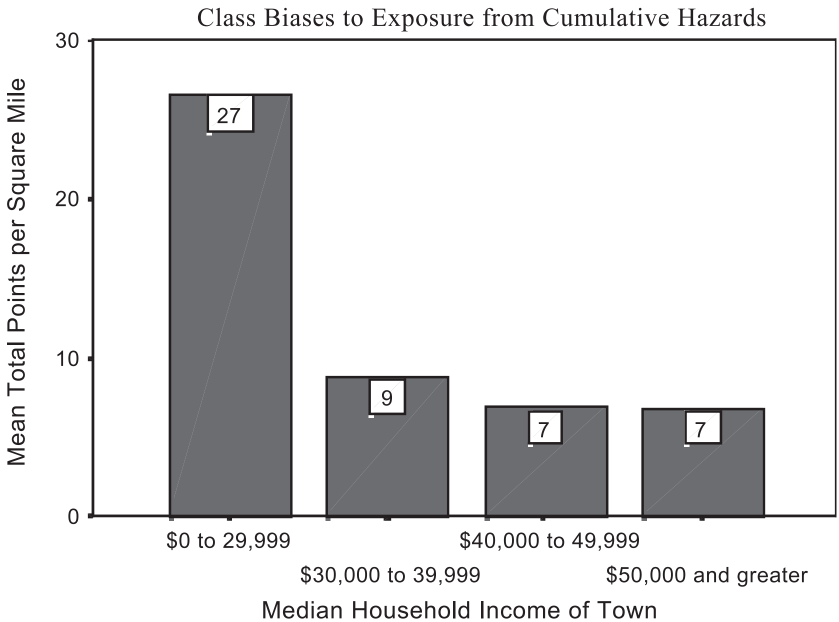

Fig. 6. Unequal exposure to all hazardous facilities and sites combined by income. Average of 10.4 points per square mile cumulative exposure rate for 368 Massachusetts communities.

and/or symptoms of the problem is not possible. But how the social problem is framed also determines the course of collective actions, which are to be undertaken. Cable and Shriver (1995) claim that "the selection of a movement goal is influenced by social construction processes that interpret collective grievances in a way that leads to the adoption of one solution rather than another."

How environmental health problems come to be defined and framed as a social problem or an environmental justice issue depends upon a complex set of interactions and interpretations between various "claims makers" or "agents of framing," who construct their own interpretations of the problem using the frames made available to them. Before presenting their views to the public, for instance, environmental health scientists adjust these frames not only according to their own understandings but also rhetorical styles, scientific jargon and language, and areas of expertise, etc. Such a process of "framing" may constrain or limit certain forms of knowledge from becoming accessible to the larger public, as well as limit consideration of a broader set of related issues which fall outside the boundaries of the researcher's worldview.

Community members and the organizations which represent them are likewise constantly framing social issues and related events "in ways that are intended to mobilize potential adherents and constituents, to garner bystander support, and to demobilize antagonists'' (Snow and Benford, 1988). According to Snow et al. (1986), this process of frame alignment can occur in four different ways. First, frame bridging is the linking two ideologically congruent but structurally unconnected frames. Second, frame transformation is the replacement of old values, meanings, and ideas with new ones. Third, frame amplification is the clarification and invigoration of an existing interpretive frame. Fourth, frame extension is the expansion of an existing pool of members by making movement goals congruent with the values of potential members. The second of these, frame transformation, may be necessary when it is found that the values, causes, or programs being promoted by a community organization do not resonate with the researchers, public, or other institutions which the community organization wishes to mobilize (Snow et al., 1986).

Within the past two decades, a frame transformation has occurred with regard to environmental health issues. The dominant ecological paradigm utilized by environmental researchers failed to recognize and/or adequately address the fact that environmental problems are contextual and experienced unevenly across the population. The environmental justice perspective maintains that certain segments of the population—particularly those possessing less political-economic power in American society—are disproportionately exposed to environmental health hazards, and that this social injustice must be rectified. This perspective is in opposition to the dominant ecological paradigm and seeks to replace it. As Shibley and Prosterman (1998) argue, we can conceive of three competing frames at work among environmental health researchers and the broader public: the General Health Issue Frame; the Environmental Justice Frame; and the Non-Environmental Health Issue Frame.

General Health Frame (GHF): this position holds that environmentally related health problems affect, or potentially affect, a significant portion of the general population; indiscriminately cross class, racial, and/or gender lines; and are geographically widespread. This position holds that virtually anyone, regardless of age, race, sex, or geographic location is at risk from these problems. Language characteristic of this perspective often includes phrases such as ''general health issue,'' ''small but significant health threat,'' ''widespread disease,'' and others.

Environmental Justice Frame (EJF): this perspective emphasizes that people of color, low-income communities, poor women, and politically marginalized peoples are disproportionately affected by these environmental toxins and/or are at greater risk of exposure to environmental contaminants which ''trigger'' closely related health problems. This position holds these populations, particularly poor people of color are the ones suffering the brunt of the environmentally related disease—largely ignored by the mostly White, middle-class health establishment (and the larger society)—due to processes of environmental racism, sexism, classism, and other environmental injustices.

Non-Environmental Health Frame (NEHF): this perspective presents the notion that environmentally related health problems are nonexistent or of minimal concern to the public, and have been "blown out of proportion" by opportunistic and alarmist researchers in order to further their own agenda. The position often argues that such problems, if they do exist, are grossly over-exaggerated, and/or are being sufficiently addressed by current policy approaches. This perspective often downplays risks that are imposed upon affected populations and emphasizes that the most effective improvements in overall public health come from changes in individual behavior patterns, such as in smoking, drinking, and other "risky" behaviors.

The EJF has experienced difficulty in challenging the GHF because lead advocacy groups in the GHF do not insist on frame transformation as a necessary step in improving public health. With public health researchers consistently referring to environmental toxins as a small but general health threat, implying that all adults in the United States are at risk, changing this perspective will require a concerted effort. Although EJF advocates know all too well the unequal distribution of environmental health problems, they often believe they have more to lose than to gain by challenging the universal appeal of the GHF. Doing so might invite an undesirable alternative frame—as exaggerated concern—that might weaken the campaign against environmental injustice in general. As a result, the high concentration of health problems among people of color, and the unique causes and circumstances that many poor and African-American communities face in combating and living with these diseases—are ignored by many health researchers and advocates. This poses a significant dilemma for the EJF. Framing environmental toxins as a general health problem is problematic if risk is unevenly distributed across the population. Public resources ultimately are limited, and if these resources are spread throughout the general population in detection and treatment programs and services, those who need such programs the most may not be getting the attention they deserve. Furthermore, if disease is most problematic in lower income communities and communities of color, as epidemiological research shows, then research and other programs aimed at attacking the sources of the disease—a contaminated environment—might also be ignored (Shibley and Prosterman, 1998).

Yet, if health advocates and the environmental justice movement were to succeed in transforming the dominant frame of environmental toxins—stripping it of its general health issue orientation—they would risk undermining broad public support and the future allocation of public resources for addressing environmental health issues. In short, transforming toxics into an environmental justice issue could have the unintended consequence of diminishing its identity as a widespread public health problem, inviting conservative critics to downplay the social significance of environmentally related disease (Shibley and Prosterman, 1998). Thus, researchers must recognize toxics as both a general threat to all members of the public, but a particular threat to poor people of color living in environmentally overburdened communities throughout the United States. The resistance of the research and advocacy institutions connected to specific illnesses or specific toxic hazards must consider that to inadequately address the environmental causes and unique problems faced by people of color results in the failure of the GHF to broaden its constituency, find new points for policy change, and transcend the racial, class, gender, and ideological boundaries which fragment and divide communities.

Work toward the transformation of the dominant GHF toward the EJF has already begun. In Massachusetts, the neighboring communities of Dorchester, Mattapan, and Roxbury are home to a vibrant core of environmental justice-oriented organizations. The environmental health establishment in Boston is led by health experts, government officials, industry leaders, and community advocates. Alternatives for Community and Environment (ACE) was founded in1993 and, as the lead anchor organization among 30 neighborhood groups that make up the Greater Boston Environmental Justice Network has quickly grown into the premier environmental justice organization in the state. ACE is dedicated to educating citizens on their rights and opportunities for involvement in environmental and public health decision-making; developing the capacity of neighborhoods to take control over problems affecting their health and environment; and creating systems solutions to address the unequal distribution of environmental burdens and to promote safe, sustainable economic development.

ACE has initiated a number of programs and projects, including the launch of the Massachusetts Environmental Justice Assistance Network (MEJAN) and the Greater Boston Environmental Justice Network (GBEJN). MEJAN is a network of over 100 attorneys, public health professionals, and environmental consultants who provide pro bono assistance to neighborhood groups throughout the state. ACE also helped launch the award-winning Roxbury Environmental Empowerment Project (REEP), which promotes and supports local environmental leadership, with a focus on youth. REEP works with over 300 students per year in four Roxbury schools and two summer programs. An analysis of cumulative environmental impacts across communities can help clarify the difficulty that organizations such as ACE face in bridging and transforming the GHF into the EJF.

6. Cumulative environmental impact and social conditions: bridging the gap

Our CEJIA study of class and racial disparities in Massachusetts is designed to overcome a number of problems characteristic of previous research on environmental justice. First, by operationalizing multiple indicators of ecological hazards, it does not limit environmental justice issues to a single indicator. Second, by scaling the relative impacts of different types of ecological hazards using a point system, it controls for the relative severity of each. Third, by analyzing and comparing all towns (or Minor Civil Divisions) in the Commonwealth of Massachusetts, a more comprehensive basis for evaluating environmental injustices is created. Fourth, by controlling for the density of ecological hazards in each community, it analyzes averages of the overall risks posed by ecological hazards in each MCD, thereby better identifying patterns of environmental injustices. Fifth, by combining community indicators of both race and class into a composite social indicator, it analyzes communities on the basis of "community power".

6.1. Cumulative ecological hazards

The cumulative environmental indicator includes 17 different indicators of environmental hazards, ranging from Superfund sites listed on the National Priorities List (NPL) to tire piles. In addition to these indicators are socioeconomic variables taken from the 1990 U.S. Census. The units of analysis for this study are all 351 towns and cities in the Commonwealth of Massachusetts. Two of these communities (Boston and Barnstable) are subdivided into a several smaller communities, bringing the total number of cases in the database to 368.

Using the system described in Table 3, each community is assigned an Environmental Hazard Point (EHP) "score". The scoring system is identical used by the authors in a previous study (Faber and Krieg, 2003). The point system represents current opinion in the field as was reviewed favorably by various authorities, including academics and members of the Massachusetts Department of Environmental Protection. Table 4 below describes the frequency distribution of EHPs and the density of EHPs across the 368 communities. The table below shows an average frequency of 127 EHPs per community with an average density of 10.4 EHPs per square mile. The relatively large difference between the mean and the standard deviation results from 12 outliers with very high concentrations of EHPs.

6.2. Social conditions indicators

Three indicators of social conditions are used in the analysis. The first indicator is a measure of race/ethnicity and is operationalized as the percentage of each community's population that is non-White. The frequency from which this percentage was calculated was derived by subtracting the

Table 4
Descriptive statistics for cumulative environmental indicators

Descriptive statistics					
	N	Minimum	Maximum	Mean	Standard deviation
Ecological hazard points	368	0	1248	126.96	157.99
Ecological hazard points per square mile	368	0.00	224.83	10.3683	22.8305
Valid *N* (listwise)	368				

White population from the total population (Table 5). The second indicator is a measure of overall class standing operationalized as median household income. The third indicator is a measure of overall community power that is a combination of the first two. Combining race/ethnicity and class standing into a single indicator provides a measure of community power. This was achieved by summing the values of the standardized score (Z-score) for the percentage of the population that is White and the standardized score for median household income for each community. The resultant variable (community power) ranges from a low of -10.27 (the Roxbury section of Boston) to a high of 4.63 (Sherborn). Table 6 describes the frequency distribution of Median Household Income, Percent of Population that is non-White, and community power.

We assess environmental injustices using two statistical models: (1) Pearson correlations and (2) scatterplots with linear regression lines. The correlation of the variables race, income, and community power with EHP frequency and EHP density are shown in Table 6 below.

The data show that risks posed by ecological hazards are not distributed evenly. They also show that the strongest association of ecological indicators with social indicators is between EHP density and community power (-0.498, $p=0.000$). This indicates that the most intense levels of cumulative environmental hazards and health risks tend to be most strongly associated with communities that are below average in income and below average in percent of population that is White. The ability of community power (defined in terms of class and racial composition) to explain variations in EHP Frequency and EHP Density is shown in Figs. 7 and 8 below. Both figures show that as community power declines, the frequency and intensity of cumulative environmental hazards increases.

These figures show that more empowered communities have lower EHP Frequencies and EHP Densities. In fact, community power accounts for nearly 16% of the total variance in the distribution of EHP Frequency and

Table 5
Descriptive statistics for social indicators

Descriptive statistics					
	N	Minimum	Maximum	Mean	Standard deviation
Median household income (1990)	368	\$18,250	\$95,134	\$41,293.38	\$11,742.096
Percent of population that is non-White (1990)	368	0.0	94.0	4.481	9.2472
Community power (sum of income and % White population Z-scores)	368	-10.27	4.63	0.0000	1.56629
Valid *N* (listwise)	368				

Table 6
Pearson correlations for all social and environmental indicators

		EHP frequency	EHP density (per square mile)	Percent population that is non-White (1990)	Median household income (1990)	Community power (sum of income and % White population *Z*-scores)
EHP frequency	Pearson correlation					
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000
	N	368	368	368	368	368
EHP density (per square mile)	Pearson Correlation	655**	1	0.401**	0.184**	0.498**
	Sig. (2 tailed)	0.000	0.000	0.000	0.000	0.000
	N	368	368	368	368	368
Percent of population that is non-White (1990)	Pearson Correlation	337**	401**	1	227**	0.783**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000
	N	368	368	368	368	368
Median household income (1990)	Pearson correlation	– 0.182**	– 0.184**	– 0.227**	1	0.783**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000
	N	368	368	368	368	368
Community power (sum of income and % White population *Z*-scores)	Pearson correlation	– 0.399**	– 0.498**	– 0.699**	0.783**	1
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000
	N	368	368	368	368	368

** Correlation is significant at the 0.01 level (2-tailed).

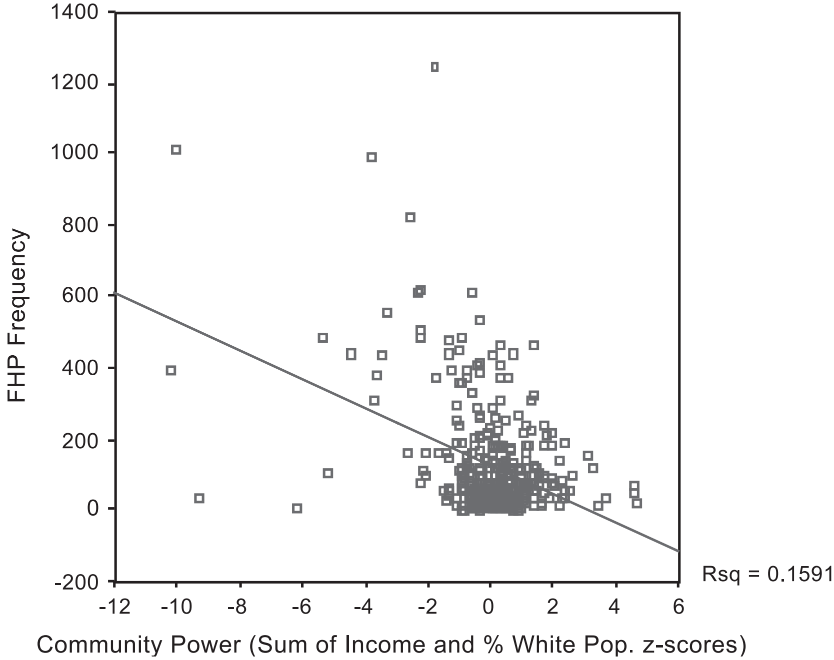

Fig. 7. Scatterplot and linear regression line for EHP frequency by community power.

25% of the total variance in the distribution of EHP Density. It is also important to note that these distributions are essentially continuous and somewhat linear. This is important because it provides evidence that the association between cumulative environmental risks and community power exists on a continuum for *all* communities. Disproportionate impact should be viewed neither as a "minority vs. non-minority" problem nor as a "rich vs. poor" problem. Environmental inequities exist well beyond the poorest communities of color, and are a problem for most communities, to varying degrees.

7. Conclusions

Our research reaffirms the claim that communities of color and low-income communities bear significantly greater ecological burdens than predominantly White and more affluent communities. However, our findings also suggest that environmental injustices exist on a remarkably consistent continuum for nearly all communities in Massachusetts. In other words, as the minority and low-income populations of a community increases, so does

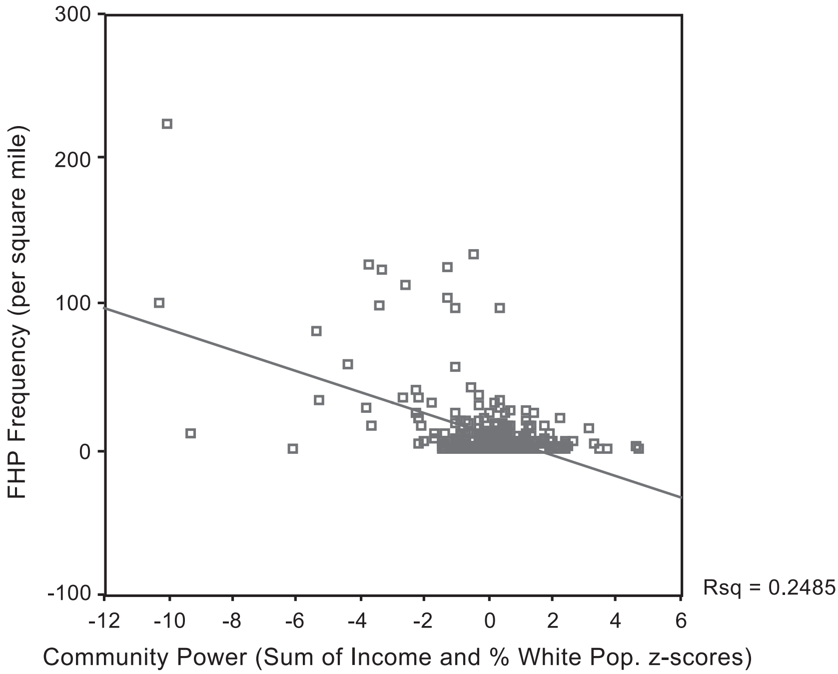

Fig. 8. Scatterplot and linear regression line for EHP density by community power.

cumulative exposure to environmentally hazardous sites and facilities. In this respect, our data show that more middle income, racially mixed communities that are not typically identified as meeting EJ demographic criteria (as adopted by the EPA and other government agencies) also face significantly greater environmental threats. Thus, the bifurcation of communities into categories of Environmental Justice and Non-Environmental Justice is problematic, and poses a serious dilemma for policy makers, public health officials, and community activists. Arriving at a solution is "not so Black and White," since there is often no identifiable "cut-off" point by which to divide such communities. Despite the statistical capabilities to do so, labeling those communities above the regression line in Fig. 7 as *EJ Communities* and those below the regression line as *Non-EJ Communities* is itself is a highly subjective act, the product of an inexact science (Eady, 2003). Nevertheless, it is our contention that the adoption of a cumulative environmental justice impact assessment is a necessary step for more fairly evaluating "disproportionate impact." In addition to considering the demographic characteristics of a community, a CEJIA would also take into account the total environmental burden and related (existing and potential) health impacts upon residents.

Because environmental inequities exist on a continuum for all communities in Massachusetts, to varying degrees, the potential for widespread mobilization of communities around threats to public health from ecological hazards holds great promise for the state's environmental justice movement. However, the existence of competing frames in the public health movement (General Health Frame and Environmental Justice Frame) indicates a tendency for communities in the state (as well as the country) to be divided into categories of EJ and Non-EJ. However, our findings indicate that environmental injustices exist on a continuum, not as categorical groupings. This suggests that the EJF could be reconceptualized to have a broader, more fluid definition. As such, it could challenge and replace the GHF as the dominant frame in environmental health politics. The different ways in which frames align are useful in understanding this change.

The EJF and GHF can be viewed as "ideologically congruent but structurally unconnected frames" (Snow et al., 1986). Both see the dangers present in ecological hazards, but the GHF tends not to view these hazards in the context of disproportionate impact. The continuous nature of environmental injustice therefore makes possible the bridging of these two frames. It could also result in a frame amplification, the clarification and invigoration of an existing interpretive frame (Snow et al., 1986), of the EJF. The outcome of a frame alignment between the EJF and the GHF is in the interest of all communities, particularly in furthering the goal of *productive justice* (Faber, 1998).

Environmental justice politics can be envisioned as either distributive or productive in nature. Distributive justice has as its goal a more even distribution of ecological hazards across all communities. In this way, disproportionate impact upon people of color and lower income families is reduced or eliminated by more evenly spreading those existing hazards across a wider range of communities. But the goal of the EJ movement should not be to insure "that all people are polluted equally" and exposed to the same environmental perils. Defensive policy strategies aimed at arresting disproportionate impact which have the result of shifting environmental hazards out of the poorest communities of color and into other neighboring communities—whether they be racially—mixed or predominantly White—runs the risk of turning potential allies into adversaries, and would thus be politically self-defeating (Faber et al., 2002). Rather than exclusively adopting a distributive EJ politics of "not-in-my-backyard," the movement should continue to develop and embrace a more inclusive productive EJ politics of "not-in-anyone's-backyard." As Faber (1998) claims, democratization of the processes that produce and distribute ecological hazards is a necessary to move beyond addressing the symptoms of environmental justice and to focus instead on the source(s) of environmental injustice.

We argue for the adoption of productive justice as defining principal goal for the EJM. Elements of productive justice include scaling back current levels of pollution at the source (source reduction), democratizing environmental decision-making, increased social governance of economic processes, and promoting alternative forms of clean production. Additionally, we argue that the goal of productive justice becomes increasingly attainable with frame alignment between the EJF and the GHF, and the adoption of the Precautionary Principle (PP) as the defining guideline in environmental policy.

Consistent with Steinemann (2000), we suggest that a precautionary principle (PP) must be applied to environmental decision-making. The PP emerged as a response to criticisms in the uncertainty of scientific evidence to link ecological hazards to health outcomes and hold that "when an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically" (Wingspread, 1998). The PP emphasizes that cause and effect associations between the environment and human health need not be established to warrant the phasing out of high-risk substance and activities. Politically, the PP shifts the responsibility for health onto project proponents and away from communities.

Given standard approaches to risk assessment, environmental policy is oriented to determining whether the dispersion of pollution from various sources leads to what are considered safe levels of public exposure (in Massachusetts, this is termed "dilution is the solution" policy). However, if pollution is highly concentrated in EJ communities, then this approach is inadequate. Overburdened communities must be granted additional protections as offered by the Precautionary Principle (PP), which includes: promoting additional study of activities of concern; shifting the burden of proof so that a chemical/activity must be proven safe; providing incentives to preventive behavior; and/or enacting measures such as bans or phaseouts of substances suspected of causing harm. Furthermore, through the adoption of the precautionary principle, source reduction, and alternative forms of "cleaner" production, EJ advocates can work for policies, which reduce the environmental threat for the full range of communities in the state.

Another way of looking at the role of the PP is in the scientific language of Type I and Type II errors (Kriebel et al., 2001). A Type I error occurs when scientists argue that something exists (such as a threat to public health) when in fact it does not. A Type II error occurs when scientists argue that something does not exist (a threat to public health) when in fact it does. Traditional epidemiological studies are rooted in the logic of Type I errors. The burden of demonstrating that a threat to public health exists depends on the ability of scientific evidence to produce associations that are significant to the 0.05 level. In other words, scientists are generally required to be *at least* 95% sure that an ecological hazard poses a risk to health before action will be taken. In this type of logic, acceptable risk levels are determined by setting threshold levels for (1) the strength of associations between hazards and health and (2) appropriate significance levels for those associations. The problem with this approach is that it is based on the logic that no threats exist until they are scientifically shown to exist with 95% confidence.

The Precautionary Principle addresses the logic of Type II errors. In this case, scientists need to show that an ecological hazard does not pose a threat to public health. This shifts the burden of proof onto the creators of the ecological hazard (to show no risk, rather than on the impacted community to show risk). Generally accepted statistical threshold levels, however, are lower for Type II errors than they are for Type I errors (Kriebel et al., 2001). In other words, scientists need to be far less than 95% confident in their results, meaning they will be wrong 20% or more of the time when they claim that no threat exists. Raising the statistical confidence of analyses dealing with Type II errors is a far more progressive form of science than lowering the necessary statistical confidence of dealing with Type I errors and it places a greater burden of proof on those responsible for the creation of ecological hazards, thereby providing additional protection for resource-strapped communities.

The PP provides a "safety net" that communities can use to empower themselves politically and protect themselves environmentally. Communities will be better able to address existing ecological hazards from past activities, oversee the current cleanup activities, and control future threats to the health of their environments. This analysis shows that the communities with the lowest community power Score are overwhelmingly the communities facing the most significant ecological hazards. The PP approach offers these communities a viable way in which to help themselves by relieving them of the burden of demonstrating causal associations of health problems with local hazards. In this way, the PP approach to local hazards holds the greatest promise for communities with the least political power. Research in the field of environmental justice shows that such hazards often follow a "path of least resistance", ultimately ending up in those communities with the least political ability to block their siting. However, a tendency for less wealthy communities to overlook the impacts of ecological hazards for job creation and tax benefits (Gould, 1991; Krieg, 1998a,b) could mean that the PP approach will be challenged by the very communities it could benefit the most. Research to address this type of issue will be dependent on measures of cumulative environmental impact.

In Massachusetts, a convergence of the environmental justice framework (EJF) and general health framework GHF) is beginning to occur. A statewide coalition of environmental, labor, consumer product safety, women's and public health groups, and EJ organizations has only recently joined hands under the umbrella of the Alliance for a Healthy Tomorrow (AHT) to help forge a precautionary principle approach to environmental policy in the Bay State. AHT is currently pushing for passage of the Act for a Health Massachusetts, which would lead the Department of Environmental Protection to create *action plans* for replacing toxic chemicals with safer substitutes. The Executive Office of Environmental Affairs has already adopted a strong EJ policy designed to promote equal enforcement and implementation of regulations and policies, as well as increased outreach and public participation by low-income, minority, foreign-born, and non-English-speaking residents in governmental decision-making.

This policy strives to address existing sources of pollution by offering technical assistance to reduce the use of toxic chemicals and to introduce cleaner production technologies. In general, the policy attempts to merge some of the defining elements of the Precautionary Principle, clean production, and Environmental Justice. The policy "targets EOEA resources to service those high-minority/low-income neighborhoods in Massachusetts where the residents are most at risk of being unaware of or unable to participate in environmental decision-making" (Executive Office of Environmental Affairs, 2002). It emphasizes a number of state services "designed to enhance public participation, target compliance and enforcement, enhance the review of new large air sources and regional waste facilities, and encourage economic growth through the cleanup and redevelopment of brownfields sites" (p. 5). The EJ movement is currently pushing legislation which would make this policy into law.

In summary, cumulative environmental impact assessment (CEIA) has much to offer as a tool for analyzing health threats and risk distribution. It promises to play a significant role in the struggle for environmental justice by furthering our understandings of: (1) disproportionate impacts, (2) risk assessment, (3) the politics of public health, and (4) community mobilization. A significant effort on behalf of state and federal agencies is necessary to collect and provide the types of data for CEIA to become a more readily available resource for communities and scientists. These efforts are badly needed and are in the interest of all communities throughout the United States.

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