A GEOGRAPHIC INFORMATION SYSTEM (GIS) ASSISTED APPROACH FOR ASSESSING ENVIRONMENTAL EQUITY IN THE EPA RCRA PROGRAM'S SITE INSPECTION SELECTION PROCESS

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Submitted to the Department of Urban Studies & Planning
In Partial Fulfillment of the Requirements for the Degree Of:

MASTER OF CITY PLANNING

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

May 1993

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ABSTRACT:

This thesis explores geographic information systems (GIS) as a means of addressing issues of environmental equity. Specifically, this thesis attempts to develop a GIS methodology to assist the U.S. Environmental Protection Agency (EPA) in program evaluation based on equity criteria and in employing equity criteria for future program planning. The EPA Region 1, Resource Conservation and Recovery Act (RCRA) program was evaluated to determine if the allocation of EPA resources, in the form of facility inspections, is consistent with the distribution of facilities across different types of communities (*e.g.* rich communities, poor communities, communities of color). The thesis focuses on Massachusetts counties and the results are compared to other environmental equity studies conducted on a nationwide basis. The level of data aggregation used to identify particular community types was varied and results show that this variation impacted the degree of equity/inequity observed. The general techniques presented in this thesis could be modified and adapted for use in other EPA enforcement oriented programs.

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ACKNOWLEDGEMENTS

The author wishes to acknowledge the following individuals for their ideas, support assistance and friendship. First, of course, is my best friend Julia and our faithful footwarmer Althea. They have given me all of the above, in abundance. Second, to the supportive crew at Applied Geographics, Inc, - David, Joan, Nadja, Richard, Beth, Linda, Joel and Dorlis - who both had to put up with my moodiness and stress and still helped me to pay the bills. Third, to my thesis committee, Pat Hynes and Joe Ferreira, who guided me through this process and provided valuable insights and critiques. Fourth, to the talented crew in the backyard of the CRL: Paul, Tom, Rob, Anniek, Phil, and John. While tuition doesn't cover their services, that's where the a good piece of the learning experience of MIT comes from, the front lines. Fifth, my helpful and studious EPP and environmental equity buddy, Lisa Maller. In addition I would like to thank the large number of cooperative and professional individuals at the US EPA Region I office who helped in the information gathering process. Last, I would like to dedicate this thesis to my Grandfather, Dr. Leonard Lincoln Heimoff, whose strong character and warm love helped to mold me, and whose memory will never be forgotten.

INTRODUCTION

Environmental equity has recently emerged as a major new issue within the environmental and civil rights communities. While much initial effort went into documenting inequity and pushing for an acknowledgement of the problem, recent attention has been devoted to examining what can be done to avoid future inequities and evaluating what governmental agencies can do to account for, and redress existing inequities.

This thesis attempts to move beyond merely further documenting the existence of environmental inequity. Specifically, this thesis explores data collection and evaluation techniques that can be used by government to insure that the allocation of governmental resources is fair and equitable. While this thesis looks at one particular aspect, of one EPA program, in one state, the techniques can be easily modified to assist other EPA enforcement oriented programs, in any geographic area.

The data assembly and evaluation techniques include the use of the geographic information systems (GIS) and the digital products created as part of the 1990 United States Census. While many of the past quantitative studies examining environmental equity issues were conducted as one-time consultant studies, computer technology has advanced to the point where data evaluations that explore the spatial relationships that underlie issues of environmental equity can be conducted on a routine basis, by governmental program managers. GIS is widely implemented by

the EPA and the techniques developed in this thesis were designed such that they could be adapted for ordinary use within the agency. Use of such techniques can aid EPA's commitment to achieving the goal of environmental equity.

The first chapter of this thesis provides an overview of the issue of environmental equity. This chapter discusses EPA's current activities aimed at environmental equity and introduces GIS an appropriate analytic tool for examining environmental equity. Chapter two provides an overview of the current quantitative literature that describes environmental inequity. The chapter goes on to describe the particular aspect of environmental equity that the analytic portion of the thesis focuses on. The chapter introduces EPA's RCRA program and discusses why using facility inspections is an appropriate test for environmental equity. The chapter also introduces hypotheses on what may lead to inequity in an inspection program.

Chapter three describes the analytic methods that were used and the results that were obtained. The chapter describes the assembly of the Census and RCRA data bases as well as the technical manipulations that were required to test for equity. The chapter pays particular attention to the importance of selecting an appropriate level for data aggregation and on the many options one has for classifying a population into groups (e.g. rich, poor, people of color). The chapter then describes the current distribution of inspection resources by EPA's RCRA program, in several counties in Massachusetts, across communities of different racial and economic makeup.

The final chapter provides a self-critique of the approach and results. The

chapter then summarizes the conclusions that were drawn from the analysis. The thesis concludes with various recommendations aimed at EPA and to others using GIS for environmental equity evaluations.

CHAPTER 1

OVERVIEW OF ENVIRONMENTAL EQUITY AND GEOGRAPHIC INFORMATION SYSTEMS

1.1 OVERVIEW

Governmental attention to environmental issues is fairly new. Earth Day 1970 coincided with the birth of the US Environmental Protection Agency and the federal environmental bureaucracy. The two decades preceding 1970 were the height of the Civil Rights movement. During that time people of color, particularly black people, fought for and gained equal rights (at least under the law). Fundamentally, the notion of environmental equity brings these two movements together.

The general concept of environmental equity can be described as a condition where: there is equal access to environmental quality and equal access to governmental attention aimed at addressing environmental problems for all sectors of the population. As William Reilly, Administrator of the US EPA in the Bush Administration, stated in an article in the EPA Journal:

> [Environmental equity] speaks to the impartiality that should guide the application of laws designed to protect the health of human beings and the productivity of ecological systems on which all human activity, economic activity included, depends. It is emerging as an issue because studies are showing that certain groups of Americans may disproportionately suffer the burdens of pollution (Reilly, 1992).

As Reilly mentions, many argue that institutionalized racism has forced a disproportionate share of environmental hazards on people of color. Further, government's environmental programmatic response has focused on other issues and

has not addressed the environmental hazards that minorities most often face.

While environmental equity is a goal, most recent attention devoted to this issue has focused on **environmental inequity.** As environmental equity has emerged as a pressing issue, many specific manifestations of **environmental inequity** have been highlighted. Examples of types of environmental equity are listed in the bullets below:

- ***Unequal distribution of pollution and/or hazards.*** This condition arises when it is discovered that certain segments of the population (e.g. poor people, people of color) are found to house a disproportionate share of noxious facilities, or the ill-health affects resulting from exposure to environmental hazards. A prime example of this is this higher lead levels found in black children when compared to white children (Schwartz, Levin, 1992).

- ***Unequal protection under, or enforcement of, environmental laws.*** This condition arises when the amount of government resources directed at implementing or enforcing environmental laws is greater for one segment of the population. A prime example of this is the higher average penalties assessed to violators of environmental laws that reside in white neighborhoods (Lavelle, Cole, 1992).

- ***Snob zoning.*** This condition arises when certain communities attempt to limit development activity, or the settlement of certain types of people, in their neighborhoods under the guise of protecting the environment. The classic snob zoning scenario involves the institution of low density zoning by-laws (minimum lot sizes of 2 acres) that prevent more affordable housing being developed. Such measures have been 'justified' as a means of preserving the environment (e.g. providing adequate aquifer protection).

- ***Elitist environmental movement.*** People have charged that the environmental movement is dominated by upper-income white individuals who overlook the environmental problems of such people as the 'urban-poor'. Charges have been levied that environmentalists are 'more interested in saving trees than in saving people'. Since the environmental movement wields great clout in promoting environmental legislation in Washington D.C., the absence of certain groups of people from this movement may result in overall environmental laws and policies that do not represent the priorities or interests of large segments of the population (Adams, 1992).

- *International environmental inequity.* This condition arises because richer nations can afford to force their companies to undertake environmental safeguards, while poorer developing countries cannot. The developing world resents the richer nations trying to force a more expensive, environmentally sound development strategy on them. They argue that the industrial world developed without such safeguards and only implements them now, after untold environmental degradation has occurred. This concept also covers cases where richer nations export their wastes to the developing world. Poorer nations are 'blackmailed' into accepting the waste due to the low standards of living, and a lack of other income generating options.

Although many of the problems have been observed for some time, environmental equity has only recently gained prominence as a legitimate issue in the environmental and civil rights movements. This issue has been pushed forward by both movements and today popular press articles describing and discussing environmental equity are commonplace. The author encountered stories or articles on environmental equity in such media as the Delaware Sunday News Journal, The Boston Globe, The New York Times, Black Enterprise Magazine, Audubon Magazine, The New Republic, U.S. News and World Report, Business Week, and National Public Radio.

This recent focus on environmental equity was partly catalyzed by the publication of the landmark study Toxic Wastes and Race in the USA by the Commission for Racial Justice, United Church of Christ (UCC), in 1987. This study documented the type of environmental inequity - unequal distribution of wastes - described in the first bullet above. The United Church of Christ coined the term 'environmental discrimination' when describing environmental inequity. Another significant event in crystallizing attention on environmental equity issues was the January 1990 Michigan Conference on Race and the Incidence of Environmental

Hazards (Bryant, Mohai, 1992). After the conference a 'group of social scientists and civil rights leaders' informally created the Michigan Coalition. This group then lobbied EPA intensely and called for action on issues of environmental equity (Reilly, 1992).

The environmental community was very sensitive to the accusations of elitism that were levied against it. In the EPA Journal, John Adams, Executive Director of the Natural Resources Defense Council (NRDC), admitted that:

> The mainstream environmental movement grew out of a white, middle-class effort to preserve the world's natural wonders. It is still true that the staffs of the major national organizations are disproportionately white and middle class, and it is not defensible (Adams, 1992).

The environmental movement thinks of itself as very progressive and it was stung when labeled as elitist and racist. Nevertheless, some of these organizations had to acknowledge that some of the criticism was justified. In response, several environmental groups have begun initiatives to recruit minorities for their staffs and boards (Adams, 1992). Perhaps more importantly, the environmental movement is beginning to recognize that issues of environmental equity can widen the environmental constituency, and can advance the environmental movement as a whole. As John Adams, Director of the Natural Resources Defense Council (NRDC) stated in an article in the EPA Journal:

> The environmental justice movement that has arisen to address the concerns of these communities is one of the strongest new forces for environmental reform to emerge in years. If we are to remain truly effective, the national environmental groups must strive to become allies of this movement and of the communities it represents (Adams, 1992).

Environmental equity is a 'hot' topic. Not only did the UCC study highlight an area of interest and inquiry, but also it has mobilized a new constituency for environmental protection. Large amounts of effort are being devoted to issues of environmental equity by government and the private non-profit sectors as well as by grass-roots, community oriented organizations. All these groups have an interest in working for a clean and safe environment. The challenge is to channel this interest into a better understanding of the problems, and to create effective plans, policy and action to combat these problems.

1.2 U.S. EPA ACTION ON ENVIRONMENTAL EQUITY

The United Church of Christ study and the work of others, such as the Michigan Coalition, has not only spurred ***discussion*** by activists and government, it has also initiated action and attention by EPA and other governmental entities. This attention is symbolized by the fact that the entire 28 article, 64 page EPA Journal magazine, subtitled 'Environmental Protection -- Has It Been Fair?' for March-April 1992 was devoted to environmental equity issues.

EPA attention to environmental equity actually began in 1990. Based on the lobbying of the Michigan Coalition, William Reilly, then Administrator of the US EPA, convened an Environmental Equity Workgroup. He gave this group the charge of: 'making certain that the consequences of environmental pollution should not be borne unequally by any segment of the population'. This group issued a report titled Reducing Risk for All Communities, in February of 1992. The Workgroup was made up of EPA people from the Washington DC headquarters office and representatives

from the regional offices. The major finding of the study was that data to fully assess the problem was poor. Among its recommendations are a call for further study, improvements in data collection to support environmental equity assessments, and a call for EPA to 'review and revise...its permit, grant, monitoring and enforcement procedures to address high concentrations of risk in racial minority and low income communities' (Wolcott, Milligan, 1992). The report also urged EPA to emphasize its concerns about environmental equity to the state environmental bureaucracies which it funds and cooperates with.

This report received mediocre reviews from many in the environmental equity community. Dr. Robert Bullard, a sociologist and environmental equity scholar and advocate, stated in a talk he gave to the MIT Department of Urban Studies and Planning in 1992, that he thought the report earned a grade of 'C-' and that it amounted to more of a 'public relations campaign' than a coherent strategy to address the problem. Mr. James Younger from the EPA Region 1 (Boston office) a member of the Workgroup, acknowledged that the report was imperfect and had its critics. He categorized the criticism by stating that many thought that 'the report did not go far enough, and was inconclusive'. He described the process of putting together the report as very difficult with much debate between, and differences of opinion among, the EPA workgroup members. He stated that there was central disagreement as to whether the problems of environmental equity were caused by issues of race, or whether the root cause was economic and that more poor people happened to be minorities. In spite of the United Church of Christ findings, this

proved to be a very contentious issue.

The EPA has moved forward beyond publication of the Reducing Risks for All Communities report. In October of 1992 the EPA opened the Environmental Equity Office within its headquarters office in Washington DC. While the office maintains only a moderate staff of 7 and a yearly budget of $800,000 (Gaylord, personal communication, 1992), its creation signals a recognition by EPA that these issues are important and deserving of attention. The office will focus on coordinating 'communication, outreach, education and training of the public on equity issues'. In addition, the office will coordinate EPA's equity policies with those of other Federal agencies. The office will also attempt to foster grass-roots interest in environmental equity and environmental education in the minority community by providing technical assistance and 'helping these groups steer through the bureaucratic maze of EPA' (Gaylord, 1992). The office will also engage in special projects which include:

> ...helping to develop environmental equity analysis and risk mapping methodologies, instituting an accountability system to track implementation of the Environmental Equity Report, and establish a clearinghouse on data and success stories (Gaylord, 1992).

Another sign of the new importance assigned to environmental equity is the fact that legislation passed by the U.S. Senate in May, 1993, that would establish the EPA as a cabinet level department includes a provision that would create a Bureau of Minority Affairs (National Public Radio, 1993).

In addition to the Environmental Equity Office at headquarters, each of EPA's ten regional offices has an environmental equity contact person. Many

regional offices are conducting their own environmental equity special projects. EPA's Environmental Equity Update Memo for October of 1992 listed 18 ongoing environmental equity projects and analyses (Gaylord, 1992).

The EPA Region 1 office, in Boston, will be used as an example of regional attention to environmental equity. Region 1 designates Key Priority Areas (KPA) every year as part of an internal 'strategic planning initiative'. KPA's are viewed as Region-wide priorities and staff resources are made available to work on activities related to the KPA. One of the goals in designating a KPA is to highlight an area of an importance and work towards having the agency integrate this area into normal work flow. Environmental equity was designated as one of three EPA Region 1 KPAs for fiscal year 1993. The EPA Region 1 KPA has three working groups which are focusing on 1) producing a Region 1 environmental equity policy, 2) disseminating and promoting awareness of the policy, and 3) creating and maintaining the data necessary to support the policy.

An example of one of EPA Region 1's environmental equity projects involves using geographic information system (GIS) technology to identify disadvantaged communities. Disadvantaged communities will identified and then assigned a score based on the proportion of poor and minority residents found in specific areas. Evidence, such as the UCC study, indicates that these disadvantaged communities house a disproportionate share of EPA's regulated facilities. EPA is currently evaluating the scoring system and discussing various ways that the scoring system can be used to insure that adequate resources are allocated to these communities.

Examples of how the scoring system might be used include using the score as one of several factors (risk is another factor) that are considered when assigning priority for inspections or other types of corrective actions. Accounting for equity through a scoring system may serve to counteract the societal biases that have resulted in concentrations of facilities in minority and poor areas. It is hoped that EPA can progressively address issues of environmental equity in this manner.

In summary, EPA at both the national and regional level has undertaken many initiatives to address issues of environmental equity. Current activity raises the hope that EPA is committing itself to insuring that environmental equity remain an important goal. New research and analyses should lead to new and more equitable EPA policies and procedures. The grass-roots community, strengthened by EPA's outreach to foster environmental education, will be well positioned to insure that those policies and procedures make it from the conference room into the field.

1.3 GEOGRAPHIC INFORMATION SYSTEMS

GIS are computer based systems used to store, analyze and display geographic data. Analytic capabilities include proximity calculations, area and length measurement and overlay analysis. Importantly, a GIS enables the researcher to present data in a graphic format. The use of graphics helps in the display of complex, quantitative data. It is easier for most humans to see patterns in space than it is to see patterns in rows and columns of numbers. To realize these benefits the analysis conducted in this thesis will use GIS technology.

As mentioned above, geographic information systems are already being used

to help EPA identify and map the areas where people of color, and poor people are concentrated. A couple of factors make GIS particularly relevant for this type of examination of issues of environmental equity. First, the best demographic data, the US Census files, are readily available in a GIS format. This means that the demographic assessments necessary to demonstrate environmental unfairness can be performed in a short amount of time at a reasonable cost. Second, once data is in a GIS format it can be easily manipulated with the software to flexibly perform a wide variety of equity evaluations.

Another factor leading to use of GIS in this thesis is EPA's wide, general implementation of GIS. EPA has already made a sizable investment in acquiring these expensive tools and they are currently using them for environmental equity purposes. The GIS techniques explored herein are offered as a feasible mode of environmental equity analysis. It is hoped that these techniques may be used by EPA (with appropriate modification) to promote environmental equity.

CHAPTER 2

STATEMENT OF PROBLEM AND HYPOTHESIS

2.1 INTRODUCTION

On April 9th, 1993, the National Association for the Advancement of Colored People (NAACP), the oldest and one of the largest civil rights organizations in America, named the Rev. Benjamin Chavis as its Executive Director (Boston Globe, 1993). The front page notice in the Boston Globe noted that the Reverend Chavis was 'a pioneer of the "environmental racism" movement'. Indeed, this announcement symbolizes the ascension of the environmental equity issue in both the civil rights and environmental communities.

Despite some activity in the early 1970's significant public discussion of, or academic attention to issues of environmental equity, did not begin until the publication of the landmark study Toxic Wastes and Race in the USA in 1987. This study was published by the Commission for Racial Justice, United Church of Christ (UCC), a group headed by Reverend Chavis. The United Church of Christ study looked at the distribution of commercial hazardous waste facilities and uncontrolled toxic waste sites across the U.S. and determined that the percentage of minority individuals in a community was a powerful predictor of the number of waste sites housed in that community. In fact, the study found that the race of a community was a stronger predictor of the number of toxic waste sites than was the economic status of a community.

In 1992 the National Law Journal (NLJ) sponsored a study and devoted an entire special section of the journal to examining whether the enforcement of environmental laws afforded equal protection to different races and economic classes. The NLJ looked at the size of penalties levied by EPA under environmental statutes and found that facilities located in minority communities received less severe penalties than those located in predominantly white communities. Again, the NLJ study found that the size of the penalty was more closely associated with the race of a community than it was with the economic status of a community (Lavelle, Cole, 1992).

While other work, such as Robert Bullard's Dumping In Dixie, provides other evidence of environmental inequity, these two studies form the core of quantitative research into issues of environmental equity/inequity. Many groups have highlighted the need for further study. The United Church of Christ study called for 'further epidemiological and demographic research' as one of their core recommendations (United Church of Christ, 1987). Additionally, the EPA study Reducing Risk for All Communities (EPA, 1992) recommends further study. This recommendation was summarized in an article in the EPA Journal in 1992:

> EPA should establish and maintain information which provides an objective basis for assessing risks by income and race, commencing with developing a research and data collection plan.

This thesis aims to partially meet these challenges for additional data collection and quantitative analysis.

2.2 GAPS IN EXISTING RESEARCH

Both the United Church of Christ and the National Law Journal conducted large scale, nationwide studies that relied on the ZIP code area as the unit of aggregation for demographic data. The nationwide nature of the studies and the ZIP code level of aggregation suggest potential gaps in knowledge and opportunities for further inquiry.

First, nationwide results do not necessarily reflect the conditions in various regions or states in the nation. For example, if large scale environmental discrimination in the west outweighed general environmental progressivity in the east, then a nationwide study would determine the entire country to have a similar environmental racism problem. It is well known that the United States is a diverse country with very different racial patterns from state to state. The density of minority population varies significantly between the Southern USA and the Northeastern USA. Consequently, a nationwide study is useful for highlighting a problem, however, it may have limited use in providing a blueprint for a regional solution or a national plan that prioritizes the use of limited resources for environmental equity on a regional basis.

Second, ZIP code areas are fairly large in size and one cannot assume that the populations within a ZIP code area are homogenous (see figure 2). For example, it is easy to imagine a single ZIP code area which has a white dominated population on one half and minority dominated population on the other half. If there was a greater tendency for facilities to be located in the minority-half of the

ZIP code areas, then one would observe greater inequity than was measured by UCC or NLJ. The use of the ZIP code area as a unit of population aggregation has the potential to mask subtle spatial effects of the distribution of facilities. These subtle effects could either amplify or reduce the inequity observed in these studies.

The importance of selecting an appropriate level of aggregation was also highlighted in one of the key environmental equity cases that was brought to court, East Bibb Twiggs Neighborhood Association v. Macon-Bibb County Planning & Zoning Commission (Collin, 1992). The use of census tract based analysis was challenged as a legitimate method of classifying the ethnicity of a community. It was felt that a census tract, although significantly smaller than a ZIP code area, was too big an area and that the ethnicity of the tract as a whole did not reflect the ethnicity of those who would be impacted by the siting decision in question. Robert Collin, the author of a Virginia Environmental Law Journal analysis of this and other environmental equity cases states in a footnote 'the court overstated the importance of using census tract analysis'. Mr. Collin goes on to quote Rachel Godsil in that footnote as stating:

> A better alternative would be to determine the population of the area *physically affected* by the siting: the area in which the residents suffer the smell, the traffic, the sight, the lowered land values and the potentially polluted groundwater resulting from the facility. Focusing the inquiry on the physically affected areas would better measure the *impact* for purposes of determining disparate impact than arbitrarily chosen political boundaries.

While using a proper level of aggregation may be decisive in a court room context, it is also an important question in general study design for environmental equity

research.

The geographic information system (GIS) assisted techniques for assessing environmental equity presented in this thesis enable the researcher to easily vary the level of aggregation. The researcher can work with the smallest units of census data aggregation, census blocks (equivalent to a city-block), and can combine them into specialized 'areas of interest', such as a 'physically affected area'. Researchers need not be locked into using 'arbitrarily chosen political boundaries' like ZIP codes or census tracts.

Finally, neither the UCC nor NLJ studies make effective use of maps when trying to describe what is essentially a spatial phenomena. The UCC study has a map on the cover and group of maps as one of the appendices. However, the maps in the appendix are graphically ineffective in supporting the UCC case. No maps are used in the entire NLJ special section.

This research aims to address the aforementioned research opportunities. First, this thesis will examine environmental data pertaining to Massachusetts. This will provide an opportunity to compare the conditions in one state to the nationwide trends observed in the UCC and NLJ studies. Additionally, this study will examine several individual counties providing opportunities to assess whether environmental equity/inequity varies on a county by county basis.

Second, this thesis will use state-of-the art geographic information systems (GIS) technology to enable the research to be conducted at varying levels of racial and economic class aggregation. These aggregations will range from the census block

to census blockgroup and census tract. Each of these levels of aggregation are significantly smaller than ZIP code areas. This variable analysis should provide insights into how different levels of aggregation affect results, and guidance in selecting appropriate levels of aggregation for research.

Last, the use of GIS technology will allow extensive mapping to be conducted. While mapping included in this thesis will be limited to several figures, these figures will be integrated throughout the text. Additionally, the GIS data base assembled for this thesis provides the ability to generate an unlimited number of large size, color plots depicting various relationships among the data sets. Human beings can see spatial relationships graphically in the form of maps more easily than they can extrapolate abstract numbers such as the R-squared value from a regression analysis. Effective use of maps can assist in policy development and can help communities understand the specific manifestations of the problems of environmental inequity. Unlike the UCC or the NLJ, The New York Times took advantage of graphic media and created a very effective, full-page map to accompany a Sunday edition story titled 'In My Back Yard? Where New York City Puts Its Problems' (Roberts, 1992).

2.3 HYPOTHESES ON THE EQUITY OF EPA ALLOCATION OF RESOURCES

Much effort, notably the UCC study and the work of Dr. Bullard, has gone into documenting the existence of environmental discrimination based on the distribution of existing facilities. Unfortunately, it is very difficult to reverse this trend of facility siting, and wholesale movement of facilities to a more equitable distribution is unfeasible. Appropriately, Dr. Bullard has led a call for more

equitable future siting and has worked to develop environmental activism in minority communities so that current siting decisions can be effectively opposed.

The National Law Journal departed from the trajectory of looking merely at the *distribution of facilities* and began to look at the equity of the *application of environmental law*. The NLJ found that the size of penalties, and types of remedies, administered under environmental law did not seem equitably distributed among communities of color and white communities. Since environmental laws are administered by people, there is great potential that inequitable policies can be redressed by government within a relatively short period of time. In short, it is easier to remedy inequitable government practices than it is to correct inequitable historical land use patterns.

This thesis aims to build on the National Law Journal approach by looking at the distribution of ***resources government allocates*** to enforcing environmental laws. This study will look at the expenditure of government resources in the form of inspections of facilities that are regulated under federal environmental law. In theory, governmental resources should be allocated in, at least, a race-blind and class-blind fashion. Often government response to historical inequity attempts to offset past injustice through progressive programs such as 'affirmative action'. While such remedies to past environmental inequity may be worthwhile, they fall beyond the scope of this thesis. Research in this thesis will explore the following hypotheses:

- That institutional racism has led to environmental inequity whereby it is more difficult for minority communities to get a fair share of governmental environmental resources.

An example of this outcome would be the hypothesis that:

- That facilities located in minority communities will be less likely to have been inspected than facilities located in white communities.

One can speculate about how 'institutional racism' makes it more difficult for poorer or minority communities to get attention from the government. For example, if an environmental problem crops up in an affluent community, those citizens may be better educated and may be more likely to have friends who work in government, the media, and the legal profession. These people may also have more time to fight for the preservation of their community values (in this case the value of a clean and safe neighborhood). These people may be able mobilize resources and actively court the EPA (or other government organizations) to take action on the problem that they face.

On the other hand, a poorer or minority community may not have the same access to government officials nor the education, time and experience necessary to lobby for their own interests. This lack of action may lead to a situation where problems in poorer or minority neighborhoods are less likely to be addressed by government. As Dr. Robert Bullard described in an article in the National Law Journal: 'It's almost as if (communities of color) have to convince the powers that be that these are problems, whereas other communities can use elected representatives, zoning boards, and commissioners to cut through that particular process.'

It is not that these communities get less attention because they have fewer problems (research indicates they have more problems), these communities get less

attention because they have less access to the power necessary to push for attention. Institutional racism has lead to a situation where people of color have less access to educational opportunity, high paying jobs and political power.

2.4 USE OF FACILITY INSPECTIONS AS AN APPROPRIATE TEST FOR ENVIRONMENTAL EQUITY

The use of inspections as a metric for EPA resource allocation is supported by a criticism of the National Law Journal study that was voiced in an article in the Journal. The EPA claims that 'many factors go into its determination of penalties, such as the seriousness of an offense, the ability of a polluter to pay, the polluter's history and level of cooperation' (Lavelle, Cole, 1992). It is possible that, contrary to the NLJ findings, EPA does allocate penalties in a race-blind and class-blind fashion and that the most severe offenses happen to occur in white areas. The National Law Journal quoted Scott Fulton, EPA's deputy assistant administrator for enforcement, as saying that penalties are 'an unreliable point of departure' for studying equity. The article continued the quote 'EPA is considering using some other benchmark for enforcement effectiveness'. Among examples of alternative benchmark, the article listed 'number of inspections at a facility, or the amount of time between the uncovering of a violation and the lodging of charges'.

One could argue that inspections are a good benchmark because all inspections are more or less equal. All regulated facilities ought to be inspected at one time or another. Unlike penalties where there is no presumption of equality (a spill contaminating a water supply ought to be more severely treated than a mis-

labeled drum)[1], one could argue that there should be a presumption of equality in inspection policy for facilities with same type of permits. This thesis will use the presumption of equality in inspection policy when assessing whether EPA's allocation of inspection resources has been equitable.

2.5 THE EPA RCRA PROGRAM AND CURRENT EPA INSPECTION POLICY AND PRACTICES

This thesis will examine facility inspections carried out under the EPA Resource Conservation and Recovery Act (RCRA) program. In short, RCRA is the EPA program that permits and regulates the use, and disposal of hazardous wastes. EPA regulates hazardous waste facilities under a number of categories. A 'large quantity generator' (LQG) is a facility that handles over 1,000 kg /month of hazardous waste. At no time can an LQG store waste on-site for over 90 days. A 'treatment, storage or disposal' facility is any facility that stores hazardous waste on-site for a period greater than 90 days, and all facilities which dispose of, or treat hazardous waste. In addition to these categories EPA regulates 'small quantity generators' (SQG) which handle from 100 kg to 999 kg per month. These facilities can store waste on-site for up to 180 days. Facilities which handle hazardous waste, but in quantities of less than 100 kg/month are consider 'conditionally exempt small quantity generators'. Unlike other RCRA facilities, the conditionally exempt SQGs do not have rigorous reporting requirements, although they are required to dispose

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[1] The National Law Journal study made no attempt to control for the type or severity of infraction. They looked simply at the aggregate penalty assessed. They did no follow up work to classify the types or severity of infractions by race or class composition of community.

of their waste at 'secure sanitary landfills'.

Currently, the vast majority of RCRA facility inspections are carried out by state environmental officials. EPA administers grants to the states and the states must meet mandatory guidelines for the number of inspections conducted in order to receive the full amount of the grant. In Massachusetts, the Department of Environmental Protection (DEP), Division of Hazardous Waste carries out EPA mandated inspections under RCRA. In addition, the EPA itself administers a much smaller number of inspections. The state must report all inspections to EPA and thus this study will use an EPA inspection data base that houses **both** state and EPA inspections.

EPA guidelines demand that each state inspect **all land disposal** and **all commercial hazardous waste treatment, storage or disposal (TSD)** facilities **every year.** Further, 50% of the full universe of TSDs[2] in any state must be inspected every year. Thus, every two years, all TSDs should be inspected. The guidelines also require that 8% of all large quantity generators (LQGs) in each state must be inspected, every year. Theoretically, every 13 years all LQGs will be inspected, at least once. The state has **full discretion** in selecting which 8% of LQG facilities should be inspected. Approximately 90% of the combined LQG and TSD category are LQG-only facilities that would be subject to discretionary inspections. Also, the guidelines are minimum requirements and states are encouraged to perform more

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[2] Examples of non-commercial TSDs include manufacturing facilities that are permitted to treat their own wastes or store their wastes on-site longer than normal RCRA generator limits.

inspections than the minimum. Gary Gosbee, the EPA Region 1 RCRA Section Chief, stated that Massachusetts generally performs more than the minimum number of inspections mandated under RCRA grant guidelines. Lisa Papetti, a member of Mr. Gosbee's staff and the Massachusetts state specialist, estimated that the Massachusetts DEP performs in excess of 600 inspections per year under RCRA[3]. In addition, the EPA itself performs approximately 30 inspections per year in Massachusetts.

EPA conducts mid-year and end-of-year evaluations of state inspection performance as part of the issuance of grant monies. These evaluations aim to insure that the states are actually meeting the inspection targets set forth in the RCRA guidelines. The evaluations include a statistical review of the inspection data submitted by the states. The statistical review identifies whether mandatory guidelines have been met and what additional inspections have been conducted. Currently, the data are not evaluated on environmental equity criteria.

Occasionally additional inspection data analysis will be undertaken as part of special EPA initiatives. Examples of special initiatives include geographic focuses on particular natural resources, such as the Merrimac River Basin Initiative. These data analyses may include ad hoc, historical evaluations of the RCRA compliance and inspection data bases. Such special evaluations of the RCRA inspection data base provide a model for conducting analyses based on environmental equity criteria.

While the states make individual decisions on which facilities to visit, EPA has

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[3] This figure includes inspections of small quantity generators (SQG) and conditionally exempt SQGs.

the ability to impact state behavior. If states were instituting inequitable inspection policies, then EPA may be able to compel them to take environmental equity into consideration. Possible options for achieving this include giving states 'special credit' on their evaluations if they conduct a given percentage of their additional (beyond mandatory) inspections in poor or minority neighborhoods. These special credits could result in additional grants, if funding levels permit. Alternatively, EPA could mandate that a certain proportion of the 8% of LQG inspections be conducted in poor or minority neighborhoods. At the same time, EPA could use environmental equity criteria, as one of several factors, when planning the smaller number of their own inspections.

The remainder of this thesis will describe methods for assembling and analyzing the data that are necessary for EPA to evaluate the equity of current practices, and to consider environmental equity criteria in future program planning.

CHAPTER 3:

ANALYTIC METHODS AND RESULTS OF ANALYSIS

3.1 DATA ACQUISITION

Prior to developing a data analysis tool that could be used for inquiries into environmental equity, two distinct data bases needed to be assembled. The first data base was an historical listing of all large facilities regulated under EPA's Resource Conservation and Recovery Act (RCRA) program, and a further detailed listing describing the compliance, monitoring and enforcement actions taken on those facilities. The second data base stored comprehensive tabular and cartographic data pertaining to the 1990 United States Census. The following describes the specifics of data assemblage for these two data bases.

3.1.1 EPA RCRA DATA BASE

An initial decision was made to limit the inquiry to large RCRA facilities that were categorized as either large quantity generators (LQG) or hazardous waste treatment, storage or disposal facilities (TSD). Data covering the time period from 1987-1992 were obtained from the US EPA Region I office in Boston via a Freedom of Information Act Request. The data obtained from this request came in the form of three distinct computer files generated from EPA's Resource Conservation and Recovery Information System (RCRIS). The first file contained the Compliance Monitoring and Enforcement (CME) data for all facilities in Massachusetts which had been inspected or had another type of enforcement action taken between 1987

and 1992. The second file contained the complete list of all LQG and TSD facilities currently regulated in Massachusetts.

While these files were generated from the RCRIS data base, they were delivered in a cumbersome report form and in simple ASCII format. The report form made each discrete record easily readable to human eyes, all information had column headings and pages were numbered, however, it made loading the files into a data base system difficult. Loading the information into a data base was necessary so that the data could be aggregated and analyzed according to user defined specifications. Without loading information into a data base it would have been extremely difficult to answer even basic questions such as: "how many facilities were inspected in 1989?". In order to overcome this problem a series of data parsers were written that would extract key data from the report form and would then write them to secondary files which were formatted in the familiar column and row format and which could be easily loaded into a data base. When this step was complete, the two reports had been converted into a series of related data base tables which were further manipulated to perform various analyses.

3.1.2 THE US CENSUS DATA BASE

For the first time the 1990 US Census was made available on optical compact discs (CD). Three separate series of discs were used to perform this analysis: 1) the topologically integrated geographically encoded reference system (TIGER) files, 2) the public law 94 (PL94) files, and 3) the summary tape files version 3a (STF3a). In each case the appropriate CD was read to extract relevant information for

Massachusetts.

In the case of the TIGER files the data for six counties in Massachusetts - Essex, Hampden, Middlesex, Norfolk, Suffolk and Worcester - were extracted and then processed using the ARC/INFO geographic information system (GIS) software. The result of this TIGER data processing was a series of cartographic data coverages which stored the geography necessary to view the census data in a mapped form. Specifically, maps of US census blocks, census blockgroups and census tracts were prepared[4] (see figure 1, and table 2).

Subsequently, the PL94 data were used to develop information on the racial composition of the six counties so that these data could be viewed in both tabular and mapped formats. Similarly, the STF3a data were used to develop information on the income compositions of Suffolk County.

3.2 DATA PREPARATION AND MANIPULATIONS

Once the basic data bases were assembled, various data manipulations allowed an inquiry into issues of environmental equity. The key step enabling this inquiry was to calculate the racial and economic characteristics of areas surrounding permitted RCRA LQG and TSD facilities. GIS technology was used to perform this

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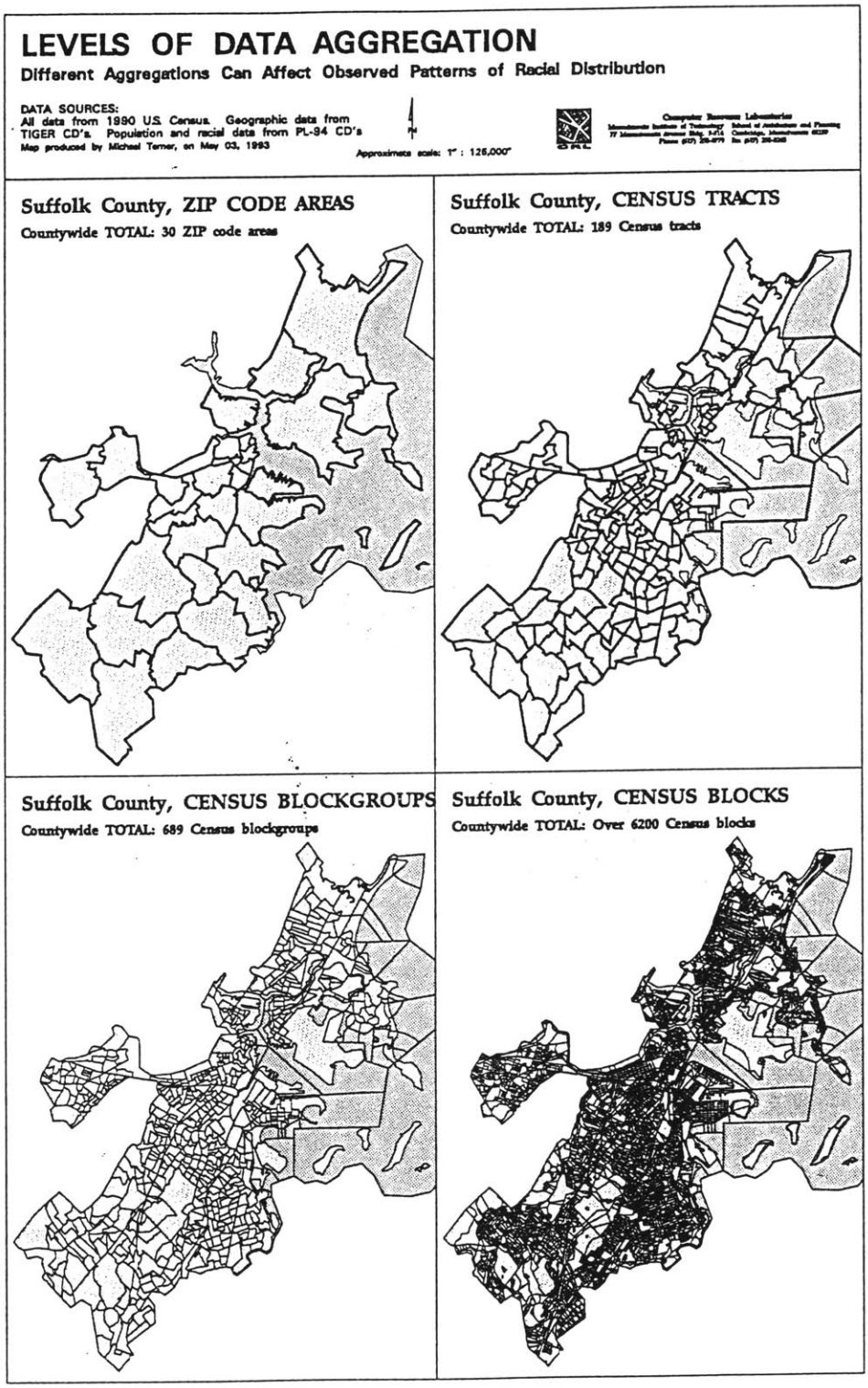
[4] A census block roughly corresponds to a city block. A census blockgroup is a group of approximately 10 contiguous census blocks and is used by census for aggregating detailed census information, such as income and housing characteristics, for which privacy must be maintained. A census tract is a group of 4-6 contiguous blockgroups and provides a coarser level of aggregation for census information.

FIGURE 1.


LEVELS OF DATA AGGREGATION
Different Aggregations Can Affect Observed Patterns of Racial Distribution
DATA SOURCES:
All data from 1990 U.S. Census. Geographic data from TIGER CD's. Population and racial data from PL-94 CD's
Map produced by Michael Terner, on May 03, 1993
Approximate scale: 1" : 126,000'
Suffolk County, ZIP CODE AREAS
Countywide TOTAL: 30 ZIP code areas
Suffolk County, CENSUS TRACTS
Countywide TOTAL: 189 Census tracts
Suffolk County, CENSUS BLOCKGROUPS
Countywide TOTAL: 689 Census blockgroups
Suffolk County, CENSUS BLOCKS
Countywide TOTAL: Over 6200 Census blocks

key step by first generating point locations for all facilities and then overlaying those points with maps of census geography. Once this overlay is complete, the facility data set has identification numbers for the census block, blockgroup and tract within which it is found. These identification numbers can then be used as keys to calculate the racial and economic characteristics of the areas surrounding the facility[5]. The following describes key issues and the problems that were encountered in performing this overlay.

3.2.1 ADDRESSMATCHING

Most geographic information systems allow a user to perform an operation called addressmatching. Addressmatching requires that the user have a spatial data base of roads and that this data base contain the road name as well as the high and low address number for each side of the road. If this information is present, then the GIS can read an address, locate the street segment that the address falls on and then interpolate a point location based on the address number. In essence, addressmatching automatically places a pin on the map for each facility. Addressmatching is an efficient means of digitizing spatial point data when maps are not available but street addresses are.

In this case, the LQG and TSD data bases acquired from EPA had street addresses, but they did not have any other cartographic information (e.g. maps or

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[5] Both the UCC and NLJ studies avoided this step by using the ZIP code level of aggregation. Since facility addresses already have ZIP codes associated with them, they did not need to perform a GIS overlay to add any census id numbers. This simplified their task, but it locked them into using the coarse, ZIP code level of aggregation for their census statistics.

plotted coordinates such as latitude/longitude). Thus, addressmatching was applied to generate point locations that could be subsequently overlain with the census data.

Addressmatching is not a perfect process. First, the coordinate location is not wholly accurate because it is **interpolated** from the road data base. The addressmatched coordinate represents an approximate location based on the roads data, not where it actually is[6]. Second, not all addresses in a given data base are successfully matched. The address data base can have errors, such as misspelled street names or records that do not contain a street number, and the roads data can also have errors, such as missing roads or incorrectly entered address ranges for roads. Further, the addressmatching software has limitations which prevent fully automatic addressmatching. For example, some cities may have two or more roads named 'Main St.' and the software cannot differentiate which of two possible '66 Main St.' addresses it should match.

A separate addressmatching problem is that properly formatted roads data is extremely expensive to create and can be difficult to acquire. Fortunately, the aforementioned US Census TIGER files contain roads data that are properly formatted to support addressmatching. While TIGER data is available for the entire country, the data are only coded for addressmatching in metropolitan areas. In Massachusetts, only 88 of 351 cities and towns are coded for addressmatching

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6 The accuracy of an addressmatched location depends on the density of the road network. Generally, addressmatching is better when there is a dense, regular array of roads. Addressmatched coordinates will generally fall in the correct quadrant of the correct block. Addressmatching approximations are more inaccurate in rural settings where there are relatively few addresses, irregularly spaced on longer street segments.

(MassGIS, 1992). These 88 communities are more or less the largest cities and towns in Massachusetts and roughly correspond to US Census standard metropolitan statistical areas (SMSA). Alternative commercial data sources that have complete addressmatching coding for Massachusetts are available, however, they are quite expensive and were not acquired for this study.

In the six county study area considered in this thesis there were a total of 532 facilities, 379 of these facilities (71%) were in towns where data supporting addressmatching were available. This relatively high percentage is not surprising because it is expected that the brunt of industrial, waste generating facilities will be located in the most metropolitan areas of counties. The 6 county study area was also very representative of metropolitan area of the entire state. The study area contained 93% of facilities that were in communities for which TIGER addressmatching data existed across all 13 counties in Massachusetts (i.e. only 7% of facilities which could be addressmatched were found in the other 7 counties).

It should be emphasized that this study focuses on examining equity within the 6 most metropolitan counties. Due to historic settlement patterns most people of color live in these metropolitan areas. As table 1 shows, 87.7% of all people of color live in the 6 county study area. Thus, at a statewide level, the vast majority of people of color happen to be concentrated into the counties where 82.7% of the RCRA LQG and TSD facilities are. This study looked at a greater proportion of all people of color (87.7%) than the proportion of all white people (73.6%). This result implies that some inequity at a statewide level might be observed, however,

this statewide analysis was not pursued in this thesis.

	Minority Pop.	White Pop.	TOTAL Pop.	Percent Minority
6 County Study Area	535,848	3,978,708	4,514,556	11.9%
Other 8 Counties	75,203	1,426,666	1,501,869	5.0%
TOTAL	**611,051**	**5,405,374**	**6,016,425**	**10.2%**
% of State Tot. in 6 Co. Study Area	87.7%	73.6%	75.0%	

Table 1 The vast majority of people of color are found in the 6 metropolitan counties of Massachusetts (Source: US Census PL94 CD).

All of the aforementioned error types were encountered when performing addressmatching of the RCRIS data to the TIGER roads data. In all, 204 of the 379 facilities, or 54%, were successfully addressmatched on the first, wholly automatic pass. As table 2 shows, addressmatching success rates varied from 43% to 63% for individual counties (TIGER data is available on a county by county basis). These 204 facilities comprise a sample of RCRA facilities which were later combined with census data to test for potential racial and income-based bias in the distribution of facilities and in EPA's allocation of inspection resources.

County	% Of All Fac. In this County w/ TIGER Addresses	# RCRA Facilities In towns w/ TIGER Addresses	# RCRA Facilities Successfully Address-matched	Percent of RCRA Facilities w/ TIGER addresses Successfully Matched
Essex	68.2%	60	26	43.3%
Hampden	96.2%	51	23	45.1%
Middlesex	68.5%	135	85	63.0%
Norfolk	64.9%	37	18	48.6%
Suffolk	100.0%	55	27	49.1%
Worcester	50.0%	41	25	61.0%
TOTAL	**71.0%**	**379**	**204**	**53.8%**

Table 2 Addressmatching success rates for six county study area.

This sample was not considered a scientific random sample because it was selected due to a combination of technical and data quality factors and not in a process controlled by the investigator. Further, several plausible hypotheses could be generated explaining why this sample would not be random. Examples of these hypotheses include:

- Large facilities with campus-like sites might be more likely to not have street addresses. The data base included several entries for facilities with addresses such as Logan Airport or Gillette Park.
- Facilities that had not been inspected or investigated by EPA might have a greater chance of not having an accurate street address recorded. Having EPA take action against a facility makes it more likely that an incorrect address would be uncovered and corrected.

In order to control for inadequacies in this sample, and due to the fact that fixing addressmatching errors is a very time consuming process, it was decided

that a complete mapping of facilities in Suffolk County would be pursued by manually plotting the 28 facilities that were not addressmatched on the first pass. This manual plotting was achieved by researching the location of campus facilities with no street address (e.g. UMASS Boston, Gillette Park, Logan Airport) and manually resolving cases where there were multiple possible matches (e.g. 50 Park St.) by using ZIP code digital data. This process was imperfect and required some manual interpolation when the TIGER street data, even in this metropolitan area, were lacking address range data for certain road segments. Despite this imperfection, the investigator aimed to plot the facility location within the correct census block. If this was not achieved, it is reasonable to assume that the location was plotted within the correct census block group. In spite of phone calls to the firms, two facilities could not be plotted. Thus, the final Suffolk County sample was 53 of 55 facilities (96.4%).

If the EPA is interested in using the Census data in association with facilities data to assess issues of environmental equity, then extra care should be taken in assembling their data bases so that coordinate locations are made available, or so that high-success rate addressmatching can be completed. Ideally, the EPA should collect a coordinate location (e.g. latitude/longitude, or state plane X and Y) for each facility. Providing this information could be required as part of permitting, or EPA could develop this information, through addressmatching or other techniques, during the permit approval process. Not only would having comprehensive and accurate coordinate locations fuel GIS

assisted demographic and equity assessments, but also these data could be used in many other GIS assisted analyses, such as natural resource assessments to determine which facilities are closest to wetlands, aquifers or other mapped natural features.

In fact, EPA has begun to address this issue by instituting the Locational Data Policy (LDP) of 1992. In short, this policy commits EPA to tracking the coordinate location of all facilities that it regulates, to an accuracy of +/- 25 meters, by the end of 1995 (EPA, 1992). The EPA hopes to implement the policy and acquire accurate coordinate locations through a mix of coordinate capture technologies that range from addressmatching to the use of global positioning systems (GPS, a satellite assisted surveying technique). Due to the relevance of locational data for GIS assisted equity and natural resource assessments, EPA should consider accelerating the pace of implementation of the LDP or they should make coordinate locations that are already acquired available to researchers through Freedom of Information Act channels[7].

3.2.2 DATA OVERLAY

Once data layers existed for census geography and for RCRA LQG and TSD facility locations, then ARC/INFO was used to perform a point-in-polygon overlay. During this process ARC/INFO assigns the census block number of the block within which a point falls to the facility data base. The census block

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[7] This researcher included a request for coordinate locations in his Freedom of Information Act request. The request was not met. Later the researcher found out that EPA Region 1 had a data base that included coordinate locations of RCRA facilities, that was generated in concert with the LDP.

number used in this analysis was a concatenation of the county id number, the tract id number and block number. Thus, this single number could be used to determine which tract, block and blockgroup (blockgroup number is the tract number plus the first digit of the block) a given facility fell within. Upon completion of this step, several assessments of the distribution of RCRA facilities, and EPA inspection resources, among various racial and economic groups could be made.

3.2.3 DEFINING A MINORITY COMMUNITY

There are numerous methodologies for characterizing communities. For the purposes of this study communities of color were determined by aggregating the minority population of units of census geography to determine the minority percentage of the total population. Minority population totals were taken from the US Census PL94 data on a census block basis. These totals were then aggregated by the investigator to blockgroup and tract totals. Minority population was determined by totalling the black, hispanic, asian, native american and 'other' population totals for each census block. No effort was made to look at any single minority group, such as black or latino, individually.

Minority areas were considered to be the quartile of all census areas where the minority percentage was the highest. Similarly, white areas were considered to be the quartile of all census areas where the minority percentage was the lowest. This classification scheme followed that used by the National Law Journal in its environmental equity assessment (Lavelle, Coles, 1992).

3.2.4 LEVEL OF AGGREGATION

The level of aggregation can greatly affect characterizations of population. Selecting the quartile of highest minority population determined by census block will give one a different population than if one selected the quartile of highest minority population determined by census tract (see figure 2).

Earlier studies such as the United Church of Christ (United Church of Christ, 1987) study and the above-cited National Law Journal study only looked at racial and economic statistics as calculated for ZIP codes. One can argue that ZIP code areas are too large for detailed studies of environmental equity. The size of a ZIP code area can potentially mask racial or economic heterogeneity within a ZIP code area. For example, a ZIP code could have summary statistics which say that it has a 10% minority population. Further, the 10% of minorities might all live in one community, in one concentrated area in the ZIP code. Thus, if a facility was located in the ZIP code it might be classified as being in a white area based on the low aggregate number of minorities across the entire ZIP code. However, the facility could be located in the minority enclave within the white ZIP code. The ZIP code level of aggregation would mask the fact that this facility was in a minority community.

At the same time, smaller levels of aggregation are not always better. Working at the census block level presents different masking effects. For example, a facility might be located on an industrial block within a minority community. Since the block is industrial, the census data would not show any

population, white or minority, living in the block. Thus, the facility would be classified as not being in a minority community (percentage of minorities would be zero). The small size of the census block would mask the fact that a facility might have impacts on surrounding blocks and thus should be classified by the characteristics of those surrounding blocks.

Aggregation is necessary to model patterns of human settlement, however, it may always introduce some masking effects. The precise position of a facility within a unit of aggregation is important in determining whom the may facility affect. For example, a facility that is located at the edge of a predominantly white blockgroup could have equal or greater impacts on the adjacent, predominantly minority blockgroup located down wind[8]. GIS holds great promise for exploring these more complex spatial relationships. Using GIS technology the investigator can easily alter the level of aggregation and can test how these alterations affect results.

Several portions of this study are conducted at multiple levels of aggregation -census block, blockgroup and tract - to examine how this issue can affect results and as a means of recommending a most appropriate level of aggregation for environmental equity inquiries at a regional level. Table 3, shows the relative density of various units of census data aggregation for Suffolk County. Different levels of aggregation may be most appropriate for different geographic

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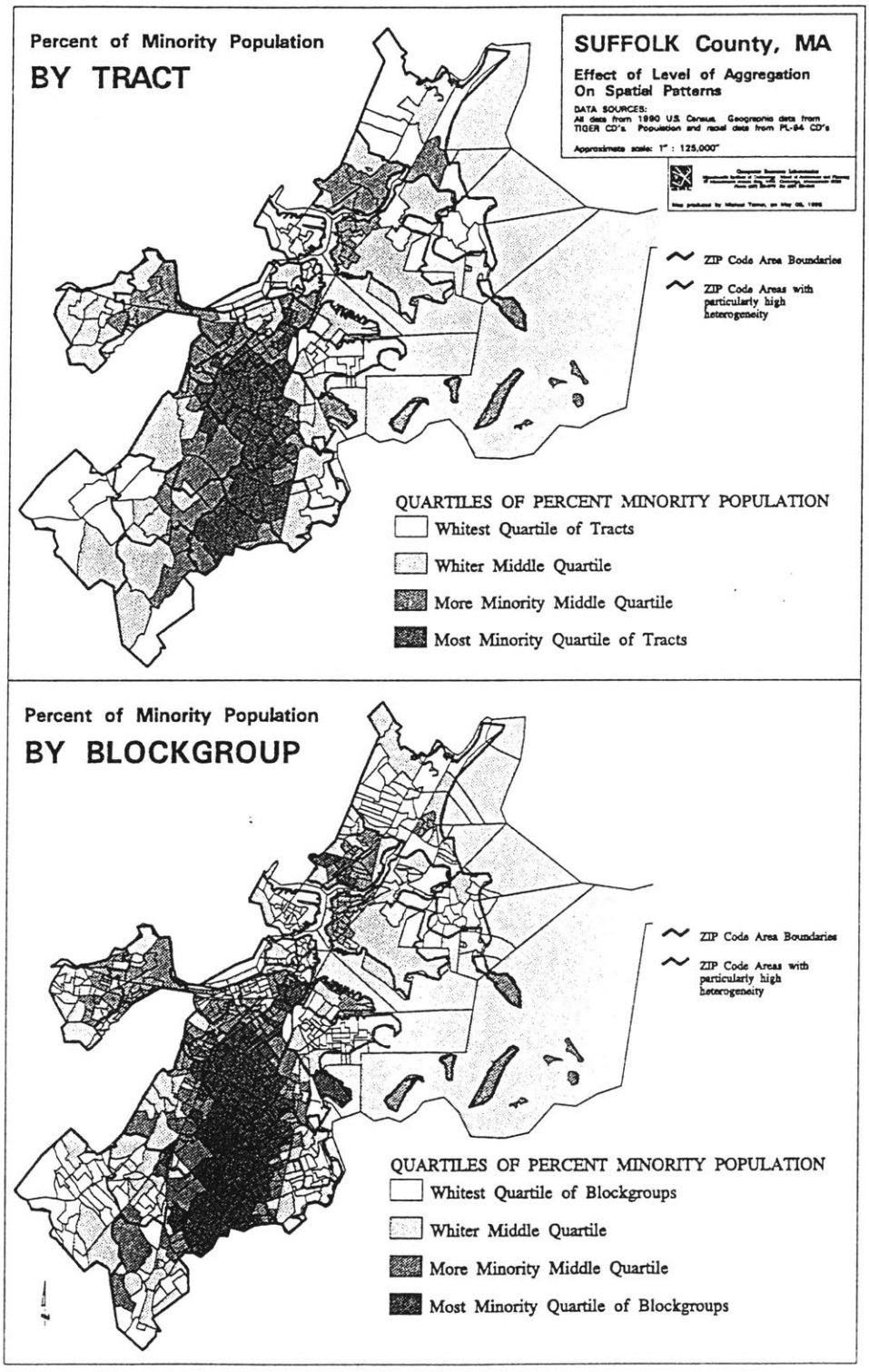
[8] Many other impacts of a facility might be felt more greatly by one part of a neighborhood than another. Examples include increased traffic, waste storage location and noxious smells.

FIGURE 2.


Percent of Minority Population
BY TRACT
SUFFOLK County, MA
Effect of Level of Aggregation
On Spatial Patterns
DATA SOURCES:
All data from 1990 U.S. Census. Geographic data from TIGER CD's. Population and racial data from PL-94 CD's
Approximate scale: 1" : 125,000"
ZIP Code Area Boundaries
ZIP Code Areas with particularly high heterogeneity
QUARTILES OF PERCENT MINORITY POPULATION
Whitest Quartile of Tracts
Whiter Middle Quartile
More Minority Middle Quartile
Most Minority Quartile of Tracts
Percent of Minority Population
BY BLOCKGROUP
ZIP Code Area Boundaries
ZIP Code Areas with particularly high heterogeneity
QUARTILES OF PERCENT MINORITY POPULATION
Whitest Quartile of Blockgroups
Whiter Middle Quartile
More Minority Middle Quartile
Most Minority Quartile of Blockgroups

scopes of inquiry (e.g. nationwide vs. regional vs. municipal studies). It is likely that census blockgroup and tract, which are both larger than census blocks and smaller than ZIP code areas, hold the most promise for regional analyses of issues of environmental equity. Due to the size of the USA, and the complexity of handling very large data sets, it is possible that ZIP codes (there are over 40,000 ZIP code areas in the USA) may still be an appropriate level of aggregation for some **nationwide** studies.

Alternatively, GIS enables groups that are conducting environmental equity inquiries to create their own units of aggregation that are based on the census blocks. These units of aggregation may be based on neighborhoods or other meaningful political or community based boundaries. GIS can be used to apportion population to these non-census units of aggregation by counting up the census blocks that comprise these units.

Unit	Number of Units in Suffolk Co.
ZIP Code Areas	30
Census Tracts	189
Census Blockgroups	689
Census Blocks	6211

Table 3

3.3 DATA ANALYSIS

The following section describes several analyses that were conducted to assess the extent of environmental equity/inequity in the distribution of RCRA

facilities in Suffolk County and in the allocation of EPA's RCRA inspection resources in Suffolk County and the six county sample described above. It is important to note that this study is principally interested in developing techniques for looking at issues of environmental equity within a public policy decision making framework. While specific results are discussed below, it is not the intent to blame or exonerate any group or agency. This study aims to demonstrate that GIS allows the routine use of analytic methods to assess the extent of base-line environmental equity/inequity as well as governmental performance on addressing equity issues. It is hoped that these preliminary results and techniques are used as a springboard for further inquiry.

3.3.1 DISTRIBUTION OF RCRA FACILITIES AMONG MINORITY COMMUNITIES IN SUFFOLK COUNTY

A quartile analysis using a similar methodology to that used by the National Law Journal was conducted in order to determine if RCRA LQG and TSD facilities were more concentrated in minority communities than in predominantly white communities in Suffolk County. This assessment was conducted at both the census blockgroup and tract levels.

First, the census data, including minority percentage of population for all census blockgroups, were assembled. Second, the file of 689 blockgroups was sorted by percentage minority as calculated by blockgroup. Second, the 172 blockgroups (highest quartile) with the highest percentage of minorities, those with 67.8% minority population or higher, were considered the 'most-minority communities'. Similarly, the 172 blockgroups (lowest quartile) with the lowest

percentage of minorities, those with 6.3% minority population or lower, were considered the 'most-white communities'. While the quartile classification is based on the number of census blocks, blockgroups or tracts, this classification scheme also succeeded in roughly apportioning the population into quartiles as well. In this analysis the whitest 172 blockgroups contained 22% of the total population while the most-minority 172 blockgroup contained 25% of the population. This result is not unexpected since the U.S. Census Bureau attempts to have all census blockgroups and tracts contain roughly the same number of people.

Third, this file was joined to the listing of the 53 RCRA LQG or TSD facilities that were mapped in Suffolk County, based on the blockgroup id number which was added during the 'data overlay' step described earlier. Once this join was complete it was possible to calculate the number of facilities in the most-minority areas and in the most-white areas (see figure 3). The same process was then followed after sorting the census file of 189 census tracts based on percent minority as calculated by census tract.

This analysis indicated that 13.2% of the facilities were located in the most-minority blockgroups and that 26.4% of the facilities were located in the most-white blockgroups. The remaining facilities were split among the two middle quartiles[9]. The census tract based analysis yielded similar, although non-identical results.

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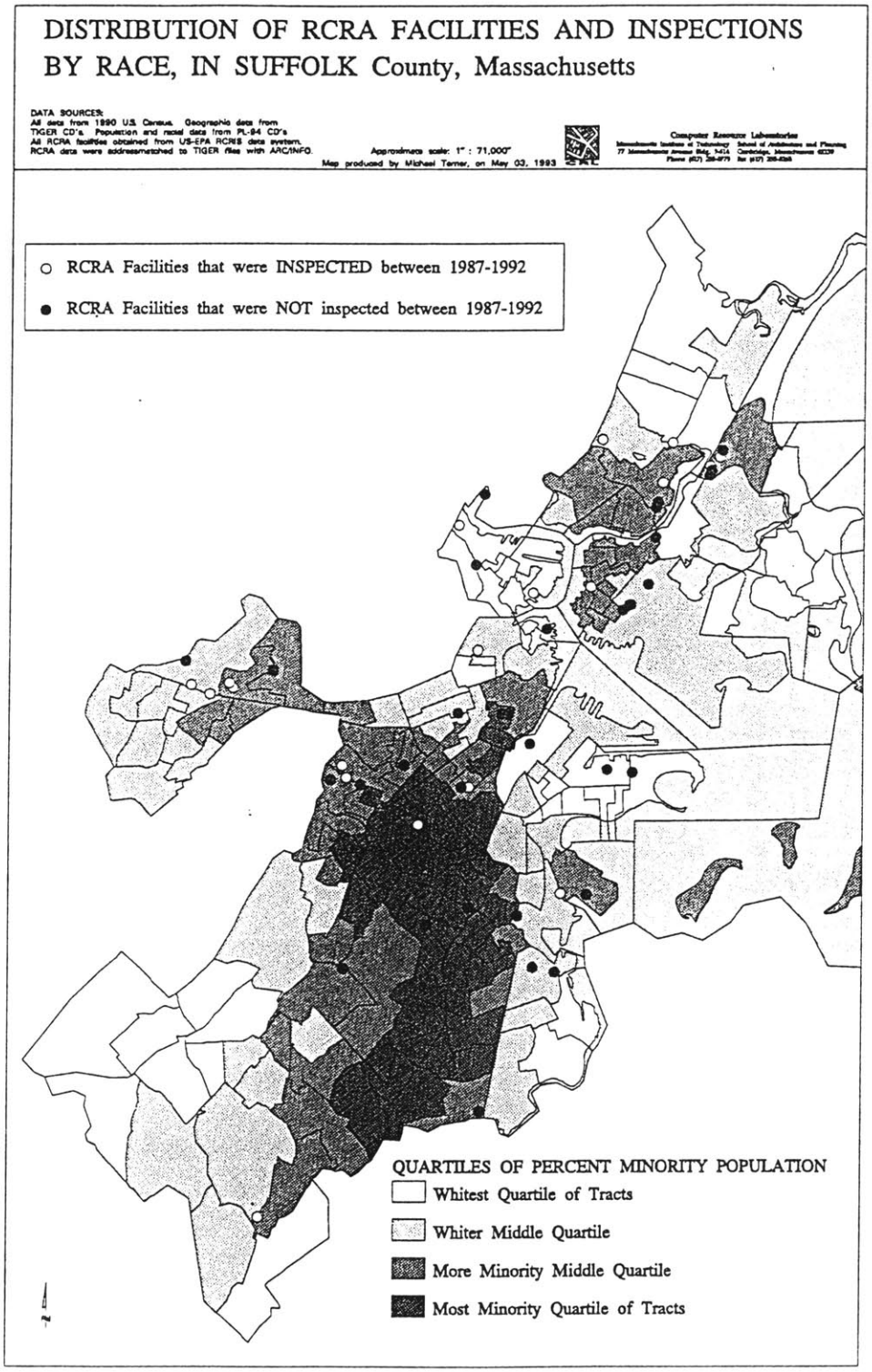
[9] Because 689 is not divisible by 4, even quartiles could not be created. For this study, 3 quartiles had 172 blockgroups and the more-white middle quartile had 173 blockgroups.

FIGURE 3.


DISTRIBUTION OF RCRA FACILITIES AND INSPECTIONS
BY RACE, IN SUFFOLK County, Massachusetts
DATA SOURCES:
All data from 1990 U.S. Census. Geographic data from
TIGER CD's. Population and racial data from PL-94 CD's
All RCRA facilities obtained from US-EPA RCRIS data system.
RCRA data were addressmatched to TIGER files with ARC/INFO.
Approximate scale: 1" : 71,000"
Map produced by Michael Terner, on May 03, 1993
Computer Resource Laboratories
RCRA Facilities that were INSPECTED between 1987-1992
RCRA Facilities that were NOT inspected between 1987-1992
QUARTILES OF PERCENT MINORITY POPULATION
Whitest Quartile of Tracts
Whiter Middle Quartile
More Minority Middle Quartile
Most Minority Quartile of Tracts

Approximately 9.4% of the facilities were located in the most-minority tracts while 17.0% of the facilities were located in the most-white tracts. The middle two quartiles had the remaining 73.6% of facilities with a total of 45.3% of all facilities in the more minority middle quartile[10].

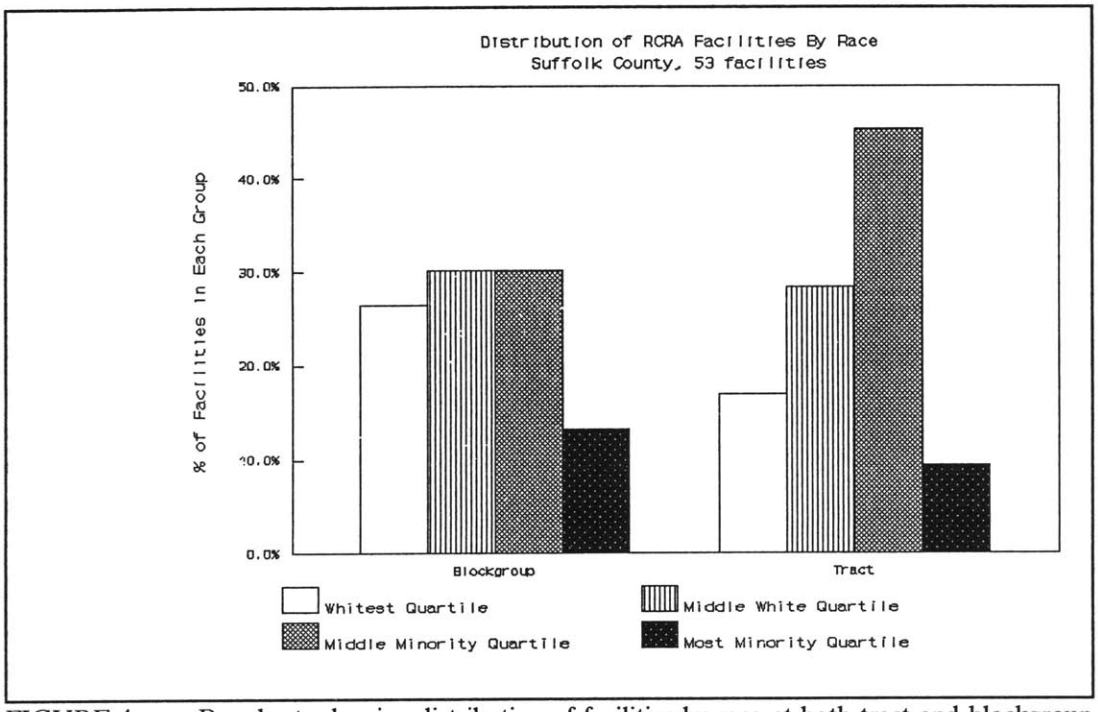


FIGURE 4. Bar charts showing distribution of facilities by race at both tract and blockgroup levels of aggregation.

10 Because 189 is not divisible by 4, even quartiles could not be created. For this study, 3 quartiles had 47 tracts and the more-white middle quartile had 48 tracts.

These numbers were tested for statistical significance using a normal approximation of the binomial distribution[11]. If the distribution of all facilities was independent of demographic patterns, one would expect that approximately 25% of the facilities would be found in the most-minority quartile of census blockgroups or tracts and 25% of the facilities would be found in the most-white quartile of blockgroups or tracts. While the observed value of 26.4% of facilities residing in white areas is relatively close to the expected value of 25%, the observed value of 13.2% of facilities residing in minority areas might indicate 'significant under-representation'. In fact, the statistical test indicated that given a sample size of 53, there is only a 7%[12] probability that a value as extreme, or more extreme, than 13.2% would be observed if facility location was independent of racial concentration. This compares with an 82% probability that a value as extreme, or more extreme, than 26.4% would be observed if facility location were independent.

It is interesting to note that it does not appear that in Suffolk County RCRA LQG and TSD facilities are concentrated in minority communities. Equally, it is important to notice the extent to which the distribution of facilities varies simply by altering the level of aggregation at which one calculates the percentage of minority population.

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11 The normal approximation of the binomial distribution was used because the sample size of 53 passed the "large sample size" tests that determine legitimate use of the normal approximation (Anderson, Sweeney, Williams, 1991).

12 A two-tailed significance test was applied due to the fact that there was not an a priori assumption as to the direction away from 25% one would expect to find a result. In fact, the environmental inequity hypothesis suggested that the extreme value would be in the opposite direction, and higher than 25%.

This initial analysis may not tell the whole story, however. It is possible to envision many other ways that the distribution of facilities across minority neighborhoods could be assessed. Choosing to look at 'the most-minority areas' is a single measure and certainly does not cover all communities which would be considered a 'community of color'. Other options include assessing communities which have minority populations higher than the county average, or looking at communities which have a simple majority of minority population.

3.3.2 DISTRIBUTION OF RCRA FACILITIES AMONG POOR COMMUNITIES IN SUFFOLK COUNTY

The same basic methodology was followed to examine whether facilities were concentrated in poor communities in Suffolk County. This analysis was conducted using census STF3a data that comes aggregated on a census blockgroup basis. This analysis was only completed at the blockgroup level of aggregation.

First, the 689 blockgroups were sorted based on the median household income calculated by blockgroup. Next, this file was classified into the richest and poorest quartiles. Subsequently, the file was joined to the listing of 53 RCRA LQG and TSD facilities mapped in Suffolk County to count the number of facilities in the richest and poorest quartiles. It was found that 34.0% of the facilities were located in the poorest quartile of blockgroups, median income of $21,615 or less, while 22.6% of facilities were found in the richest quartile, median income of $37,452 or higher (see figure 5).

Again the sample size allows us to use normal approximation of the binomial distribution to evaluate whether the observed value 34.0% of facilities residing in the

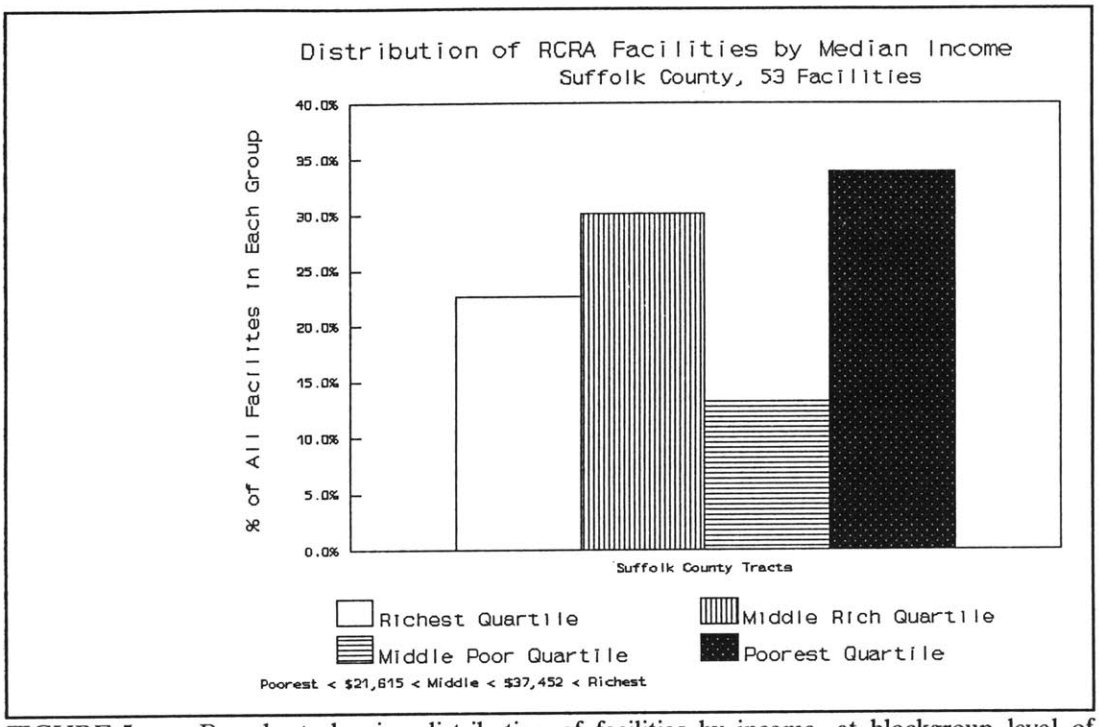


FIGURE 5. Bar chart showing distribution of facilities by income, at blockgroup level of aggregation.

poorest areas constituted 'statistically significant over-representation'. The statistical test implied that, given a sample size of 53, there is 17% probability that a value as extreme, or more extreme, than 34.0% would be observed. The same test indicated that there is a high probability of 77% that a value as extreme, or more extreme, than 22.6% of facilities residing in the richest areas would be observed.

Although the analyses described above looked at race and income discretely, this does not mean that the two factors are separate. In fact, if one looks at the racial composition of the poorest quartile, one finds that over 56% of those people individuals are people of color (see table 4 below). Again, decisions that the researcher makes in classifying groups of people can affect the results one observes. Analyzing the 'most-minority' areas is only one of many possible approaches and

does not fully explain the distribution of RCRA facilities by race.

Group	Total Population	Minority Population	% Minority
Richest Quartile	153624	31947	20.8%
Poorest Quartile	154844	88008	56.8%
County Total	**663906**	**251696**	**37.9%**

Table 4

It is interesting to note that while the United Church of Christ and the National Law Journal both found, based on nationwide studies and ZIP code demographic aggregations, that environmental conditions were more strongly biased based on race than on income, this does not seem to be the case in Suffolk County. The distribution of RCRA LQG and TSD facilities in Suffolk County may be biased toward the poorest blockgroups, but the most-minority blockgroups do not have a disproportionate share of facilities. However, the data also show that the majority of the 'poorest people' are people of color. The findings suggest that people of color are more likely to live near a RCRA facility because of their economic status.

3.3.3 DISTRIBUTION OF INSPECTIONS OF RCRA FACILITIES BY RACE AND INCOME GROUPINGS IN SUFFOLK COUNTY

This analysis explores the aforementioned hypothesis that facilities in minority communities may be more poorly inspected than those in predominantly white communities. It was hypothesized that for reasons of institutional racism and access to power, minority communities may have less access to the resources necessary to

rally EPA attention to problems in these communities. If this is the case, one could hypothesize that facilities in white communities are more likely to be inspected than facilities in minority communities.

Again, the general methods of analysis of the National Law Journal were followed to examine this hypothesis. The EPA CME data base was used to determine which of the 53 facilities in Suffolk County had been inspected or had had another type of enforcement action during the 5 year period from 1987 to 1992. The CME data base contains only records on facilities which have received an inspection, thus this data base could be related to the comprehensive data base of all RCRA LQG and TSD facilities to determine what percentage of all facilities were inspected during the time period. For Suffolk County as a whole, only 20 of the 53 (37.7%) facilities that were successfully addressmatched had been inspected or otherwise visited by EPA.

This time, the file of all 53 facilities was sorted by the percentage minority population of the census block, blockgroup or tract that the facility fell within. This analysis was performed at all three levels of census aggregation. Subsequently, the most-minority quartile of facilities and most-white quartile of facilities were determined by sorting the list on percent minority population and then dividing the list into fourths. In this analysis, a quartile had only 13 members (25% of 53). Next, the number of facilities that were inspected was counted for each quartile so that a percentage of facilities inspected could be determined. At the blockgroup level, 31% of facilities in the most-minority quartile had been inspected and 46% of facilities in

the most-white quartile had been inspected. At the tract level, 23% of facilities in the most-minority quartile had been inspected and 39% of facilities in the most-white quartile had been inspected.

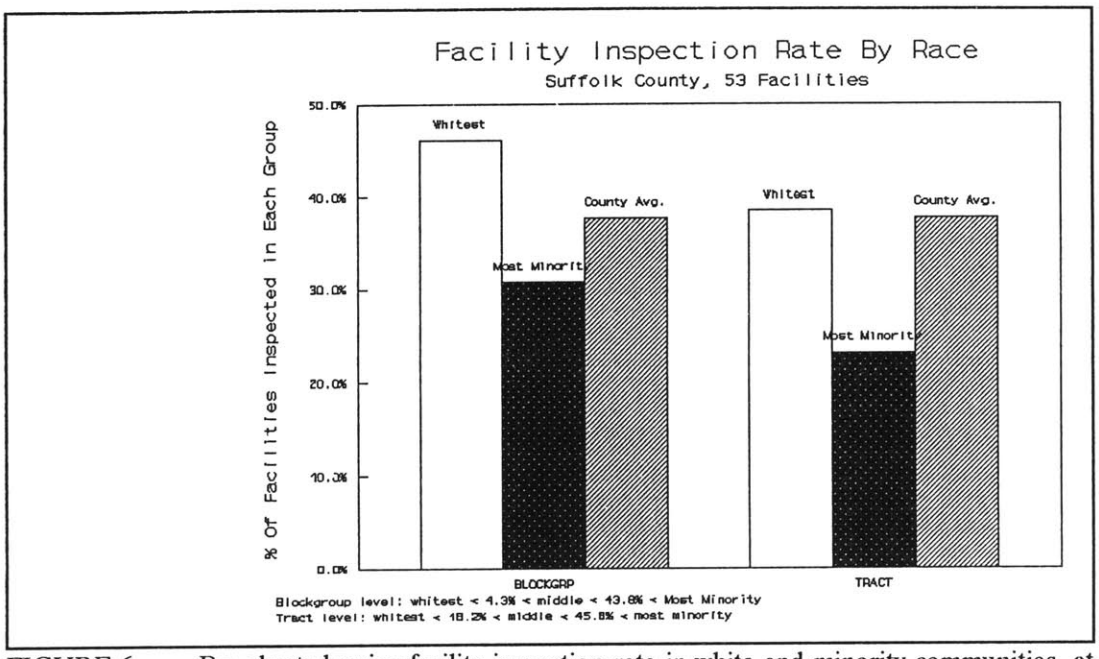


FIGURE 6. Bar chart showing facility inspection rate in white and minority communities, at both blockgroup and tract level of aggregation.

At the block level the general trend was reversed and 46% of facilities in the most-minority quartile had been inspected and 33% of facilities in the most-white quartile had been inspected. At the block level, the quartile break for 'most-white communities' was 0% minority population and 30 facilities fell into this group. Even though all other quartiles had only 13 members, 30 facilities fell into the bottom class. This overly high representation of facilities in the most-white quartile illustrates the aforementioned phenomena of the census block being too small a unit of aggregation. A large proportion of facilities are in census blocks with zero population and thus they artificially end up in the 'whitest quartile'. These facilities

may well be found in zero population census blocks within predominantly minority neighborhoods. This phenomena complicates the simple quartile analysis and likely makes the census block aggregation result bogus.

The same analysis was also conducted for the richest and poorest quartiles. The income based analysis was only performed at the census blockgroup level of aggregation. In the richest quartile of facilities 31% were inspected, while in the poorest quartile of facilities, 46% were inspected (see figure 7 and figure 8).

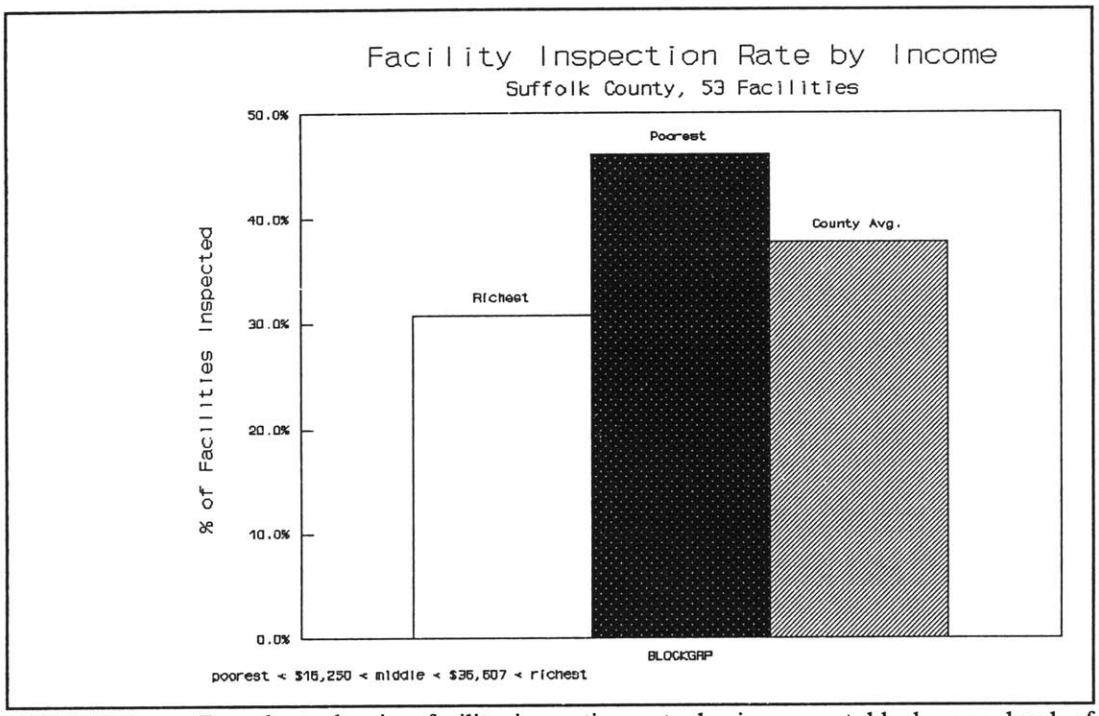


FIGURE 7. Bar chart showing facility inspection rate by income at blockgroup level of aggregation.

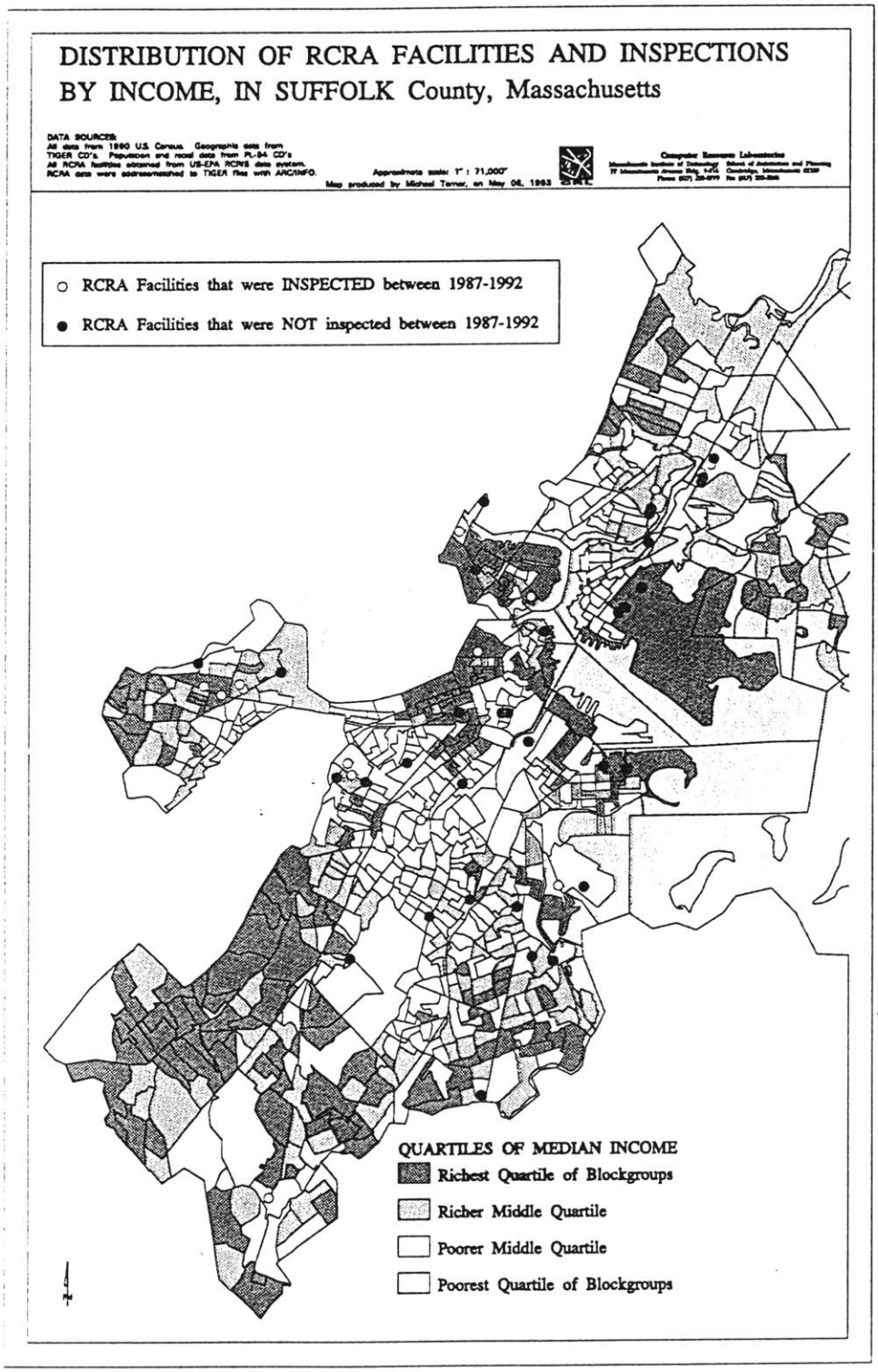
Due to the small sample size of 13 facilities per quartile, it is difficult to determine the statistical significance of these results. With this sample size the observed percentage can vary drastically with a difference of only one 'yes' or 'no' case. For example, if in a minority area one observes 7 of 13 facilities having an

inspection one would calculate an inspection rate of 53.8%. If only one more facility was inspected, 8 instead of 7, then the inspection rate would jump significantly to 61.5%. An expected value and standard deviation for the binomial probability distribution was calculated for the inspection rate data described above. The inspection rate for the entire county, 37.7% of facilities were inspected, was used as the expected probability when calculating the expected value and standard deviation within the quartiles. The results indicate that we would expect 4.8 of 13 facilities to be inspected with a standard deviation of 1.7 facilities in each quartile. At the blockgroup level, it was observed that 4 facilities were inspected in the most-minority areas, while 6 facilities were inspected in the most-white areas. Thus while neither result matched the rounded expected value of 5, both were within a single standard deviation. These results reinforce the impression that although there are observed differences in inspection rates, the small sample size precludes detecting statistically significant bias.

3.3.4 DISTRIBUTION OF INSPECTIONS OF RCRA FACILITIES BY RACE IN SIX COUNTY STUDY AREA

Even though the sample of 204 addressmatched facilities was not considered a random sample, EPA's performance in inspecting these facilities was evaluated. This evaluation attempted to explore whether a county by county disaggregation is useful in data interpretation and ultimately for policy development. One should recall that the two largest quantitative studies documenting environmental inequity reported conclusions based on data aggregated on a nationwide basis. This study first focuses on Massachusetts to see how it might compare to the nationwide trend

FIGURE 8.


DISTRIBUTION OF RCRA FACILITIES AND INSPECTIONS
BY INCOME, IN SUFFOLK County, Massachusetts
DATA SOURCES:
All data from 1990 U.S. Census. Geographic data from
TIGER CD's. Population and racial data from PL-94 CD's.
All RCRA facilities obtained from US-EPA RCRIS data system.
RCRA data were address-matched to TIGER files with ARC/INFO.
Approximate scale: 1" : 71,000'
Map produced by Michael Turner, on May 06, 1993
RCRA Facilities that were INSPECTED between 1987-1992
RCRA Facilities that were NOT inspected between 1987-1992
QUARTILES OF MEDIAN INCOME
Richest Quartile of Blockgroups
Richer Middle Quartile
Poorer Middle Quartile
Poorest Quartile of Blockgroups

data reported by United Church of Christ and the National Law Journal, and second it looks at variations within individual counties within Massachusetts.

Within the six county study area, a total of 121 of 204 (59%) facilities were inspected between 1987 and 1992. As table 5 demonstrates, there was a large variance in both the number of facilities and the inspection rate of individual counties. In Worcester county almost 90% of automatically addressmatched facilities were inspected, while in Suffolk county less than 50% of automatically addressmatched facilities were inspected.

County	Total Address-matched Facilities	Number Inspected	Number **Not** Inspected	Percent Inspected
Essex	26	19	7	73.1%
Hampden	23	13	10	56.5%
Middlesex	85	51	34	60.0%
Norfolk	18	11	7	61.1%
Suffolk	27	13	14	48.1%
Worcester	25	22	3	88.0%
ALL Cos. Totaled	**204**	**129**	**75**	**63.2%**

Table 5

The entire sample of 204 facilities was used to look at whether potential bias was evident when aggregating many counties together. To do this, the sample was divided into quartiles of 51 facilities each. Next, the most-minority quartile and most-white quartile were identified. Finally, the inspection rate was calculated for

the most-minority and whitest areas separately. At the blockgroup level it was found that 62.7% of facilities in the most-minority areas were inspected while 54.9% of facilities in the most-white areas were inspected. At the tract level 66.7% of facilities in the most-minority areas were inspected and 56.9% of facilities in the most white areas were inspected.

A normal approximation of the binomial distribution was used to determine if these observed results varied from the overall inspection rate of 63.2% for all 204 facilities in the 6 county study area. At both the tract and blockgroup level there did not appear to be much bias against inspecting facilities located in the most minority areas. There was an over 55% probability that results as extreme as the observed most-minority area inspection rates would be observed if inspections were doled out randomly to 63.2% of all facilities. Also, there is not much certainty in concluding that there is bias against inspecting facilities in the most white areas. There was an over 22% probability that the extremeness of the observed inspection rate would be due to random variation.

It is interesting to note that disaggregating individual counties from a multiple county grouping seems to make a difference. In Suffolk county, facilities in minority areas had a **lower** inspection rate than facilities white areas, while in the six county study area facilities in minority areas had a **higher** inspection rate than facilities in white areas. While these particular samples have some statistical limitations, the results imply that disaggregation to a county level may be useful in better understanding issues of environmental equity. This makes intuitive sense due to the

very different general characteristics of counties (e.g. rural vs. urban vs. suburban counties).

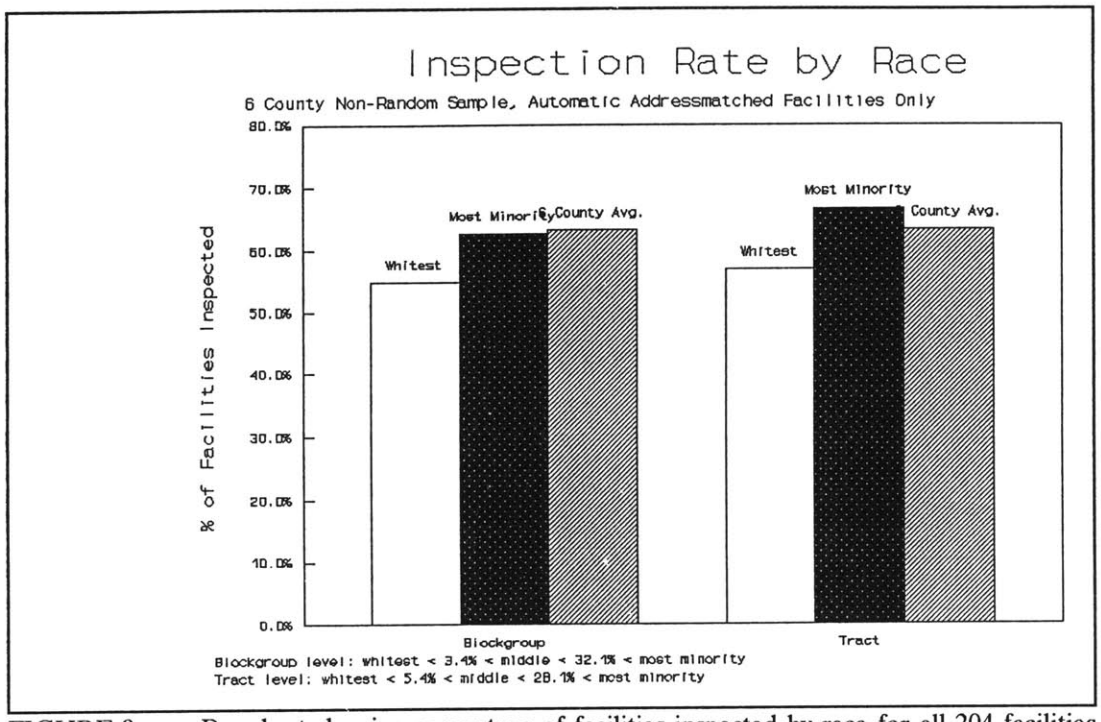


FIGURE 9. Bar chart showing percentage of facilities inspected by race for all 204 facilities aggregated together at both blockgroup and tract level.

The same type of inspection rate analysis was conducted looking at each county separately. It was found that the same county by county variability observed in looking at overall inspection rates was also observed when looking at potential racial biases in the facilities that were inspected. The same methods used for Suffolk county, described above in section 3.3, were followed for the automatically addressmatched sample in the six county study area. These analyses were performed at the block, blockgroup and tract levels of aggregation. As described above in 3.3, the level of aggregation affected the specific results. While the general trend was the same for blockgroup and tract, the block level analysis is impacted by zero

population census blocks to the point where the trend is reversed.

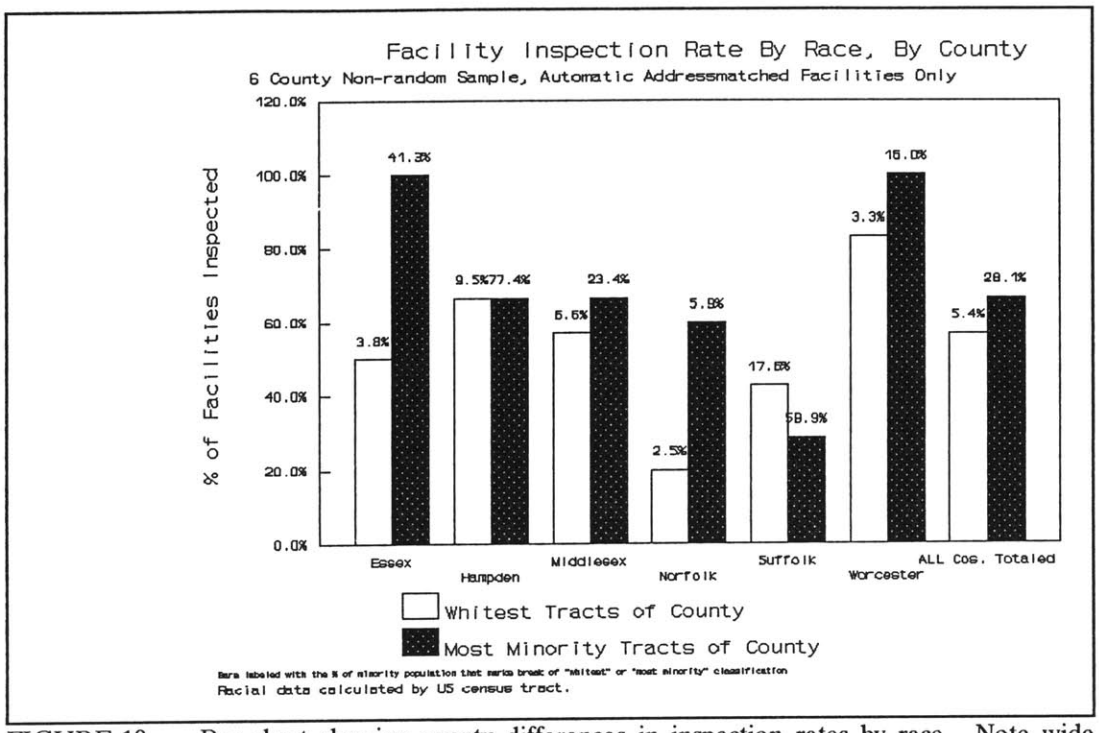


FIGURE 10. Bar chart showing county differences in inspection rates by race. Note wide variance in the break points for racial classification (bar chart labels).

When looking at individual counties at the blockgroup level of aggregation, three counties showed minority areas receiving a higher rate of inspection, and three counties showed minority and white areas having the same inspection rate. At the tract level of aggregation, four counties showed minority areas receiving a higher rate of inspection, one county showed minority areas having a lower rate of inspection

and one county had the same inspection rate for minority and white areas[13].

Again, the relatively small sample size makes assessing the significance of variations in the inspection rate difficult. However, the data seem to imply that there is not wholesale bias against inspecting facilities located in minority areas. Additionally, these data imply that regional differences in inspection rate are apparent at the county level. The EPA, or its state government counterpart, the Massachusetts Department of Environmental Protection (DEP), may want to examine county by county performance on both overall inspection rates, as well as potential racial or economic biases in which facilities get inspected.

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[13] In Suffolk county there did not appear to be a significant difference between the inspection rates of the 27 facilities that were automatically addressmatched and the full sample of 53 facilities. While the percentages varied, the overall trend held. For the automatically addressmatched facilities, at the blockgroup level, a slightly higher percentage of facilities in the most-white areas were inspected, 42% in white areas, 29% in minority areas. For all 53 facilities, at the tract level, 38.5% were inspected in the most-white areas and 23.1% were inspected in the most-minority areas. Again, it was difficult to find any significance in these results due to very small sample sizes in these tests.

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 OVERVIEW

This thesis is primarily an exploration of analytic methods that can be used to support policy and decision making aimed at redressing environmental inequity. Obviously, assembling clear information on the many manifestations of this problem is an important aspect of developing fair and effective policy. Simply stated, one must understand the problems before one is able to solve the problems. The following discusses some of the limitations of this study and outlines areas for further inquiry. The chapter then summarizes the main conclusions and recommendations that are drawn from this thesis. The recommendations listed below pertain to the technical aspects of data collection and data analysis, as well as to the broader issues of developing an approach to addressing the concerns of the environmental equity movement.

4.2 DISCUSSION OF FINDINGS

Like most studies, this study was conducted using a set of hypotheses and assumptions. This section of the thesis outlines alternative interpretations of the findings discussed in chapter 3 and presents some alternative assumptions that might imply opportunities for further research.

4.2.1 ASSUMPTION OF EQUALITY OF INSPECTION RESOURCES MAY BE FAULTY.

This thesis argued that EPA should assign roughly equal priority to inspecting

facilities in the same category of the RCRA program. It was argued that all RCRA LQG and TSD should be inspected under the same policy. In fact, EPA already differentiates between facilities in the LQG and TSD categories. It was noted that **all** commercial TSD facilities and **all** land disposal facilities must be inspected every year. Further, TSDs must be inspected every other year. Since over 90% of the facilities fall into the LQG category, one could argue that similar differentiation may be applicable. Perhaps the largest LQGs should be inspected more often. Perhaps facilities handling the most toxic chemical, or located nearest to sensitive natural resources should be inspected more frequently. If this was the case, then one would expect EPA inspection patterns to follow the distribution of the 'biggest' or 'worst' facilities. Any bias that was detected might be a function of the **societal factors** that lead to the siting of these facilities, not a bias in EPA's **inspection or resource allocation policy**.

4.2.2 'UNDER REPRESENTATION' OF RCRA FACILITIES IN MINORITY COMMUNITIES MAY REPRESENT INDUSTRIAL DISINVESTMENT FROM THESE NEIGHBORHOODS

Unlike the United Church of Christ study which looked at *commercial hazardous waste facilities*, this study looked at the full universe of the largest RCRA facilities. The universe of TSDs and LQGs includes both commercial hazardous waste treatment and disposal facilities as well as *manufacturing facilities* which use hazardous materials in the production process. The UCC found that commercial facilities seemed to be concentrated in minority areas. This study found that, if anything, TSDs and LQGs were found less often in minority areas. Such a finding

may be more indicative of a general disinvestment by manufacturing operations, than it is of less hazardous environmental conditions in minority areas. The UCC may be correct in its observations that the worst of facilities regulated by RCRA are concentrated in minority areas, while the less hazardous manufacturing facilities, and the jobs that they provide, are more concentrated in other areas.

4.2.3 NATIONAL STUDIES MAY BE RELEVANT FOR EPA PROGRAMS THAT INVOLVE SMALL NUMBERS OF FACILITIES.

While this study critiques the UCC and NLJ studies for both their level of aggregation and the potential limitations of their nationwide scope, national studies remain important and relevant. First, the U.S. government and its agencies institute national laws and policies. In some cases, specific implementation is conducted on a regional basis, but the institution of the law must occur in a the national congress. Thus, to convince law makers that problems are national in scope, nationwide data must be assembled. Second, both the UCC and NLJ looked at relatively rare facilities or phenomena. The UCC looked at commercial TSD facilities. In Massachusetts there were only 6 of these facilities and there were only 21 in all of New England. The NLJ looked at EPA enforcement actions where penalties were levied. From 1985 to 1991 there were only a little over 1,000 cases in the entire country. Thus, due to the small sample sizes in these areas of inquiry, there is limited ability to conduct statistically significant analyses on a less-than-national basis.

At the same time, there is no technical reason that such analyses could not be conducted, even on a nationwide basis, at finer levels of aggregation. In fact, this thesis argues that the one-time-only nature of these studies is not necessary. EPA

maintains the equipment and technical expertise necessary to measure for environmental equity as part of its normal programmatic review process. If EPA views environmental equity as a priority, they have the ability to use their internal data[14] in association with 1990 census data, assembled at the blockgroup or tract level, to routinely evaluate environmental equity.

4.2.4 MEASUREMENT OF INEQUITY IN METROPOLITAN AREAS, DISCOUNTS THE FACT THAT MOST OF THE MINORITY POPULATION IS ALREADY CONCENTRATED IN THESE AREAS.

Just as aggregation can potentially mask subtleties in environmental equity data, disaggregation to the county level can mask other effects. In this study, environmental equity was measured on a county by county basis. The 'most minority' and 'most white' areas of each county were examined. Even when multiple counties were combined to look at 'regional' equity issues, certain counties were omitted from the analysis. This was partly done because the vast majority (83%) of facilities were found in this subset of counties. But, this disaggregation masks the fact that most people of color are concentrated in the metropolitan areas which house the vast majority of facilities. Over 87% of the minority population is concentrated the six 'metropolitan' counties that house 83% of the facilities. Thus, this thesis does not explore macro-trends of facility and minority coincidence that are only observed at the more aggregate, statewide level.

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[14] The UCC, NLJ and researcher conducting this thesis all began their inquiries with requests for programmatic information from the EPA.

4.3 CONCLUSIONS

The following bullets describe the major general conclusions of this inquiry:

- Geographic information systems (GIS) and relational data base management systems (RDBMS) are effective and appropriate tools for assessing the extent of environmental equity/inequity.

- The 1990 U.S. Census provides invaluable data for developing a picture of current environmental equity issues. Further, the 1990 Census data products are formatted in a way that greatly facilitates the use of GIS and RDBMS.

- The same techniques for evaluating equity applied by this thesis to the RCRA program, could be modified for use in other EPA or state regulatory programs.

- Equity issues are one of several factors that EPA should evaluate when making prioritization and resource allocation decisions. Other factors might include health risks or protection of natural resources. Some of the same GIS and RDBMS techniques used for equity assessments can be used to explore issues of facility proximity to natural resources such as wetlands, public water supplies or aquifers.

- In looking at the distribution of RCRA facilities and the allocation of inspection resources across communities of different ethnic and economic makeup, in Massachusetts, different patterns were observed on a county by county basis.

- Broad, nationwide studies documenting environmental inequity are useful, however, they do not show the whole picture. More detailed regional and program specific studies are feasible to conduct and are useful for explaining regional variations from national trends.

- The methods used to classify populations based on race or economic condition can affect the measures of how much equity or inequity one observes. Factors, such as level of data aggregation, play an important role and should be studied further.

- It is important to explore potential environmental inequity in **both** racial and economic class contexts. Efforts to redress one type of inequity over the other may serve to foster continued inequity in the other group.

4.4 RECOMMENDATIONS

The following bullets outline major recommendations based on the conclusions listed above:

- EPA should aggressively implement its Locational Data Policy of May 1990. While the policy outlines a 1995 goal for having all regulated facilities mapped, these locational data could provide a critical resource for environmental equity investigators now. Locational data should be integrated into the RCRIS system so that freedom of information requestors are provided existing locational information.

- In light of the complexities of issues of environmental equity and regional differences in settlement patterns across the United States, EPA should consider developing regional approaches to redressing environmental inequity. In some areas race may be the preeminent determinant of inequity, in other areas economic status may be the primary determinant. Calling for redressing inequity as a national goal is appropriate, however, specific implementation to reach that goal should be pursued on a state by state, if not county by county, basis.

- Census tract and blockgroup data aggregations are most appropriate for exploring issues of environmental equity on a regional basis. These units of geography are large enough to capture a meaningful and representative number of people for classification by race or economic condition, but they are also small enough to identify relatively small clusters of people within larger, homogenous areas. Also, GIS can be used to aggregate data to other geographic units determined not by the census, but by government agencies (state, regional or municipal) or community organizations which work at the community or neighborhood levels.

- EPA should consider developing program by program evaluations of environmental equity. These evaluations should examine both the base line distribution of facilities among different types of communities as well as EPA's performance in prioritizing facilities for EPA enforcement action. In addition EPA should review its policy in allocating resources, such as funds for cleanup, to facilities, based on race and economic class criteria.

4.5 SUMMARY

In summary, environmental equity is a complex issue. Not only is description of the many manifestations of the problems of inequity difficult, but also the analytic

techniques of quantifying inequity are intricate and contingent on trade-offs and subjective decisions made by the researcher.

Equally, there are many options for attempting to overcome inequity. Options include: instituting programmatic prioritization and resource allocation criteria to insure equity; avoiding the siting of additional noxious facilities in already burdened minority communities; and providing communities which face environmental inequity with resources that can create environmental ***amenities*** which can partly offset other environmental risks. Good information and appropriate analytic techniques will doubtless play an important role in better understanding the problems and crafting workable solutions.

Both government and the environmental equity advocacy community should begin the process of building a consensus on what measures should be taken to redress inequity, and move towards environmental justice.

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