GIS Methods for Screening Potential Environmental Justice Areas in New England

By
Chitra M. Kumar

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Author

Department of Urban Studies and Planning
May 17, 2002

Certified by

Professor Joseph Ferreira, Jr.
Department of Urban Studies and Planning
Thesis Supervisor

Accepted by

Professor Dennis Frenchman
Chair, MCP Committee
Department of Urban Studies and Planning
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Chitra M. Kumar

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Abstract

Over the past decade scholars, scientists, and community advocates have argued that minority and low-income communities have been exposed to disproportionate amounts of hazardous pollution as a result of systematic biases in policy making and discriminatory market forces. Geographic Information Systems (GIS) is an important tool used to assist regulatory agencies in identifying these potentially vulnerable or “potential environmental justice” areas so that programmatic decision-making can incorporate EJ concerns. Yet, few studies have documented or evaluated methodologies for EJ-GIS analyses utilized by public agencies.

This paper explores various methodologies that approximate where communities at risk of disproportionate burden may be with respect to the unique character and composition of New England. Specific variables explored are race/ethnicity, poverty, and population density. For each variable a scale and threshold/reference value is determined; also, the possibility of establishing a ranking system was contemplated. The importance of investigating spatial clustering and integrating variables into combined criteria was also discussed.

This research began with the problem being framed. Then, a survey of the literature and public institutions was done to identify relevant practices and state-of-the-art technology in environmental justice analysis. Next, a process was designed to develop and select an appropriate methodology. This process included meeting systematically with members of the U.S. Environmental Protection Agency New England GIS team and Mapping Workgroup of the Environmental Justice Council to discuss and compare various methods of analysis. Based on research results, recommendations were made to the EPA New England regional office on how to improve their demographic mapping system. These recommendations are hoped to be adopted by EPA New England and introduced in a desktop GIS tool by the end of 2002.

Thesis Supervisor: Joseph Ferreira, Jr.
Title: Professor
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A special thanks goes to Chrissy for staying late with me on many occasions to distill these issues, help me make maps, present information to the Workgroup, proof my drafts, and just being herself. I would also like to extend my appreciation to the GIS team at EPA for providing entertainment and "Snack-Shack" runs over these last several months.

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I dedicate this to my family and friends who have lavished their love and support on me through the years.
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Introduction

Over the past decade scholars, scientists, and community advocates have argued that minority and low-income communities have been exposed to disproportionate amounts of hazardous pollution as a result of systematic biases in policy making and discriminatory market forces. Facing activist pressure and seeing greater evidence for "environmental justice", President Clinton issued Executive Order 12898 in February 1994, requiring all federal agencies to examine the effects of their policy-making, regulatory, and enforcement activities with regards to environmental justice concerns. Consequently, promoting environmental justice (EJ) -- defined by the Environmental Protection Agency Office of Environmental Justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies\(^1\) -- became one of the US Environmental Protection Agency's top priorities.

As EJ was becoming an important concept, in 1993 EPA New England created a methodology for mapping demographic characteristics of the Region using geographic information systems (GIS). GIS allows users to spatially correlate data in order to identify "Potential Environmental Justice Areas". Since the time when the first methodology was conceived, analytic tools, data availability, and geographic mapping capabilities have greatly advanced. In response to these changes and an improved knowledge-base about EJ issues, the Region's Office Directors chartered an Environmental Justice Council in 1999 with the goal of institutionalizing EJ philosophy and principles in the Region's daily program activities. The EJ Council's Mapping Workgroup, a subset of the larger Council, was tasked

To develop a computer-based Environmental Justice mapping tool covering all six New England States which is accessible to EPA New England personnel through the desktop PC and provides useful data regarding Environmental Justice issues such that Environmental Justice becomes better incorporated into the day-to-day work of the Region (U.S. EPA, Action Plan, 2001).

The key requirements of the tool were that it allow the Region to prioritize its permitting and inspection resources and that it help the Agency move from a primarily reactive, site-specific analysis that responds to complaints, to a proactive, region-wide programmatic decision-making tool. This paper aids their mandate by exploring various methodologies to identify one that better approximates where communities at risk of disproportionate burden may be. Specifically, I will investigate different statistical methodologies to perform demographic analyses using GIS.

Environmental indicators, such as facility locations and risk indices, are crucial to understanding the extent of health risk posed to communities and thus should be a part of an agency screening tool. However, because risk assessment techniques are so variable and contentious and other proxy data may be misleading or may not be available across the Region, much work needs to be done before including environmental indicators into a screening tool. Therefore, this thesis suggests appropriate methods for developing only a demographic screen, anticipating the future creation of an additional environmental screen.

**Objectives**

The main objective of this research is to identify a defensible methodology for EPA New England to use in a new EJ mapping tool that employees will access using the agency Intranet. This tool will incorporate demographic variables into a preliminary EJ index that will narrow the number of communities in which environmental justice problems might exist. The screening tool will assist EPA programs in targeting resources and will raise staff awareness of EJ concerns by providing a tangible method for prioritizing EPA examination of a potentially contentious policy issue.

**Scope**

The scope of my research is limited foremost by the availability of data. Any data layer chosen must be available for all the New England States (Massachusetts, Vermont, New Hampshire, Maine, Rhode Island, and Connecticut). Because each state has its own data collection and storage mechanisms, finding data that is interpretable across state boundaries other than through Federal sources may be currently impossible.

Moreover, the methodology may not be generalizable beyond New England because it should be sensitive to the socio-economic character of this region. For instance, poverty indices should reflect the higher cost of living in New England compared to some of the largely rural western regions. Also, EPA would like the methodology to be easily applied to all states in the entire region, easily explained to users, and the resulting maps easily understood. These requests bound the level of complexity of statistical techniques explored and serve as a few of the evaluation criteria for the methodology.

**Current Practice**

EPA Region 1 has a regional screening methodology and EJ ranking scheme that rank orders and categorizes census block group percentages of minority and low-income people in categories of 25 percent and assigns a point scale with each consecutive category receiving one point higher; no reference value is used (Figure 1). Map 1,
"Potential Environmental Justice Areas in New England," and Map 2, "Potential Environmental Justice Areas Around Boston, MA," portray the current methodology. Map 2 is at a much larger scale than Map 1 to provide a closer look of neighborhood data.

**Figure 1. Current EPA New England EJ Screening Methodology**

<table>
<thead>
<tr>
<th>The areas are ranked relative to each other. Each block group is assigned a score based on both minority population and income, which are then added together. The scores are assigned according to the following point system:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 25% minority population</td>
</tr>
<tr>
<td>25% &lt; 50% minority population</td>
</tr>
<tr>
<td>50% &lt; 75% minority population</td>
</tr>
<tr>
<td>75% or more minority population</td>
</tr>
<tr>
<td>Less than 25% of population income is less than 200% of established federal poverty level (FPL)</td>
</tr>
<tr>
<td>25% &lt; 50% of population income is less than 200% of established federal poverty level (FPL)</td>
</tr>
<tr>
<td>50% &lt; 75% of population income is less than 200% of established federal poverty level (FPL)</td>
</tr>
<tr>
<td>75% or of population income is less than 200% of established federal poverty level (FPL)</td>
</tr>
</tbody>
</table>

There are several specific problems with the current demographic screening methodology. First, originally, EPA Region 1's model was developed using towns as the unit of analysis and only in recent years was adapted to use block group data. Using towns in the development phase may have resulted in a method that is much too coarse to confidently detect potential environmental justice areas, which can vary by neighborhood. Also, income comparisons, currently measured as percentage of people in a block group within 200 percent of the census-defined poverty threshold, do not reflect differences in cost of living between and within states. In addition, the current methodology incorporates a ranking system that weights areas with greater percentages of minorities more heavily than areas with the same percentage of poor. As a result, the vulnerability of some low-income rural areas may be obscured.

**Methods**

After framing the problem, there were several phases to my research. First, I surveyed the literature and public institutions to identify relevant practices and state-of-the-art
technology in environmental justice analysis. Then, I defined key questions to explore and formulate the process by which I would develop and select an appropriate methodology. This process included meeting systematically with members of the EPA New England GIS team and the Mapping Workgroup of the Environmental Justice Council to discuss and compare various methods of analysis. Each phase of this process will be documented in this thesis.
Mapping Low Income and Minority Populations

The areas in this map are ranked relative to each other. Each block group is assigned a score based on minority population and income, which are then added together. The scores are assigned according to the following point system:

- Less than 25% minority population: 0 points
- 25% < 50% minority population: 2 points
- 50% < 75% minority population: 3 points
- 75% or more minority population: 4 points

- Less than 25% of population income is less than 200% of established federal poverty level (FPL): 0 points
- 25% < 50% of population income is less than 200% of established federal poverty level (FPL): 1 point
- 50% < 75% of population income is less than 200% of established federal poverty level (FPL): 2 points
- 75% or more population income is less than 200% of established federal poverty level (FPL): 3 points

**Map 1. Potential Environmental Justice Areas (block groups) in New England:**

Current EPA Region 1 Methodology

Chapter 1. Background and Literature Review

To begin such a task, it is important to understand the socio-political history of environmental justice, the state-of-the-art in environmental justice screening, and the role of screening in regulatory agencies. This information provides insight into commonly used options and pitfalls for developing a GIS tool.

Existence of Environmental Injustice

Many previous studies have shown the existence of a relationship between the locations of regulated facilities and underrepresented racial/ethnic populations. Some articles, like Anderton et al. (1994a), Morello-Frosch et al. (2001), and Lejano and Iseki (2001) specify that Hispanic communities are disproportionately located near potentially polluting facilities. In addition, several studies have shown that income level is inversely associated with morbidity and disproportionate environmental burden, such as proximity to hazardous facilities and exposure to particulate air pollution.

A body of literature criticizing these findings has arisen, which point to market forces or methodological problems as misleading the results of studies that support environmental justice claims. Despite these contradictory findings, Clinton issued Executive Order 12898, presumably in recognition of the historic socio-economic and political conditions that have disadvantaged low income and minority communities for centuries. Well documented characteristics of these communities include limited residential and economic mobility, political disenfranchisement, and limited community resources, as

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3 Gragg III, 1-25.
6 Bullard, Unequal Protection; Morello-Frosch, Rachel, Manuel Pastor, and James Sadd, 557.
well as higher mortality rates. Furthermore, disadvantaged groups face increased risks from social and behavioral health determinants (e.g. smoking, poor diet), creating a "double jeopardy" effect if environmental hazard exposures exist.

If such conditions truly exist, these disadvantaged groups stand the most to gain by changing regulatory practices to better protect their health. Given that the federal government has accepted the principles of environmental justice, the task of this thesis is to develop an improved screening methodology for identifying New England communities most vulnerable to incremental increases in pollution (henceforth referred to as potential EJ areas), so that resources can be appropriated accordingly. This strategy aims to prevent (or even reverse) severe cases of exposure prior to individual complaints arising.

**State-of-the-Art Methods**

Many early studies used simple univariate analysis, while later studies used multivariate or more sophisticated statistical techniques to examine relationships between certain populations and environmental factors. More and more, GIS and spatial analysis techniques have been used to both supplement and supersede traditional statistical packages to display and spatially correlate data. Prospects and problems associated with adoption of GIS as an analysis tool for EJ are discussed in the Analysis and Results chapter (#3).

**Environmental Justice Screening in Federal Government**

Most academic studies deal with "proving" or disproving the existence of inequities.

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8 Jarret, 971.
9 For univariate methods see Anderton et al, 1994a, b.
based on race and class, and identifying appropriate indicators that predict such a relationship. In contrast, public agencies attempt to utilize promising indicators to guide regulatory decision-making. Few studies examining public agency decision tools for environmental justice concerns have been conducted. One recent noteworthy article, by Bradford Mank (2001), sheds light on the statistical techniques used to prove Title VI and Title VII cases, with particular attention on determining comparison populations, or reference values. Other articles report on use of GIS to measure environmental risk as well as potential EJ areas.

In order to fill the gap of information on the practice of incorporating EJ concerns into a government agency, the EPA conducted and released a survey of the ten EPA regional offices and EPA Headquarters in 2001, probing into EJ screening tools used in those offices. This landmark survey was among the first to report on GIS screening methods used in the agency primarily responsible for overseeing environmental justice affairs. EPA and the Department of Transportation are two government agencies that use GIS for environmental justice applications in a systematic manner and, thus, can provide important insight into the development of a new methodology for an EJ screen in New England.

The 2001 survey found that EPA does not use sophisticated statistical models to identify potential environmental justice areas, but rather simple and easy to understand spatial screens. More advanced environmental models may be used on a program-specific or case-specific basis, but are not instituted agency-wide or even region-wide. The most relevant information from the survey is displayed in Appendix B.

This thesis hopes to further the understanding of appropriate use of GIS for environmental justice analysis and provide recommendations for the creation of an EJ screening tool by EPA Region 1.

The following sections describe the approaches from the literature and Agency practice on several fundamental concepts in developing a GIS tool for EJ analysis.

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12 Title VI of the Civil Rights Act of 1964 prohibits discrimination in federally funded programs, and Title VII prohibits employment discrimination in cases where the employer practices interstate commerce.

13 366-428.


Level of Geography

There is little consistency on even the level of geography used by previous environmental justice studies that utilize GIS. Most academic studies use tracts as the smallest unit of analysis, while some use zip codes or even towns. Furthermore, many studies concentrate on a small area in order to flesh out a specific methodology.

Studies comparing different units of analysis have corroborated that changing the spatial scales leads to varied conclusions. For example, a paper by S.L. Cutter, D. Holm, and L. Clark (1996) showed that the median household income of tracts with certain regulated facilities was 5% lower than those without a facility. Meanwhile, this same association was not found when using block groups. Instead, "block groups hosting facilities were characterized by higher populations, higher percentages of children, poorer education levels, and higher percentages of residents working in laboring professions."

There is consensus among academe and government that the appropriate spatial unit depends upon the goal of the research and the scale at which data is available for all variables incorporated in the methodology. Because EJ is such a localized issue, focusing on the smallest unit of area possible can help to isolate areas of concern. However, disaggregating too much can render analysis meaningless because there would be nothing left to average together that would help suggest a level of concern for an area. For instance, disaggregating to the housing unit level could identify individual household or family characteristics but would say nothing of neighborhood or community phenomena.

Variables of Interest

Many variables have been identified in the literature and are commonly used by regulatory agencies as indicators of the level of community well-being or potential

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18 (Faber, 2001)
20 Cutter, Holm, and Clark, 523.
vulnerability to environmental injustice. Two of these demographic variables are race/ethnicity and income, though they may be measured in different ways. For example, all ten of EPA's regions (Appendix B), EPA Headquarters and the Department of Transportation, incorporate measures of race and income in their studies. Furthermore, racial/ethnic minority and income are indicators that are consistent with the mission of the US Executive Order 12898 and subsequent environmental justice policies.

Another criterion that could be highly correlated with EJ disputes and could play into resource targeting is population density. This correlation exists because polluting facilities such as those listed in EPA's Toxic Release Inventory (TRI) and as Treatment, Storage, and Disposal Facilities (TSDFs) tend to site in densely populated or urbanized areas where they can gain from public services and infrastructure developed around industrial land uses. Industrial land uses, in turn, are in areas that are economically depressed to take advantage of cheap land values. These areas are also where poor and minority communities reside because of availability of inexpensive or public housing.

Many academic studies have investigated the association between population density and disparate impact and have reported equivocal results. Some use the census definition of urbanized area (UA) as a proxy for population density because it acknowledges that a minimum concentration of population is necessary to gain economies of scale, which is desirable for industries; it requires a level of infrastructure development (or built-up area) that could facilitate new development; and it represents areas where higher land value and, thereby, higher cost of living might be. Moreover, for various socio-political reasons minorities tend to be concentrated in urban areas. One study that examines the composition of communities surrounding targeted environmentally hazardous sites considers urban areas separately from rural areas. This study found that households in mostly urban areas were more likely to be near facilities than households in mostly rural areas. Embracing this theory, EPA Region 2 (New York, New Jersey, Puerto Rico, and the Virgin Islands) incorporates urban and rural criteria into their methodology (see Appendix B). Only one other EPA region (Region 6) includes population density in its definition. Most other regions leave population density or urbanized areas as an optional layer.

The literature and EPA have identified other demographic variables that predict the existence of potential EJ areas with varying strength. These variables include:

- dwelling value,
• unemployment,
• rates of home ownership,
• tribal lands,
• language(s) spoken,
• level of education,
• age of housing, and
• age of household member.

Some frequently included indicators that go beyond demographics are various land uses (e.g., industrial, commercial, transport),

health data (e.g., blood lead levels, asthma cases, cancer rates, mortality), permit violations, and recent regulatory inspections. These proxies for community vulnerability can provide valuable additional information on where to focus Agency attention.

For each issue of concern, (a) an appropriate measure or indicator and (b) a threshold, dividing the category into groups (i.e., high and low), must be chosen. Defining measures requires an understanding of the various ways to gather those data. For example, one could measure income as per capita income, household income, family income, or by using the FPL. The benefits and limitations of definitions are discussed in depth in Chapter 3.

Approaches for Setting Thresholds

Setting a threshold involves dividing a scale of variable values into high and low groups. To do this methodologies that do not use regression or correlation analysis often subscribe to the use of "reference values," or comparison values, computed from larger geographic areas than the study area. Several different levels of geography could be used to set this reference value: town, county, metropolitan area, state, entire New England region, or the nation. Each has validity depending on its use, as described in Chapter 3. Environmental Defense's Scorecard on-line EJ mapper uses the next largest political boundary for each of its comparisons (i.e., when doing county analysis they use a state reference value; when doing state analysis, they use a national reference value).

Of the ten EPA regions, seven currently perform comparative analysis. Five regions

27 Jarret, et al.
28 Morello-Frosh, Pastor, Sadd.
29 Chitra M. Kumar, 19-22.
30 Scorecard is a web site with free, easily accessible, and comprehensive local environmental information. The site compares environmental hazards in areas across the US using data from scientific and government sources. Scorecard was created to build public awareness and promote communities' right-to-know. For more see: Scorecard from Environmental Defense, “About Scorecard,” 2002, <http://www.scorecard.org/about/about.tcl> (21 April 2002).
compare a selected area’s low-income percentage with the state average and four regions compare minority percentage with the state average. One region multiplies the state average by 1.2 to find the low-income threshold, while two regions do the same for the minority threshold. Some regions included county averages for a comparison threshold, as well, but did not use this as an automatic default in their tool. Meanwhile, Region 2 uses cluster analysis, a more complex and statistically sophisticated method, to calculate thresholds for both low income and minority.

Another way to set a reference value, used by Scorecard and in some Title VI cases, is comparisons with another community with similar physical, demographic, and/or economic attributes in an entirely different geographic area. This form of using comparison locations has been criticized by some for being unnecessarily complicated to characterize areas, weighing which factors should be similar in order to deem it a reference area, and often this can lead to inappropriate comparisons. For example, a high minority urban area need not be compared only to another urban area when determining potential vulnerability to health risk, as this method might suggest.

Once a level of geography is selected, one must decide whether to use an absolute scale (e.g. mean) or a relative scale (e.g. percentile) to create a cut-off. Many academic studies on EJ use medians or percentiles rather than means when determining cut-offs because the median is the measure of central tendency that is not affected by outliers. However, no EPA region uses the percentile approach (Appendix B).

Also, the level that determines what is an extreme value must be decided. The mean or median value represents the ordinary or normal value, while a multiple of the mean or a higher percentile than the 50th would constitute a situation outside of the usual. This is why agencies like Housing and Urban Development use some percentage of the median household income when setting income limits for their tax credit and other programs. A few EPA regions use 120% or 150% of the mean to identify the extraordinarily high percentage block groups for minority and low-income (Appendix B).

In setting a threshold, one must also consider if there should be a minimum number or percentage of people in an area who meet certain criteria in order to constitute an area of concern. For example, should an area with only 2% minorities require regulatory action based on allegations of disproportionate impact? Guidance written for other federal agencies (Federal Highway Administration, Federal Transit Authority, Department of Transportation) explicitly states that the number of people affected is not so much the concern as is disproportionate effects on any size population. However, other agencies

34 Gragg III, et al.; Foreman, Wilkins, and West; Faber and Kreig.
35 See footnote in Chapter 3 section on HUD Qualified Census Tracts for explanation of one HUD method.
use static percentage (i.e. 15%, 25%, etc.) thresholds that are applied evenly throughout the study area. This implies that there is a minimum vulnerability measure independent of density under which no community can be considered a priority, regardless of whether their county, state, or regional reference value is lower.

Ranking System

Establishing a ranking or scoring system can provide another way for regions to prioritize scarce resources by understanding the extent to which potential EJ groups are concentrated in particular areas. Seven of the ten EPA regions have established thresholds (statistical reference numbers) with which to compare low income and minority percentages, usually based on proportions of the state population. Areas that meet the threshold are considered potential EJ areas. Two of ten regions (Regions 1 and 6) go one step further by assigning numerical values, or scores, based on established cut-off levels of low income and minority. Region 1's current system divides percentages of low-income population and minority population into 25% breaks and assigns each consecutively higher level one additional point (see Chapter 1, Figure 1). Other ways in which ranking systems have been used around the nation include Region 2's use of scoring in the tool's secondary environmental risk analysis. Also, Region 5 shows areas that have greater than two times the state average percentage of low income or minority in a darker shade from areas with greater than the state average, while Region 10 uses 1.2 and 1.5 times the state average for their cut-offs. Two other regions graphically differentiate areas that meet both minority and income criteria from areas that meet only one or the other criterion. Even regions that do not rank can easily do this last type of "ranking", but some have chosen specifically to not make this capability explicit in their demographic tool.

One reason that Regions do not use a ranking system is a feeling that scores can be misleading given data accuracy limitations. In addition, some regions worry that scoring can prompt users to focus solely on demographic criteria at the expense of environmental burden analysis. The most valuable information for decision-makers, however, is the relationship between the two. Members of the Mapping Workgroup expressed similar concerns, saying that the original intent of Region 1's ranking methodology was to draw attention to any and all areas with a score greater than zero. However, Workgroup members recognized that this rule may not have been consistently followed, and low-scoring areas may have been obscured in relation to high-scoring areas in the eyes of some users.
My thesis research began with a thorough review of literature about the socio-political phenomena that led to the inequitable distribution of environmental risk. I then read about current practice of measuring environmental justice in academic and agency contexts.

To fully understand real world applications of EJ-GIS tools I worked directly with staff from EPA for several months. I chose EPA because it is the federal body with a clear mandate to oversee integration of environmental justice in regulation. Through regulatory contact, I learned about the processes that regulatory agencies go through to address EJ concerns in their daily activities, such as permitting, performing inspections, and distributing grants. I looked at EPA New England's political constraints, such as dealing with and through states. I also took into account the general demographic characteristics of New England's states and became acquainted with data that are available for this type of research. As a result of US EPA New England's interest in my work, I was granted unlimited access to their on-site resources at their office in Boston, Massachusetts.

Based on this background research and initial examination of EPA structure and discussions with the Mapping Workgroup, I identified critical questions to guide the scope of methodology options. Consisting of eight staff members from various EPA New England offices and programs, the Workgroup commented on subjects such as what type of functionality in the tool (e.g. statewide, regionwide) and what criteria to identify EJ communities would be most useful (esp. given data limitations) in the EPA context. A few of the most pressing questions included how to quantify economic hardship and which GIS techniques to use for manipulating census data. With the help of the Mapping Workgroup, criteria were established to judge the methodology. These criteria were initially guided by the Region's policy and programmatic concerns and, later, incorporated other considerations as well.

Then maps were created for one northern New England state and one southern state. Of the three sparsely populated, mostly rural northern states -- Maine, New Hampshire, and Vermont -- Maine was chosen. Massachusetts was chosen from the three southern states -- Connecticut, Massachusetts, and Rhode Island -- to represent the more densely populated and urbanized states. Many combinations of geographic units of analysis and state approaches were tested; and the top few choices were presented to the Mapping Group for input and discussion. Finally, a recommendation for the methodology, guided by the outlined evaluation criteria and background research, was proposed.

Data for this study originally came from the US Bureau of the Census, which publishes aggregate, processed data from its decennial survey of all US residents on the Web. Data used in this thesis was from the 1990 survey and was free of cost. To use census data in
GIS, the tables must be saved onto a local server, cleaned, and projected into the appropriate coordinate system (in this case, Albers Equal-Area, NAD 1983, meters). US EPA New England office had this processed data for the entire region available on-site.

To better evaluate and lucidly convey myriad approaches, I also familiarized myself with descriptive statistics during the developmental stages of the methodology. Meanwhile, I researched various statistical techniques such as mean and median univariate analysis, as well as K-mean cluster analysis, used by EPA Region 2 in computing their thresholds.

**Evaluation Criteria**

The following criteria were established as useful for EPA Region 1 to contemplate and evaluate the various potential methodologies. These five criteria were developed through a series of discussions with the EJ Mapping Workgroup.

1. Congruity between variables – the method applied to one variable (i.e. low-income, minority) should make sense or work together with other variables’ methodologies. This is a greater consideration when applying a ranking system to the model.

2. Transferability – other regions should be able to adopt the model.

3. Simplicity – The model should be fairly easy to explain to and comprehend by non-technical staff.

4. Equity among the six New England states – the model should be politically feasible without causing contention between state governments.

5. Practicality – analysis has to be refined and restrictive enough for EPA program staff to feel confident that the tool identifies communities with a high likelihood of being most impacted. For instance, if the methodology resulted in a large proportion of the region or of each state being flagged as potential EJ, it may not aid staff in selectively targeting their efforts.

Criteria 3, 4, and 5 were considered to be of greater importance than the 1 and 2. In addition, each methodology considered was assumed to be both a) statistically sound and b) verifiable on the ground.

**Determining Variables, Definitions, and Thresholds**

The first step in the process is to choose variables identified in the literature and through Agency practice as key predictors of environmental justice communities. Chosen variables must measure minority and community well-being at a minimum. The role of
population density and urbanized areas in the methodology was contemplated as well. Each of these variables is discussed at length in Chapter 3 with respect to how to combine them into a New England regional screening tool.

For each variable, available data is identified, appropriate definitions of chosen variables are constructed, and thresholds dividing measures into groups of concern and non-concern are set.

**Specific Questions Explored**

Important additions to the current methodology include improving upon the income measure by finding an indicator that accounts for cost of living better than the federal poverty level (FPL); computing reference values for thresholds; and exploring both relative and absolute scales in determining the final thresholds. For reasons stated in the literature review (Chapter 1), this study excludes analysis of reference values based on similarly situated communities in different locations.

Various geographic units were explored for the reference values, such as New England region, state, nation, and urbanized areas. In addition, for some variables, it may be appropriate to assign separate thresholds for urban and rural areas. For instance, what constitutes low-income is dependent on cost of living, and it is commonly known that urban areas have a higher cost of living than rural areas. In the absence of more accurate cost of living indices, it may be possible to construct proxies using this separate urban and rural logic.

This paper also addresses ways to represent areas that have extremely low population density (less than 0.001 person per square mile), prevalent in some northern New England states.
Chapter 3. Results and Analysis

GIS as an Analysis Tool for Environmental Justice

Prospects

By nature, environmental justice issues are place-based. Proximity to regulated (and unregulated) polluting facilities, natural resources, and other community assets, plays a large role in how community planning occurs and can lead to impacts on human health. This type of spatial analysis, examining the relationship between human populations and points of exposure, lends itself to the use of geographic information systems, which are designed to associate any type of data, including demographic data, with locations—be they neighborhoods, states, or buildings.

GIS is now widely used in environmental related fields because of its unique ability to manage and manipulate large, spatially referenced data sets and visually represent complex spatial patterns predicted by environmental models including health risk, health outcomes, and pollutant emissions. GIS has become deeply integrated into planning disciplines in part because of the visual appeal of the resulting maps. The technology also provides users with a tangible, defensible, reproducible, and understandable method for implementing policy in a more informed manner. It also allows users to perform sensitivity analyses, where they can easily change parameters and quickly get results. For public agencies, this can be especially important because they often receive policies created at the intellectual or abstract level and are expected to monitor and enforce them. Meanwhile, implementation guidance is scarce or vague.

Limitations

As with any tool used for data analysis, there are certain limitations to the appropriateness and usefulness of GIS. First of all, data availability often dictates the approach utilized. For example, fine grain data, that is accurate to the neighborhood level, is difficult to find for any community and expensive to generate, not to mention that this type of data raises privacy concerns. According to many environmental justice advocates, this is a major hurdle that especially plagues poor and minority areas where resources to collect and maintain such data are scarce. Furthermore, as stated previously (see Chapter 1, Scope) obtaining these data for the entire area of study, such as New England, may be short of impossible.

37 Jarret et al., 969.
38 Mank, 385.
Another noteworthy potential pitfall is that studies generally adopt census designations for unit of analysis (i.e., tracts, blocks, block groups, etc.) as their definition of community, which may not be accurate. Although the Bureau does attempt to draw boundaries based on local knowledge of communities, true, cohesive communities can still be obscured or divided, making the task of identifying the demographics or risk profile of an area of concern all the more complex. A further important question that is beyond the scope of this study is what constitutes a “community”. The answer certainly influences the approach to any environmental justice study.

A more philosophical consideration is the potential for abuse or misuse of results from demographic analysis. For instance, some EPA regional offices that employ EJ mapping technology have been approached by businesses such as insurance companies and developers who intended to use their maps for redlining, or delineating areas as undesirable for investment.\(^{39}\)

Moreover, a GIS tool can encourage the tendency for users to interpret the results as the final word on categorizing areas of concern. Despite considerable efforts to distinguish demographic mapping applications as “screens”, or the first of a long series of steps in regulatory guidance, some agencies have found that these types of caveats get lost when the tool’s usage is institutionalized.

Despite these concerns with utilizing GIS for environmental justice analyses, the need remains for tools to assist regulators in decision-making. GIS is currently the only tool for spatial referencing and managing large regional data sets that can still be user-friendly. Furthermore, absent a GIS tool developed specifically for environmental justice, agencies run the greater risk of having EJ overlooked all together.

**Level of Geography**

Many methods of analysis used by academic studies cannot be replicated for an entire region because of lack of data availability or computational intensity, and thus are not quite appropriate for EPA New England's use. Some of the reasons for variations in level of geography among the literature could be the scope of the analysis. Larger area coverage, like national or subnational, is more conducive to using larger units of analysis to prevent the number of records the GIS has to handle from being unwieldy. Whereas, smaller study areas (e.g. regional, state, town) can afford to use the smallest unit of analysis available, which is likely to be census block or block groups. Neighborhood analysis can be even further refined. For the purposes of this thesis, focused on New England, block groups were the smallest units for which data of interest were available and, thus, were adopted as the unit of analysis. According to the 2001 Survey of EPA GIS tools (Appendix B) all EPA regions use block groups as the unit of analysis, supporting this decision.

\(^{39}\) Terry Wesley, EJ Coordinator EPA Region 2, and Reggie Harris, EJ Coordinator EPA Region 3, conversation with author in San Francisco, 16 August 2001.
**Spatial Units Used for the Reference Value**

There are a few considerations when choosing the spatial unit for the reference value. The unit should either represent a relatively homogeneous market or a political boundary that has political power to effect changes in the event that disproportionate burden is found. Of the options considered for developing a reference value -- county, metropolitan area, state, entire New England region, or nation -- a few were ruled out from the start. Counties have negligible political power in New England states. However, counties are often used to characterize cost of living since neighborhoods are too fine a scale (i.e. considering commuting patterns) and states, or even metropolitan areas, can be too coarse. Counties’ lack of political clout to influence well-being or vulnerability issues led the Mapping Workgroup to discount them as a standard unit of analysis, unless a county-based cost of living index was found.

Metropolitan area was not considered as a unit of analysis because, as explained later in this section, indices of how to adjust thresholds or definitions in metropolitan areas relative to rural areas were not found. Just as with counties, metropolitan areas can include many sub-markets, as well as multiple municipalities, making it difficult to set income limits or characterize other phenomena appropriately. Furthermore, metropolitan areas generally do not have political power except when the municipalities coordinate their authority. An example of a situation where an agency might use metropolitan area boundaries as a reference value is when Metropolitan Planning Organizations, being regional planning entities, limit their analyses to the area that they have jurisdiction over. Based on these factors, the Mapping Workgroup suggests that this be left for future exploration and not be incorporated into this version of the methodology.

The remaining three geographic areas -- state, New England region, and nation -- were evaluated for each variable included in the screen.

**Variables of Interest**

**Minority**

Deciding on a definition for race/ethnicity is relatively simple. The racial or ethnic groups that constitute “minority” are stated in the EPA environmental justice guidance documents as all groups that are of non-white and/or white-Hispanic origin. All EPA regions, Headquarters and most other agencies follow this convention using the 1990 census data. This method is careful not to double-count any groups, which can be a problem if the data is not well understood.

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42 Because Hispanic is an ethnicity rather than a race, care must be taken to count Hispanics as minorities whether they have identified themselves as racially white, black, etc. in the census.
Seeing no reason to contradict the EPA definition of minority, this study adopts the common definition for minority. The census fields used are: 

_African American, Asian and Pacific American, American Indian, Eskimo, Aluet, all those of Hispanic origin, and Other non-white persons._

This definition will change with the use of the 2000 Census data since the latest survey allowed people to identify themselves under multiple race/ethnicity categories. Once 2000 census data is integrated into the GIS, the minority definition should include all people who report themselves as at least one of the non-white or Hispanic categories.

**Threshold**

In choosing a threshold many options were considered. Options included state, regional, or national reference values and whether to incorporate separate urban and rural thresholds. In addition, one could use an absolute scale (e.g. mean) or a relative scale (e.g. percentile). Based on discussions with EPA staff, the list of options for dividing the scale into high and low groups was narrowed down to the following most promising categories:

1. **Static Percent:** _Picking 1 threshold for the region and applying consistently (e.g. 30% or 50%)_
2. **Regional or National Mean:** _Apply the national or regional average percentage of minorities to the entire region; acts much like a static percent._
3. **Factor of the Mean:** _Multiplying mean percentage for blockgroups in state or region by some factor (e.g. 1.5 or 2)_
4. **Percentile:** _Sets threshold where necessary to have a set percent of blockgroups above it (e.g. 80th percentile would have 20% of blockgroups above the threshold)_
5. **Dual Criteria:** _Using combination of the above options_

If means were used, a choice had to be made between the two ways to calculate an average when dealing with census data. The most common way to calculate an average is to add all the percentages of the variable in question (here, minority) and divide by the total number of block groups. Alternatively, one could calculate a weighted average, where the total number of minorities across block groups in a given area (i.e. state or region) is divided by the total number of people in the same area. This is called a _weighted average_ because the percentage value of a block group is given a weight depending on the number of people in it.

The latter method prevents a situation where a state with high concentration of minorities in a few block groups of high population (urban areas) would be completely obscured by the many block groups with low population density and low minority percentage. Although the straight average method takes an average of averages, leaving potential for misleading results, an argument could be made for using it.
Block groups are delineated to have roughly equal population sizes. As population size changes, block group boundaries adjust, and therefore weighting has an even effect throughout the region. The relative consistency of block group population sizes was confirmed when the two methods for calculating averages were tested in Massachusetts and Maine. In both cases the weighted average came out to be 0.15 less than the straight average (see Table 1). The similar results between straight and weighted averages confirmed that the block group designations are not a significant hurdle for the purposes of this analysis.

Table 1. Percentage Minority in Two New England States Using Two Different Methods to Calculate Overall State Average

<table>
<thead>
<tr>
<th></th>
<th>Mean (%)</th>
<th>Weighted Avg (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maine</td>
<td>2.21</td>
<td>2.06</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>12.19</td>
<td>12.04</td>
</tr>
</tbody>
</table>

Given that the straight average is easier to calculate and is the method used by all other EPA regions that espouse reference values with means, this study proceeds by calculating the straight average whenever necessary.

A discussion of the pros and cons of each pre-selected category of thresholds follows.

1. Static Percent:
A static percent assigns a baseline percentage that any block group must meet in order to warrant attention. This method indicates an acceptance that there is some minimum concentration of minorities independent of spatial distribution that constitutes an area of concern. For example, the Public Issues Education Web site from North Carolina State University states that the reference value for areas is "25% of the total population of a defined area or jurisdiction." Three EPA Regional offices, including New England, use 25% as the first tier cut-off for minority, though they do not intend for this to be considered a reference value. Alternatively, the National Environmental Policy Act (NEPA) guidance sets the threshold at 50% of a community, supporting the use of a simple majority.

One benefit of using a static percentage is that it is relatively easy to explain if the value chosen can be justified. On the other hand, setting a value that seems appropriate for the southern New England states, which have much larger minority populations than northern states, may seem too stringent for northern states. Map 3 of Region 1 areas that meet the static threshold of 50% is shown on the next page.
Map 3. Percent Minority by Block Group in New England: Threshold = 50% for all States

Data Source: US Census Bureau (1990)
Map Created: May 10, 2002
U.S. EPA New England GIS Center
L:/projects/gis/Chin/reshellng_statc.mxd
2. State, Regional, or National Mean:
Comparing block group composition to the regional or national mean is a method to determine the static percent to apply evenly throughout the region. There is no known precedence within EPA for using either of these reference values. One reason that they may not be used is because neither method is sensitive enough to state or sub-state demographic differences. Nevertheless, both are simple to explain, are fairly restrictive for all New England states, and could be replicated by other EPA Regional offices.

The state mean, although used by many sources including two EPA Regions (3 and 6) and Scorecard, does not signify an extreme level of minority concentration, but rather the normal situation. However, it does provide a basis for dividing minority into two relatively even groups, high and low.

3. Factor of the Mean:
This method, used by two EPA regions, attempts to identify areas that are extraordinarily situated, as opposed to the mean, which identifies the norm in a specified area. A factor could be applied to the regional mean or state means under the same reasoning.

If utilizing a factor of a state mean, this ensures that more block groups in northern states (e.g. Maine) would qualify than if a static, regional, or national mean were used as the threshold. Using 2 times the mean seems to be significantly greater than the norm of the local area. The idea of being "significantly greater than the norm" of the local area is in language commonly used to determine "EJness". A sample of this type of system is shown in Maps 4 and 4.5 for Maine and Massachusetts, respectively.

Using the mean or factor of the mean makes sense for predicting community well-being or vulnerability only if there is a sizeable number of individuals of concern in an area. In states with means of 1 or 2 percent, a multiple of the mean does not raise the bar in a meaningful or fair manner in relation to states with larger averages of percentage minority. In cases of small numbers, a methodology to address EJ concerns of individuals should be developed; however, that type of analysis is beyond the scope of this paper.

4. Percentile:
In this case, a percentile describes the rank ordering of cases and considering them relative to their peers. The 50th percentile is called the median, where exactly half of all block groups have minority percentages above this point. Unlike with the mean or factors of the mean methods, which are based on the absolute scale, the percentile method

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44 The national mean for minority is extracted from the census Summary Tape Files using the U.S Census Bureau's online American Factfinder <http://www.census.gov/dads/www>; it is the weighted average.
45 Scorecard, "Environmental Justice Report Descriptions."
46 Region 10 has a ranking system using 1.2 and 1.5 times the state mean and Region 4 uses 1.2 times the state mean only.
is based on a relative scale. The threshold for each state or for the region results from choosing the percentile value. Higher percentiles (75th, 80th, 90th, etc.) imply greater stringency and aim at identifying the abnormally high concentrations of minorities.

If applied on a state basis, thresholds may vary by state, but the percentage of block groups in each state that qualify as high minority would be equivalent. One problem with this approach is that extremely low minority percentage block groups may end up qualifying as high minority, unless an extremely high percentile is chosen. For instance, even the 80th percentile in Maine includes block groups composed of just over 3% minority (Map 5).

Another issue of concern with the percentile method is that one must still chose which percentile to set the limit, which can be somewhat subjective.

5. Dual Criteria:
A dual criteria system applies two of the aforementioned scales to each block group. Block groups would be held to the lower of the two criteria if flexibility were the key. Or block groups could be held to the more extreme criteria if stringency were paramount. This method would only be useful in creating state-based thresholds and is helpful in that it relaxes the range of differences between state thresholds, which is a particular concern for New England since the northern states and southern states' demographics greatly differ.

The primary problem with using state-based thresholds for minority is that the percentages of minority in northern states are so low that it is very difficult to justify even a factor of 2 or 3 times the mean or the 80th percentile as a percentage of minority that requires institutional attention (see Table 2). For example, the mean percentage minority in Maine is a mere 2.21% (so 2 times the mean = 4.42%) and the 80th percentile break is at 3.16%. Although these numbers represent the extraordinary situation for Maine, a block group with three to four people of color out of one hundred people hardly warrants special attention from EPA on the basis of community vulnerability. Although individuals in these areas may face disproportionate burden and lack political clout, the probability is low that these individuals constitute a community that was intentionally or accidentally discriminated against. Furthermore, Maine's mean is almost one sixth of Massachusetts' mean. This large difference could leading one to question why states should be held to different standards.
Map 4. Percent Minority By Block Group in Maine
Threshold = Two Times State Mean

Legend
% Minority by block group
0.000 - 4.280
4.281 - 100.000
Unpopulated
Map 4.5. Percent Minority by Block Group in Massachusetts

Threshold = Two Times State Mean

Legend
- State Boundaries
- Atlantic Ocean
- % Minority by Block Group
  - 0.000 - 24.338
  - 24.339 - 100.000

Data Sources:
- U.S. Census Bureau (1990)
- Map Created: May 10, 2002
- U.S. EPA New England GIS Center
  L:/projects/ej/Chitra/thesis/minor2mass.mxd

MIT
EPA
New England
Map 5. Percent Minority by Block Group in Maine: Threshold = State 80th Percentile

Legend
% Minority by Block Group
- 0.000 - 3.160
- 3.161 - 97.417
- Unpopulated

Data Sources:

Map Created: May 10, 2002
US. EPA New England GIS Center
Liprieaply/Chmtfsesis/minot/times.mxd

MIT
EPA
New England

41
Map 6. Percent Minority by Block Group in Maine: Threshold = Dual Criteria, Higher of 2 x State Mean and 2 x Regional Mean.

Data Sources: US Census Bureau (1990).
Map Created: May 10, 2002.
L:\projects\Chitra\thesis\dualhgh.mxd
Table 2. Various Thresholds for Percentage Minority Population in New England Region, Maine, and Massachusetts

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regional</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>10.545</td>
<td>14.577</td>
<td>2.642</td>
</tr>
<tr>
<td>1.5x mean</td>
<td>15.8175</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2x mean</td>
<td>21.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>3.118</td>
<td>5.178</td>
<td>1.314</td>
</tr>
<tr>
<td>80th %ile</td>
<td>12.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Maine</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.214</td>
<td>3.405</td>
<td>1.783</td>
</tr>
<tr>
<td>1.5x mean</td>
<td>3.187</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2x mean</td>
<td>4.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>1.06</td>
<td>2.034</td>
<td>0.918</td>
</tr>
<tr>
<td>67th %ile</td>
<td>1.847</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75th %ile</td>
<td>2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80th %ile</td>
<td>3.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cluster</td>
<td>26.37</td>
<td>26.37*</td>
<td>25.78</td>
</tr>
<tr>
<td><strong>Massachusetts</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>12.19</td>
<td>14.058</td>
<td>3.944</td>
</tr>
<tr>
<td>1.5x mean</td>
<td>18.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2x mean</td>
<td>24.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>4.118</td>
<td>5.024</td>
<td>2.074</td>
</tr>
<tr>
<td>67th %ile</td>
<td>8.28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75th %ile</td>
<td>12.216</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80th %ile</td>
<td>16.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cluster</td>
<td>38.1</td>
<td>38.36</td>
<td>10.85</td>
</tr>
</tbody>
</table>

* Only 1 bg in upper cluster

Table 3 provides an example of how the dual criteria method would transpire in New England. This system incorporates an element of state flexibility along with a baseline value under which no block group can be considered "of concern". The factor "2 times" for both the state and regional means was chosen to highlight the extreme conditions. Shaded areas highlight the value that each state would follow. Massachusetts block groups would be held to the state threshold of 24.38% (shown in Map 4.5) while Maine would be held to the regional mean of 21.09%. Map 6 of Maine gives one an idea of which areas would be excluded from the potential EJ category with this higher criterion as compared to the lower thresholds portrayed in Maps 4 and 5.

Table 3. Example Values for Dual Criteria Approach: 2x state mean, but not less than 2x regional mean

<table>
<thead>
<tr>
<th></th>
<th>2x State Mean (%)</th>
<th>2x Regional Mean (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massachusetts</td>
<td>24.38</td>
<td>21.09</td>
</tr>
<tr>
<td>Maine</td>
<td>4.4</td>
<td>21.09</td>
</tr>
</tbody>
</table>

45
This example shows how more believable thresholds, based on what one would expect the composition of an EJ area to be, could be arrived at. The foreseeable counter argument is that states with low values would have to defer to a non-local approach under this method, which could seem contrary to the local nature of EJ disputes.

After testing several different methods, the Mapping Subcommittee narrowed down the options by eliminating those that were not adequate based on the evaluation criteria laid out in Chapter 2 (i.e. Congruity, Transferability, Simplicity, Equity, and Practicality). The remaining five schemes and their respective characteristics are described below in Table 4. For reference, Table 5 lists the means and factors of the mean for each of the six New England states.

<table>
<thead>
<tr>
<th>Table 4. Pros and Cons of Selected Methods for Setting the Minority Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. 2x Regional Mean</strong> (21.09%)</td>
</tr>
<tr>
<td><strong>Pros</strong></td>
</tr>
<tr>
<td>- Adequately restrictive</td>
</tr>
<tr>
<td>- Can explain relevance by saying it is significantly higher than the mean</td>
</tr>
<tr>
<td>- Close to national average, so perhaps more believable, yet it’s geographic specific</td>
</tr>
<tr>
<td>- Consistent and easier to explain than some of the other methods</td>
</tr>
<tr>
<td><strong>Cons</strong></td>
</tr>
<tr>
<td>- Might as well use the national average</td>
</tr>
<tr>
<td><strong>2. Dual criteria: higher of 2x state mean &amp; 2x regional mean (range 21% - 31%)</strong></td>
</tr>
<tr>
<td><strong>Pros</strong></td>
</tr>
<tr>
<td>- More stringent</td>
</tr>
<tr>
<td>- 2x Regional average is close to national average while being geographic specific</td>
</tr>
<tr>
<td><strong>Cons</strong></td>
</tr>
<tr>
<td>- Disadvantages northern states</td>
</tr>
<tr>
<td>- More complicated</td>
</tr>
<tr>
<td><strong>3. Dual criteria: higher of 2x state mean &amp; 1x regional mean (range 10.5% - 31%)</strong></td>
</tr>
<tr>
<td><strong>Pros</strong></td>
</tr>
<tr>
<td>- Filters out “insignificant” minority areas</td>
</tr>
<tr>
<td><strong>Cons</strong></td>
</tr>
<tr>
<td>- Varying application could make all states unhappy</td>
</tr>
<tr>
<td><strong>4. Percentile by region (80th = 12.6%)</strong></td>
</tr>
<tr>
<td><strong>Pros</strong></td>
</tr>
<tr>
<td>- Other regions could replicate the system</td>
</tr>
<tr>
<td>- Relatively simple to explain - intuitive</td>
</tr>
<tr>
<td>- Can easily be incorporated into a ranking system with different percentiles indicating degrees of importance</td>
</tr>
<tr>
<td><strong>Cons</strong></td>
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<tr>
<td>- Don’t know what the percentile break should be</td>
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<tr>
<td><strong>5. National average (24.6%)</strong></td>
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<tr>
<td><strong>Pros</strong></td>
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<tr>
<td>- Standardized</td>
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<tr>
<td>- Easy to explain</td>
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<tr>
<td><strong>Cons</strong></td>
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<tr>
<td>- Don’t know of any others who use it</td>
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<td>- Not geographic specific</td>
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<table>
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<th>Table 5. Possible Minority Threshold Values for 6 New England States</th>
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<td><strong>Mean</strong></td>
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<td><strong>2x Mean</strong></td>
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From these options the group then selected #4, percentile regionally, as the method to adopt for the GIS tool. Members believed that the regional approach eliminated perceived bias between states and represented the most extreme cases. Whereas, any method using averages represented a contrived threshold imposed upon an area. Although there is precedence for the use of state-based reference values, the group felt that state socio-political factors were not strong enough determinants of variation in distribution of minority populations to justify separate thresholds for each state. To further support this case, we are reminded that EPA is a regional office, interested in servicing areas in need irrespective of geographic distribution — though the office does keep spatial equity in mind — and funds and resources are distributed accordingly.

In choosing the percentile approach, various levels were examined. For the tool to be practical, it was decided that the percentile level should be sufficiently restrictive and higher than the 80th percentile. The 85th percentile resulted in a regional break of 18.3% with block groups that have higher than the break considered “potential environmental justice areas.” This break is somewhat less restrictive than the current threshold of 25% and hovered around other values the Mapping Workgroup was considering such as the national average (24.6%) and twice the regional average (21.1%). The chosen percentile means that the top 15 percent of block groups with highest minority percentages will be included. It assures that unusually high percentage minority populations will be identified, which is representative of communities most vulnerable to “double-jeopardy” (see Chapter 1) or disproportionate burden.

Many of the minority threshold options and the path taken to reach the final recommendation are given in the decision tree diagram below (Figure 2).
Low Income

The literature review and common practice led to EPA’s acceptance of low-income status as an indicator of vulnerability to disproportionate burden.

There are three primary issues with identifying low-income communities. First, one must choose an indicator that adequately reflects the amount of income to an individual, family, or household. Second, the cut-off value that divides low-income from non-low-income must be decided. Third, one must choose what concentration, or percentage, of the population in an area must be low-income in order to merit attention from an agency’s programmatic standpoint.
Low-Income Indicator/Definition

Income and economic well-being indicators are available through many sources such as the US Bureau of the Census, state and local departments of commerce, and private vendors. In order to maintain data consistency, for a study such as this, it is important to gather data for the entire region from one source. Hence, the federal census data is the best option for the six New England states.

The census reports data on per capita income, household income, and family income. Per capita averages income by wage-earners by the entire population, including non-wage-earners like children, elderly, and those not in the job market. Family income and household income give us a better sense of how income is shared and economies of scale are achieved by having multiple people in the same living unit. Most income studies measure household income since it is very difficult to accurately differentiate between related (families) and unrelated members of a household who share income. In addition, household income better indicates the distribution of wealth, especially coupled with data on the number of people in the household.

The challenge with defining an appropriate value for income is to account for geographic differentiation in cost of living. To date there is only one known data set of household income limits that is geographic specific and is available for the entire US. This special tabulation by the HUD and the Bureau of the Census is discussed later on in this chapter.

Other measures have drawbacks that will have to be compensated for by estimation. For example, the poverty level accounts for difference in income based on household size but not geography. Whereas computing median (or percentage of median) household income can be varied by geography but is not specific to household size due to limitations in the way census data is aggregated and reported.

Low Income Cut-off

There are several options for determining the cut-off value that defines a low-income versus a high-income area. Two commonly used methods are: a) choosing a dollar amount for household income, like the median of an area, and b) the poverty level

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47 Loren Hall, “Interim DRAFT EJ Issues Discussion.” January 21, 1997. Text reads: "TECHNICAL ISSUES: The Bureau offers a special tabulation service, which allows users to specify a set of specific cross-tabulations of interest, which the Bureau then produces within the limits of privacy protection for responses. HUD requested such a tabulation for the 1990 Census...The product includes a HUD-Adjusted Median Family Income (HAMFI) derived for each metropolitan area in a state, plus a single value for each state’s non-metropolitan counties. The data were tabulated down to the Census tract level, with some variables derived only to the county level. Few of the variables released in the CHAS have been incorporated in EPA data products."
calculated by the US Bureau of the Census. Each method has its benefits and drawbacks as explained below.

**Household Income**

As discussed in the literature review (Chapter 1) calculating average or median household income values can provide a more geographic specific picture of the economic makeup of an area. Agencies like the US Housing and Urban Development and some state financial support programs rely on median household income data, as opposed to the poverty level, for defining their low-income limits.

Four EPA regions use this method. One region that is mostly rural defines low income as percentage of population with household income less than $12,500. Three regions use $15,000 as their low-income cut-off, while one of those three uses a secondary cut-off at $25,000. In a study done by Northeastern University, on environmental justice areas in Massachusetts, low income was defined as percentage of population with household income less than $40,000.48

The problem with household income thresholds is they involve aggregating income limit data that is set by household size and type in order to fit the data available from the census. This means that the threshold can be inappropriate for many household sizes, giving us a false sense of the economic hardship. Often, using this measure inflates the percentage of households that qualify as low-income.

**HUD Qualified Census Tracts**

HUD's special tabulation, Qualified Census Tracts (QCTs), was initially seen as the best option for the low-income measure because it provided geographic specificity in its income limits. After some testing, this tract-based method turned out to be too restrictive identifying only 191 out of 3,021 tracts in the entire region (about 6%) for income only as shown in Map 7. By contrast, EPA Region 1's current potential EJ methodology identifies 4,379 of 12,394 block groups across the Region (about 35%) as low-income. The HUD method may be this stringent, in part, because of the administrative cap placed on the percentage of people in a state allowed to qualify for HUD benefits.49

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49 "Explanation of HUD Designation Methodology: A. Qualified Census Tracts
In developing this revised list of LIHTC Qualified Census Tracts, HUD used 1990 Census data and the MSA/PMSA definitions established by the Office of Management and Budget ("OMB") in OMB Bulletin No. 99-04 on June 30, 1999. Beginning with the 1990 census, tract-level data are available for the entire country. Generally, in metropolitan areas these geographic divisions are called census tracts while in most non-metropolitan areas the equivalent nomenclature is Block Numbering Area ("BNA"). BNAs are treated as census tracts for the purposes of this Notice.
"The LIHTC Qualified Census Tracts were determined as follows:
1. A census tract must have 50% of its households with incomes below 60% of the AMGI to be eligible. HUD has defined 60% of AMGI as 120% of HUD's Very Low Income Limits (VLIL's), which are based on 50% of area median family income, adjusted for high cost and low income areas. The 1999 income estimates were then deflated to 1989 dollars, so they would match the 1990 Census income data.

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This artificial stringency led the group to reject HUD QCTs as the EPA New England methodology. However, QCTs were overlayed onto the final low-income methodology to verify its accuracy. The results of this comparison are given later in this chapter.

**Poverty Level**
The census defines poverty based on an algorithm that accounts for level of household income, as well as the number of people within the household. This pre-defined value, calculated at the national level, has been criticized for being too low or otherwise inappropriate across the board. It is even more questionable when dealing with regions (especially ones with many large urban areas) where the cost of living is higher than the national average. As a reference, in 2000 the FPL for a household of two adults and two children was $17,463; in 1989 FPL for the same household type was $12,575.

Specific criticisms of the methodology for calculating poverty include that it is out of date, does not reflect changes in consumption and relative spending, and does not take taxes, non-cash resources, or work expenses into account. When created in the early 1960's, poverty thresholds were based on two criteria: "costs assumed necessary to meet basic food needs of low-income families of differing sizes and types, and the share of income spent on food by all families."  

In 1955 when the FPL system was being researched, food represented the greatest expense as a proportion of income to families. At that time it was assumed that all families of three or more people spent one third of their post-tax money income on food, whether they were poor or not. Therefore, the cost of food based on the U.S. Department of Agriculture’s dietary guidelines was used. However, the poverty allowed the supplemental food program, which targeted families with children, to exist by reducing the poverty line to $11,000 in 1964.

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2. For each census tract, the percentage of households below the 60% income standard was determined by (a) calculating the average household size of the census tract, (b) applying the income standard after adjusting it to match the average household size, and (c) calculating the number of households with incomes below the income standard.  
3. Qualified Census Tracts are those in which 50% or more of the households are income eligible and the population of all census tracts that satisfy this criterion does not exceed 20% of the total population of the respective area.  
4. In areas where more than 20% of the population qualifies, census tracts are ordered from the highest percentage of eligible households to the lowest. Starting with the highest percentage, census tracts are included until the 20% limit is exceeded. If a census tract is excluded because it raises the percentage above 20%, then subsequent census tracts are included to determine if one or more census tract(s) with smaller population(s) could be included without exceeding the 20% limit." Procedures for dealing with areas where greater than 20 percent of the population lives in eligible census tracts is also given. For more details, see: Mel Martinez, Secretary, "Statutorily Mandated Designation of Difficult Development Areas and Qualified Census Tracts for Section 42 of the Internal Revenue Code of 1986," Docket No. FR-4401-N-05, 11 September 2001, <http://www.huduser.org/datasets/qct/NOTICE2002.htm> (1 April 2002), Explanation of HUD Designation Methodology. To download the data set visit: U.S. Department of Housing and Urban Development, "Qualified Census Tracts and Difficult Development Areas," PD&R Data Sets, 11 December 2001, <http://www.huduser.org/datasets/qct.html> (1 April 2002), 2002 Qualified Census Tracts - Geocoded dBase File.  
of Agriculture’s low-cost food plan was multiplied by three. This original formula is still used [though it is updated for price changes using the Consumer Price Index (CPI)] despite the fact that food constitutes a much smaller percentage of families’ income today. Instead families spend relatively more on housing, transportation, and health care.51

In response to these and other criticisms, many institutions have taken on the task to improve upon the poverty calculations by calculating their own low income indices. These improved methods may take into account differences in housing cost throughout the country, varying family composition, locally specific costs of other goods and services, and taxes. A few of these alternative methods are “Family Budgets” created by Economic Policy Institute, and the “Economic Self-Sufficiency Standard” developed for several states by the Washington, DC based non-governmental organization (NGO) Wider Opportunities for Women in conjunction with local NGOs.

The problem with using such indices is that census data is not available for income by household size as is needed to correspond to these budgets. Moreover, types of families determined by the census do not necessarily match the categories determined by alternative indices. Although there are techniques to estimate incomes for these alternative categories, this is a time intensive process and the accuracy of resulting estimates could be called into question. Therefore, this study does not utilize an alternative cost of living index.

Although the FPL is better than other methods at accounting for changing needs based on household size, through this research it has become clear that the FPL is too low to be used on its own, especially for communities in southern states. In the next section ways to manipulate the FPL to accommodate higher cost of living are discussed.

200% of the Federal Poverty Level
By using the census data category P121, Ratio of Income to Poverty, one can differentiate percentage levels of poverty in various increments up to 200% of FPL. If one believes that the poverty level is too low, as Region 1 does, one could increase the FPL to estimate differences in cost of living, or one could apply a higher limit across all areas, under the assumption that the FPL is universally too low. One study by Economic Policy Institute (Hardships in America) stated that a reasonable proxy for calculating geographic specific low income indices is using 200% of the current poverty level as the cut-off.52 Moreover, many states use multiples of the FPL as income limits for assistance programs, many using values even greater than 200%.53 Interestingly, EPA New England’s previous EJ

51 Ibid, 5-6.
methodology uses 200% of the FPL as the low-income definition.

In the absence of data indicating differentials in cost of living between urban and rural areas and states, there is no basis for adjusting the multiple of the poverty level to suit state or metropolitan area characteristics. Therefore, based on precedent set by state programs and the recommendation of private studies, this paper recommends that 200% of the FPL (the highest multiple of the FPL computed by the Bureau of the Census) be maintained as the low-income definition.

**Low-Income Thresholds**

After reviewing maps and tables of various low-income thresholds broken down by state and region, urban and rural, the character of the Region became clearer. In Table 6 one can see that northern New England states have, on average, more low-income people, and that those high percentage block groups tend to be concentrated in rural areas. In southern states, however, poor tend to be concentrated in urban areas. This means that when separate urban and rural thresholds are computed, there is an opposite response from the overall state thresholds. In northern states, the overall average is more similar to the rural average because there are more people living in rural areas, which weights any reference value calculation. Additionally, perhaps, issues of urban poor and disinvestment in urban centers are not prevalent in these mid-sized northern cities, as they are in larger southern New England cities like Boston, Hartford, and Providence. The larger populations and concentration of poor in urban areas in southern states influences overall state thresholds to be more similar to the urban thresholds.

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The differing effects of applying urban and rural thresholds to the six New England states refutes the theory that urbanization could monolithically adjust for cost of living. This research brought to the fore that the relationship between urbanization and environmental justice concerns is much more nuanced than originally expected. This realization supports an idea that came out during a Mapping Workgroup meeting: there is a fundamental difference in the way northern versus southern New England bureaucrats perceive EJ issues. Northern states see EJ as primarily concerning rural poor, while southern states generally think of urban minorities.

As with the low-income definition and minority threshold, there is inadequate data on how to adjust the low-income threshold by state or by urban and rural areas. It is not clear that political conditions alone could substantiate using political boundaries as the determinant for different thresholds (as opposed to metropolitan statistical areas, northern states versus southern states, etc.). Thus, this thesis recommends the use of a regional threshold. Table 6 shows that the regional urban and rural thresholds are within one percentage point of each other, so it does not make sense to complicate the methodology with that added step. It is important to note that Region 2 discontinued use of separate urban and rural thresholds for the low-income variable. This was done because after mapping the region with the distinct thresholds, certain states appeared to have more low-income areas relative to maps of other states, which was politically unpopular.

Finally, in the interest of maintaining congruity with the method applied to minority, it is recommended that the 85th percentile be used for the low-income percentile as well (Map 8). The percentage break arrived at from this relative scale is 39.80%. When compared to the HUD QCTs, 185 of the 191 tracts matched up with at least one block group identified by the proposed methodology (Map 9). This nearly 97% congruence rate is seen as a strong indicator of the validity of the new methodology. The six non-conforming tracts were all in Massachusetts or Connecticut and were adjacent to block groups that qualified under the proposed methodology. Four of the six tracts were in metropolitan areas. One possible reason that six tracts did not overlap with the proposed methodology is that high cost of living in those areas caused HUD tracts to qualify but was not accounted for by the non-geographic specific FPL used in the proposed methodology. Another reason could be that HUD’s special tabulation uses annually reported data, and these six areas represent recently developed areas not captured in the 1990 census.

A simplified version of the decision process to reach the recommendation for the income threshold is show in the diagram below (Figure 3).
Figure 3. Decision Tree for Setting the Income Threshold

Map 7. HUD Qualified Census Tracts as the Low-Income Indicator in New England
Map 9. Comparison of HUD Qualified Census Tracts with the Proposed Methodology

To qualify as a Potential EJ area, a block group must be composed of a percentage low-income or minority population in the top 15% of all block groups in the New England Region.

Legend:
- State Boundaries
- Potential EJ Status
  - Neither
  - Low-Income
  - Minority
  - Both
- HUD QCTs

Data Sources:
- US Census Bureau (1990)

Map Created: May 10, 2002
U.S. EPA New England GIS Center
L:/projects/ej/Chitra/thesis/hud.mxd
Population Density

Population density is an additional indicator that EPA New England has been considering for the tool. In environmental justice analyses population density is computed as the number of people per unit area (e.g., people per square mile). This variable gives a picture of how concentrated or dispersed certain populations are. For targeting purposes, population density can be used to achieve two goals. First, it can draw attention to areas where EPA would garner the "greatest bang for the buck." Second, it can help distinguish areas with extremely low population counts so that users could decide whether or not to exclude them from the analysis.

For example, there are large tracts of land in northern Vermont and Maine where twenty or fewer people are scattered across thousands of square miles. Although they appear to have high percentage of low-income people, the EPA staff may not wish to distribute resources to this area based on this information alone. These areas may need to be screened using different criteria that would be sensitive to phenomena that could erode community well-being in those block groups. Upon further investigation, one could find out that these areas are owned by papermill companies, and their potential for environmental justice could be better understood by researching the companies rather than by using the GIS screening tool. Alternatively, in low-density areas an environmental hazard could be located in the same block group as a potential EJ community without being anywhere near the residents. If no further analysis into the situation is conducted, one may be misled by the screening methodology's results.

Population density can be incorporated into the tool either as a part of the definition of a potential environmental justice area or as an overlay to the preliminary screen. Either method of utilizing population density can help targeting efforts. If it is made part of the definition, EPA implies that that population density is an intrinsic part of the decision-making process. On the other hand, keeping population density as a removable overlay gives users the flexibility to decide the importance of density with respect to other layers based on their programmatic functions and goals.

When discussing population density it is important to note that the land area of the unit of analysis, block group, varies drastically throughout the Region based on household concentration. In densely populated areas, a small increase in block group size could easily change an area's potential EJ status. Also, a community could encompass several block groups, making it necessary to investigate the spatial distribution of block groups in relation to neighboring block groups. In other words, block groups cannot and should not be treated as isolated individual entities but, rather, the existence of clusters of potential EJ block groups should also be identified. Clustering in low-density areas could also suggest an EJ concern depending on the programmatic issue at hand. Therefore, low-density and high-density areas would have to be considered by distinct criteria that
accounted for the role of both the size and density of clusters in defining community vulnerability.

There are two significant reasons not to include population density alone in the preliminary screen. First, urban areas dominate population density maps and can attract attention away from equally deserving rural areas. This may also show a bias towards the more populous southern states. During Mapping Meetings the issue was raised that in northern New England states, environmental justice problems are equated with concerns of the rural poor. Second, and perhaps more importantly, while race and income are explicitly mentioned in the Regional Environmental Justice Policy, population density (or even population size) is not.  

Creating a method that evaluates clustering could satisfy the need to assess population distribution over land area and evaluate larger units of analysis. Although this concept was not discussed by the EPA Region 1 Mapping Workgroup for incorporation into the 2002 version of the EJ-GIS application, it does merit investigation for future versions of the GIS tool. In the meantime, population density should be included in the GIS tool as an overlay, separate from the basic potential environmental justice definition of minority and income status. Since population density was deemed a secondary consideration, the specifics of threshold choice were not explored fully before publication of this thesis. However, thresholds should be set before the release of the GIS application.

In order to address the issue of exceedingly low population density in northern areas that skew calculations and distract attention, some studies exclude such areas from analyses. For instance, in a Logan Airport study, areas with less than 10 persons per square mile were displayed as unpopulated.  

To address this problem, the population density overlay should demarcate areas that have extremely low population densities (i.e., less than 1 person/square mile; see Map 10) as well as the high end of most densely populated block groups. In Map 10.5 of Boston, population density is displayed at the 85th percentile, following suit of the thresholds for minority and income variables.

**Ranking**

Although a ranking would provide more information for users, allowing them more flexibility in their analysis, the Mapping Workgroup felt that a ranking or scoring system implied a level of precision that is not available. In addition, it was decided that without a ranking system, users would be more likely to critically examine the results of the EJ

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maps and might look into other overlays that could help prioritize areas, rather than relying too heavily on the low-income and minority factors alone.

As a result, maps will be displayed as "one-other-both" -- areas that are only minority ("one") will be distinguishable from areas that are low-income only ("other"); and areas that are both minority and low-income will be a third variation, distinguishable from the rest. The minority variable is no longer weighted as it was in the previous Region 1 methodology since there is no consensus in the literature as to which of the minority and income variables is a better predictor of environmental justice concerns. This symbolization will be available at the 85th percentile and 95th percentile (Maps 11 and 12).

Up until this point, this paper has discussed the potential of each variable for predicting environmental justice concerns independently of the other. It is crucial to recognize, however, that the variables discussed (minority, income, population density) are intrinsically linked and influence one in another so deeply that researchers have had great difficulty parsing them. For instance, minority communities are often poor and vice versa; and each issue presents a set of socio-political hurdles that compounds one another. This interdependence could deserve regulatory attention to aid in counterbalancing the lack of political clout or lack of general community well-being in areas that meet multiple criteria.

In the previous section, accounting for the interrelationship between population density and the other two variables through analysis of spatial clusters was argued. One way to account for the association between income and race/ethnicity would be to have two thresholds for screening. The higher percentile threshold would be the cutoff needed to be categorized as potentially EJ based on a single criterion (either minority or income). The lower percentile threshold would be the cutoff needed if both factors were extreme but neither was extreme enough to meet an individual criterion. In the proposed method that allows users to view 85th and 95th percentiles, staff could achieve this functionality by viewing the 85th percentile for the "both" category and switch to the 95th percentile view when considering minority or income alone. In the future, if a more integrated approach is sought, then other lower percentile levels could be considered for the "both" threshold and this ranking approach could be combined into one display.

---

Map 10. Proposed Potential EJ Screening Methodology with Population Density as Overlay, Maine

Poverty and Minority Thresholds = 85th Percentile Regionally

Legend
Population Density (persons/sq mi)
- Block Groups with Less than 1
Potential EJ Status
- Neither
- Poverty
- Minority
- Both
- Unpopulated

Data Sources: US Census Bureau (1990).
Map Created: May 10, 2002
U.S. EPA New England GIS Center
To qualify as a Potential EJ area, a block group must be composed of a percentage low-income or minority population in the top 15% of all block groups in the New England Region.

Legend
- Boston Neighborhoods
- Town Boundaries
- Population Density (persons/sq mi)
  - Densest 15% of block groups

Potential EJ Areas
- Neither
- Low-Income
- Minority
- Both


Data Sources:
US Census Bureau (1990)
U.S. EPA New England GIS Center
L:n强奸er/Chris/hers/bostonpd2.mxd
Map 11. Potential Environmental Justice Areas (block groups) in New England: Proposed Methodology

To qualify as a Potential EJ area, a block group must be composed of a percentage low-income or minority population in the top 15% of all block groups in the New England Region.

Data Sources: US Census Bureau (1990).
Map Created: May 18, 2002
U.S. EPA New England GIS Center
L:/projects/k/China/Heads/regionfinal.mxd

Legend
- State Boundary
- International Boundary
Potential EJ Status
- Neither
- Low-Income
- Minority
- Both
- Unpopulated
To qualify as a Potential EJ area, a block group must be composed of a percentage low-income or minority population in the top 10% of all block groups in the New England Region.

Map 12. Potential Environmental Justice Areas (block groups) Around Boston, MA: Proposed Methodology

Data Sources: US Census Bureau (1990).
Map Created: May 10, 2002
U.S. EPA New England GIS Center
L:\projects\ej\Chitrathesis\boston_prop.mxd
Chapter 4. Summary and Conclusions

Summary of Recommendations

The methodology recommendations laid out in this thesis represents extensive research and close interaction with EPA Region 1 staff. In this section, I will describe how the chosen methodology compared to the evaluation criteria and to the current EPA New England method, with regard to the perceived problems of the current system.

The proposed screening methodology meets all five evaluation criteria established by the Mapping Workgroup. Specific features that apply towards the criteria are as follows:

1. Congruity between variables – thresholds for both minority and low-income use the percentile approach at the regional scale and are set at the same levels (85th and 95th).

2. Transferability – the percentile method could easily be applied in other regions and would be reasonable even in states where the demographic composition is very different from New England. This is true because the percentile approach uses a relative scale that takes the most extreme cases in an area and is less sensitive to outlying values. Moreover, the definitions for minority and low-income, race/ethnicity and 200% of the federal poverty limit, respectively, are drawn from federal databases and thus can be used by any region in the U.S. Census data is uniformly collected and computed and more easily available as compared to private or localized information sources.

3. Simplicity – the percentile approach used for thresholds is easily explained relative to other statistical techniques like K-mean cluster analysis or analysis of variance, and krigging. In addition, as explained in 2, the definitions for minority and low-income, based on national sources, are relatively well-known and therefore easy to explain/understand.

4. Equitable to states – Arguably, regional scale analysis eliminates some bias between states and focuses on the scale of authority of EPA New England, a regional office.

5. Practical – The proposed methodology identifies approximately 50% fewer block groups than the current system, which represents a sufficiently restrictive level for EPA program staff to prioritize scarce resources based on EJ concerns with confidence.

Of the initial goals for improvement upon the current methodology (see Chapter 1), some of the concerns are better addressed by the proposed approach than others. Table 7 summarizes and compares the main components of the current and proposed methodologies for easy reference. First, the proposed method uses block groups as the unit of analysis just as EPA Region 1 has been doing in recent years. However, the
recommended approach was developed to be sensitive to the finer-grain analysis of block groups, which is not the case for the original 1993 EPA method that used towns. Block group scale analysis seems to be very important based on a survey of areas qualifying under the proposed methodology. One can see that towns are not homogeneous in minority and/or low-income composition. For example, the town of Boston is extremely diverse, and of Boston’s many neighborhoods not one is uniformly potential EJ or non-potential EJ. Each neighborhood has pockets of each status area, and conversely, more affluent and predominantly white towns such as Brookline have some block groups that meet the screening criteria.

In addition, the proposed spatial clustering analysis can compensate for the inherent dependence on census-defined units of analysis. From a brief scan of the results, there is no clear, universal pattern of clustering of areas identified by the proposed methodology. Some potential EJ block group clusters occur in urban and/or rural areas and other block groups are scattered around like a checkerboard, though minority areas are less scattered than low-income areas. Indeed, block group clusters exist in southern New England states’ urban areas, especially of minority populations. This could be true because minorities tend to reside in homogeneous communities that often expand over time, attracting more people of the same races/ethnicities. It could also be a sign of “ghettoization” or marginalization of minorities, requiring government attention. Clusters of low-income block groups are in both urban and rural areas and show up most glaringly in northern Vermont and much of Maine. This is most probably indicative of problems of rural poor, or alternatively, of unconventional lifestyles that depend less on cash income. These varied results of block group clustering prompt greater investigation as to the driving forces behind such patterns, the conclusions of which could lead to very different policy implications.

Another improvement goal was to be able to adjust the low-income definition based on cost of living differences across New England. Unfortunately, because of data availability and resource constraints, such a measure was not established for this thesis. However, a defensible proxy was found in the 200% of the FPL together with the percentile threshold. Finally, the proposed method replaces the ranking system that weights the minority variable over the income criteria with a simple display that shows which of the variables an area qualifies for or if both criteria are met. The display will be at both the 85th and 95th percentiles so that users can choose if and how to weight individual criterion versus the combination of the two. Nonetheless, it is suggested that areas that qualify by multiple criteria be held to lower percentile levels because the cumulative effects of those combined factors may indicate levels of community vulnerability similar to higher percentile levels of any one criterion.
Table 7. Comparison of the Current EPA New England Potential Environmental Justice Screening Methodology versus the Newly Proposed Method

<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th>Proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit of Analysis</td>
<td>town and block group</td>
<td>block group</td>
</tr>
<tr>
<td>Minority</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable</td>
<td>Race/ethnicity</td>
<td>same</td>
</tr>
<tr>
<td>Definition</td>
<td>non-white + Hispanic</td>
<td>same</td>
</tr>
<tr>
<td>Threshold</td>
<td>&gt;25%, Regionally</td>
<td>85th Percentile, Regionally</td>
</tr>
<tr>
<td>Income</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable</td>
<td>Federal Poverty Limit (FPL)</td>
<td>same</td>
</tr>
<tr>
<td>Definition</td>
<td>200% of FPL</td>
<td>same</td>
</tr>
<tr>
<td>Threshold</td>
<td>&gt;25%, Regionally</td>
<td>85th Percentile, Regionally</td>
</tr>
<tr>
<td>Population Density</td>
<td>Optional overlay</td>
<td>same</td>
</tr>
<tr>
<td>Ranking</td>
<td>Sum of low-income score</td>
<td>No numerical ranking;</td>
</tr>
<tr>
<td></td>
<td>(0,1,2,3) and minority score</td>
<td>minority and low-income,</td>
</tr>
<tr>
<td></td>
<td>(0,2,3,4); each consecutive</td>
<td>one-other-both displayed</td>
</tr>
<tr>
<td></td>
<td>25% group gets a higher score</td>
<td>at 85th and 95th percentiles</td>
</tr>
</tbody>
</table>

The proposed method is effective at identifying areas that could most benefit from Agency attention because of their probable lack of internal resources to protect from environmental hazards. EPA can choose to administer its authority by limiting approval of new facility permits, increasing the rate of facility inspections, increasing community outreach on issues of lead abatement, asthma, brownfields redevelopment, and much more.

**Future Studies**

There are several areas in which further research should be done before subsequent versions of the GIS tool are released. First, the Mapping Workgroup recognizes the need for more research on how to better account for cost of living differences across the region. Next, an improved understanding of ways in which population density and urbanization impact environmental justice issues would greatly enhance any EJ-GIS methodology. Especially, investigating techniques to calculate the extent and strength of spatial clusters could lead to a more robust understanding of environmental burden. Also, ways to weight areas that meet multiple criteria should be explored.
One step that could be carried out in the future to assure accuracy is field-testing borderline cases (block groups identified in some tested methodologies but not others). Doing further research on-the-ground, rather than solely from census data, would provide a deeper understanding of those borderline communities. Finally, the methodology that best locates areas with the greatest potential for facing environmental injustice should be selected.

**Proposal for Phase 2 of the Tool - "Putting the 'E' Back in EJ"**

To get a true picture of environmental justice, one must be able to characterize both the demographics of an area plus environmental burden. This paper has suggested ways to improve New England’s screening methodology based on demographic factors only. Now it is up to each regulatory program to capture environmental impacts on communities through whatever means they seem fit. In the future, EPA may consider ways of standardizing this process through a secondary environmental screen, such as Region 2’s Environmental Load Profile. As of yet, this is a very contentious idea because there is a lack of consensus in the field of environmental health regarding the effects of pollutants on human health. Epidemiology, toxicology, and risk assessment are imprecise sciences that leave public agencies open to intense scrutiny and possible litigation when practiced.

**Environmental Justice Analysis at a Regional Scale**

There are many challenges to doing environmental justice analysis at a regional scale. From acquiring uniform data to applying theories of only local concern across multiple geopolitical boundaries, this thesis contended with many pressing policy and practicality issues. Throughout this process the question arose as to how valid or applicable screening tools are to the field of environmental justice. Usually determined on a case-by-case basis, creating a resource-targeting strategy such as this one can seem hasty or even careless.

Such sentiments impress upon the reader that, as with any decision-making tool, the user must exercise good judgment and keen awareness of factors that are important to addressing EJ concerns but may be omitted from the tool. Explicit guidance on the limitations of GIS analysis is essential. Furthermore, mandatory EJ awareness training, as is being implemented in Region 1, is a key antecedent to institutionalization of a screening tool. Awareness training can elevate staff members’ interest in EJ mapping and capacity to view them critically.
Alternative Models

In the context of EPA (and thereby for this research) GIS represents a technocratic, top-down approach to environmental decision-making. It allows little room for community involvement during or after methodology selection. Indeed, the compressed timeline for this thesis presupposed the lack of participation by community representatives. Although the GIS tool can still be opened up for public comment, there is no guarantee that the concerns of those groups will be met. In addition, without an environmental component to the methodology it may not be productive to open the methodology to public scrutiny because the integration of the two phases is of greater relevance to communities. Instead, we must rely on the fact that the Mapping Workgroup is composed of astute, thoughtful members who try to represent the interests of the community in good faith. To examine whether or not that is enough is crucial to any study involving environmental justice but is beyond the scope of this thesis because of resource limitations.

When dealing with issues that are relatively undeveloped scientifically, there is great need to create new systems to define and quantify terms like "disproportionate burden" in a way that is meaningful to regulators and community members alike. The technocratic approach, thus, must have a more participatory, community-based method of collecting information if the government is to gain legitimacy in the eyes of disadvantaged communities. Quantifying risk perception and community asset mapping are a few growing techniques to garner community input. Although they are much more resource intensive than using screening tools, these ideas have an important place in addressing EJ concerns and eventually should be incorporated into regulatory processes.

Conclusion

This thesis has proposed a methodology to identify potential environmental justice areas in New England. Although many other systems may be defensible, based on a year of detailed research, the approach laid out here is the most appropriate for the specific character and composition of New England and regulatory needs of EPA Region 1. The methodology is flexible enough to apply to the entire region equitably, yet refined enough to be practical for prioritizing efforts. In addition, the method is broad enough in scope that it can be easily tailored to other regions' needs in the event that others would like to replicate it.

The proposed methodology is believed to be a defensible indicator of areas that are most vulnerable to adverse health effects from environmental pollutants because of pre-existing negative socio-economic conditions. These areas may also have less political power and/or resources to maneuver through a complex capitalist and democratic system that arguably created a need for an environmental justice movement in the first place. Furthermore, communities identified through the screening tool may benefit most from
special attention from regulatory bodies, such as the Environmental Protection Agency, that are interested in equitably distributing their resources and reversing harmful trends.

It is hoped that the recommendations laid out in this thesis will be the basis of a GIS tool to be introduced to EPA New England staff by the end of 2002.
Bibliography


Appendix A: Glossary

Block group: A unit for census data reporting formed by a cluster of census blocks. Census block groups generally contain between 250 and 550 housing units.

Community of Concern: see Potential Environmental Justice Area

Cut-off: A value (or values) used to categorize a measurement scale into groups. For example, income might be divided by the cut-off into low and high-income groups.

Disproportionate Impact or Effect: An incidence (or prevalence) of an effect, a risk of an effect, or likely exposure to environmental hazards potentially causing such adverse health effects on a minority and/or low-income population, or sub-population such as children, that significantly exceeds that experienced by a comparable reference population.

EJ-GIS Application: see Tool

Environmental Burden: The adverse human health or environmental effect on a particular community or segment of the population related to a specific source or sources, resulting from cumulative or area-wide sources, and/or resulting from uneven application of government’s regulatory authority.

Exposure: Subject to the action or influence of environmental contaminants through ingestion, inhalation, or skin contact.

GIS Tool: A computer program that allows users to access, query, or display geographical data from their own computer via either desktop software or a web-based program.

Mean: The average value of a group of values (for any given variable, the sum of all observation values divided by the number of observations).

Median: The middle (50th percentile) observation in a ranked group of values.

Potential Environmental Justice Area: A target area that contains a significant minority and/or low-income population but for which the existence of disproportionate environmental health impacts has not yet been shown.

Proxy: A demographic or other factor assumed to be representative of a second factor for which data are unavailable (i.e., housing value is often used as a surrogate measure for income).
Regional Screening: An Environmental Justice analysis intended to highlight potential EJ hot-spots by viewing the demographics of large geographical areas (usu. state or EPA Regional boundaries). This type of analysis is considered proactive since it is primarily used as a preliminary screen from which users can decide where to focus their attention/resources before a particular problem is identified.

Redlining: The practice of banks and insurance companies of designating certain areas, especially ghetto areas, as bad risks.57

Screening Analysis: An initial Environmental Justice analysis for identifying areas that may have Environmental Justice concerns.

Site-specific Analysis: An Environmental Justice analysis intended to determine whether a specific identified area has Environmental Justice concerns. This type of analysis is associated with being reactive because it is often done in response to complaints.

Statistical Reference Number: A value of a variable that is used in comparison to another value in order to determine the unusualness of the second value. For example, in regions that use the state average percentage of low income as the reference number, the percentage of low income people in a community is considered unusually high, making it a potential EJ area, only if that percentage is greater than the state average.

Threshold: see Statistical Reference Number

## Appendix B. Nationwide U.S. EPA Environmental Justice Tools Survey

<table>
<thead>
<tr>
<th>Question</th>
<th>Basic description of the EJ Screening tool</th>
<th>Does the tool differentiate levels within variables, either visually or numerically (Ranking)?</th>
<th>Did you use statistical analyses?</th>
<th>Does the tool do comparative analyses?</th>
<th>Does it identify where inspections and assistance should be focused (proactive)?</th>
<th>Main Attributes in EJ Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reg. 1</td>
<td>A region-wide EJ ranking scheme available by request from the GIS team.</td>
<td>Yes. Score ranges from 0-7; Point value increases as percentage of minority or low income exceeds 25%, 50%, and 75% levels.</td>
<td>No</td>
<td>No</td>
<td>Yes. Provide maps to do inspections in high scoring areas</td>
<td>poverty, minority</td>
</tr>
<tr>
<td>Reg. 2</td>
<td>A site-specific EJ Screening tool that is available on the desktop for all users</td>
<td>Yes. In secondary environmental burden analysis but not for preliminary EJ screen.</td>
<td>Yes. Cluster Analysis</td>
<td>Yes. Uses cluster analysis to find statistical reference number for minority &amp; low income in each state. Minority is broken down by urban and rural areas.</td>
<td>Yes. Areas can be identified in preliminary screening.</td>
<td>income, minority</td>
</tr>
<tr>
<td>Reg. 3</td>
<td>A site-specific demographic screening tool that is available on the desktop for all users</td>
<td>No</td>
<td>No</td>
<td>Yes. Uses state average as screening cut-off. Can also compare to county and regional averages.</td>
<td>No</td>
<td>poverty, minority</td>
</tr>
<tr>
<td>Reg. 4</td>
<td>The Environmental Accountability Division provides maps to users by request.</td>
<td>Yes. Shows low income, high minority, and combo such as a different color in same layer.</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>income, minority</td>
</tr>
<tr>
<td>Reg. 5</td>
<td>Two tools. 1 tool produces paper maps and is available on request through the GIS center. 2nd tool is an Intranet that is available to all Regional users.</td>
<td>Yes. Color darker as either income or minority meets higher threshold of state average and 1x state average.</td>
<td>No</td>
<td>Yes. Uses 2x the state average as screening cut-off</td>
<td>Yes. They do use this for targeting areas that fit the EJ definition</td>
<td>poverty, minority</td>
</tr>
<tr>
<td>Reg. 6</td>
<td>A site-specific numerical ranking system with 2 phases: an EJ screen and a more complex risk analysis. Changes in software have made the previously Intranet accessible tool available only through the GIS center.</td>
<td>Yes. 1-5 for income and minority, 1-4 for population density; multiply 3 #s.</td>
<td>No</td>
<td>Yes. Uses state average for the screening cut-off.</td>
<td>Yes. They do make maps to target areas above a set number.</td>
<td>income, minority, population density</td>
</tr>
<tr>
<td>Reg. 7</td>
<td>A Sitemapper tool available to all users on the Desktop.</td>
<td>Yes. Areas that meet &gt; 25% criteria for both income and minority have darker color.</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>income, minority</td>
</tr>
<tr>
<td>Reg. 8</td>
<td>Maps available by request through select people with access to this Unix-based tool.</td>
<td>No</td>
<td>No</td>
<td>Yes. A report that accompanies the map compares the statistics in the radius on the map to the state statistics.</td>
<td>Yes. Provide this information to our inspectors as requested for yearly planning purposes.</td>
<td>poverty, minority</td>
</tr>
<tr>
<td>Region 9</td>
<td>A SiteEval, site-specific tool used by request in the GIS Center.</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>poverty, minority</td>
</tr>
<tr>
<td>Reg. 10</td>
<td>A tool which is available on the Intranet for all Regional users.</td>
<td>Yes. Color darker as either income or minority meets higher threshold of 1 2x and 1.5x state average. Used 1998 Peer Review EJ Guidance</td>
<td>Yes</td>
<td>Yes?</td>
<td>income, minority</td>
<td></td>
</tr>
<tr>
<td>H1</td>
<td>Enviro Justice Mapper - InRet: A tool with nationwide coverage available to the Public.</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>poverty, minority, population density, per capita income</td>
</tr>
<tr>
<td>H2</td>
<td>Enviro Justice Mapper - InRet: A tool which is available on the Intranet.</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>poverty, minority, population density, per capita income</td>
</tr>
<tr>
<td>H3</td>
<td>OTIS - Allows Users to Select % Minority and % Poverty intervals to determine what facilities are in high minority, or densely populated areas</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes. tool can provide facilities near high minority areas that have not been inspected, or are in violation</td>
<td>minority, population density</td>
</tr>
</tbody>
</table>
## Appendix B. Nationwide U.S. EPA Environmental Justice Tools Survey

<table>
<thead>
<tr>
<th>Region</th>
<th>Low Income/Poverty Definition or Threshold</th>
<th>Minority Definition or Threshold</th>
<th>Does the tool include Density Measures? (e.g. Facility or Population)</th>
<th>Other Attributes displayed</th>
<th>Can it show location of recent inspections?</th>
<th>Does it include language(s) spoken?</th>
<th>Does it include Education Level?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reg. 1</td>
<td>% w/ household income &lt; 2x Census poverty level scored from 0-3 points based on 25%, 50%, 75% thresholds</td>
<td>% non-white + white-Hispanic scored from 0-4 points based on 25%, 50%, 75% thresholds</td>
<td>No. Can do population density upon request.</td>
<td>Schools, regulated facilities</td>
<td>Can upon request</td>
<td>Can upon request</td>
<td>Can upon request</td>
</tr>
<tr>
<td>Reg. 2</td>
<td>% population below census poverty level = the cutoff value calculated from cluster analysis</td>
<td>% non-white + white-Hispanic = cutoff value calculated from cluster analysis</td>
<td>Yes. Cluster analysis urban v. rural. Facility density and population density used in environmental profile if area passes initial demographic screen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reg. 3</td>
<td>% &lt; Census poverty level compared to state average</td>
<td>% non-white + white-Hispanic &gt; to state average</td>
<td>Yes. Population Density. Other criteria may be evaluated upon request.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reg. 4</td>
<td>% &lt; 1.2x state average of household income = $15,000</td>
<td>1.2x state average for % non-white + white-Hispanic</td>
<td>No. Will do population density upon request; facility locations are too bad to do facility density</td>
<td>Different data layers can be chosen by user.</td>
<td>Yes. Use OTIS to provide compliance information</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Reg. 5</td>
<td>&gt; state average and &gt;= 2x state average % w/ household income &lt; Census poverty level</td>
<td>&gt; state average and &gt;= 2x state average % of non-white + white-Hispanic</td>
<td>No. Upon request, can do population density using an application</td>
<td>Looking into education and sensitive receptors</td>
<td>No</td>
<td>Yes. Inability to understand English will complicate this with the TRI data.</td>
<td>Yes</td>
</tr>
<tr>
<td>Reg. 6</td>
<td>% w/ household income &lt; $15,000 compared to state average; rank from 1-5 (5 means &gt;2x state average)</td>
<td>% non-white + white-Hispanic compared to state average; rank from 1-5 (5 means &gt;2x state average)</td>
<td>Yes. Easier to use density since doing buffer analysis</td>
<td>90+ data layers that can be chosen by user. Do 1-5 rankings for: telephone, language, sewer system, high school education. Water division uses 1-10 scale. Lead (housing dates, roads, age of children, smelters in the area). Not all variables are on everyone's desktops.</td>
<td>Yes, in the optional 2nd tier analysis.</td>
<td>Yes, in the optional 2nd tier analysis.</td>
<td>Yes, in the optional 2nd tier analysis.</td>
</tr>
<tr>
<td>Reg. 7</td>
<td>&gt;25%, 50%, 75% w/ household income &lt; $12,500</td>
<td>&gt;25%, 50%, 75% non-white + white-Hispanic</td>
<td>No. Can overlay as separate layer though</td>
<td>Regulated facilities</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Reg. 8</td>
<td>% w/ household income &lt; Census poverty level compared to state average</td>
<td>% non-white + white-Hispanic &gt; to state average</td>
<td>No</td>
<td>Tribal areas, regulated facilities</td>
<td>No. Could probably do so if requested.</td>
<td>No. We can only determine this by direct contact with community members, if possible.</td>
<td>No.</td>
</tr>
<tr>
<td>Region 9</td>
<td>% &lt; Census poverty level displayed in 25% levels. There is no reference number.</td>
<td>% non-white + white-Hispanic displayed in 25% levels. There is no reference number.</td>
<td>Yes. Population Density</td>
<td>Regulated facilities, Endangered Species, Drinking Water Wells. In Hawaii, there are additional layers about sensitive environments.</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Reg. 10</td>
<td>% w/ household income &lt; $15,000 and $25,000 compared to state average</td>
<td>% &gt;1.2 and 1.5x state average % of non-whites + white-Hispanic</td>
<td>No. Sometimes use population density to &quot;get a handle on where people are located&quot;</td>
<td>If and type of facilities, NAAQS attainment status, health data</td>
<td>No. Have done this for specific programmatic projects.</td>
<td>No. Currently get this information from US Census database.</td>
<td>No. Currently get this info. from US Census database.</td>
</tr>
<tr>
<td>HQ</td>
<td>% &lt; Census poverty level</td>
<td>% non-white + white-Hispanic</td>
<td>Yes</td>
<td>Hospitals, schools, Envirofacts facilities</td>
<td>No</td>
<td>No</td>
<td>No - but maybe later</td>
</tr>
<tr>
<td>HQ</td>
<td>% &lt; Census poverty level</td>
<td>% non-white + white-Hispanic</td>
<td>Yes</td>
<td>OSHA compliance data (Inspections by EPA and OSHA)</td>
<td>No</td>
<td>No - but maybe later</td>
<td>Yes</td>
</tr>
<tr>
<td>HQ</td>
<td>Low income based upon HUD definitions being added</td>
<td>Same as Census</td>
<td>Yes. Population Density and Facility Density</td>
<td>RCRInfo, PCS, AFs, Enforcement Docket, TRI, Hospitals, schools, etc.</td>
<td>Yes</td>
<td>No</td>
<td>Report shows education level</td>
</tr>
</tbody>
</table>
Calculating Population Under 200% of Federal Poverty Level:

\[(P1210001 + P1210002 + P1210003 + P1210004 + P1210005 + P1210006 +
P1210007 + P1210008 + P1210009) - P1210009\]

(poverty universe) - (2.00x FPL and over) = those with income less than 200% of FPL

Determining Race:

\[P0010001 - P0120001\]

(all people) - (non-hispanic whites) = non-whites and hispanic whites