IEc

Review of EJ Literature and Screening Tools & Recommendations for Alternative EJ Definitions

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1. INTRODUCTION

In addition to reducing health risks to the general population, another goal of U.S. environmental policy is to address issues of environmental justice (EJ). That is, preferred policies will reduce the likelihood that environmental health risks are inequitably distributed and that particularly vulnerable and susceptible or otherwise disadvantaged populations do not bear a disproportionate burden of health risk. The U.S. EPA defines EJ 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 (US EPA, 2015b)." In order to achieve environmental justice gains, policy makers must consider not only how a regulation will impact average exposures across a population, but how regulations will impact the distribution of exposures in the affected population.

The South Coast Air Quality Management District (SCAQMD) develops air pollution control strategies to help California's South Coast Air Basin (SCAB) achieve compliance with Federal and State air quality standards. As part of its upcoming 2016 Air Quality Management Plan Socioeconomic Analysis, SCAQMD plans to include considerations of expected impacts of its air pollution control measures on EJ communities. SCAQMD currently defines an EJ community as "an area with at least 10% of the population below the federal poverty line and a $PM_{2.5}$ concentration greater than 11.1 μg/m^3 per year or a toxic cancer risk of greater than 894 in a million (South Coast Air Quality Management District, 2015)."[1] These $PM_{2.5}$ and toxic cancer risk thresholds represent the current top 15th percentile of mean values in each grid cell, and are updated over time. This definition, which SCAQMD uses for air pollution-related community grant allocation purposes, identifies communities that are exposed to greater than average air pollution exposures and that experience economic disadvantage and is thus fit for its intended purpose. Our review of the EJ literature suggests there may be additional factors that also warrant consideration when designating EJ areas for the purpose of evaluating the spatial distribution of benefits from air pollution control measures. These factors include other demographic characteristics that may make a community particularly vulnerable to air pollution exposure impacts, such as age distribution. To understand whether inclusion of these other characteristics would have a substantial impact on a distributional analysis of the benefits of air pollution control measures, we set out to define an alternative set of definitions for use in a sensitivity analysis within the 2016 Socioeconomic Analysis.

[1] This definition is most current as of February 2016, and does not reflect the definition included in the 2012 Air Quality Management Plan Socioeconomic Analysis.

IEc has conducted an analysis that reviews the existing literature for working definitions of EJ communities, evaluates screening tools that have been developed to help identify EJ communities, and assesses how these definitions impact the policy maker's ability to compare and contrast regulations. Based on these reviews, we recommend alternative sets of criteria SCAQMD could apply to define EJ communities as a sensitivity analysis of SCAQMD's current EJ definition to evaluate socioeconomic impacts of air quality management policies. In the remainder of this report, we first describe our approach to this analysis, then summarize our results and present our recommendations.

2. METHODS

We began by consulting extensively with SCAQMD to understand their current approach and their goals for EJ-related analysis. Once we had a sound understanding of SCAQMD's needs and goals for an EJ analysis, we reviewed alternative working definitions of EJ areas using a three-step approach. First, we reviewed U.S. EPA guidance on EJ and studies identified by SCAQMD. Next, we conducted a supplemental review of the published literature based on the criteria provided in Table 1, below. Finally, we reviewed the EJ definitions employed by other state and local departments of environmental protection or air quality agencies across the U.S.

TABLE 1. EJ DEFINITION LITERATURE REVIEW CRITERIA

CRITERIA
GENERAL:
1. Study is peer-reviewed. 2. Study is written in English. 3. Study analyzes definition of environmental justice areas, vulnerable and sensitive areas, or environmental justice screening method. 4. Study was published after 2010. Earlier studies were considered if they were in the South Coast Air Basin or California.
GEOGRAPHY AND STUDY POPULATION:
5. Study uses a location whose characteristics are similar to the South Coast Air Basin. Order of preference of study location: a. South Coast Air Basin (Los Angeles, Orange, Riverside, and San Bernardino Counties) b. Within State of California c. Within Western United States d. Within United States or Canada 6. Study uses study population with similar characteristics as found in Los Angeles, Orange, Riverside, and San Bernardino counties.

We began by searching existing SCAQMD documents and guidance documents that address EJ issues, including SCAQMD's 2012 Socioeconomic Report; and U.S. EPA's Guidance on Considering Environmental Justice during Development of Regulatory Actions (2015), Guidelines for Preparing Economic Analyses (2014), and Draft Technical Guidance for Assessing Environmental Justice in Regulatory Analysis (2013). We then conducted a literature review of studies that compared alternative definitions of EJ communities. We searched PubMed and Google Scholar for peer-reviewed articles from 2010 onward, using search terms "environmental AND justice AND definition" and "environmental AND justice AND define." We also included important studies that were referenced by those identified in our search, as well as studies that were recommended by our scientific advisors, Dr. Jon Levy of Boston University and Dr. Sam Harper of McGill University.

In addition to a literature review, IEc also reviewed relevant screening tools used to identify EJ areas. We analyzed tools identified by SCAQMD, as well as those previously identified by IEc. Tools were evaluated based on data resolution, data availability, ranking methods, and inclusion of environmental and demographic indicators as determined through the literature review.

IEc participated in a number of discussions with SCAQMD staff to understand their current practices for designating EJ communities and their interest in conducting a sensitivity analysis of EJ definitions in the 2016 Socioeconomic Analysis. IEc then compiled a set of guidelines based on these calls to aid in creation of an alternate EJ definition.

3. RESULTS

In this section, we summarize the results of our research, first presenting our understanding of SCAQMD's needs for an EJ analysis; then presenting the results of our literature review on defining EJ and our EJ screening tool analysis; and, finally, recommending a set of potential EJ definitions.

Based on our conversations with SCAQMD, the intention of this analysis is to evaluate and compare the implications of one or more alternative definition or definitions of EJ areas that can be included in its 2016 AQMP EJ analyses. The definition should incorporate SCAQMD's air quality and toxic cancer risk matrices, along with relevant socioeconomic data.[2] Other non-air quality environmental indicators may be included in an alternative definition used for comparison purposes in sensitivity tests.

3.1 REVIEW OF DEFINITIONS OF EJ COMMUNITIES

Below, we analyze definitions of EJ communities based on common factors and themes identified throughout the literature review. We first describe federal guidelines for how EJ analyses should be incorporated in policy making, major findings of the literature review, and indicators of vulnerability and susceptibility, and then consider indicators to which EJ community definitions are sensitive. Finally, we present currently used working definitions of EJ in other state and local government agencies.

[2] Race and ethnicity are not included in the definition of EJ communities to facilitate use of the definition in circumstances where use of these factors is prohibited. This exclusion is not intended to minimize the importance of examining race and ethnicity in the context of environmental impacts and vulnerability. Neither is the exclusion intended to prevent subsequent consideration of race and ethnicity when legally appropriate.

3.1.1 How do Federal Guidelines Suggest Incorporating EJ Analysis in Policy Making?

Executive Order 12898, issued by President Clinton in 1994, directs federal agencies to identify and address disproportionately high and adverse human health or environmental effects of policies on minority and low-income populations (*Executive Order 12898 - Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, 1994). According to U.S. EPA's 2014 Guidelines for Preparing Economic Analyses, the purpose of analyzing distributional effects of a regulation is to examine how costs and benefits are distributed across population groups and life stages of interest, as it is challenging to assume that tighter regulatory standards improve environmental quality for everyone (US EPA, 2014). Policies may create disproportionate impacts on EJ communities or exacerbate existing inequalities (US EPA, 2015c).

Due to the variability in communities across the nation and within individual states or cities, it is both difficult and impractical to choose a single technical definition of an EJ community. The EPA's 2013 Draft Technical Guidance for Assessing Environmental Justice in Regulatory Analysis suggests that population groups should be defined within the context of particular regulatory actions such that the definition can inform necessary data collection and analysis.

According to these guidance documents, no single definition of EJ suits all regulatory scenarios, but rather the definition should be "fit for purpose." However, the Federal guidance suggests that when defining EJ communities, analysts should consider factors that allow for evaluation of combined risks from exposure to multiple chemical and nonchemical stressors, and include factors that influence susceptibility, potentially including genetics, diet, nutrition and disease status, other stress, co-exposure to similar toxics, making particular note of children, elderly, pregnant women, and those in high risk occupations (US EPA, 2013).

3.1.2 How Have EJ Communities Been Defined in the Literature?

Major takeaways from the literature review include the importance of creating a "fit for purpose" definition of EJ for a particular area or policy analysis (as discussed above), the need for quantitative environmental and demographic indicators in a definition, and the vast variability in EJ definitions that are appropriate in different contexts. In a study analyzing inequalities of environmental health, Morello-Frosch et al. (2011) provided evidence that policy makers must analyze health disparities, environmental exposure disparities, intrinsic biological factors, and extrinsic social factors across different groups to address cumulative impacts of environmental and social stressors. These factors have been aggregated traditionally under the umbrella of vulnerability and susceptibility, where vulnerability is related to socioeconomic qualities and susceptibility is related to inherent qualities like age or genetics. Inclusion of quantitative indicators that describe a community's vulnerability and susceptibility is necessary for determining what kind of policies and mitigation strategies can be employed to improve public health for those who are most affected.

Vulnerability

Vulnerability has been defined by the U.S. EPA as "differential exposure and differential preparedness," and elsewhere, as "$PM_{2.5}$-related effects due to factors including socioeconomic status" (Fann et al., 2011). The construct has been quantified most commonly through use of U.S. Census data for demographic factors affecting preparedness. In the literature, a community that may be made up of a particularly vulnerable population has been described by proportion minority or people of color (Gilbert & Chakraborty, 2011; Miranda, Edwards, Keating, & Paul, 2011; R. Morello-Frosch, Pastor, & Sadd, 2001; Sadd, Pastor, Morello-Frosch, Scoggins, & Jesdale, 2011), proportion below poverty level or median household income (Fann et al., 2011; Gilbert & Chakraborty, 2011; Kershaw, Gower, Rinner, & Campbell, 2013; Miranda et al., 2011; R. Morello-Frosch et al., 2001; Prochaska et al., 2014; Sadd et al., 2011), educational attainment status (Fann et al., 2011; Kershaw et al., 2013; Sadd et al., 2011), home ownership or renter status (Gilbert & Chakraborty, 2011; Kershaw et al., 2013; R. Morello-Frosch et al., 2001; Prochaska et al., 2014; Sadd et al., 2011), as well as other socio-demographic indicators. There is overlap between how vulnerable populations are defined and populations that are historically disadvantaged.

Studies in Southern California (Rachel Morello-Frosch, Pastor, Porras, & Sadd, 2002) and elsewhere have found that health risk outcomes including estimated lifetime cancer risk from environmental exposures and demographic factors (Gilbert & Chakraborty, 2011) proximity to toxic release facilities (Kershaw et al., 2013; Rachel Morello-Frosch et al., 2002), and air pollution exposure (Miranda et al., 2011; Schweitzer & Zhou, 2010) are significantly different between communities with different income characteristics. In the SCAB, Morello-Frosch et al. (2002) found that as household income increased, lifetime cancer risk decreased generally based on race and ethnicity (with cancer risk nearly 50% greater for Asian Americans, African Americans, and Latinos compared with Caucasians); whereas Gilbert and Chakrabarty (2011) found using two different statistical methods that the proportion of owner-occupied housing units below poverty, and proportion minority were significant predictors of lifetime cancer risk. Low income communities tend to have greater sources of environmental risk (Miranda et al., 2011), though this tendency is inconsistent across type of risk and level of geographic aggregation (Ringquist, 2005). The results of these studies demonstrate a need for inclusion of both an income-related indicator and other non-income sociodemographic indicators in defining EJ areas.

Results of studies performed in the SCAB and in Southern California do not differ greatly from the results of other studies performed across the U.S. and Canada. In a study analyzing environmental inequality in the SCAB, Marshall (2008) found mean exposures to ambient air pollutants (including diesel particles) are 16% - 40% different between whites and nonwhites (Marshall, 2008). Both an older study of EJ in Southern California and a nationwide meta-analysis assessing evidence of environmental inequalities found that there is "ubiquitous" evidence of differences in exposure based upon race alone, after controlling for other economic, land-use, and population factors (R. Morello-Frosch et al., 2001) and irrespective of other indicators (Ringquist, 2005). The importance of race in defining an EJ community is described by Miranda et al. (2011), who found that EJ concerns are more prominent along race and ethnicity lines. In U.S. counties whose air is monitored by U.S. EPA, those with the worst air quality are home to more predominantly black and Hispanic populations (Miranda et al., 2011). Ringquist's 2005 meta-analysis found that race-based environmental inequities exist and are unaffected by type of risk analyzed, level of geographic aggregation, or type of control communities, while class, income, and economic based inequities demonstrate weaker evidence. Due to the sensitive nature of reporting race and ethnicity in some jurisdictions, linguistic isolation has been used as a surrogate, attempting to capture the same underlying construct as proportion minority in a population. Linguistic isolation has been defined as the proportion of residents under age 4 living in households where no one over age 15 speaks English well (Sadd et al., 2011), and may serve as stand-in for the community's decreased resources to advocate for action on improving inequalities.

Another sociodemographic factor included in some EJ definitions is educational attainment, defined as proportion of the population over age 24 (or under age 25 (Kershaw et al., 2013)) with less than high school education (Sadd et al., 2011), or those with less than a high school education (Alexeeff et al., 2012; Fann et al., 2011). Using educational attainment to identify vulnerable populations, Fann et al. (2011) found that when comparing air quality management approaches, overall inequality across the population decreases, though they found greater inequalities within education groups than between education groups. Kershaw et al. (2013) found significant differences in educational attainment between census tracts hosting toxic air pollution emitters versus those that do not.

In addition to demographic indicators, a community also may be more vulnerable to the impacts of air pollutant exposures based on its members' exposures to environmental contaminants, including, but not limited to, air and water pollution and hazardous chemical exposures. In a study of a multi-pollutant risk-based approach to air quality management, Fann et al. (2011) analyzed different definitions of vulnerable and susceptible populations using combinations of baseline health, demographic, education, poverty, and air quality data. The largest differences in annual mean population-weighted $PM_{2.5}$ exposures per person were found between EJ and non-EJ communities when EJ communities were defined using both baseline $PM_{2.5}$ exposure and asthma hospitalization rates (Fann et al., 2011). A study assessing cumulative impacts in California included measures of $PM_{2.5}$ concentrations, ozone concentrations, toxic releases from industrial facilities, traffic volumes, and pesticide use in addition to other public health and socioeconomic factors (Alexeeff et al., 2012). The Environmental Justice Screening Method (EJSM), tested in the SCAB, includes measures of air quality hazards, sensitive land use, hazardous land use, and health risks and exposures, in addition to social and health vulnerability indicators (Sadd et al., 2011). While the potential correlation between indicators makes it difficult to determine which factors are important to include and which are not, there is evidence based on the above analysis of vulnerability to include air quality measures and potential environmental exposures when the goal of a potential regulation or policy is to improve air quality.

Susceptibility

Susceptibility differs from vulnerability, because it is related to a person's underlying biology rather than social constructs. The U.S. EPA defines susceptibility as the "degree to which a given population experiences a greater or lesser biological response to exposure (US EPA, 2009).” Baseline health data, including mortality rates and hospital admissions rates, are commonly used surrogate susceptibility indicators (Fann et al., 2011), as well as age (Alexeeff et al., 2012; Kershaw et al., 2013; Miranda et al., 2011; Sadd et al., 2011). Fann et al. (2011) found that when paired with poverty and education status, both baseline rates of asthma-related hospital admissions and mortality indicate a common pattern of vulnerable and susceptible populations in Detroit. Young children (those under 5 years) and the elderly (those over 65 years) may be more susceptible to the health impacts of air pollution. Across U.S. counties, proportion of the population aged 65 and over was found to be a significant predictor of the worst 20% of counties for annual and daily $PM_{2.5}$ concentrations, while proportion of the population under age five is a significant predictor of the worst 20% of counties for ozone exposures (Miranda et al., 2011). When comparing the socioeconomic status of census tracts within two kilometers of the top ten highest emitting toxic release facilities with the rest of host census tracts, children under 14 years of age are significant predictors of differences in toxic equivalency potential scores (Kershaw et al., 2013).

3.1.3 Are Analysis Results Sensitive to the Definition of EJ?

While some studies explicitly categorize the indicators used in defining EJ communities as related to vulnerability or susceptibility, others do not, instead simply employing different environmental, health, and demographic data to define communities. As is clear from IEc’s review of relevant literature, there is not a one-size-fits-all working definition that can be employed to define particularly vulnerable and susceptible communities in different geographic areas across the US. However, certain definitions have been found to be more successful in appropriately designating potential EJ communities (Downey, 2005; R. Morello-Frosch et al., 2001; Ringquist, 2005; Sadd et al., 2011). Fann et al. (2011) analyzed use of different indicators for defining EJ communities, including a measure of vulnerability (poverty, education, and air quality) and a measure of susceptibility (mortality rate, hospital admissions due to asthma rate). Though they included no measures of race/ethnicity in their EJ definitions, they found that while education attainment and poverty status may be interchangeable as measures of vulnerability, highly resolved baseline asthma hospital admissions and mortality rates are not interchangeable measures of susceptibility. The largest population-weighted changes in air quality were observed when EJ communities were defined by health incidence rates and air quality exposure, more so than definitions based on health incidence rates and poverty or health incidence rates and education (Fann et al., 2011).

3.1.4 Cumulative Impacts

A common thread among studies of EJ communities is the need for inclusion of cumulative impacts, or cumulative risks, in a community. Cumulative impacts include the aggregation of environmental and social stressors faced by vulnerable communities (US EPA, 2003). Consideration of cumulative exposure helps to determine what disparities in exposure mean for inequities in health risks, as the relationship between health risks and a single environmental exposure is not direct. Sadd et al. (2011) employed an environmental justice screening method in the SCAB and analyzed 23 indicator metrics organized as hazard proximity and land use, air pollution exposure and estimated health risk, and social and health vulnerability measures. Areas with high cumulative impact scores had high minority proportion, low income populations, and were located near industrial activities (Sadd et al., 2011).

3.1.5 How Do Other Agencies Define EJ Areas?

SCAQMD aims to assess and employ state of the science definitions for EJ areas. To ensure our recommended definitions are up to date, we also reviewed the definitions used by other State agencies to identify EJ areas. Table 2 below lists EJ definitions by agency. As described below, the California Environmental Protection Agency (CalEPA) has developed a tool, CalEnviroScreen 2.0, to identify communities that are disproportionately burdened by multiple pollutant sources (California Office of Environmental Health Hazard Assessment, 2015). The California Air Resources Board (CARB) employs the state definition of EJ, "The fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies," and defers to the CalEnviroScreen 2.0 tool to define EJ communities.

TABLE 2. EJ DEFINITIONS OR SCREENING TOOLS USED BY STATE AND LOCAL ENVIRONMENTAL AGENCIES

AGENCY	EJ DEFINITION OR SCREENING TOOL USED
California EPA	CalEnviroScreen2.0
California Air Resources Board	Utilizes the state definition of EJ, "The fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies (California Air Resources Board, 2010)."
Massachusetts Department of Environmental Protection	If any of the following are true: • Block group whose annual median household income is equal to or less than 65% of the statewide median; or • 25% or more residents identified as minority; or • 25% or more of households having no one over age 14 who speaks English only or very well (Massachusetts Department of Environmental Protection, 2014)
Connecticut Department of Energy and Environmental Protection	Uses the list of distressed municipalities from the Department of Economic and Community Development, based on per capita income, % of poverty, unemployment rate, % change in population, % change in employment, % change in per capita income, % of house stock built before 1939, % population with high school degree or higher, and per capita adjusted equalized net grand list (Connecticut Department of Energy and Environmental Protection, 2015).
DC Department of Energy and Environment	Ensures "District citizens who are low-income, minority, or have limited English proficiency receive equal protection under environmental laws and have meaningful opportunities to participate in environmental decision making undertaken by DOEE (DC Department of Energy & Environment, 2015)."
New York State Department of	"Potential EJ Areas are 2000 U.S. Census block groups of 250 to 500 households each that, in the 2000 Census, had populations that met or exceeded at least one of the following statistical thresholds:

AGENCY	EJ DEFINITION OR SCREENING TOOL USED
Environmental Conservation	1. At least 51.1% of the population in an urban area reported themselves to be members of minority groups; or 2. At least 33.8% of the population in a rural area reported themselves to be members of minority groups; or 3. At least 23.59% of the population in an urban or rural area had household incomes below the federal poverty level. (New York State Department of Environmental Conservation, 2003)."
Pennsylvania Department of Environmental Protection	Any census tract where 20% or more live in poverty, and/or 30% or more is minority (Pennsylvania Department of Environmental Protection, 2014).
Michigan Department of Environmental Quality	Defined by U.S. EPA EJSEAT tool (Michigan Environmental Justice Working Group, 2010).
Rhode Island Department of Environmental Management	Based on 2000 census block groups, those with percentages in the top 15% for low income residents and/or non-white populations (Rhode Island Department of Environmental Management, 2014).
Tennessee Department of Environment and Conservation	Defined by U.S. EPA EJScreen Tool (Tennessee Department of Environment and Conservation, 2015).

Outside of California, the Massachusetts Department of Environmental Protection defines EJ communities as those where any of the following are true: a block group whose annual median household income is equal to or less than 65% of the statewide median ($62,072 in 2010); or 25% or more of the residents identify as minority; or 25% or more of households having no one over the age of 14 who speaks English only or very well (Massachusetts Department of Environmental Protection, 2014). Connecticut's Department of Energy and Environmental Protection utilizes the list of distressed municipalities from the Department of Economic and Community Development, which ranks 169 towns in Connecticut based on income, poverty, unemployment, population change, employment change, income change, housing characteristics, and education characteristics as described by the U.S. Census and American Community Survey (ACS) estimates, and defines the 25 towns with the highest scores based on those components as the distressed municipalities. Connecticut General Statute Section 32-9p indicates that a distressed municipality should be based on "high unemployment and poverty, aging housing stock, and low or declining rates of growth in job creation, population, and per capita income" (Connecticut Department of Energy and Environmental Protection, 2015). New York State Department of Environmental Conservation defines potential EJ areas as block groups that had populations that met or exceeded at least one of the following statistical thresholds: at least 51.1% of the population in an urban area reported themselves to be members of minority groups, at least 33.8% of the population in rural areas reported themselves to be members of minority groups, or at least 23.59% of the population in an urban or rural area had household incomes below the federal poverty level (New York State Department of Environmental Conservation, 2003). The Pennsylvania Department of Environmental Protection defines EJ areas as a census tract where 20% or more individuals live in poverty and/or 30% or more of the population is minority (Pennsylvania Department of Environmental Protection, 2014).

While these states provide specific definitions for EJ communities, we can see that their definitions differ from one another. Some states consider a set of indicators and require multiple thresholds be met before an area is defined as an EJ area, while others allow an EJ area to be defined based on a single indicator. Other state agencies, including the Michigan Department of Environmental Quality and Tennessee Department of Environment and Conservation, utilize U.S. EPA's Environmental Justice Strategic Enforcement Assessment Tool (EJSEAT) tool and U.S. EPA's EJScreen tool, respectively, to define EJ areas. EJSEAT was created for the EPA Office of Enforcement and Compliance Assurance to identify areas with potentially high public health burdens, and uses federal databases to include environmental, human health, compliance, and social demographic indicators (EPA Office of Enforcement and Compliance Assurance, n.d.). Most state environmental protection departments do not specify EJ definitions publicly.

3.2 ENVIRONMENTAL JUSTICE SCREENING TOOLS

To further inform our assessment of alternatives to enhance SCAQMD's current EJ analysis, we reviewed existing EJ tools and methodologies. The reviewed tools identify environmentally burdened communities, socially burdened communities, or both. We assessed common parameters across the tools, compared these parameters to the current SCAQMD EJ area definition, and ultimately assessed which tool would be most useful in choosing alternative EJ definitions. The tools are particularly useful as a means to compare and contrast how varying EJ definitions affect the identification of EJ communities within the SCAQMD.

This review included four tools or methods identified by SCAQMD: EJScreen, CalEnviroScreen 2.0, Environmental Justice Screening Method (EJSM), and Cumulative Environmental Vulnerabilities Assessment (CEVA), as well as several others IEc identified in its literature review above or from previous work. Tools were evaluated with a focus on the following parameters: data resolution, data availability, ranking methodology, and inclusion of key environmental and population indicators. Understanding that SCAQMD analyzes data at the sub-county level, preference was given to tools with sub-county data resolution. Also, tools with publicly available easy-to-use processed source data were preferred, as this both facilitates transparency with constituents and simplifies the process of tailoring the data analysis for SCAQMD's goals. A review of the 2012 Socioeconomic Assessment by Abt Associates suggested percentage-based thresholds replace quantitative thresholds; thus, we assessed each tool's methodology with particular attention to the threshold-defining steps. Finally, we evaluated the inclusion of key environmental and population indicators identified both from the literature and from the current SCAQMD definition. As described below; the review resulted in the selection of CalEnviroScreen 2.0's scoring approach as the preferred methodology for creation of alternative EJ definition(s) for the proposed sensitivity analysis within the 2016 Socioeconomic Analysis.

EJScreen was developed by the U.S. EPA with contributions from U.S. EPA regional offices, Abt Associates, ESRI, and Science Applications Internal Corporation (SAIC), among others. Currently, the U.S. EPA uses EJScreen to "identify areas that may have higher environmental burdens and vulnerable populations as the Agency develops programs, policies and activities that may affect communities (US EPA, 2015a)." Both the tool and the guidance documents were updated in 2015. This tool assigns a percentile to each census block in the United States, and allows for the combination of 12 environmental indicators and 6 population indicators in two ways:

- Any one environmental indictor may be combined with two pre-selected population indicators (% minority and % low-income); or
- Any one environmental indicator may be combined with all 6 population indicators.

The processed source data are available as GIS or Excel files (US EPA, 2015a). Though the data are publicly available and resolved to census blocks, EJScreen guidance cautions that the tool should not be used to define an EJ community, consistent with Executive Order 12898 (US EPA). Additionally, the tool allows for combining population indicators with only a single environmental indicator, which is limiting for SCAQMD's purposes.

The EJSM was developed by Rachel Morello-Frosch of UC Berkeley, Manuel Pastor of USC, and James Sadd of Occidental College; the most recent update was released in 2015. The method was initially developed for the California Air Resources Board, and provides no user-accessible tool. This method assigns a value (1-5) to each census tract for each of four categories, resulting in a cumulative score (0-20). Ten hazard proximity indicators and five sensitive land use indicators comprise the Hazard Proximity category; six indicators comprise the Health Risk & Exposure category; nine indicators comprise the Social & Health Vulnerability category; nine indicators comprise the Climate Change Vulnerability category. Though this analysis was originally ground-truthed and performed for the SCAB region, this is a method without readily available processed source data or results. The EJSM indicators may be highly correlated with one another (e.g., "housing value" and "% residents below twice national poverty level"), and the methodology does not allow for removal or addition of indicators; the methodology allows only for the removal of one or more of the four categories listed above.

CEVA was developed by UC Davis's Center for Regional Change in November 2011 to provide spatial analysis identifying places subject to cumulative environmental hazards and social, economic, and political strains. Raw data are used to assign a mean value for each of six environmental hazard indicators, six social vulnerability indicators, and three health indicators to each census block. The means are averaged and normalized for both the cumulative environmental hazard indicators and social vulnerability indicators. The resulting environmental and social scores are mapped, with a different color assigned to each category bin based on percentiles (Low, Medium, and High). This analysis does not provide readily accessible source data or results. Additionally, the cumulative environmental hazard indices (e.g., proximity to hazardous waste treatment facilities, chrome platers) do not align with SCAQMD's emphasis on air quality burdens.

U.S. EPA's Community-Focused Exposure and Risk Screening Tool (C-FERST) is a pilot tool currently in development that will help communities understand potential environmental public health issues in EJ communities. Currently, the beta-version is available upon request for pilot testing, and the full public release is not yet scheduled.

The University of South Carolina's Social Vulnerability Index (SoVI) 2006-10 measures the social vulnerability of U.S. counties to environmental hazards. However, the data are resolved to counties, and thus is inconsistent with the spatial requirements for SCAQMD's analysis, which need to be more fine-grained than the county level.

The 2010 Social Vulnerability Index (SVI) was developed by the Agency for Toxic Substances & Disease Registry to assess social vulnerability for each census tract, especially as it relates to disaster relief. Because the tool includes indicators customized to disaster relief (e.g., percent housing structures with 10 or more units or percent households with no vehicle available) and did not include environmental burden, the tool would require significant alterations to meet SCAQMD's analytic needs.

CalEnviroScreen 2.0 was developed by the California Environmental Protection Agency (CalEPA) and the Office of Environmental Health Hazard Assessment (OEHHA). Guidance documents were updated in October 2014, and the tool was updated in November 2015. The tool was designed to aid in the identification of EJ communities for SB 535, which dictates that 25% of money from the Greenhouse Gas Reduction Fund must be directed to projects benefitting disadvantaged communities. Thus, both CalEPA and CARB currently use the tool to identify disadvantaged communities. CalEPA also uses the tool to aid in environmental justice grant administration, prioritizing clean-up sites, promoting compliance with environmental laws, and identifying opportunities for sustainable economic development. Raw data are used to assign each census tract a percentile for each indicator (indicators listed in Table 3 below), relative to the State of California. The percentiles are averaged and normalized for both the pollution burden indicators and the population indicators. The resulting pollution burden score and population score are multiplied. The product (0-100) is ranked against all census tract scores. The overall score is a percentile calculated using the ordered (0-100) values.[3] The tool is accompanied by a thorough guidance document, and all processed source data are available as GIS or Excel files. Because all source data are available and resolved to census tracts, the methodology is consistent with SCAQMD's goals and is replicable, and key indicators are included, CalEnviroScreen 2.0 was identified as the preferred methodology for enhancing SCAQMD's EJ analysis.

3.3 EJ DEFINITION OPTIONS

[3] SCAQMD has provided comments to CalEPA OEHHA regarding a potential concern with the percentile rank scoring method, namely that if the probability density distribution of an air quality measure is highly skewed (e.g., there are a small number of areas with very high $PM_{2.5}$ concentrations compared to the median $PM_{2.5}$ concentration), percentile rank scoring would not reflect this skewness. We have discussed this issue with SCAQMD and agreed that this method is still reasonable for use in the anticipated context for the 2016 Socioeconomic Analysis.

Through a series of discussions with SCAQMD, IEc aimed to create a set of alternative EJ definitions that provide a sensitivity analysis for SCAQMD's current grand distribution definition of EJ based on the following guidelines:

- An alternative definition should use SCAQMD's air quality-related data and matrices (including but not limited to $PM_{2.5}$ concentrations and toxic cancer risk) rather than values from another source,
- An alternative definition of EJ must include air quality measures,
- An alternative definition of EJ should include relevant socio-economic data; and
- An alternative definition of EJ may include non-air quality environmental indicators.

The use of multiple definitions that build on each other, adding related groups of indicators one at a time, provides a useful set of comparisons for sensitivity analysis. To best enhance SCAQMD's EJ analysis, we suggest developing these alternative definitions by tailoring CalEnviroScreen's source data and methodology to the SCAB, supplemented by air quality matrices generated by SCAQMD. Table 3 shows the indicators used by CalEnviroScreen and those that IEc proposes.

TABLE 3. COMPARISON OF CALENVIROSCREEN INDICATORS AND POTENTIAL INDICATORS PROPOSED BY IEC

INDICATOR TYPE	CALENVIROSCREEN INDICATORS	POTENTIAL INDICATORS PROPOSED BY IEC
Environmental	Ozone concentration $PM_{2.5}$ concentration Diesel PM concentration Drinking water contaminants Toxic releases from facilities Traffic density Pesticide use Cleanup sites Groundwater threats Hazardous waste generators and facilities Impaired water bodies Solid waste sites and facilities	Ozone concentration $PM_{2.5}$ concentration Diesel PM concentration Drinking water contaminants Toxic cancer risk Pesticide use
Demographic	Children and elderly Asthma rate Low birth weight infants Educational attainment Linguistic isolation Poverty Unemployment	Children and elderly Asthma rate Educational attainment Linguistic Isolation Poverty

Comparing the list of indicators used by Cal Enviro Screen and proposed by IEc, alternative definitions were created to best suit the needs of SCAQMD. Environmental indicators of potential hazard (e.g., proximity to hazardous waste facilities, groundwater threats, impaired water bodies, solid waste sites and facilities, and cleanup sites) were eliminated in favor of including indicators of measured environmental contaminant concentrations faced by communities. Toxic cancer risk values generated by SCAQMD were included in lieu of toxic releases from facilities. The proportion of low birth weight infants was removed due to lack of evidence for inclusion from the EJ literature review. Unemployment was removed as it may not be substantively different from other indicators (like poverty) for inclusion in an index. Because SCAQMD has jurisdiction only over the SCAB, percentiles should be generated relative to the SCAB region (rather than relative to all of California), incorporating SCAQMD cancer risk estimates, and replacing CalEnviroScreen's $PM_{2.5}$ data with SCAQMD's $PM_{2.5}$ data. In the remainder of this section we present our recommendations for EJ definitions and how the CalEnviroScreen 2.0 methodology and data can be used to identify EJ areas based on the recommended definitions.

For each indicator of interest (other than $PM_{2.5}$ concentration and toxic cancer risk as explained above), raw data from CalEnviroScreen is used to assign each census tract a percentile ranking. For example, the census tract with the highest $PM_{2.5}$ value in the SCAB region would fall into the 100^{th} percentile for the $PM_{2.5}$ indicator. Gridded $PM_{2.5}$ and toxic cancer risk values modeled by the SCAQMD are joined to the census tracts layer using population-weighted averages by area, and assigned percentile rankings. Percentile rankings were calculated for each indicator separately – zero and one hundred percentiles are included, and if there are zero values in the raw data, those were equated to zero values in the percentile rankings, as well. The environmental burden indicator percentiles are averaged across indicators, resulting in an average environmental burden percentile by census tract. This average percentile is divided by the maximum environmental burden percentile in the SCAB region and subsequently multiplied by 10, resulting in a 1-10 environmental burden score. The above process is repeated for the demographic indicators, resulting in a 1-10 demographic score. The pollution burden score and demographic score are multiplied. The product (0-100) is ranked against all SCAB census tract scores. The overall score is a percentile calculated using the ordered (0-100) values and sorted based on rank. To more closely align with the methods used by SCAQMD, the area of each census tract was then divided by the total area of the SCAB region to determine the percent of the region's area within each census tract. Beginning with the highest-scoring tract, all census tracts were deemed EJ, until the EJ tracts' percent area coverage summed to 15% of the total region area, a percentile threshold consistent with that applied by SCAQMD currently.

When defining EJ communities in an effort to analyze regulation or control policies, it is important to utilize information at the highest geographic resolution possible. Based on both our literature and EJ screening tool review, we recommend the following set of definitions to determine which communities are particularly vulnerable or susceptible to air pollution exposures (Table 4). The definitions are created based on CalEnviroScreen's framework summarizing environmental and sociodemographic indicators separately, then multiplying their respective scores together for an overall score, based on percentile ranking. Scores are multiplied together rather than added because often these indicators are understood in scientific literature as effect modifiers, which amplify risk; risk assessment applies numerical multipliers to account for human susceptibility; and in the related field of emergency response, many priority rankings are created via multiplication of factors rather than addition (California Office of Environmental Health Hazard Assessment, 2015). These ranked percentiles are relative to the SCAB rather than the state of California or the United States, as the definition of EJ areas should be limited to the area that is subject to SCAQMD's authority. CalEnviroScreen uses census tracts to define EJ areas, whereas SCAQMD uses its 4km x 4 km air quality grid. We constructed these definitions using census tracts, then weighted them based on area as explained above. Census tracts are created with an optimal population size of 4,000 people, are created with the intention of being maintained over time, generally follow visible features, and are updated by local participants (US Census Bureau, 2010). Identifying EJ communities based on area rather than count of census tracts, which are defined in part by population, differentially weights smaller area urban census tracts and larger area rural census tracts. For example, if an environmental indicator is more common in urban areas (e.g., diesel PM), EJ communities will include a larger population. If an environmental indicator is more common in rural areas (e.g., pesticide use), EJ communities will include a much smaller population.

TABLE 4. RECOMMENDED ALTERNATIVE EJ DEFINITIONS FOR SENSITIVITY ANALYSIS

ALTERNATIVE DEFINITION	DEMOGRAPHIC INDICATORS		ENVIRONMENTAL INDICATORS	
	Income	Other Sociodemographics	Air Quality	Other Environmental Burdens
1	Poverty status		$PM_{2.5}$, toxic cancer risk, ozone, diesel	
2	Poverty status	Age, asthma, linguistic isolation	$PM_{2.5}$, toxic cancer risk, ozone, diesel	
3	Poverty status	Age, asthma, linguistic isolation	$PM_{2.5}$, toxic cancer risk, ozone, diesel	Drinking water, pesticides

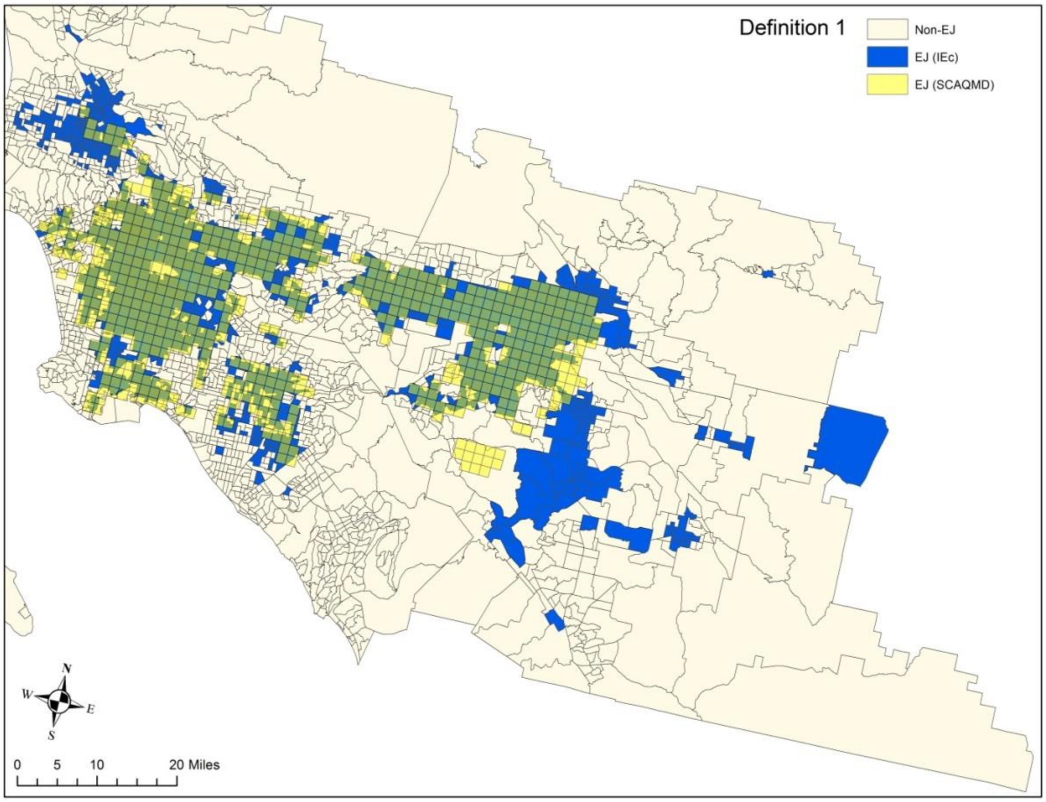
Definitions and data sources for the environmental and sociodemographic indicators included in the alternative EJ definitions are presented below.

- Poverty status is the percent of the population within a census tract whose income is less than twice the federal poverty level, as low income populations are more likely than wealthier populations to face adverse environmental burden. In their grant allocation EJ definition, SCAQMD includes areas where at least 10% of the population is below the federal poverty level. We recommend updating this to twice the federal poverty level to account for the higher than average cost of living in the SCAB and conservative federal poverty level value. Poverty data are from the ACS 5-year estimates for 2008-2012.
- Age is the percent of the population within a census tract under age 10 or over age 65. Children can be particularly sensitive to the effects of air pollution due to both their high activity levels and their developing body and organ systems, and the elderly can be particularly sensitive to air pollution effects due to preexisting health conditions. Data are from the U.S. Census Bureau's 2010 decennial census.
- Asthma is included as the age-adjusted rate of emergency department visits per 10,000 averaged between 2007 and 2009. These rates were modeled by the California Office of Statewide Health Planning and Development.
- Linguistic isolation is the percentage of households in which no one over age 14 speaks English very well or at all, as determined by the U.S. Census Bureau's 2008-2012 ACS estimates (California Office of Environmental Health Hazard Assessment, 2015).
- $PM_{2.5}$ concentrations were provided by SCAQMD, based on monitored and modeled $PM_{2.5}$ concentrations throughout the SCAB, gridded to 4km x 4km grid cells. These concentrations are then mapped to census tracts to appropriately incorporate the values into the Cal EnviroScreen geographic framework.

- Toxic cancer risks are modeled by SCAQMD in the SCAB, gridded to 4km x 4km grid cells. These risks are then mapped to census tracts to appropriately incorporate values into these definitions.
- Ozone is incorporated as the amount of daily maximum 8-hour standard, averaged 2009-2011.
- Diesel PM data are produced by CARB and modeled as the spatial distribution of gridded diesel PM emissions from on-road and non-road sources for a 2010 July day, distributed to census tracts.
- Drinking water contaminants are included as the drinking water contaminant index from the Drinking Water Systems Geographic Reporting Tool by the California Department of Public Health.
- Pesticides are the total pounds of active pesticide ingredients (filtered for hazard and volatility) used in production-agriculture per square mile.

Based on SCAQMD's current EJ definition, it is most appropriate to begin with a definition inclusive of an income or poverty indicator and air quality metrics (Definition 1). We then expand upon this definition, including other sociodemographic indicators that may better capture the vulnerable and susceptible population by incorporating age, asthma baseline rates, and linguistic isolation (Definition 2). We expand this definition further in Definition 3 to include additional environmental burden factors, drinking water and pesticides. CalEnviroScreen provides data on other demographic and environmental indicators, however these indicators were removed as possibilities for inclusion in the definition based on data quality (e.g., traffic density) and whether the indicator represented a true exposure or only a potential exposure based on the contained presence of a hazard. The indicators retained (listed in Table 4 and described above) are based on our literature and screening tools review. The maps shown in Figures 1a, b, and c below show EJ areas identified by applying each proposed EJ definition.

FIGURE 1a. MAP OF CENSUS TRACTS IN SCAB DESIGNATED BY PROPOSED EJ DEFINITIONS (BLUE) WITH SCAQMD EJ DEFINITION OVERLAID (YELLOW). DEFINITION 1 INCLUDES INCOME AND AIR QUALITY INDICATORS[4]



[4] These maps are likely to change pending receipt of updated air quality data from SCAQMD.

FIGURE 1b. MAP OF CENSUS TRACTS IN SCAB DESIGNATED BY PROPOSED EJ DEFINITIONS (BLUE) WITH SCAQMD EJ DEFINITION OVERLAID (YELLOW). DEFINITION 2 INCLUDES INCOME, OTHER SOCIODEMOGRAPHIC, AND AIR QUALITY INDICATORS

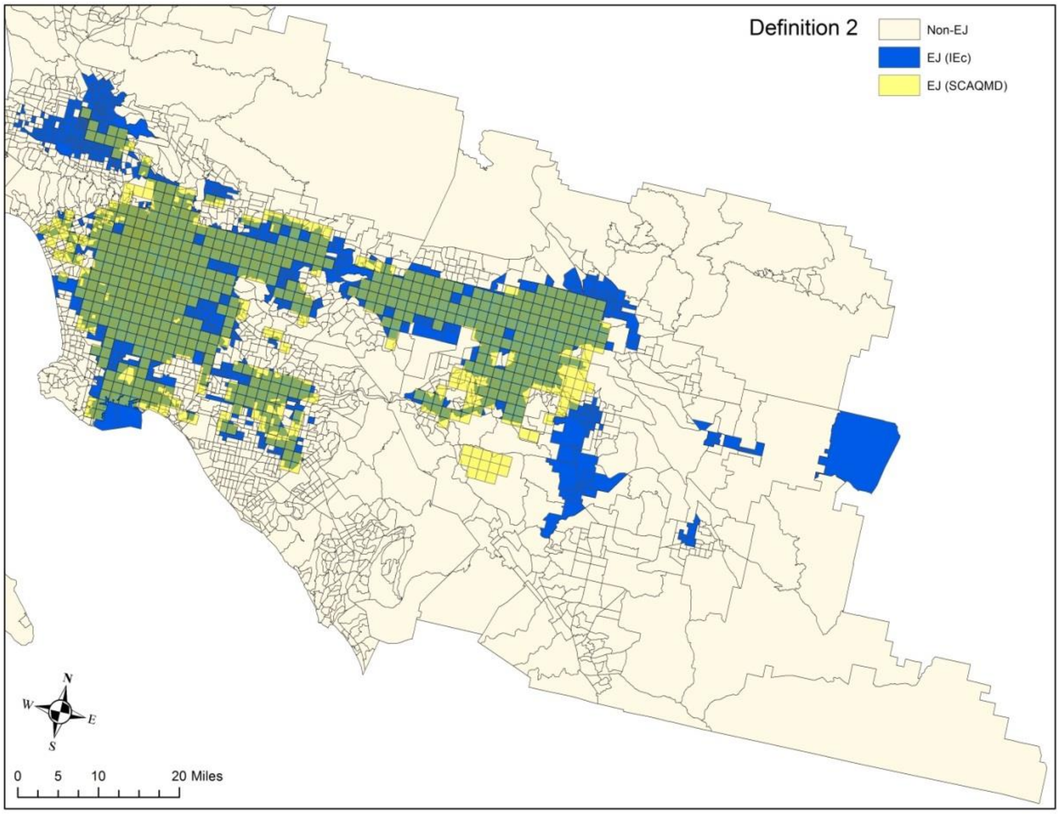
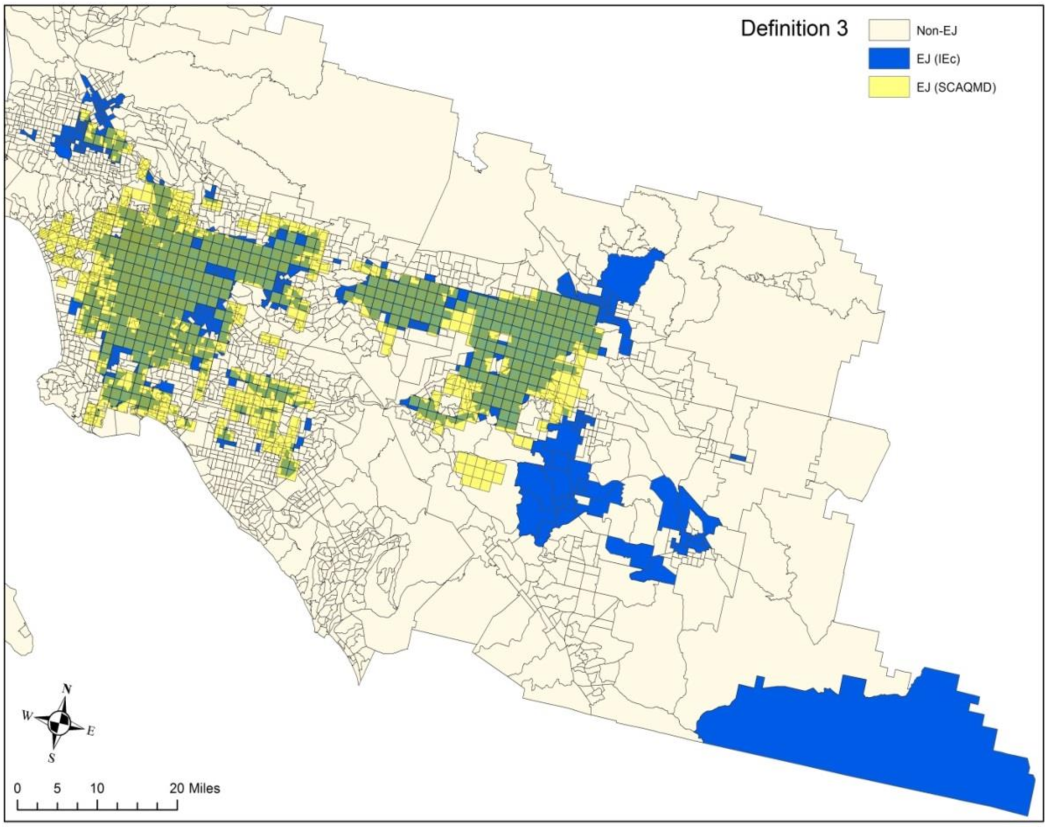


FIGURE 1c. MAP OF CENSUS TRACTS IN SCAB DESIGNATED BY PROPOSED EJ DEFINITIONS (BLUE) WITH SCAQMD EJ DEFINITION OVERLAID (YELLOW). DEFINITION 3 INCLUDES INCOME, OTHER SOCIODEMOGRAPHIC, AIR QUALITY, AND OTHER ENVIRONMENTAL BURDEN INDICATORS



The findings in Figures 1a, b, and c are consistent with expectations based on the indicators included in each definition. SCAQMD defines their EJ areas based on a 4km x 4km grid, so EJ areas do not line up directly with those included in the proposed definitions by census tract. Generally, communities which have been defined as EJ areas by SCAQMD overlap with those defined as EJ areas by the proposed set of definitions in this report. Definition 1 is the most basic, including only poverty status and air quality indicators, but with a more inclusive definition of poverty than used in SCAQMD's current definition. EJ areas defined in this manner tend to be located along major roadways, and are in the more western urban part of the SCAB. Definition 1 overlaps largely with the SCAQMD definition, though also includes additional census tracts in both the northwest and southeastern part of the basin. Definition 1 does not include some areas that have been defined by SCAQMD as EJ areas, including certain tracts in the dense EJ area of the city of Los Angeles and tracts in the eastern central area of SCAB. Definition 2, which includes poverty status, air quality indicators, and other demographic indicators, shows a similar pattern to Definition 1, with fewer tracts in the southeastern area of the SCAB included. Definition 2 overlaps largely with the SCAQMD definition, but also includes additional census tracts in the northwestern part of the basin and in the central and eastern part of the city of Los Angeles. Among the three alternatives, Definition 2 EJ areas appear to overlap most with EJ areas designated by SCAQMD, with the exception of some tracts in the eastern central part of the SCAB. Definition 3, which is the most robust definition and includes poverty status, air quality indicators, other demographic indicators, and other environmental indicators, shows the greatest difference with the SCAQMD definition due to its inclusion of other environmental burden indicators. Definition 3 does not include as many tracts on the western coast of the SCAB that are defined as EJ by SCAQMD. Most notably, Definition 3 includes the southeastern most census tract, which is large and rural with low population. Table 5 shows the percent of population identified as living within an EJ area by county. Values add up to 100% of total EJ area. With the exception of $P.M_{2.5}$ and cancer risk data, all source data was obtained from CalEnviroScreen 2.0. Population data used in CalEnviroScreen 2.0's analysis, and thus our calculations below, were sourced from the 2010 U.S. Census.

TABLE 5. DISTRIBUTION OF EJ POPULATIONS FOR EACH PROPOSED DEFINITION BY COUNTY

	SCAQMD DEFINITION	IEC DEFINITION 1	IEC DEFINITION 2	IEC DEFINITION 3
Los Angeles	74.4%	70.6%	73.9%	74.1%
Orange	10.0%	9.8%	8.7%	4.4%
Riverside	5.9%	8.3%	6.2%	8.2%
San Bernardino	9.8%	11.3%	11.2%	13.3%
Total SCAB	100%	100%	100%	100%

Los Angeles County contains the majority of the EJ populations in the SCAB based on each proposed definition. Definition 3 shifts more of the affected population to San Bernardino and Riverside counties, which have greater other environmental burden, as they have fewer urban census tracts and more rural tracts. Orange and Riverside counties have the smallest percent of population identified by the proposed EJ definitions.

Table 6 shows the percent of population in each county identified as living within an EJ area. Similar proportions of Los Angeles and San Bernardino County's populations are identified as living within EJ areas. Orange County exhibits the smallest percentage of EJ impact on its population. Additionally, the proportion of population in an EJ community for each county is much lower when applying Definition 3, which tends toward including less populated rural census tracts based on non-air quality environmental indicators. As such, Definition 3 includes approximately 2 million fewer people than Definitions 1 and 2, which may not be an appropriate choice for reaching a majority of disadvantaged populations

TABLE 6. PROPORTION OF COUNTY POPULATION LIVING IN AN EJ COMMUNITY BY PROPOSED EJ DEFINITION

	SCAQMD DEFINITION	IEC DEFINITION 1	IEC DEFINITION 2	IEC DEFINITION 3
Los Angeles	58.7%	62.8%	66.5%	48.1%
Orange	24.7%	27.3%	24.6%	8.9%
Riverside	25.2%	40.1%	30.4%	29.0%
San Bernardino	47.6%	61.9%	62.4%	53.6%
Total SCAB	47.4%	53.4%	54.1%	39.0%
	Note: Values by definition do not add up to 100%, as this table depicts the percent of county population affected.			

These definitions can be used in conjunction with one another as sensitivity analyses to determine how the inclusion of various communities varies with the selection of different combinations of factors. They also can be compared with one another, as well as with SCAQMD's current EJ definition, to analyze the socioeconomic impacts of air pollution control strategies.

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