California Communities Environmental Health Screening Tool, Version 1.1 (CalEnviroScreen 1.1)

Guidance and Screening Tool

September 2013 Update

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PREFACE TO VERSION 1.1

CalEnviroscreen 1.1 is the latest iteration of the CalEnviroScreen tool. It uses the same methodology as Version 1.0 except that the indicator for race/ethnicity was removed from the calculation of a community's CalEnviroScreen score. This change was made to facilitate the use of the tool by government entities that may be restricted from considering race/ethnicity when making certain decisions. While race and ethnicity will not be used in compiling a score using CalEnviroScreen, a new section has been added that provides information on the racial and ethnic composition of communities throughout the state. This information will help us to better understand the correlation between race/ethnicity and the pollution burdens facing communities in California. Cal/EPA and OEHHA are committed to updating and expanding this section as new versions of the tool are released.

GUIDANCE FROM THE SECRETARY

During the past three years, one of our top priorities has been to integrate environmental justice principles throughout the California Environmental Protection Agency's (Cal/EPA's or Agency's) boards, departments and office. State law defines environmental justice to mean "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." This definition should not just be words or an illusory concept; rather, it must be a goal to strive for and achieve. Cal/EPA's mission is to restore, protect and enhance the environment, and to ensure public health, environmental quality and economic vitality. Environmental justice and investment in communities burdened by pollution are critical to accomplishing this mission.

Despite the best efforts of many segments of society, a large number of Californians live in the midst of multiple sources of pollution and some people and communities are more vulnerable to the effects of pollution than others. In order to respond to this situation, it is important to identify the areas of the state that face multiple pollution burdens so programs and funding can be targeted appropriately toward improving the environmental health and economic vitality of the most impacted communities. For this reason, the Agency and the Office of Environmental Health Hazard Assessment (OEHHA) have developed a science-based tool for evaluating multiple pollutants and stressors in communities, called the California Communities Environmental Health Screening Tool (CalEnviroScreen).

To ensure that CalEnviroScreen is properly understood and utilized, we are providing the following guidance to the Agency, its boards, departments, and office, as well as the public and stakeholders.

CalEnviroScreen should be used primarily to assist the Agency in carrying out its environmental justice mission: to conduct its activities in a manner that ensures the fair treatment of all Californians, including minority and low-income populations. The tool is the next step in the implementation of the Agency's 2004 Environmental Justice Action Plan, which called for the development of guidance to analyze the impacts of multiple pollution sources in California communities.

The tool shows which portions of the state have higher pollution burdens and vulnerabilities than other areas, and therefore are most in need of assistance. In a time of limited resources, it will provide meaningful insight into how decision makers can focus available time, resources, and programs to improve the environmental health of Californians, particularly those most burdened by pollution. The tool uses existing environmental, health, demographic and socioeconomic data to create a screening score for communities across the state. An area with a high score would be expected to experience much higher impacts than areas with low scores.

Cal/EPA and OEHHA are committed to revising the tool in the future, using an open and public process, as new information becomes available in order to make the tool as meaningful and as current as possible. Over the next several years, we plan to refine the tool by considering additional indicators, modifying the geographic scale, enhancing the current indicators, and reassessing the tool's methodology. In addition, we will look for new ways to ensure the tool is accessible and comprehensible to the public.

Background

Cal/EPA released the first draft of CalEnviroScreen for public review and comment in July 2012. This draft built upon a 2010 report[1] that described the underlying science and a general method for identifying communities that face multiple pollution burdens. It further developed and explained the methodology described in the 2010 report. After releasing the first draft, Cal/EPA and OEHHA conducted 12 public workshops in seven regions throughout the state. At these workshops, the methodology and our conclusions were discussed with the public and a wide range of stakeholders, including community, business, industry, academic and governmental groups. These regional workshops yielded over 1000 oral and written comments and questions. A subsequent draft was released in January 2013. Cal/EPA and OEHHA solicited additional comments and suggestions, and considered them in making additional changes to the tool.

Potential Uses

Potential uses of the tool by Cal/EPA and its boards, departments, and office include administering environmental justice grants, promoting greater compliance with environmental laws, prioritizing site-cleanup activities, and identifying opportunities for sustainable economic development in heavily impacted neighborhoods. Other entities and interested parties may identify additional uses for this tool and the information it provides.

Implementation of SB 535

CalEnviroScreen will inform Cal/EPA's identification of disadvantaged communities pursuant to Senate Bill 535 (De León, Chapter 830, Statutes of 2012). SB 535 requires Cal/EPA to identify disadvantaged communities based on geographic, socioeconomic, public health, and environmental hazard criteria. It also requires that the investment plan developed and submitted to the Legislature pursuant to Assembly Bill 1532 (John A. Pérez, Chapter 807, Statutes of 2012) allocate no less than 25 percent of available proceeds from the carbon auctions held under California's Global Warming Solutions Act of 2006 to projects that will benefit these disadvantaged communities. At least 10 percent of the available moneys from these auctions must be directly allocated in such communities. Since CalEnviroScreen has been developed to identify areas that are disproportionately affected by pollution and those areas whose populations are socioeconomically disadvantaged, it is well suited for the purposes described by SB 535.

Environmental Justice Activities

CalEnviroScreen will be useful in administering the Agency's Environmental Justice Small Grant Program, and may guide other grant programs as well as environmental education and community programs throughout the state. It will also help to inform Agency boards and departments when they are budgeting scarce resources for cleanup and abatement projects. Additionally, CalEnviroScreen will help to guide boards and departments when planning their community engagement and outreach efforts. Knowing which areas of the state have higher relative environmental burdens will not only help with efforts to increase compliance with environmental laws in disproportionately impacted areas, but also will provide Cal/EPA and its boards, departments, and office with additional insights on the potential implications of their activities and decisions.

Local and Regional Governments

Local and regional governments, including regional air districts, water districts, and planning and transit

[1] OEHHA and Cal/EPA (2012) *Cumulative Impacts: Building a Scientific Foundation*, Sacramento, CA. Available online at: http://www.oehha.ca.gov/ej/cipa123110.html

agencies, may also find uses for this tool. Cal/EPA will continue to work with local and regional governments to further explore the applicability of CalEnviroScreen for other uses. This includes the possibility of helping to identify and plan for opportunities for sustainable development in heavily impacted neighborhoods. These areas could also be targeted for cleaning up blight and promoting development in order to bring in jobs and increase economic stability. As an example, the tool could assist efforts to develop planning and financial incentives to retain jobs and create new, sustainable business enterprises in disproportionately impacted communities.

Of course, it will be important to work with organizations such as economic development corporations, workforce investment boards, local chambers of commerce, and others to develop strategies to help businesses thrive in the identified areas and to attract new businesses and services to those areas. CalEnviroScreen may also assist local districts and governments with meeting their obligations under certain state funding programs. Finally, it is important to remember that CalEnviroScreen provides a broad environmental snapshot of a given region. While the data gathered in developing the tool could be useful for decision makers when assessing existing pollution sources in an area, more precise data are often available to local governments and would be more relevant in conducting such an examination.

General Notes and Limitations

CalEnviroScreen was developed for Cal/EPA and its boards, departments, and office. Its publication does not create any new programs, regulatory requirements or legal obligations. There is no mandate express or implied that local governments or other entities must use the tool or its underlying data. Planning, zoning and development permits are matters of local control and local governments are free to decide whether the tool's output or the information contained in the tool provide an understanding of the environmental burdens and vulnerabilities in their localities.

While CalEnviroScreen will assist Cal/EPA and its boards, departments, and office in prioritizing resources and help promote greater compliance with environmental laws, it is important to note some of its limitations. The tool's output provides a relative ranking of communities based on a selected group of available datasets, through the use of a summary score. The CalEnviroScreen score is not an expression of health risk, and does not provide quantitative information on increases in cumulative impacts for specific sites or projects. Further, as a comparative screening tool, the results do not provide a basis for determining when differences between scores are significant in relation to public health or the environment. Accordingly, the tool is not intended to be used as a health or ecological risk assessment for a specific area or site.

Additionally, the CalEnviroScreen scoring results are not directly applicable to the cumulative impacts analysis required under the California Environmental Quality Act (CEQA). The statutory definition of "cumulative impacts" contained in CEQA is substantially different than the working definition of "cumulative impacts" used to guide the development of this tool. Therefore, the information provided by this tool cannot be used as a substitute for an analysis of the cumulative impacts of any specific project for which an environmental review is required by CEQA.

Moreover, CalEnviroScreen assesses environmental factors and effects on a regional or community-wide basis and cannot be used in lieu of performing an analysis of the potentially significant impacts of any specific project. Accordingly, a lead agency must determine independently whether a proposed project's impacts may be significant under CEQA based on the evidence before it, using its own discretion and judgment. The tool's results are not a substitute for this required analysis. Also, this tool considers some social, health, and economic

factors that may not be relevant when doing an analysis under CEQA. Finally, as mentioned above, the tool's output should not be used as a focused risk assessment of a given community or site. It cannot predict or quantify specific health risks or effects associated with cumulative exposures identified for a given community or individual.

Conclusion

We are proud of the collaborative work of OEHHA and the input of the departments and boards in Cal/EPA as well as the level of public participation and level of input we received in the development of CalEnviroScreen. This project represents the largest public screening tool effort in the nation – both in geographic scope and level of detail. It is an achievement that could not have been realized had it not been for the tireless efforts of OEHHA and the invaluable input of all of our stakeholders. The development of CalEnviroScreen involved many residents, community-based organizations, nongovernmental organizations, local officials, state agencies and representatives from business, industry and academia. The release of the CalEnviroScreen was just the first step. If CalEnviroScreen is to succeed, that cooperative effort must continue. I welcome your active participation as we move forward with future versions of CalEnviroScreen and work to advance environmental justice and economic vitality.

Matthew Rodriquez
Secretary for Environmental Protection

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INTRODUCTION

Californians are burdened by environmental problems and sources of pollution in ways that vary across the state. Some Californians are more vulnerable to the effects of pollution than others. This document describes a science-based method for evaluating multiple pollution sources in a community while accounting for a community's vulnerability to pollution's adverse effects. Factors that contribute to a community's pollution burden or vulnerability are often referred to as stressors. The CalEnviroScreen tool can be used to identify California's most burdened and vulnerable communities. This can help inform decisions at the California Environmental Protection Agency's (Cal/EPA) boards and departments by identifying places most in need of assistance.

Statewide Evaluation

Using CalEnviroScreen, a statewide analysis has been conducted that identifies communities in California most burdened by pollution from multiple sources and most vulnerable to its effects, taking into account their socioeconomic characteristics and underlying health status. In doing so, CalEnviroScreen

- Produces a *relative*, rather than absolute, measure of impact.
- Provides a baseline assessment and methodology that can be expanded upon and updated periodically as important additional information becomes available.
- Demonstrates a practical and scientific methodology for evaluating multiple pollution sources and stressors that takes into account a community's vulnerability to pollution.

Community impact assessment from multiple sources and stressors is complex and difficult to approach with traditional risk assessment practices. Chemical-by-chemical, source-by-source, route-by-route risk assessment approaches are not well suited to the assessment of community-scale impacts, especially for identifying the most impacted places across all of California. Although traditional risk assessment may account for the heightened sensitivities of some groups, such as children and the elderly, it has not considered other community characteristics that have been shown to affect vulnerability to pollution, such as socioeconomic factors or underlying health status.

Given the limits of traditional risk assessment, the Office of Environmental Health Hazard Assessment (OEHHA) and Cal/EPA developed a workable approach to conduct a statewide evaluation of community impacts. It built upon the general method and a description of the underlying science published in Cal/EPA's and OEHHA's 2010 report, *Cumulative Impacts: Building A Scientific Foundation*. The method emerges from basic risk assessment concepts and is sufficiently expansive to incorporate multiple factors that reflect community impacts that have not been included in traditional risk assessments. The tool presents a broad picture of the burdens and vulnerabilities different areas confront from environmental pollutants.

Stakeholder Involvement

Transparency and public input into government decision making and policy development are the cornerstones of environmental justice. In that spirit, the framework for the CalEnviroScreen was developed with the assistance of the Cumulative Impacts and Precautionary Approaches (CIPA) Work Group, consisting of representatives of business and non-governmental organizations, academia and government. The CIPA Work Group also reviewed draft versions of this report and provided critical feedback and input that guided the development of this tool. We appreciate the considerable time and effort that the Work Group has devoted to this project since 2008. We also appreciate the input from the general public we heard during the Work Group meetings.

Cal/EPA also received input on a previous draft of this document at a series of regional and stakeholder-specific public workshops and an academic workshop.[2] Input from California communities, businesses, local governments, California tribes, community-based organizations, and other stakeholders as well as academia was critical in the development of this project and is reflected in changes made to the final document.

Work in this field continues and presents opportunities to refine the tool. Thus, over the next several years we plan to release new versions of the tool that include improvements to the indicators used, the geographic scale, the methodology employed and the accessibility of the tool to the public. Cal/EPA remains committed to an open and public process in developing future versions of the tool.

This report describes CalEnviroScreen's methodological approach, which relies on the use of indicators to measure factors that affect pollution impacts in communities. The report describes the indicators and the criteria used to select them as well as the geographic scale used to define communities. Data representing the indicators for the different areas of the state were obtained and analyzed and are presented here as statewide maps.[3] All the indicators for a locale are combined to generate a score for the community. The report concludes by providing general results for the statewide evaluation, presented as maps showing the top 5 and10 percent of the most impacted communities in California.

[2] Additional information on these workshops as well as the CIPA Work Group meetings and the development of the tool are available at www.oehha.ca.gov/ej/index.html.

[3] The community scores for individual indicators are available online at http://www.oehha.ca.gov/ej/index.html.

What is New in CalEnviroScreen 1.1?

Since CalEnviroScreen was originally released in April 2013, interest has emerged in using the screening tool for a number of applications outside of Cal/EPA, including for grant funding allocation decisions. In light of concerns over whether CalEnviroScreen's inclusion of a race/ethnicity indicator may place legal barriers to certain uses of the tool by government agencies, Cal/EPA has determined that removing it would best support these additional applications. Version 1.1 incorporates this change.

While the CalEnviroScreen 1.1 score no longer includes a race/ethnicity indicator, the report retains other key socioeconomic indicators, such as poverty, linguistic isolation, and educational attainment. Additionally, the CalEnviroScreen 1.1 report adds a new section that evaluates the relationship between CalEnviroScreen scores and race/ethnicity. These results reveal the disproportionate pollution burden and population vulnerability facing non-white communities.

METHOD

Definition of Cumulative Impacts

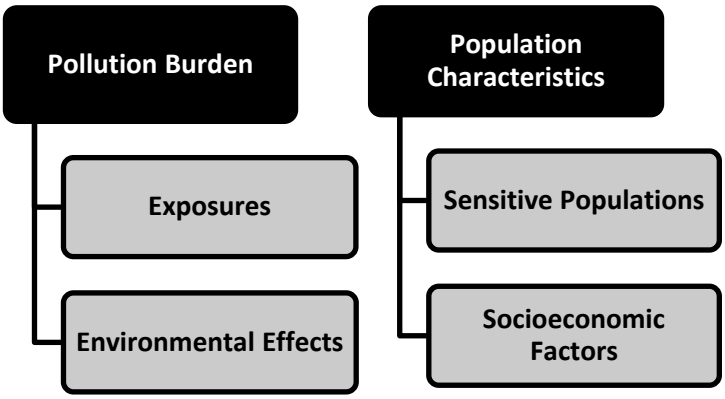
Cal/EPA adopted the following working definition of cumulative impacts[4] in 2005:

> *"Cumulative impacts means exposures, public health or environmental effects from the combined emissions and discharges, in a geographic area, including environmental pollution from all sources, whether single or multi-media, routinely, accidentally, or otherwise released. Impacts will take into account sensitive populations and socioeconomic factors, where applicable and to the extent data are available."*

CalEnviroScreen Model

The CalEnviroScreen model is based on the Cal/EPA working definition in that:

- The model is place-based and provides information for the entire State of California on a geographic basis. The geographic scale selected is intended to be useful for a wide range of decisions.
- The model is made up of multiple components cited in the above definition as contributors to cumulative impacts. The model includes two components representing pollution burden – exposures and environmental effects – and two components representing population characteristics – sensitive populations (e.g., in terms of health status and age) and socioeconomic factors.



[4] This definition differs from the statutory definition of "cumulative impacts" contained in the California Environmental Quality Act (CEQA). While the term is the same, they cannot be used interchangeably. For a detailed discussion of this issue, please see the Guidance from the Secretary.

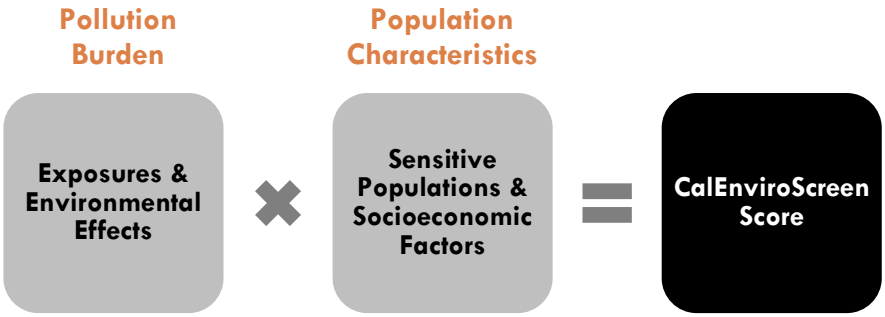
Model Characteristics

The model:

- Uses a suite of statewide indicators to characterize both pollution burden and population characteristics.
- Uses a limited set of indicators in order to keep the model simple.
- Assigns scores for each of the indicators in a given geographic area.
- Uses a scoring system to weight and sum each set of indicators within pollution burden and population characteristics components.
- Derives a CalEnviroScreen score for a given place relative to other places in the state, using the formula below.

Formula for Calculating CalEnviroScreen Score

After the components are scored, the scores are combined as follows to calculate the overall CalEnviroScreen Score:



Rationale for Formula

The mathematical formula for calculating scores uses multiplication. Scores for the pollution burden and population characteristics categories are multiplied together (rather than added, for example). Although this approach may be less intuitive than simple addition, there is scientific support for this approach to scoring.

Multiplication was selected for the following reasons:

1. *Scientific Literature*: Existing research on environmental pollutants and health risk has consistently identified socioeconomic and sensitivity factors as "effect modifiers." For example, numerous studies on the health effects of particulate air pollution have found that low socioeconomic status is associated with about a 3-fold increased risk of morbidity or mortality for a given level of particulate pollution (Samet and White, 2004). Similarly, a study of asthmatics found that their sensitivity to an air pollutant was up to 7-fold greater than non-asthmatics (Horstman *et al.*, 1986). Low-socioeconomic status African-American mothers exposed to traffic-related air pollution were twice as likely to deliver preterm babies (Ponce *et al.*, 2005). The young can be 10 times more sensitive to environmental carcinogen exposures than adults (OEHHA, 2009). Studies of increased

risk in vulnerable populations can often be described by effect modifiers that amplify the risk. This research suggests that the use of multiplication makes sense based on the existing scientific literature.

2. *Risk Assessment Principles*: Some members of the general population (such as children) may be 10 times more sensitive to some chemical exposures than others. Risk assessments, using principles first advanced by the National Academy of Sciences, apply numerical factors or multipliers to account for potential human sensitivity (as well as other factors such as data gaps) in deriving acceptable exposure levels (US EPA, 2012).
3. *Established Risk Scoring Systems*: Priority-rankings done by various emergency response organizations to score threats have used scoring systems with the formula: Risk = Threat × Vulnerability (Brody *et al.*, 2012). These formulas are widely used and accepted.

Maximum Scores for Combined Components

Component Group	Maximum Score*
Pollution Burden	
Exposures and Environmental Effects	10
Population Characteristics	
Sensitive Populations and Socioeconomic Factors	10
CalEnviroScreen Score	**Up to 100 (= 10 × 10)**

* The scores for each group were rounded to one decimal place before multiplying to calculate the CalEnviroScreen Score (for example, 6.5 out of a possible 10)

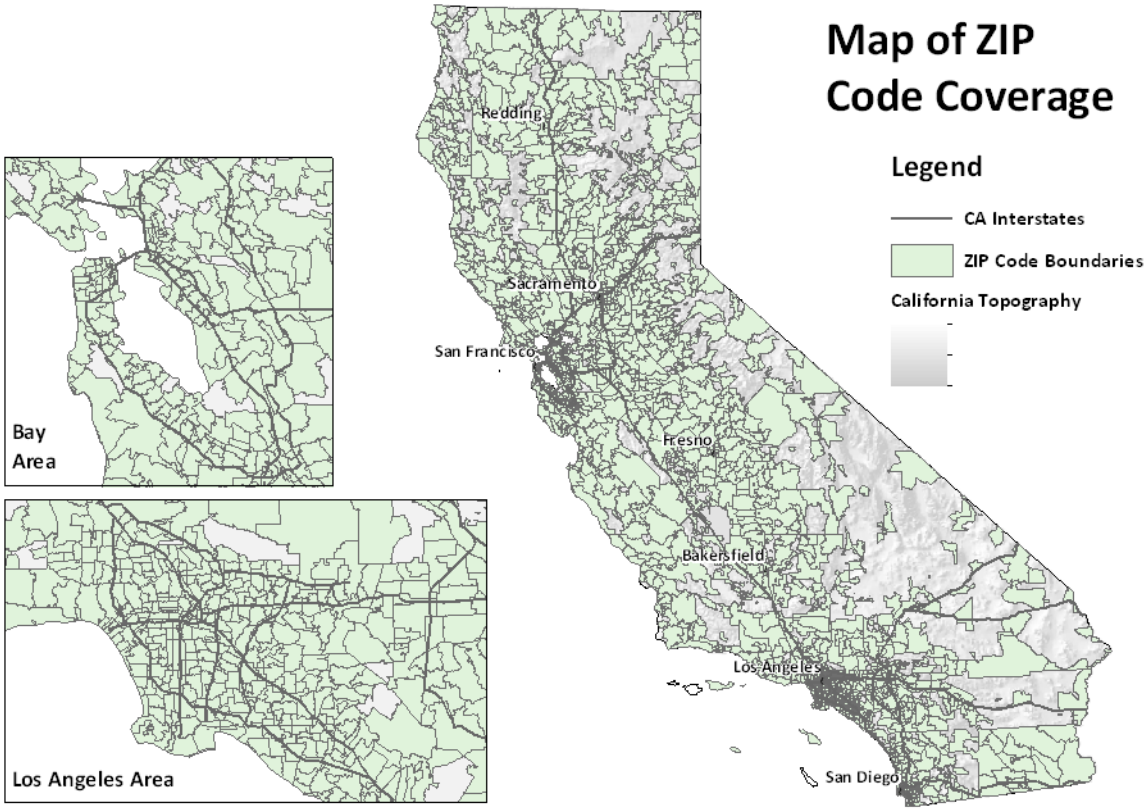
Notes on Scoring System

In the CalEnviroScreen scoring model, the Population Characteristics are considered to be a modifier of the Pollution Burden. In mathematical terms, the Pollution Burden is the multiplicand and Population Characteristics is the multiplier, with the CalEnviroScreen Score as the product. Because the final CalEnviroScreen score represents the product of two numbers, the final ordering of the communities is independent of the magnitude of the scale chosen for each (without rounding scores). That is, the communities would be ordered the same in their final score if the Population Characteristics were scaled to 3, 5, or 10, for example. Here, a scale up to 10 was chosen for convenience.

Selection of Geographic Scale

For this version of CalEnviroScreen, the ZIP code scale is the unit of analysis. A representation of ZIP codes, called ZCTAs (ZIP Code Tabulation Areas), is available from the Census Bureau. These were updated in 2010.[5] For simplicity, these areas are referred to as ZIP codes throughout this report.

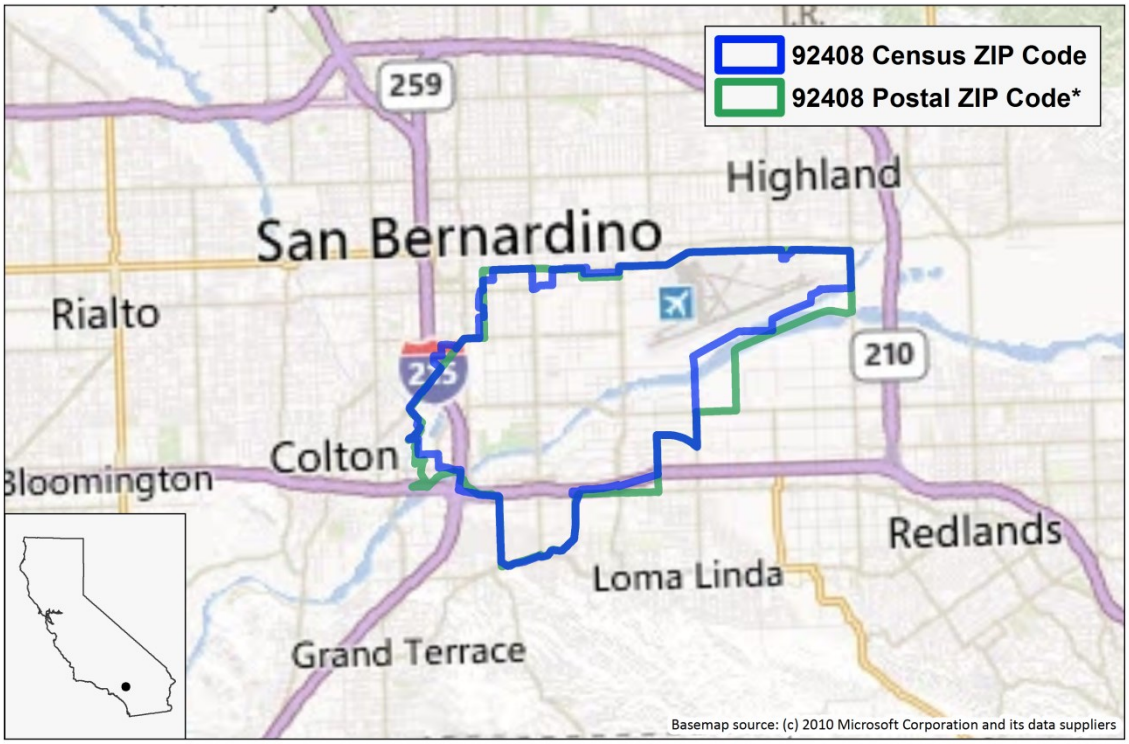
The census ZIP codes cover areas where people live, but do not include many sparsely populated places, like national parks. There are approximately 1,800 census ZIP codes in California, representing a relatively fine scale of analysis.[6]



[5] Additional information on the U.S. Census Bureau's ZIP Code Tabulation Areas may be found on their website: http://www.census.gov/geo/ZCTA/zcta.html.

[6] In a future version of the tool, results will also be available at the census tract scale.

The following map shows the relationship between census-derived ZIP codes (ZCTAs) and approximate postal service ZIP codes for an area in San Bernardino. For many ZIP codes they are similar.



* Postal service ZIP code approximations were obtained from Esri, Inc.

Analysis of CalEnviroScreen 1.1 Scores and Race/Ethnicity

The relationship between the calculated CalEnviroScreen score and race/ethnicity was examined. After sorting all the ZIP codes by CalEnviroScreen score, ZIP codes were placed in 10 groups (deciles), highest to lowest. The racial/ethnic composition of each decile was examined by using data from the U.S. Census Bureau.

References

Brody TM, Di Bianca P, Krysa J (2012). Analysis of inland crude oil spill threats, vulnerabilities, and emergency response in the midwest United States. *Risk Analysis* **32**(10):1741-9. [Available at URL: http://onlinelibrary.wiley.com/doi/10.1111/j.1539-6924.2012.01813.x/pdf].

Horstman D, Roger L, Kehrl H, Hazucha M (1986). Airway Sensitivity of Asthmatics To Sulfur Dioxide *Toxicol Ind Health* **2**: 289-298.

OEHHA (2009). Technical Support Document for Cancer Potency Factors: Methodologies for derivation, listing of available values, and adjustments to allow for early life stage exposures. May 2009. Available at URL:

http://www.oehha.ca.gov/air/hot_spots/2009/TSDCancerPotency.pdf.

Ponce NA, Hoggatt KJ, Wilhelm M, Ritz B (2005). Preterm birth: the interaction of traffic-related air pollution with economic hardship in Los Angeles neighborhoods. *Am J Epidemiol* **162**(2):140-8.

Samet JM, White RH (2004) Urban air pollution, health, and equity. *J Epidemiol Community Health*, **58**:3-5 [Available at URL: http://jech.bmj.com/content/58/1/3.full].

US EPA (2012). Dose-Response Assessment [Available at URL: http://www.epa.gov/risk/dose-response.htm].

INDICATOR SELECTION AND SCORING

The overall CalEnviroScreen community scores are driven by indicators. Here are the steps in the process for selecting indicators and using them to produce scores.

Overview of the Process

1. Identify potential indicators for each component.
2. Find sources of data to support indicator development (see Criteria for Indicator Selection below).
3. Select and develop indicator, assigning a value for each geographic unit.
4. Assign a percentile for each indicator for each geographic unit, based on the rank-order of the value.
5. Generate maps to visualize data.
6. Derive scores for pollution burden and population characteristics components (see Indicator and Component Scoring below).
7. Derive the overall CalEnviroScreen score by combining the component scores (see below).
8. Generate maps to visualize overall results.

The selection of specific indicators requires consideration of both the type of information that will best represent statewide pollution burden and population characteristics, and the availability and quality of such information at the necessary geographic scale statewide.

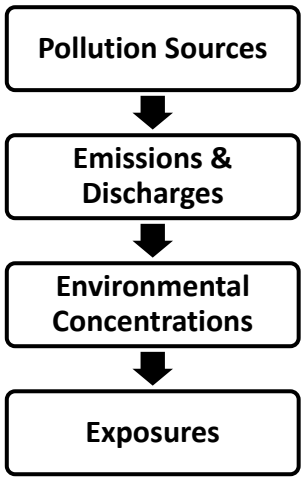
Criteria for Indicator Selection

- An indicator should provide a measure that is relevant to the component it represents, in the context of the 2005 Cal/EPA cumulative impacts definition.
- Indicators should represent widespread concerns related to pollution in California.
- The indicators taken together should provide a good representation of each component.
- Pollution burden indicators should relate to issues that may be potentially actionable by Cal/EPA boards and departments.
- Population characteristics indicators should represent demographic factors known to influence vulnerability to disease.
- Data for the indicator should be available for the entire state at the ZIP code level geographical unit or translatable to the ZIP code level.
- Data should be of sufficient quality, and be:
    - Complete
    - Accurate
    - Current

Exposure Indicators

People may be exposed to a pollutant if they come in direct contact with it, by breathing contaminated air, for example.

No data are available statewide that provide direct information on exposures. Exposures generally involve movement of chemicals from a source through the environment (air, water, food, soil) to an individual or population. For purposes of the CalEnviroScreen, data relating to pollution sources, releases, and environmental concentrations are used as indicators of potential human exposures to pollutants. Six indicators were identified and found consistent with criteria for exposure indicator development. They are:



- Ozone concentrations in air
- PM2.5 concentrations in air
- Diesel particulate matter emissions
- Use of certain high-hazard, high-volatility pesticides
- Toxic releases from facilities
- Traffic density

Environmental Effect Indicators

Environmental effects are adverse environmental conditions caused by pollutants.

Environmental effects include various aspects of environmental degradation, ecological effects and threats to the environment and communities. The introduction of physical, biological and chemical pollutants into the environment can have harmful effects on different components of the ecosystem. Effects can be immediate or delayed. In addition to direct effects on ecosystem health, the environmental effects of pollution can also affect people by limiting the ability of communities to make use of ecosystem resources (e.g., eating fish or swimming in local rivers or bays). Also, living in an environmentally degraded community can lead to stress, which may affect human health. In addition, the mere presence of a contaminated site or high-profile facility can have tangible impacts on a community, even if actual environmental degradation cannot be documented. Such sites or facilities can contribute to perceptions of a community being undesirable or even unsafe.

Statewide data on the following topics were identified and found consistent with criteria for indicator development:

- Toxic cleanup sites
- Groundwater threats from leaking underground storage sites and

cleanups
- Hazardous waste facilities and generators
- Impaired water bodies
- Solid waste sites and facilities

Sensitive Population Indicators

Sensitive populations are populations with biological traits that result in increased vulnerability to pollutants.

Sensitive individuals may include those undergoing rapid physiological change, such as children, pregnant women and their fetuses, and individuals with impaired physiological conditions, such as the elderly or people with existing diseases such as heart disease or asthma. Other sensitive individuals include those with lower protective biological mechanisms due to genetic factors.

Pollutant exposure is a likely contributor to many observed adverse outcomes at the population level, and has been demonstrated for some outcomes such as asthma, low birth weight, and heart disease. People with these health conditions are also more susceptible to health impacts from pollution. With few exceptions, adverse health conditions are difficult to attribute solely to exposure to pollutants. High quality statewide data related to these and other health conditions that can be influenced by toxic chemical exposures were identified and found consistent with criteria for development of these indicators:

- Prevalence of children and elderly
- Asthma
- Low birth-weight infants

Socioeconomic Factor Indicators

Socioeconomic factors are community characteristics that result in increased vulnerability to pollutants.

A growing body of literature provides evidence of the heightened vulnerability of people of color and lower socioeconomic status to environmental pollutants. For example, a study found that individuals with less than a high school education who were exposed to particulate pollution had a greater risk of mortality. Here, socioeconomic factors that have been associated with increased population vulnerability were selected.

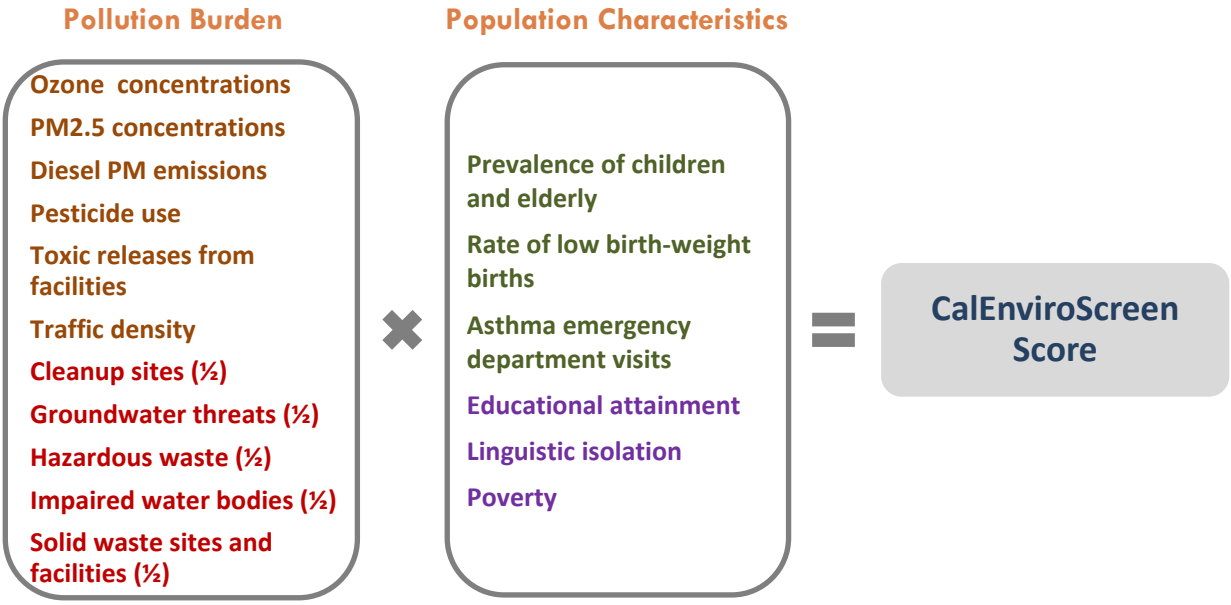
Data on the following socioeconomic factors were identified and found consistent with criteria for indicator development:

- Educational attainment
- Linguistic isolation
- Poverty

Indicator and Component Scoring

- The indicator values for the entire state are ordered from highest to lowest. A percentile is calculated from the ordered values for all areas that have a score.* Thus each area's percentile rank for a specific indicator is relative to the ranks for that indicator in the rest of the places in the state.
  - The indicators used in this analysis have varying underlying distributions, and percentile rank calculations provide a useful way to describe data without making any potentially unwarranted assumptions about those distributions.
  - A geographic area's percentile for a given indicator simply tells the percentage of areas with lower values of that indicator.
  - A percentile cannot describe the magnitude of the difference between two or more areas. For example, an area ranked in the 30th percentile is not necessarily three times more impacted than an area ranked in the 10th percentile.
- Indicators from Exposures and Environmental Effects components were grouped together to represent Pollution Burden. Indicators from Sensitive Populations and Socioeconomic Factors were grouped together to represent Population Characteristics (see figure below).
- Scores for the Pollution Burden and Population Characteristics groups of indicators are calculated as follows:
  - First, the percentiles for all the individual indicators in a group are averaged. Each indicator from the Environmental Effects component was weighted half as much as those indicators from the Exposures component. This was done because the contribution to possible pollutant burden from the Environmental Effects indicators was considered to be less than those from sources in the Exposures indicators. Thus the score for the Pollution Burden category is a weighted average, with Exposure indicators receiving twice the weight as Environmental Effects indicators.
  - Second, Pollution Burden and Population Characteristics group percentile averages are assigned scores from their defined ranges (up to 10) by dividing by 10 and rounding to one decimal place (e.g., 5.4).

* When a geographic area has no indicator value (for example, the area has no facilities with toxic releases present), it is excluded from the percentile calculation and assigned a score of zero for that indicator. When data are unavailable or missing for a geographic area (for example, the area is greater than 50 kilometers from an air monitor), it is excluded from the percentile calculation and is not assigned any score for that indicator. Thus the percentile score can be thought of as a comparison of one geographic area to other localities in the state where the hazard effect or population characteristic is present.



CalEnviroScreen Score and Maps

- The overall CalEnviroScreen score is calculated from the Pollution Burden and Population Characteristics groups of indicators by multiplying the two scores. Since each group has a maximum score of 10, the maximum CalEnviroScreen Score is 100.
- The geographic areas are ordered from highest to lowest, based on their overall score. A percentile for the overall score is then calculated from the ordered values. As with the percentiles for individual indicators, a geographic area's overall CalEnviroScreen percentile equals the percentage of all ordered CalEnviroScreen scores that fall below the score for that area.
- Maps are developed showing the percentiles for all the ZIP codes of the state. Maps are also developed highlighting the ZIP codes scoring the highest.

Uncertainty and Error

There are different types of uncertainty that are likely to be introduced in the development of any screening method for evaluating pollution burden and population vulnerability in different geographic areas. Several important ones are:

- The degree to which the data that are included in the model are correct.
- The degree to which the data and the indicator metric selected reflect meaningful contributions in the context of identifying areas that are impacted by multiple sources of pollution and may be especially vulnerable to their effects.
- The degree to which data gaps or omissions influence the results.

Efforts were made to select datasets for inclusion that are complete, accurate and current. Nonetheless, there are uncertainties that may arise because environmental conditions change over time, large databases may contain errors, or there are possible biases in how complete the

data sets are across the state, among others. Some of these uncertainties were addressed in the development of indicators. For example:

- Clearly erroneous place-based information for facilities or sites has been removed.
- Low incidences or small counts (e.g., health outcomes) have been excluded from the analysis.
- Highly uncertain measurements (for example, >50 kilometers from an air monitor) have been excluded from the analysis.

Other types of uncertainty, such as those related to how well indicators measure what they are intended to represent in the model, are more difficult to measure quantitatively. For example:

- How well data on chemical uses or emission data reflect potential contact with pollution.
- How well vulnerability of a community is characterized by demographic data.

Generally speaking, indicators are surrogates for the characteristic being modeled, so a certain amount of uncertainty is inevitable. That said, this model comprised of a suite of indicators is considered useful in identifying places burdened by multiple sources of pollution with populations that may be especially vulnerable. Places that score highly for many of the indicators are likely to be identified as impacted. Since there are tradeoffs in combining different sources of information, the results are considered most useful for identifying communities that score highly using the model. Using a limited data set, an analysis of the sensitivity of the model to changes in weighting showed it is relatively robust in identifying more impacted areas (Meehan August *et al.*, 2012). Use of broad groups of areas, such as those scoring in the highest 5 and 10 percent, is expected to be the most suitable application of the CalEnviroScreen results.

Reference

Meehan August L, Faust JB, Cushing L, Zeise L, Alexeeff, GV (2012). Methodological Considerations in Screening for Cumulative Environmental Health Impacts: Lessons Learned from a Pilot Study in California. *Int J Environ Res Public Health* **9**(9): 3069-3084.

INDIVIDUAL INDICATORS: DESCRIPTION AND ANALYSIS

AIR QUALITY: OZONE

Exposure Indicator

Ozone pollution causes numerous adverse health effects, including respiratory irritation and lung disease. The health impacts of ozone and other criteria air pollutants (particulate matter (PM), nitrogen dioxide, carbon monoxide, sulfur dioxide, and lead) have been considered in the development of health-based standards. Of the six criteria air pollutants, ozone and particle pollution pose the most widespread and significant health threats. The California Air Resources Board maintains a wide network of air monitoring stations that provides information that may be used to better understand exposures to ozone and other pollutants across the state.

Indicator

Portion of the daily maximum 8-hour ozone concentration over the federal 8-hour standard (0.075 ppm), averaged over three years (2007 to 2009).

Data Source

Air Monitoring Network,
California Air Resources Board (CARB)

CARB, local air pollution control districts, tribes and federal land managers maintain a wide network of air monitoring stations in California. These stations record a variety of different measurements including concentrations of the six criteria air pollutants and meteorological data. In certain parts of the state, the density of the stations can provide high-resolution data for cities or localized areas around the monitors. However, not all cities have stations.

The information gathered from each air monitoring station audited by the CARB includes maps, geographic coordinates, photos, pollutant concentrations, and surveys.

http://www.arb.ca.gov/aqmis2/aqmis2.php
http://www.epa.gov/airquality/ozonepollution/
http://www.niehs.nih.gov/health/topics/agents/ozone/

Rationale

Ozone is an extremely reactive form of oxygen. In the upper atmosphere ozone provides protection against the sun's ultraviolet rays. Ozone at ground level is the primary component of smog. Ground-level ozone is formed from the reaction of oxygen-containing compounds with other air pollutants in the presence of sunlight. Ozone levels are typically at their highest in the afternoon and on hot days (NRC, 2008).

Adverse effects of ozone, including lung irritation, inflammation and exacerbation of existing chronic conditions, can be seen at even low exposures (Alexis *et al.* 2010, Fann *et al.* 2012, Zanobetti and Schwartz 2011). A long-term study in southern California found that rates of asthma hospitalization for children increased during warm season episodes of high ozone concentration (Moore *et al.* 2008). Additional studies have shown that the increased risk is higher among children under 2 years of age, young males, and African American children (Lin *et al.*, 2008, Burnett *et al.*, 2001). Increases in ambient ozone have also been

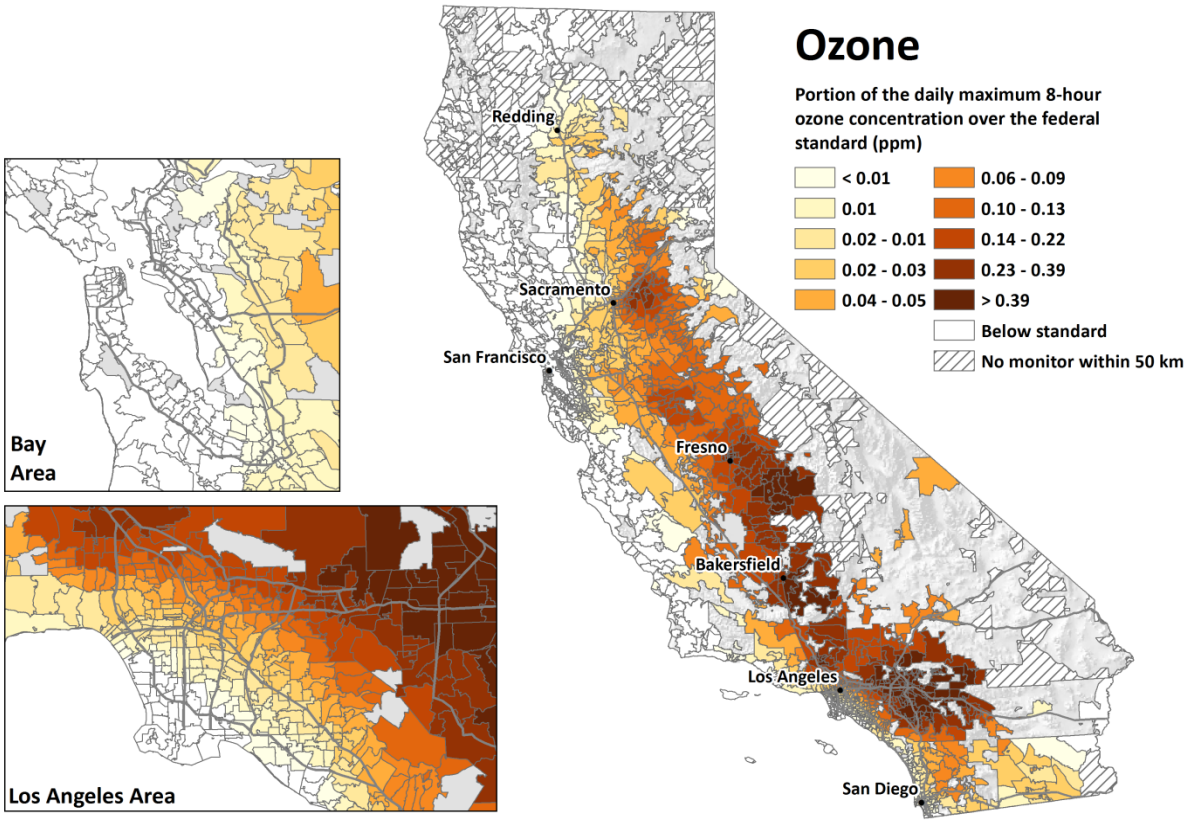
associated with higher mortality, particularly in the elderly, women and African Americans (Medina-Ramon, 2008). Some of the relationships between CalEnviroScreen scores and race are explored in the final section of the report. Together with PM2.5, ozone is a major contributor to air pollution-related morbidity and mortality (Fann *et al*. 2012).

Method

- Daily maximum 8-hour average concentrations for all monitoring sites in California were extracted from CARB's air monitoring network database for the years 2007-2009.
- The federal 8-hour standard (0.075 ppm) is subtracted from the monitoring data to arrive at the portion of the 8-hour concentration above the federal standard. Only concentrations over the federal standard from 2007-2009 were used.
- For each day in the 2007-2009 time period, the 8-hour ozone concentrations over the standard were estimated at the geographic center of the ZIP code using a geostatistical method that incorporates the monitoring data from nearby monitors (ordinary kriging).
- The estimated daily concentrations over the standard were averaged to obtain a single value for each ZIP code.
- ZIP codes were ordered by ozone concentration values and assigned a percentile based on the statewide distribution of values.

Indicator Map

Note: Values at ZIP codes with centers more than 50km from the nearest monitor were not estimated (signified by cross-hatching in the map below).



References

Alexis NE, Lay JC, Hazucha M, Harris B, Hernandez ML, Bromberg PA, *et al*. (2010). Low-level ozone exposure induces airways inflammation and modifies cell surface phenotypes in healthy humans. *Inhal Toxicol* **22**(7):593-600.

Burnett RT, Smith-Doiron M, Stieb D, Raizenne ME, Brook JR, *et al*. (2001). Association between Ozone and Hospitalization for Acute Respiratory Diseases in Children Less than 2 Years of Age. *American Journal of Epidemiology* **153**(5):444-452.

Fann N, Lamson AD, Anenberg SC, Wesson K, Risley D, Hubbell BJ (2012). Estimating the National Public Health Burden Associated with Exposure to Ambient PM2.5 and Ozone. *Risk Analysis* **32**(1):81-95.

Lin S, Liu X, Le, LH, Hwang, S (2008). Chronic Exposure to Ambient Ozone and Asthma Hospital Admissions among Children. *Environ Health Perspect* **116**(12):1725-1730.

Medina-Ramón M, Schwartz J (2008). Who is more vulnerable to die from ozone air pollution? *Epidemiology* **19**(5):672-9.

Moore K, Neugebauer R, Lurmann F, Hall J, Brajer V, Alcorn S, *et al*. (2008). Ambient ozone concentrations cause increased hospitalizations for asthma in children: an 18-year study in Southern California. *Environ Health Perspect* **116**(8):1063-70.

NRC (2008). National Research Council Committee on Estimating Mortality Risk Reduction Benefits from Decreasing Tropospheric Ozone Exposure (2008). *Estimating Mortality Risk Reduction and Economic Benefits from Controlling Ozone Air Pollution*. The National Academies Press.

Zanobetti A, Schwartz J (2011). Ozone and survival in four cohorts with potentially predisposing diseases. *Am J Respir Crit Care Med* **184**(7):836-41.

AIR QUALITY: PM2.5

Exposure Indicator

Particulate matter pollution, and fine particle (PM2.5) pollution in particular, has been shown to cause numerous adverse health effects, including heart and lung disease. PM2.5 contributes to substantial mortality across California. The health impacts of PM2.5 and other criteria air pollutants (ozone, nitrogen dioxide, carbon monoxide, sulfur dioxide, and lead) have been considered in the development of health-based standards. Of the six criteria air pollutants, particle pollution and ozone pose the most widespread and significant health threats. The California Air Resources Board maintains a wide network of air monitoring stations that provides information that may be used to better understand exposures to PM2.5 and other pollutants across the state.

Indicator

Annual mean concentration of PM2.5 (average of quarterly means), over three years (2007-2009).

Data Source

Air Monitoring Network,
California Air Resources Board (CARB)

CARB, local air pollution control districts, tribes and federal land managers maintain a wide network of air monitoring stations in California. These stations record a variety of different measurements including concentrations of the six criteria air pollutants and meteorological data. The density of the stations is such that specific cities or localized areas around monitors may have high resolution. However, not all cities have stations.

The site information gathered from each air monitoring station audited by CARB includes maps, locations coordinates, photos, pollutant concentrations, and surveys.

http://www.arb.ca.gov/aqmis2/aqmis2.php
http://www.epa.gov/airquality/particlepollution/

Rationale

Particulate matter (PM) is a complex mixture of aerosolized solid and liquid particles including such substances as organic chemicals, dust, allergens and metals. These particles can come from many sources, including cars and trucks, industrial processes, wood burning, or other activities involving combustion. The composition of PM depends on the local and regional sources, time of year, location and weather. The behavior of particles and the potential for PM to cause adverse health effects is directly related to particle size. The smaller the particle size, the more deeply the particles can penetrate into the lungs. Some fine particles have also been shown to enter the bloodstream. Those most susceptible to the effects of PM exposure include children, the elderly, and persons suffering from cardiopulmonary disease, asthma, and chronic illness (US EPA, 2012a).

PM2.5 refers to particles that have a diameter of 2.5 micrometers or less. Particles in this size range can have adverse effects on the heart

and lungs, including lung irritation, exacerbation of existing respiratory disease, and cardiovascular effects. The US EPA has set a new standard for ambient PM2.5 concentration of 12 μg/m^3, down from 15 μg/m^3. According to EPA's projections, by the year 2020 only 7 counties nationwide will have PM2.5 concentrations that exceed this standard. All are in California (US EPA, 2012b).

In children, researchers associated high ambient levels of PM2.5 in Southern California with adverse effects on lung development (Gauderman *et al.,* 2004). Another study in California found an association between components of PM2.5 and increased hospitalizations for several childhood respiratory diseases (Ostro *et al.,* 2009). In adults, studies have demonstrated relationships between daily mortality and PM2.5 (Ostro *et al.* 2006), increased hospital admissions for respiratory and cardiovascular diseases (Dominici *et al.* 2006), premature death after long-term exposure, and decreased lung function and pulmonary inflammation due to short term exposures (Pope, 2009). Exposure to PM during pregnancy has also been associated with low birth weight and premature birth (Bell *et al.* 2007; Morello-Frosch *et al.,* 2010).

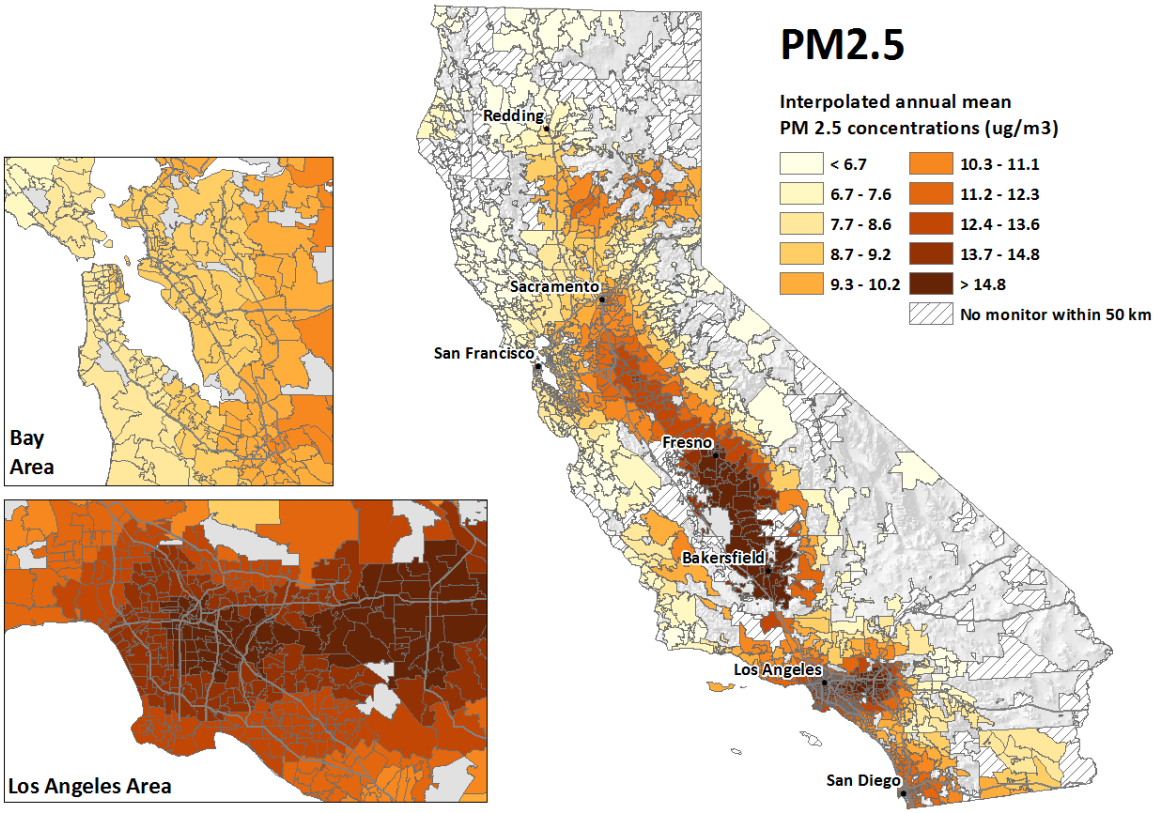
An additional source of PM2.5 in California is wildfires. Fires are not uncommon during dry seasons, particularly in Southern California and the Central Valley. Smoke particles fall almost entirely within the size range of PM2.5. Although the long term risks from exposure to smoke during a wildfire are relatively low, sensitive populations are more likely to experience severe symptoms, both acute and chronic (Lipsett *et al.* 2008). During the wildfires that spread throughout the state in June 2008, PM2.5 concentrations at a site in the northeast San Joaquin Valley were far above air quality standards and approximately ten times more toxic than normal ambient PM (Wegesser *et al.* 2009).

Method

- PM2.5 annual mean monitoring data for was extracted all monitoring sites in California from CARB's air monitoring network database for the years 2007-2009.
- Monitors that reported fewer than 75% of the expected number of observations, based on scheduled sampling frequency, were dropped from the analysis.
- For all measurements in the time period, the quarterly mean concentrations were estimated at the geographic center of the ZIP code using a geostatistical method that incorporates the monitoring data from nearby monitors (ordinary kriging).
- Annual means were then computed for each year by averaging the quarterly estimates and then averaging those over the three year period.
- ZIP codes were ordered by the PM2.5 concentration values and assigned a percentile based on the statewide distribution of values.

Indicator Map

Note: Values at ZIP codes with centers more than 50km from the nearest monitor were not estimated (signified by cross-hatching in the map below).



References

Bell ML, Ebisu K, Belanger K (2007). Ambient air pollution and low birth weight in Connecticut and Massachusetts. *Environmental Health Perspectives* **115**(7):1118.

Dominici F, Peng RD, Bell ML, Pham L, McDermott A, Zeger SL, *et al.* (2006). Fine particulate air pollution and hospital admission for cardiovascular and respiratory diseases. *JAMA: The Journal of the American Medical Association* **295**(10):1127-34.

Gauderman WJ, Avol E, Gilliland F, Vora H, Thomas D, Berhane K, *et al.* (2004). The effect of air pollution on lung development from 10 to 18 years of age. *New England Journal of Medicine* **351**(11):1057-67.

Lipsett M, Materna B, Stone SL, Therriault S, Blaisdell R, Cook J (2008). Wildfire Smoke: A Guide for Public Health Officials (pp. 53). California Department of Public Health, www.ehib.org/paper.jsp?paper_key=wildfire_smoke_2008 [accessed Feb 7, 2013].

Morello-Frosch R, Jesdale BM, Sadd JL, Pastor M (2010). Ambient air pollution exposure and full-term birth weight in California. *Environmental Health* **9**:44.

Ostro B, Broadwin R, Green S, Feng WY, Lipsett M (2006). Fine particulate air pollution and mortality in nine California counties: results from CALFINE. *Environmental health perspectives* **114**(1):29.

Ostro B, Roth L, Malig B, Marty M (2009). The effects of fine particle components on respiratory hospital admissions in children. *Environmental health perspectives* **117**(3):475.

Pope III CA (2009). The expanding role of air pollution in cardiovascular disease: Does air pollution contribute to risk of deep vein thrombosis? *Circulation* **119**(24):3050-2.

US EPA. The National Ambient Air Quality Standards for Particle Pollution: Particle Pollution and Health. Washington, DC:U.S. Environmental Protection Agency (14 Dec 2012). Available: http://www.epa.gov/pm/2012/decfshealth.pdf [accessed March 12, 2013].

US EPA. Projected Fine Particle Concentrations for Counties with Monitors in 2020. Washington, DC: U.S. Environmental Protection Agency. Available: http://www.epa.gov/pm/2012/2020table.pdf [accessed March 12, 2013].

Wegesser TC, Pinkerton KE, Last JA (2009). California wildfires of 2008: coarse and fine particulate matter toxicity. *Environ Health Perspect* **117**(6):893-7.

DIESEL PARTICULATE MATTER

Exposure Indicator

Diesel particulate matter (diesel PM) occurs throughout the environment from both on-road and off-road sources. Major sources of diesel PM include trucks, buses, cars, ships and locomotive engines. Diesel PM is concentrated near ports, rail yards and freeways where many such sources exist. Exposure to diesel PM has been shown to have numerous adverse health effects including irritation to the eyes, throat and nose, cardiovascular and pulmonary disease, and lung cancer.

Indicator

Spatial distribution of gridded diesel PM emissions from on-road and non-road sources for a 2010 summer day in July (kg/day).

Data Source

California Air Resources Board (CARB)

The CARB produces grid-based emission estimates for a variety of pollutants by emissions category on a 4km by 4km statewide Cartesian grid system to support specific regulatory and research programs. Diesel PM emissions from on- and off-road sources were extracted for a July 2010 weekday from the latest grid-based emissions. This data source does not account for meteorological dispersion of emissions at the neighborhood scale, which can have local-scale and year-to-year variability, or significant local-scale spatial gradients known to exist within a few hundred meters of a high-volume roadway or other large source of diesel PM. Nevertheless it is a reasonable *regional* metric of exposure to diesel PM emissions.

http://www.arb.ca.gov/diesel

Rationale

Diesel PM is the particle phase of diesel exhaust emitted from diesel engines such as trucks, buses, cars, trains, and heavy duty equipment. This phase is composed of a mixture of compounds, including sulfates, nitrates, metals and carbon particles. The diesel particulate matter indicator is distinct from other air pollution indicators in CalEnviroScreen, PM2.5 in particular. Diesel PM includes known carcinogens, such as benzene and formaldehyde (Krivoshto *et al.*, 2008) and 50% or more of the particles are in the ultrafine range (USEPA, 2002). As particle size decreases, the particles may have increasing potential to deposit in the lung (Löndahl *et al.* 2012). The ultrafine fraction of diesel PM (aerodynamic diameter less than 0.1 μm) is of concern because researchers believe these particles penetrate deeper into the lung, can carry toxic compounds on particle surfaces, and are more biologically reactive than larger particles (Betha and Balasubramanian, 2013; Nemmar *et al.*, 2007). In urban areas, diesel PM is a major component of the particulate air pollution from traffic (McCreanor *et al.*, 2007).

Children and those with existing respiratory disease, particularly asthma, appear to be especially susceptible to the harmful effects of exposure to airborne PM from diesel exhaust, resulting in increased

asthma symptoms and attacks along with decreases in lung function (McCreanor *et al.*, 2007; Wargo, 2002).

People that live or work near heavily-traveled roadways, ports, railyards, bus yards, or trucking distribution centers may experience a high level of exposure (USEPA, 2002; Krivoshto *et al.*, 2008). People that spend a significant amount of time near heavily-traveled roadways may also experience a high level of exposure. A study of U.S. workers in the trucking industry found an increasing risk for lung cancer with increasing years on the job (Garshick *et al.*, 2008). The same trend was seen among railroad workers, who showed a 40% increased risk of lung cancer (Garshik *et al.*, 2004). Studies have found strong associations between diesel particulate exposure and exacerbation of asthma symptoms in asthmatic children who attend school in areas of heavy truck traffic (Patel *et al.* 2010, Spira-Cohen *et al.* 2011). Studies of both men and women demonstrate cardiovascular effects of diesel PM exposure, including coronary vasoconstriction and premature death from cardiovascular disease (Krivoshto *et al.*, 2008).

Exposure to diesel PM, especially following periods of severe air pollution, can lead to increased hospital visits and admissions due to worsening asthma and emphysema-related symptoms (Krivoshto *et al.*, 2008). Diesel exposure may also lead to reduced lung function in children living in close proximity to roadways (Brunekreef *et al.*, 1997).

Method

Gridded diesel PM emissions from on-road sources were calculated as follows:

- CARB's on-road emissions model, EMFAC2013, was used to calculate 2010 county-wide estimates of diesel PM emissions for a July weekday. http://www.arb.ca.gov/msei/modeling.htm
- EMFAC2013 county-wide emission estimates are spatially distributed to 4km-by-4km grid cells based on the distribution of regional vehicle activity represented in local agency transportation networks and Caltrans' statewide transportation network (where local agency data are not available) using the Direct Travel Impact model (DTIM4). Transportation networks are produced from travel demand modeling conducted by local agencies and Caltrans.

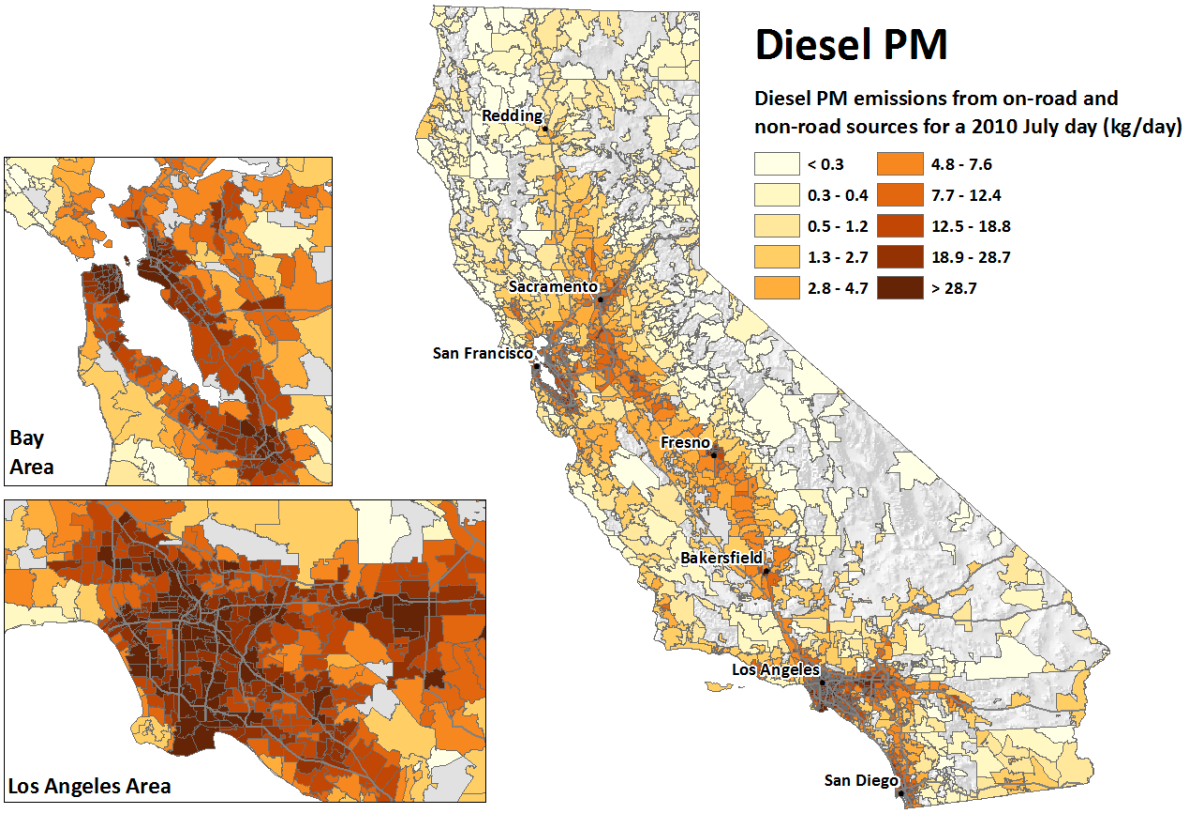
Gridded diesel PM from non-road sources were calculated as follows:

- County-wide estimates of diesel PM from non-road sources for a July weekday were extracted from CARB's emissions inventory forecasting system, CEPAM. http://www.arb.ca.gov/app/emsinv/fcemssumcat2009.php
- County-wide emission estimates are spatially distributed to 4km-by-4km grid cells based on a variety of gridded spatial surrogate datasets. Each category of emissions is mapped to a spatial surrogate that generally represents the expected sub-county

locations of source-specific activities. The surrogates include, for example: Lakes and Coastline; Population; Housing and Employment; Industrial Employment; Irrigated Cropland; Unpaved Roads; Single-Housing Units; Forrest Land; Military Bases; Non-irrigated Pasture Land; Rail Lines; Non-Urban Land; Commercial Airports; and Ports.

Resulting gridded emission estimates from the on-road and non-road categories were summed into a single gridded dataset. Gridded diesel PM emission estimates are then allocated to ZCTA zones in ArcMap using a weighted average where the proportion of a grid-cell intersecting a ZIP code is used as the weight. The resulting ZCTA totals are assigned a percentile based on the statewide distribution of values.

Indicator Map



References

Betha R, Balasubramanian R (2013). Emissions of particulate-bound elements from biodiesel and ultra low sulfur diesel: size distribution and risk assessment. *Chemosphere* **90**(3):1005-15.

Brunekreef B, Janssen NA, de Hartog J, Harssema H, Knape M, van Vliet P (1997). *Epidemiology* **8**(3): 298-303.

Garshick E, Laden F, Hart JE, Rosner B, Davis ME, Eisen EA, Smith TJ (2008). Lung Cancer and Vehicle Exhaust in Trucking Industry Workers. *Environmental Health Perspectives* **116**:1327–1332.

Garshick E, Laden F, Hart JE, Rosner B, Davis ME, Smith TJ, Dockery DW, Speizer FE (2004). Lung Cancer in Railroad Workers Exposed to Diesel Exhaust. *Environmental Health Perspectives* **112**:1539-1543.

Krivoshto IN, Richards JR, Albertson TE, Derlet RW (2008). The Toxicity of Diesel Exhaust: Implications for Primary Care. *Journal of the American Board of Family Medicine* **21**:55– 62.

Löndahl J, Swietlicki E, Rissler J, Bengtsson A, Boman C, Blomberg A*, et al*. (2012). Experimental determination of the respiratory tract deposition of diesel combustion particles in patients with chronic obstructive pulmonary disease. *Part Fibre Toxicol* **9**:30.

McCreanor J, Cullinan P, Nieuwenhuijsen MJ, Stewart-Evans J, Malliarou E, Jarup L*, et al*. (2007). Respiratory effects of exposure to diesel traffic in persons with asthma. *N Engl J Med* **357**(23):2348-58.

Nemmar A, Al-Maskari S, Ali BH, Al-Amri IS (2007). Cardiovascular and lung inflammatory effects induced by systemically administered diesel exhaust particles in rats. *Am J Physiol Lung Cell Mol Physiol* **292**(3):L664-70.

Patel MM, Chillrud SN, Deepti KC, Ross JM, Kinney PL (2012). Traffic-related air pollutants and exhaled markers of airway inflammation and oxidative stress in New York City adolescents. *Environ Res*.

Spira-Cohen A, Chen LC, Kendall M, Lall R, Thurston GD (2011). Personal exposures to traffic-related air pollution and acute respiratory health among Bronx schoolchildren with asthma. *Environ Health Perspect* **119**(4):559-65.

Wargo, J (2002). Children's Exposure to Diesel Exhaust on School Buses. *Environment and Human Health, Inc* 1-76. http://ehhi.org/reports/diesel/diesel.pdf

PESTICIDE USE

Exposure Indicator

Communities near agricultural fields, primarily farm worker communities, may be at risk for exposure to pesticides. Drift or volatilization of pesticides from agricultural fields can be a significant source of pesticide exposure. Complete statewide data on human exposures to pesticides do not exist. The most robust pesticide information available statewide are data maintained by the California Department of Pesticide Regulation showing where and when pesticides are used across the state. Pesticide use, especially use of volatile chemicals that can easily become airborne, can serve as an indicator of potential exposure. Similarly, unintended environmental damage from the use of pesticides may increase in areas with greater use.

Indicator

Total pounds of selected active pesticide ingredients (filtered for hazard and volatility) used in production-agriculture per square mile.

Data Source

Pesticide Use Reporting,
California Department of Pesticide Regulation (DPR)

In California, all agricultural pesticide use must be reported monthly to county agricultural commissioners, who report the data to DPR. California has a broad legal definition of agricultural use—production agricultural is defined as pesticides used on any plant or animal to be distributed in the channels of trade and non-production agricultural includes pesticide applications to parks and recreational lands, rights-of-ways, golf courses, and cemeteries for example. Non-agricultural control includes home, industrial, institutional, structural, vector control, and veterinary uses. Production agricultural pesticide use data are publicly available for each Meridian-Township-Range-Section (MTRS) in California and was used to create this indicator. An MTRS, or section, is roughly equivalent to one square mile. Data are available statewide except for some areas that are exempt from reporting, such as some military and tribal lands.

Non-production agricultural and non-agricultural pesticide use data is only available at the county scale and was not included in the indicator due to the large geographic scale.

http://www.DPR.ca.gov/docs/pur/purmain.htm

Rationale

To determine whether pesticide exposure may be occurring as a result of agricultural use, DPR established a pesticide air monitoring network for agricultural areas where there is high use of pesticides likely to concentrate in air. Preliminary results for the first year of monitoring show that more than half of pesticides sampled were detected, although none were above the health screening levels (CDPR, 2012). Pesticide air monitoring is not available statewide.

High use of pesticides, however, has been correlated with exposure and with acute pesticide-related illness, and there is evidence of association with chronic disease outcomes. Pregnant, low income Latinas residing in an agricultural area of California had pesticide metabolite levels in

their urine up to 2.5 times higher than a representative sample of U.S. women (Bradman *et al.*, 2005). Some research indicates that proximity to agricultural fields is correlated with measured concentrations in homes (Bradman *et al.*, 2007; Harnly *et al.*, 2009). A recent study in California comparing farmworker homes to homes of low income urban residents found indoor concentrations of an agricultural pesticide only in homes of farmworkers (Quiros-Alcala *et al.,* 2011). Another study, based on data from the California Pesticide Use Report database, found that nearby agricultural pesticide use was significantly associated with pesticide concentrations in carpet dust (Gunier *et al.*, 2011).

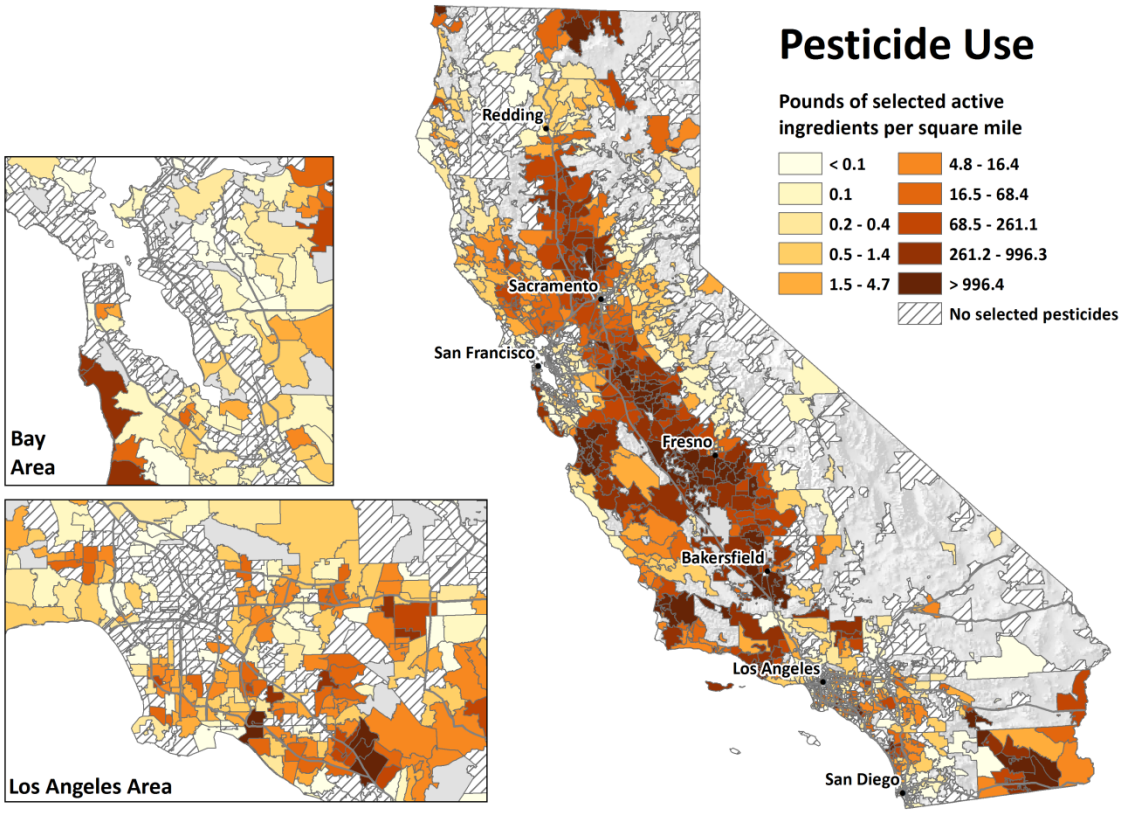
A large cohort study of male pesticide applicators found a significant association between the use of four specific insecticides and aggressive prostate cancer (Koutros *et al.*, 2012). Prenatal exposure to the organophosphate chlorpyrifos has been associated with abnormalities in brain structure in children (Rauh *et al.*, 2012). An examination of national pesticide illness data concluded that agricultural workers and residents near agriculture had the highest rates of pesticide poisoning from drift incidents. Soil fumigation accounted for most of the cases (Lee *et al.*, 2011). DPR has also documented numerous pesticide drift incidents that have led to illness in California (O'Malley *et al.*, 2005). Because of their physical and chemical characteristics, fumigants and other volatile pesticides are most likely to be involved in pesticide drift incidents and illnesses. However, any pesticide that is applied by air or sprayed during windy conditions can drift over neighboring communities (Coronado *et al.*, 2011; Lee *et al.*, 2011).

Method

Specific pesticides included in the measure of pesticide use were narrowed from the list of all registered pesticides in use in California to focus on a subset of 66 chemicals that are filtered for hazard and volatility. Volatility is indicative of higher likelihood of drift and exposure (See Appendix).

- Production agricultural pesticide use records were obtained for the entire state for the years 2009 and 2010.
- Production pesticide use (total pounds of selected active ingredient) for MTRS records were matched to ZIP codes using a match file created in the GIS software ArcMap.
- Production pesticide use for each ZIP code was divided by each ZIP code's area.

Indicator Map



Appendix

Pesticide Use – Filter for Hazard and Volatility

Specific pesticides included in the measure of pesticide use were identified from the list of all registered pesticides through consideration of both hazard and likelihood of exposure.

The more hazardous pesticides were identified using a list generated under the Birth Defect Prevention Act of 1984 (SB 950) and the Proposition 65 list (Safe Drinking Water and Toxic Enforcement Act of 1986). As part of a review process of active ingredients under the SB 950 program, pesticides are classified as "High", "Moderate", or "Low" priority for potential adverse health effects using studies of sufficient quality to characterize risk. The prioritization of each pesticide is a subjective process based upon the nature of potential adverse effects, the number of potential adverse effects, the number of species affected, the no observable effect level (NOEL), potential human exposure, use patterns, quantity used, and US EPA evaluations and actions, among others. Proposition 65 requires the state to maintain a list of chemicals that cause cancer or reproductive toxicity. For the purpose of developing an exposure indicator, pesticides that were prioritized as "Low," not prioritized under SB 950, or not on the Proposition 65 list

were removed from the analysis.

The analysis was further limited to pesticides of high or moderate volatility. Higher volatility was considered to increase the likelihood of exposures. A list of pesticide volatilities was obtained from DPR. Pesticides not appearing on this list were researched for chemical properties in the open literature. Pesticides with volatility less than 10^{-6} mm Hg were removed from the indicator analysis.

The filtering of pesticides for both hazard and volatility resulted in a list of 66 pesticides that were included in the analysis here. The pesticides that are included in the indicator calculation are identified below.

- *1,3-Dichloropropene*
- *2,2-Dibromo-3-nitrilopropionamide (DBNPA)*
- *2,2-dichlorovinyl dimethyl phosphate (DDVP, Dichlorvos)*
- *Acephate*
- *Acrolein*
- *Aldicarb*
- *Azinphos-methyl (Guthion)*
- *Bromoxynil heptanoate*
- *Bromoxynil octanoate*
- *Buprofezin*
- *Carbaryl (Sevin)*
- *Carbofuran*
- *Chloropicrin*
- *Chlorothalonil*
- *Chlorpyrifos*
- *Chlorthal-dimethyl (DCPA, Dacthal)*
- *Clomazone*
- *Cycloate (Ro-Neet)*
- *Cyprodinil*
- *Dazomet*
- *Diazinon*
- *Dichloran*
- *Dimethoate*
- *Endosulfan**
- *Ethalfluralin*
- *Ethoprop*
- *Fenamiphos*
- *Fenpropathrin*
- *Fenthion*
- *Fludioxonil*
- *Flumioxazin*
- *Hydrogen cyanamide*
- *Imazalil*
- *Linuron*
- *Malathion*
- *Metalaxyl*
- *Metam-sodium*
- *Methamidophos (Monitor)*
- *Methidathion*
- *Methomyl*
- *Methyl bromide*
- *Methyl isothiocyanate*
- *Methyl parathion*
- *Molinate*
- *Myclobutanil*
- *Naled*
- *Oxydemeton-methyl*
- *Pentachloronitrobenzene (PCNB)*
- *Phosphine*
- *Metam-potassium*
- *Propetamphos*
- *Propoxur (Baygon)*
- *Propylene oxide*
- *Pyrimethanil*
- *S,S,S-Tributyl phoshorotrithioate (DEF)*
- *S-Ethyl dipropylthiocarbamate (EPTC)*
- *Sodium cyanide*
- *Sodium tetrathiocarbonate*
- *Sulfur dioxide*
- *Sulfuryl fluoride*
- *Thiram*
- *Triclopyr butoxyethyl ester (TBEE)*
- *Triclopyr triethylamine salt (TEA)*
- *Triflumizole*
- *Trifluralin*
- *Ziram*

* *Added based on its designation as a Toxic Air Contaminant (AB 1807 Program).*

References

Bradman A, Eskenazi B, Barr DB, Bravo R, Castorina R, Chevrier J, *et al.* (2005). Organophosphate urinary metabolite levels during pregnancy and after delivery in women living in an agricultural community. *Environ Health Perspect* **113**(12):1802-7.

Bradman A, Whitaker D, Quiros L, Castorina R, Claus Henn B, Nishioka M, *et al.* (2007). Pesticides and their metabolites in the homes and urine

of farmworker children living in the Salinas Valley, CA. *J Expo Sci Environ Epidemiol* **17**(4):331-49.

CDPR (2012). California Department of Pesticide Regulation. Air Monitoring Network Results for 2011. Volume 1. [Available at URL: http://www.cdpr.ca.gov/docs/emon/airinit/amn_draft_vol1.pdf].

Coronado GD, Holte S, Vigoren E, Griffith WC, Barr DB, Faustman E, Thompson B (2011). Organophosphate pesticide exposure and residential proximity to nearby fields: evidence for the drift pathway. *J Occup Environ Med* **53**(8):884-91.

Gunier RB, Ward MH, Airola M, Bell EM, Colt J, Nishioka M, *et al.* (2011). Determinants of agricultural pesticide concentrations in carpet dust. *Environmental health perspectives* **119**(7):970.

Harnly ME, Bradman A, Nishioka M, McKone TE, Smith D, McLaughlin R, *et al.* (2009). Pesticides in dust from homes in an agricultural area. *Environ Sci Technol* **43**(23):8767-74.

Koutros S, Beane Freeman LE, Lubin JH, Heltshe SL, Andreotti G, Barry KH, *et al.* (2013). Risk of total and aggressive prostate cancer and pesticide use in the Agricultural Health Study. *Am J Epidemiol* **177**(1):59-74.

Lee SJ, Mehler L, Beckman J, Diebolt-Brown B, Prado J, Lackovic M, *et al.* (2011). Acute Pesticide Illnesses Associated with Off-Target Pesticide Drift from Agricultural Applications: 11 States, 1998–2006. *Environmental health perspectives* **119**(8):1162.

O'Malley M, Barry T, Ibarra M, Verder-Carlos M, Mehler L (2005). Illnesses related to shank application of metam-sodium, Arvin, California, July 2002. *Journal of Agromedicine* **10**(4):27-42.

Quiros-Alcala L, Bradman A, Nishioka M, Harnly ME, Hubbard A, McKone TE, *et al.* (2011). Pesticides in house dust from urban and farmworker households in California: an observational measurement study. *Environ Health* **10**:19.

Rauh VA, Perera FP, Horton MK, Whyatt RM, Bansal R, Hao X, *et al.* (2012). Brain anomalies in children exposed prenatally to a common organophosphate pesticide. *Proc Natl Acad Sci U S A* **109**(20):7871-6.

TOXIC RELEASES FROM FACILITIES

Exposure Indicator

There is widespread concern regarding exposures to chemicals that are released from industrial facilities. Statewide information directly measuring exposures to toxic releases has not been identified. However, some data on the *release* of pollutants into the environment is available and may provide some relevant evidence for potential subsequent exposures. The U.S. Environmental Protection Agency maintains a toxic substance inventory of on-site releases to air, water, and land and underground injection of any classified chemical, as well as quantities transferred off-site. The data are reported by each facility.

Indicator

Total toxicity-weighted pounds of chemicals released on-site to air or water from all facilities within the ZIP code, or within one kilometer of the ZIP code.

Data Source

Toxics Release Inventory (TRI) and
Risk Screening Environmental Indicators (RSEI),
U.S. Environmental Protection Agency (US EPA)

TRI is a database of self-reported disposal or other releases and waste management activities for certain listed toxic chemicals. It is updated annually. The TRI program was created by the federal Emergency Planning and Community Right-to-Know Act (EPCRA) and Pollution Prevention Act. The chemicals included in the database are those on EPCRA:

- Chemicals identified in EPCRA Section 313 (593 individually listed chemicals and 30 chemical categories including 3 delimited categories containing 62 chemicals); and
- Persistent, Bioaccumulative and Toxic (PBT) Chemicals (16 specific chemicals and 4 chemical classes).

Facilities are required to report if they have 10 or more full-time employees, operate within a set of industrial sectors outlined by TRI, and manufacture more than 25,000 pounds or otherwise use more than 10,000 pounds of any listed chemical during the calendar year. Lower reporting thresholds apply for PBT chemicals (10 or 100 pounds) and dioxin-like chemicals (0.1 gram).

RSEI is a computer-based chronic health screening tool developed by US EPA. It includes chemical-specific toxicity weights, which can be applied to TRI emissions data to produce a toxicity-weighted result. These weights are drawn from various programs of the US EPA, Cal/EPA, and the Agency for Toxic Substances and Disease Registry. For each facility, individual chemical weights are multiplied by the pounds of the chemical reported released. These are summed across all chemicals reported by the facility for the total toxicity-weighted pounds. Using this metric helps to incorporate toxicity considerations into the emissions data.

http://www.epa.gov/tri/index.htm
http://www.epa.gov/oppt/rsei/pubs/technical_appendix_a_toxicity_v2.3.1.pdf

Rationale

The Toxics Release Inventory (TRI) provides public information on emissions and releases into the environment from a variety of facilities across the state. TRI data do not, however, provide information on the extent of public exposure to these chemicals. That said, US EPA has stated that "[d]isposal or other releases of chemicals into the environment occur through a range of practices that could ultimately affect human exposure to the toxic chemicals ." (US EPA, 2010). A study of pollution in the printed wiring board industry found that among states with high TRI emissions in 2006, RSEI risk scores for California were by far the highest. According to the study, California combines high toxic emissions with a high risk score, based on location, composition of emissions and population exposure modeling (Lam *et al.*, 2011).

Air monitoring data at hundreds of locations across the United States have identified over a dozen hazardous air pollutants at concentrations that exceed California cancer or non-cancer benchmarks (McCarthy *et al.*, 2009). Many of the locations that these authors found to have elevated levels are near major industrial sources, and many of the chemicals monitored are the same as those that are emitted from these facilities. In California, a study that modeled concentrations of air toxic chemicals found significant levels of risk (Morello-Frosch *et al.*, 2000). Although this study found that mobile sources accounted for a major portion of the risk, the authors pointed out that for some communities, local industrial sources were a major contributor.

In addition to routine chemical releases, some communities located near TRI facilities are at risk from exposure to accidental chemical releases. A study of self-reported accident rates at U.S. chemical facilities over a five year period reported that 1,205 facilities (7.8% of facilities in the database) had at least one accident during the reporting period, and an additional 355 facilities (2.3%) had multiple accidents during the reporting period (Kleindorfer *et al.*, 2003). Associated with these events were a total of 1,987 injuries and 32 deaths among workers, and 167 injuries among nonemployees, including emergency responders. There were 215 total hospitalizations and 6,057 individuals given other medical treatments. Over 200,000 community residents were involved in evacuations and shelter-in-place incidents over that five year period.

Several studies have examined the potential for health effects from living near TRI facilities. For example, a case-control study reported an increase in risk for diagnosis of brain cancer in children of mothers living within a mile of a TRI facility that released carcinogens (Choi *et al.*, 2006). In another study, TRI air and water concentrations were associated with an increase in infant, but not fetal, mortality rates (Agarwal *et al.*, 2010).

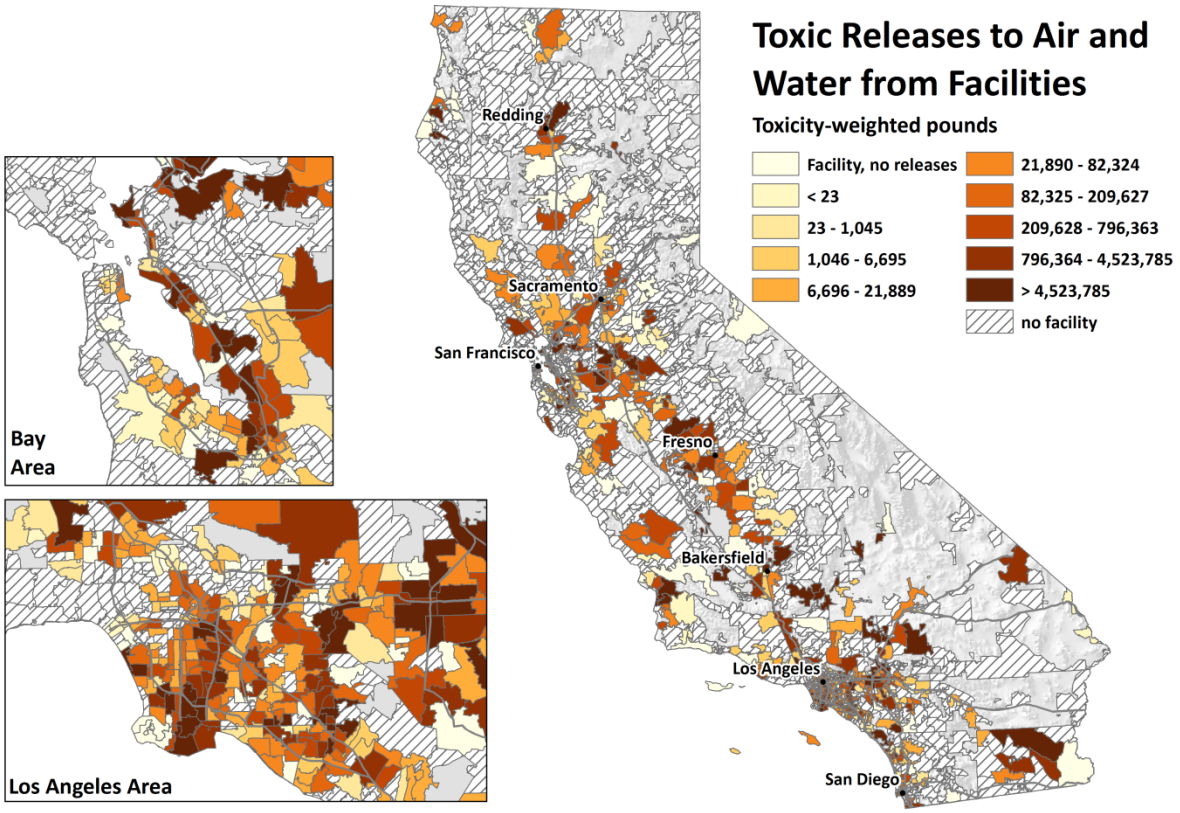
Multiple studies have observed greater emissions in low-income and

disadvantaged areas (Szasz and Meuser, 1997). Additionally, race and ethnicity have been correlated with the presence of toxic release facilities. People of color in studied regions of southern California were found to have a greater likelihood of living in areas with higher toxic releases (Morello-Frosch *et al.*, 2002; Sadd *et al.*, 1999).

Method

- Data on the location and toxicity-weighted emissions for facilities in California, or within one kilometer of California, were extracted from TRI using the TRI.NET program for 2008, 2009, and 2010. (http://www.epa.gov/tri/tridotnet/index.html)
- Toxicity-weighted on-site emissions to air and water were selected. (Releases to land and off-site transfers were excluded.)
- Facility locations with a valid latitude and longitude were mapped. Facility locations with address only were geocoded (ArcMap).
- A 1 kilometer (km) circular buffer (~3.14 km^2) was placed around each facility.
- ZIP codes were scored by summing the toxicity-weighted pounds of emissions for all facilities within the ZIP code or within one kilometer of the ZIP code, using an area-apportionment method:
  - If the 1 km buffer of a facility was fully located within a ZIP code, the toxicity-weighted pounds were fully applied to the ZIP code.
  - If the 1 km buffer crossed adjacent ZIP code(s), a portion of the toxicity-weighted pounds was applied to the ZIP codes based on the portion of the buffer located in each ZIP code area. For example, if the measured area of a facility's buffer was half in one ZIP code and half in another, 50 percent of the toxicity-weighted pounds was assigned to each ZIP code.
- Facilities that do not fall within the boundaries of census ZIP codes (or within the 1 km buffer) were added to the toxicity-weighted pounds of the census ZIP code that corresponds to the facility's ZIP code reported in the TRI database.
- For a three-year average, toxicity-weighted emissions by ZIP code were calculated for the years 2008 to 2010, individually, and then averaged.
  - ZIP codes were assigned a percentile based on their position in the distribution of ZIP codes with a facility located within it or within 1 km of the ZIP code. (If facilities are located within a ZIP code but all had no reported emissions for 2008-2010, the ZIP code is assigned the lowest percentile value.)

Indicator Map



References

Agarwal N, Banternghansa C, Bui L (2010). Toxic exposure in America: Estimating fetal and infant health outcomes from 14 years of TRI reporting. *Journal of Health Economics* **29**(4):557-74.

Choi HS, Shim YK, Kaye WE, Ryan PB (2006). Potential residential exposure to toxics release inventory chemicals during pregnancy and childhood brain cancer. *Environmental Health Perspectives* **114**(7):1113.

Kleindorfer PR, Belke JC, Elliott MR, Lee K, Lowe RA, Feldman HI (2003). Accident epidemiology and the U.S. chemical industry: accident history and worst-case data from RMP*Info. *Risk Anal* **23**(5):865-81.

Lam CW, Lim SR, Schoenung JM (2011). Environmental and risk screening for prioritizing pollution prevention opportunities in the U.S. printed wiring board manufacturing industry. *J Hazard Mater* **189**(1-2):315-22.

McCarthy MC, O'Brien TE, et al (2009). Characterization of the Chronic Risk and Hazard of Hazardous Air Pollutants in the United States Using Ambient Monitoring Data. *Environ Health Perspect* **117**(5): 790–796.

Morello-Frosch R, Pastor MJ, Porras C, Sadd J (2002). Environmental justice and regional inequality in southern California: implications for future research. *Environmental Health Perspectives* **110**(Suppl 2): 149-154.

Morello-Frosch RA, Woodruff TJ, Axelrad DA, Caldwell JC (2002). Air toxics and health risks in California: the public health implications of outdoor concentrations. *Risk Anal* **20**(2):273-91.

Sadd JL, Pastor MJ, Boer JT, Snyder LD (1999). "Every breath you take...": the demographics of toxic air releases in Southern California. *Economic Development Quarterly* **13**(2):107-23.

Szasz A, Meuser M (1997). Environmental inequalities: literature review and proposals for new directions in research and theory. *Current Sociology* **45**(3):99-120.

US EPA (2010). 2010 Toxics Release Inventory National Analysis Overview. 35 pp. http://www.epa.gov/tri/NationalAnalysis/archive/2010_National_Analysis_Overview_Document.pdf

TRAFFIC DENSITY

Exposure Indicator

While California has the strictest auto emissions standards in the U.S., the state is also known for its freeways and heavy traffic. Traffic is a significant source of air pollution, particularly in urban areas, where more than 50% of particulate emissions come from traffic. Exhaust from vehicles contains a large number of toxic chemicals, including nitrogen oxides, carbon monoxide, and benzene. Traffic exhaust also plays a role in the formation of photochemical smog. Health effects of concern from these pollutants include heart and lung disease, cancer, and increased mortality.

Indicator

Traffic density – Sum of traffic volumes adjusted by road segment length (vehicle-kilometers per hour) divided by total road length (kilometers) within 150 meters of the ZIP code boundary.

Data Source

Traffic Volume Linkage Tool,
California Environmental Health Tracking Program (CEHTP)
Environmental Health Investigations Branch,
California Department of Public Health

Data on the amount of traffic traveling on major roadways statewide are available. Traffic data are compiled under the California Department of Transportation's (Caltrans) Highway Performance Monitoring System (HPMS) every four years. The data consist of traffic volumes along various pre-defined segments of roadways across the state. Locally maintained roads are not included in the data.

A Traffic Volume Linkage Tool developed under CEHTP uses the annual average daily traffic (AADT) volumes from the 2004 HPMS data to calculate traffic-related metrics within a circular buffer of any geographic coordinate in California.

For this analysis, CEHTP used the 2004 HPMS data and the Traffic Volume Linkage Tool to calculate traffic density within a 150 meter buffer of the ZIP code boundary. Traffic density was calculated as the sum of all road length-adjusted traffic volumes per hour divided by the total road length (from HPMS) in and within 150 meters of each ZIP code.

The most recent year for which data are available for use by this tool is 2004.

http://www.cehtp.org/p/tools_traffic

Rationale

Traffic density is used to represent the number of mobile sources in a specified area, resulting in human exposures to chemicals that are released into the air by vehicle exhaust, as well as other effects related to large concentrations of motor vehicles. Major roadways have been associated with a variety of effects on communities, including noise, vibration, injuries, and local land use changes such as increased numbers of gas stations. For example, motorists often detour through residential

streets near major roads in order to avoid congestion or traffic controls, a phenomenon known as "rat-running"; this phenomenon can increase risk of injuries among pedestrians or bicyclists in these communities. Vehicle speed is directly associated with risk of pedestrian fatality, and speeds along major roadways tend to be higher than normal speeds on residential streets.

Studies have shown that non-white and low income people make up the majority of residents in high-traffic areas (Gunier *et al.* 2003; Tian *et al.*, 2013) and that schools that are located near busy roads are more likely to be in poor neighborhoods than those farther away (Green *et al.* 2004). In addition, children who live or attend schools near busy roads are more likely to suffer from asthma and bronchitis than children in areas with lower traffic density. This relationship has been seen in both developed (Patel *et al., 2011;* Schultz *et al.* 2012) and developing countries (Baumann *et al.*, 2011).

Exposure to air pollutants from vehicle emissions has been linked to adverse birth outcomes, such as low birth weight and preterm birth (Ghosh *et al.*, 2012; Ritz *et al.* 2007). A recent study of children in Los Angeles found that those with the highest prenatal exposure to traffic-related pollution were up to 15% more likely to be diagnosed with autism than children of mothers in the lowest quartile of exposure (Becerra *et al.*, 2013). The Atherosclerosis in Communities study, a cohort study with over 15,000 participants, found that traffic density and distance to roadways were associated with reduced lung function in adult women (Kan *et al.*, 2007). Road density and traffic volume were associated with adult male mortality from cardiovascular disease in an urban area in Brazil (Habermann and Gouveia, 2012). Motor vehicle exhaust is also a major source of polycyclic aromatic hydrocarbons (PAH), which can damage DNA and may cause cancer (IARC, 2010).

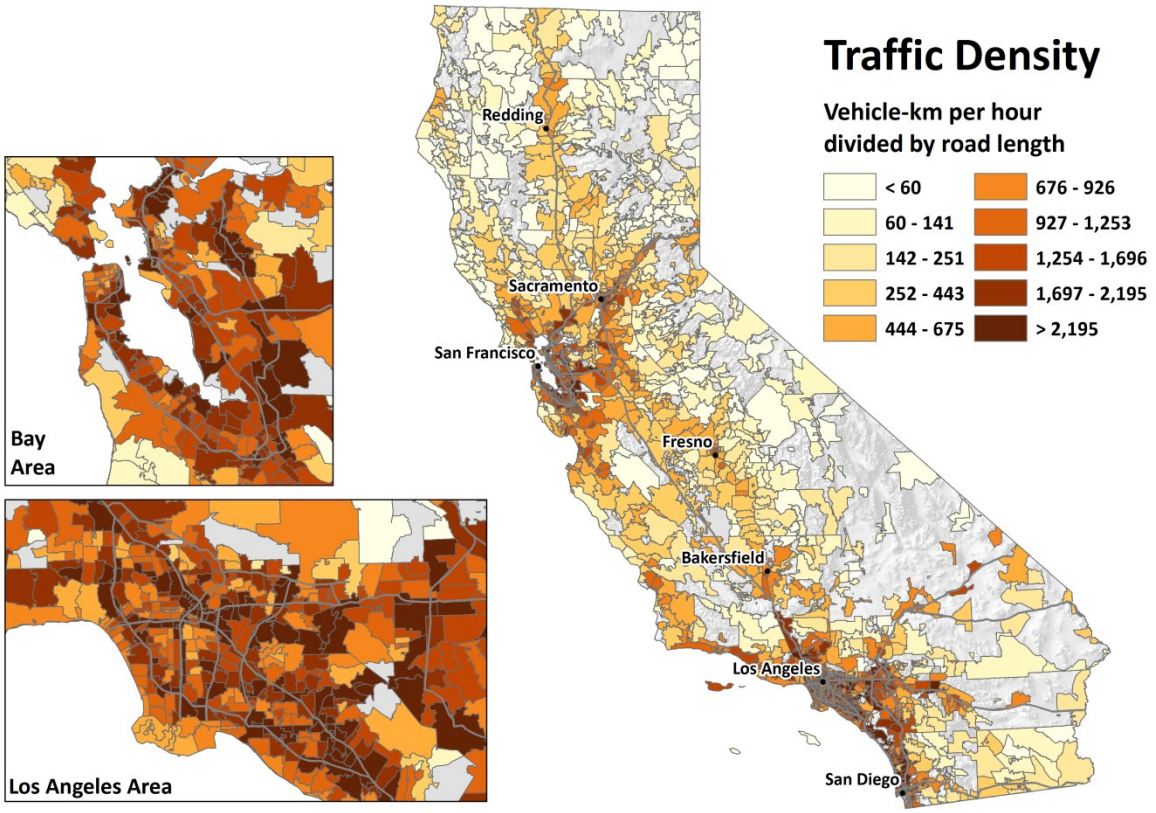
Method

- A 150 meter buffer was placed around each of the census ZIP codes in California. A buffer was chosen to account for roadways near ZIP code boundaries. The selected buffer distance of 150 meters, or about 500 feet, is taken from the California Air Resources Board Air Quality and Land Use Handbook recommendations, which states that most particulate air pollution from traffic drops off after approximately 500 feet (CARB, 2005).
- The buffered boundaries were put into the Traffic Volume Linkage Tool.
- Traffic density was calculated using two metrics from the tool: 1) the sum of all length-adjusted traffic volumes within the buffered ZIP code (vehicle-km/hr), then divided by 2) the sum of the length of all road segments within the buffered ZIP code (km).
- Due to differences in the length of road segments within Highway Performance Monitoring (HPMS), a length-adjusted traffic volumes metric was selected. This metric multiplies traffic volumes by length of the road segment in HPMS.
- Traffic density is calculated as traffic volumes (adjusted by road

segment lengths) divided by the total road length within the 150 meter buffer of each ZIP code (vehicles-km/hr/km).

- ZIP codes were sorted by traffic density and assigned percentiles based on the distribution.

Indicator Map



References

Air Quality and Land Use Handbook: A Community Health Perspective, California Air Resources Board (CARB): Sacramento, CA, USA, 2005. Available online: http://www.arb.ca.gov/ch/handbook.pdf (accessed on December 20, 2012).

Becerra TA, Wilhelm M, Olsen J, Cockburn M, Ritz B (2013). Ambient air pollution and autism in Los Angeles County, California. *Environ Health Perspect* **121**(3):380-6.

Ghosh JKC, Wilhelm M, Su J, Goldberg D, Cockburn M, Jerrett M, *et al.* (2012). Assessing the Influence of Traffic-related Air Pollution on Risk of Term Low Birth Weight on the Basis of Land-Use-based Regression Models and Measures of Air Toxics. *American Journal of Epidemiology* **175**(12):1262-74.

Green, R. S., S. Smorodinsky, *et al.* (2004). Proximity of California public schools to busy roads. *Environ Health Perspect* **112**(1): 61-66.

Gunier, R. B., A. Hertz, *et al.* (2003). Traffic density in California: socioeconomic and ethnic differences among potentially exposed children. *J_Expo Anal Environ Epidemiol* **13**(3): 240-246.

IARC. Some non-heterocyclic polycyclic aromatic hydrocarbons and some related exposures. (2010). *IARC Monogr Eval Carcinog Risks Hum* **92**:1-853.

Kan H, Heiss G, Rose KM, Whitsel E, Lurmann F, London SJ (2007). Traffic Exposure and lung function in adults: the Atherosclerosis Risk in Communities study. *Thorax* **62**:873-79.

Ritz, B., M. Wilhelm, *et al.* (2007). Ambient air pollution and preterm birth in the environment and pregnancy outcomes study at the University of California, Los Angeles. *Am J Epidemiol* **166**(9): 1045-52.

Schultz, E. S., O. Gruzieva, *et al.* (2012). Traffic-Related Air Pollution and Lung Function In Children At 8 Years Of Age - A Birth Cohort Study. *Am J Respir Crit Care Med.* 186(10).

Tian N, Xue J, Barzyk TM (2013). Evaluating socioeconomic and racial differences in traffic-related metrics in the United States using a GIS approach. *J Expo Sci Environ Epidemiol* **23**(2):215-22.

CLEANUP SITES

Environmental Effects Indicator

Sites undergoing cleanup actions by governmental authorities or by property owners have suffered environmental degradation due to the presence of hazardous substances. Of primary concern is the potential for people to come into contact with these substances. Some of these "brownfield" sites are also underutilized due to cleanup costs or concerns about liability. The most complete set of information available related to cleanup sites and brownfields in California is maintained by the Department of Toxic Substances Control.

Indicator

Sum of weighted sites within each ZIP code.

Since the nature and the magnitude of the threat and burden posed by hazardous substances vary among the different types of sites as well as the site status, the indicator takes both into account.

Data Source

EnviroStor Cleanup Sites Database,
Department of Toxic Substances Control (DTSC)
Agency for Toxic Substances and Disease Registry (ATSDR) Hazardous Waste Site Polygon Data with CIESIN Modifications, v1 (2008)

EnviroStor is a public database that provides access to information maintained by DTSC on site cleanup. The database contains information on numerous types of cleanup sites, including Federal Superfund, State Response, Corrective Action, School Cleanup, Voluntary Cleanup, Tiered Permit, Evaluation, Historical, and Military Evaluation sites. The database contains information related to the status of the site such as required cleanup actions, involvement/land use restriction, or "no involvement."

The Columbia University Center for International Earth Science Information Network (CIESIN) maintains and distributes the dataset for National Priorities List (NPL) Superfund sites nationwide. The data come in polygon format and generally represent the parcel boundaries of the sites. These data represent a subset of the larger Hazardous Waste Polygon Database, originally developed by the Center for Disease Control's Geospatial Research, Analysis, and Services Program.

http://www.envirostor.dtsc.ca.gov/public/
http://sedac.ciesin.columbia.edu/data/set/superfund-atsdr-hazardous-waste-site-ciesin-mod-1996

Rationale

Contaminated sites can pose a variety of risks to nearby residents. Hazardous substances can move off-site and impact surrounding communities through volatilization, groundwater plume migration, or windblown dust. Studies have found levels of organochlorine pesticides in blood (Gaffney *et al.* 2005) and toxic metals in house dust (Zota *et al.* 2011) that were correlated with residents' proximity to contaminated sites.

A study of pregnant women living near Superfund sites in New York state found an increased risk of having a low birth weight male child

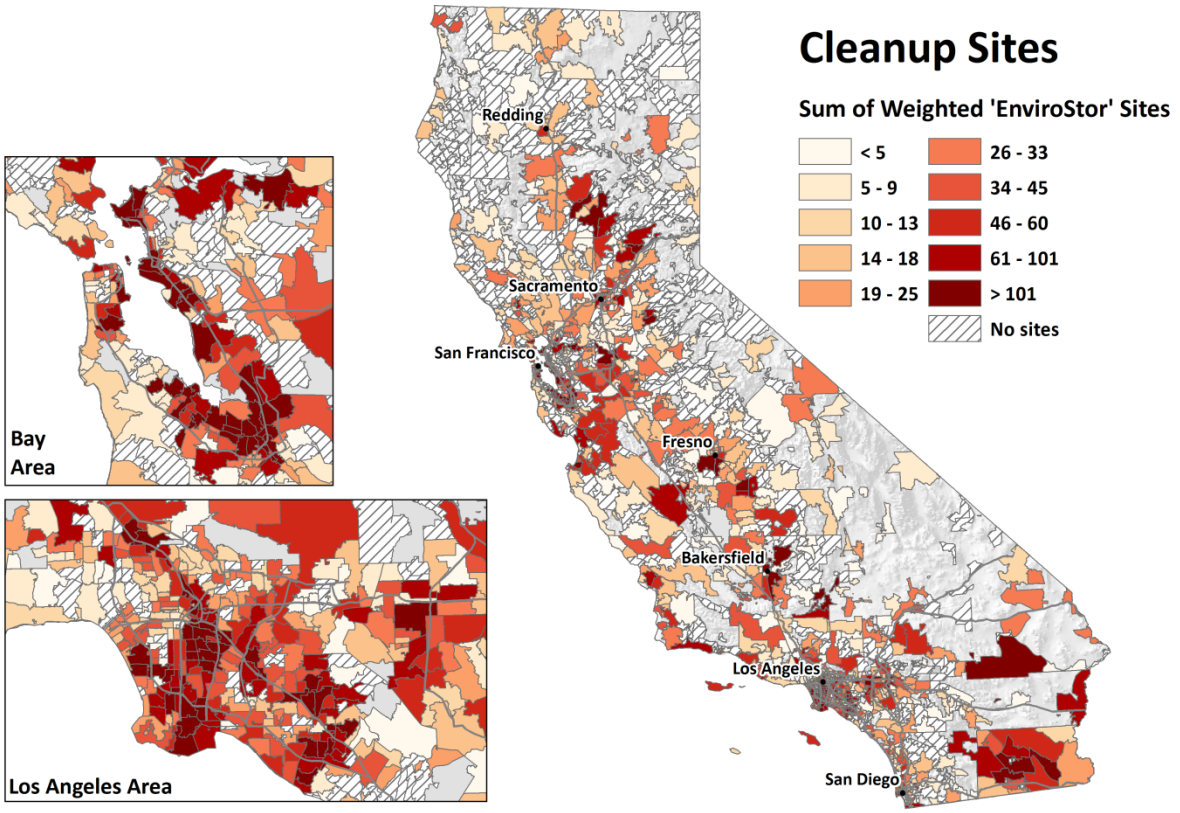
(Baibergenova *et al*. 2003). A later study in New York City found an association between prevalence of liver disease and the number of Superfund sites per 100 square miles (Ala *et al*. 2007). A demographic study of socioeconomic factors in communities in Florida found that census tracts with Superfund sites had significantly higher proportions of African Americans, Latinos and people employed in "blue collar" occupations than census tracts that did not contain a Superfund site (Kearney and Kiros, 2009). Some of the relationships between CalEnviroScreen scores and race have been added to the final section of this report.

It generally takes many years for a site to be certified as clean, and cleanup work is often delayed due to cost, litigation, concerns about liability or detection of previously unrecognized contaminants. Contaminated sites also have the potential to degrade nearby wildlife habitats, resulting in potential ecological impacts as well as threats to human health.

Method

- Data on cleanup site type, status, and location (coordinate or address) for the entire state were downloaded from the EnviroStor Cleanup Sites database.
- Several types of sites and statuses were excluded from the analysis because they indicate neither the presence of hazardous waste nor potential environmental risk (See Appendix).
- Each remaining site was scored on a weighted scale of 2 to 12 in consideration of both the site type and status (See Appendix). Higher weights were applied to Superfund, State Response sites, and cleanups compared to evaluations, for example. Similarly, higher weights were applied to sites that are undergoing active remediation and oversight by DTSC, relative to those with little or no state involvement.
- Sites with a valid latitude and longitude were mapped and sites with address only were geocoded in ArcMap.
- Agency for Toxic Substances and Disease Registry (ATSDR) Hazardous Waste Site polygon data were downloaded from the CIESIN website.
- Polygon sites in California on the NPL were identified. Sites were assigned a score of 12 (as a federal Superfund site).
- EnviroStor sites with a NPL polygon representation were replaced.
- All sites, including NPL polygon sites, were assigned a 250-meter buffer.
- Each ZIP code was scored based on the sum of the weighted sites it contains and the buffers that it intersects.
- Summed ZIP code ranks were assigned percentile scores.

Indicator Map



References

Agency for Toxic Substances and Disease Registry (ATSDR). 2008. Agency for Toxic Substances and Disease Registry (ATSDR) Hazardous Waste Site Polygon Data with CIESIN Modifications, 1996. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://sedac.ciesin.columbia.edu/data/set/superfund-atsdr-hazardous-waste-site-ciesin-mod-1996. Accessed 15 October 2012.

Ala A, Stanca CM, Bu-Ghanim M, Ahmado I, Branch AD, Schiano TD, *et al*. (2006). Increased prevalence of primary biliary cirrhosis near Superfund toxic waste sites. *Hepatology* **43**(3):525-31.

Baibergenova A, Kudyakov R, Zdeb M, Carpenter DO (2003). Low birth weight and residential proximity to PCB-contaminated waste sites. *Environ Health Perspect* **111**(10):1352-7.

Gaffney SH, Curriero FC, Strickland PT, Glass GE, Helzlsouer KJ, Breysse PN (2005). Influence of geographic location in modeling blood pesticide levels in a community surrounding a U.S. Environmental protection agency superfund site. *Environ Health Perspect* **113**(12):1712-6.

Kearney G, Kiros GE (2009). A spatial evaluation of socio demographics surrounding National Priorities List sites in Florida using a distance-based approach. *Int J Health Geogr* **8**:33.

Zota AR, Schaider LA, Ettinger AS, Wright RO, Shine JP, Spengler JD (2011). Metal sources and exposures in the homes of young children living near a mining-impacted Superfund site. *J Expo Sci Environ Epidemiol* **21**(5):495-505.

Appendix

Weighting Matrix for Cleanup Sites

Cleanup Sites from the EnviroStor Cleanup Sites database were weighted on a scale of 0 to 12 in consideration of both the site type and status. The following table shows the weights applied for each site type and status.

Site and status types excluded from the analysis:
School Investigation and *Border Zone/Hazardous Waste Evaluation* site types were not included in the analysis. Sites with the following statuses were also not included in the analysis: *Agreement – Work Completed*, *Referrals*, *Hazardous Waste Disposal Land Use,* and *De-listed*. Sites with statuses of *Certified, Completed,* and *No Further Action* were assigned a weight of zero and were effectively not included in the analysis. These sites and status types were excluded because they are not indicative of hazardous waste or potential environmental risk.

For a given ZIP code, the weighted scores of all facilities in the area were summed. Definitions used in the table are defined below.

Site Type	Status		
	Low • Certified • Completed • No Further Action	**Medium** • Inactive-Needs Eval. • Inactive • Certified Operation & Maintenance – Land Use Restrictions • Certified Operation & Maintenance	**High** • Active • Backlog • Inactive- Action Required
Low • Evaluation • Historical • Military Evaluation	0	4	6
Medium • Corrective Action • School Cleanup • Voluntary Cleanup • Tiered Permit	1	7	9
High • State Response • Superfund	2	10	12

Definitions*

- *Active*: Identifies that an investigation and/or remediation is currently in progress and that DTSC is actively involved, either in a lead or support capacity.
- *Certified Operation and Maintenance (O&M)*: Identifies sites that have certified cleanups in place but require ongoing O&M activities.
- *Certified*: Identifies completed sites with previously confirmed releases that are subsequently certified by DTSC as having been remediated satisfactorily under DTSC oversight.
- *Corrective Action*: Identifies sites undergoing "corrective action," defined as investigation and cleanup activities at hazardous waste facilities (either Resource Conservation and Recovery Act (RCRA) or State-only) that either were eligible for a permit or received a permit. These facilities treat, store, dispose and/or transfer hazardous waste.
- *Evaluation*: Identifies suspected, but unconfirmed, contaminated sites that need or have gone through a limited investigation and assessment process.
- *Inactive – Action Required*: Identifies non-active sites where, through a Preliminary Endangerment Assessment (PEA) or other evaluation, DTSC has determined that a removal or remedial action or further extensive investigation is required.
- *Inactive - Needs Evaluation*: Identifies inactive sites where DTSC has determined a Preliminary Endangerment Assessment or other evaluation is required.

- *No Further Action*: Identifies completed sites where DTSC determined after investigation, generally a PEA (an initial assessment), that the property does not pose a problem to public health or the environment.
- *School Cleanup*: Identifies proposed and existing school sites that are being evaluated by DTSC for possible hazardous materials contamination at which remedial action occurred.
- *State Response*: Identifies confirmed release sites where DTSC is involved in remediation, either in a lead or oversight capacity. These confirmed release sites are generally high-priority and high potential risk.
- *Superfund*: Identifies sites where the US EPA proposed, listed, or delisted a site on the National Priorities List (NPL).
- *Voluntary Cleanup*: Identifies sites with either confirmed or unconfirmed releases, and the project proponents have requested that DTSC oversee evaluation, investigation, and/or cleanup activities and have agreed to provide coverage for DTSC's costs.

* EnviroStor Glossary of Terms
(http://www.envirostor.dtsc.ca.gov/public/EnviroStor%20Glossary.pdf)

GROUNDWATER THREATS

Environmental Effects Indicator

Many activities can pose threats to groundwater quality. These include the storage and disposal of hazardous materials on land and in underground storage tanks at various types of commercial, industrial, and military sites. Thousands of storage tanks in California have leaked petroleum or other hazardous substances, degrading soil and groundwater. Storage tanks are of particular concern when they can affect drinking water supplies. Storage tank sites can expose people to contaminated soil and volatile contaminants in air. In addition, the land surrounding these sites may be taken out of service due to perceived cleanup costs or concerns about liability. The most complete set of information related to sites that may impact groundwater and require cleanup is maintained by the State Water Resources Control Board.

Indicator

Sum of weighted scores for sites within each ZIP code.

The nature and the magnitude of the threat and burden posed by sites maintained in GeoTracker vary significantly by site type (e.g., leaking underground storage tank or cleanup site) and status (e.g., Completed Case Closed or Active Clean up). Thus, the indicator takes into account information about both the type of site and its status.

Data Source

GeoTracker Database,
State Water Resources Control Board (SWRCB)

GeoTracker is a public web site that allows the SWRCB, regional water quality control boards and local agencies to oversee and track projects at cleanup sites that can impact groundwater. The GeoTracker database contains information on locations and water quality of wells that could be contaminated, as well as potential sources of groundwater contamination. These include leaking underground storage tanks (LUSTs), leaking military underground storage tanks (USTs) cleanup and land disposal sites, and cleanup sites, industrial sites, airports, dairies, dry cleaners, and publicly-owned sewage treatment plants. For each site, there is additional information on the status of cleanup activities. Groundwater quality data are extracted from monitoring and records maintained by SWRCB, the Department of Water Resources, Department of Public Health, Department of Pesticide Regulation, U.S. Geological Survey and Lawrence Livermore National Laboratory. The database is constantly updated and sites are never deleted from the database, where they may ultimately be designated 'clean closed.'

A separate GeoTracker database contains information on the location of underground storage tanks (not leaking), which was not used.

http://geotracker.waterboards.ca.gov/

Rationale

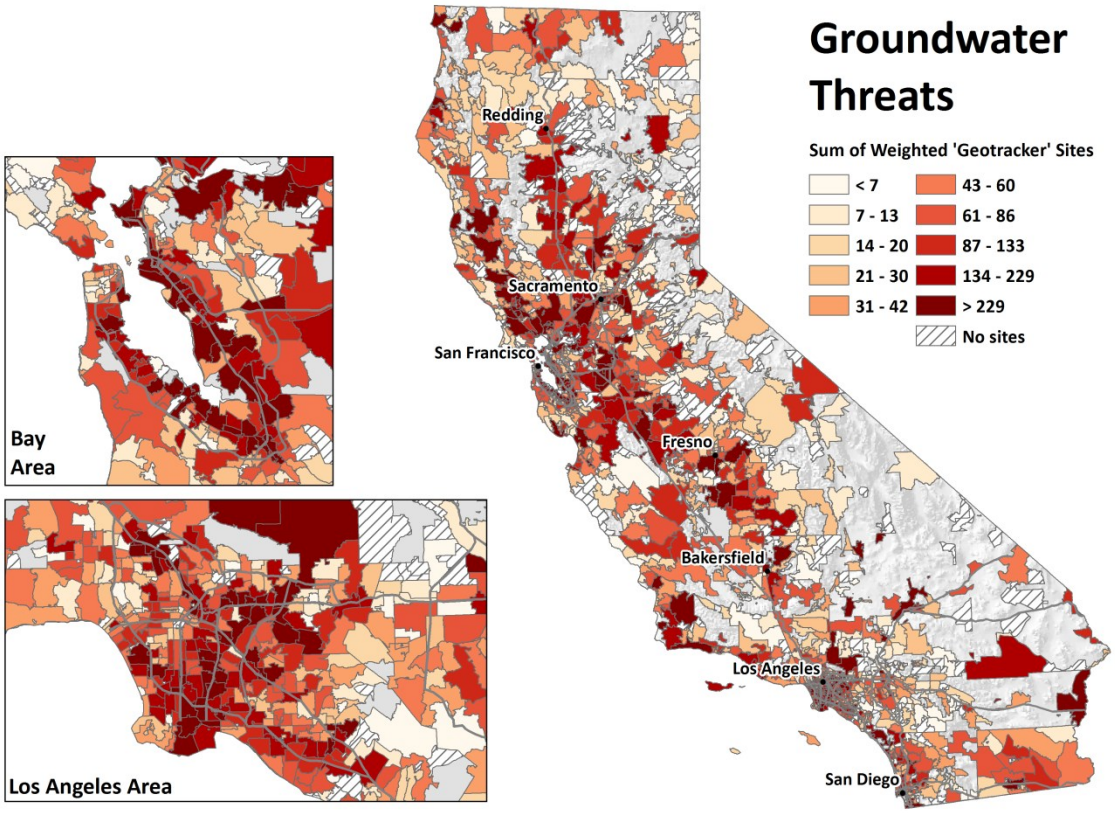
Common groundwater pollutants found at LUST and cleanup sites in California include gasoline and diesel fuels, chlorinated solvents and other volatile organic compounds (VOCs) such as benzene, toluene, and methyl tert-butyl ether (MTBE); heavy metals such as lead, chromium and

arsenic; polycyclic aromatic hydrocarbons (PAHs); persistent organic pollutants like polychlorinated biphenyls (PCBs); DDT and other insecticides; and perchlorate (SWRCB, 2012; DPR, 2011; US EPA, 2002). Dioxins and dioxin-like substances have been detected in groundwater in areas where treated wastewater has been used for irrigation (Mahjoub *et al.*, 2011) and near wood treatment facilities (Karouna-Renier *et al.*, 2007). The occurrence of storage tanks, leaking or not, provides a good indication of potential concentrated sources of some of the more prevalent compounds in groundwater. For example, the detection frequency of VOCs found in gasoline is associated with the number of UST or LUST sites within one kilometer of a well (Squillace and Moran, 2007). The occurrence of chlorinated solvents in groundwater is also associated with the presence of cleanup sites (Moran *et al.*, 2007). Some of these cancer-causing compounds have in turn been detected in drinking water supplies in California (Williams *et al.*, 2002). People who live near shallow groundwater plumes containing VOCs may also be exposed via the intrusion of vapors from soil into indoor air (Picone *et al.*, 2012; Yao *et al.*, 2013).

Method

- Data on cleanup site type, status, and location (coordinate or address) for the entire state were downloaded from GeoTracker (http://geotracker.waterboards.ca.gov/data_download.asp; GeoTracker Cleanup Sites).
- Certain types of sites and statuses were excluded from the analysis because they are not indicative of a hazard or a potential environmental risk (see Appendix).
- Each remaining site was scored on a weighted scale of 3 to 15 in consideration of both the site type and status.
- Sites with a valid latitude and longitude were mapped and sites with address only were geocoded in ArcMap. Sites without a valid latitude and longitude or unrecognizable address were excluded from the analysis.
- Sites were assigned a 250-meter buffer.
- Each ZIP code was scored based on the sum of the weighted sites it contains and the buffers it intersects.
- Summed ZIP code scores were assigned percentiles.

Indicator Map



References

Karouna-Renier NK, Rao KR, Lanza JJ, Davis DA, Wilson PA (2007). Serum profiles of PCDDs and PCDFs, in individuals near the Escambia Wood Treating Company Superfund site in Pensacola, FL. *Chemosphere* **69**(8):1312-9.

Mahjoub O, Escande A, Rosain D, Casellas C, Gomez E, Fenet H (2011). Estrogen-like and dioxin-like organic contaminants in reclaimed wastewater: transfer to irrigated soil and groundwater. *Water Sci Technol* **63**(8):1657-62.

Moran MJ, Zogorski JS, Squillace PJ (2007). Chlorinated solvents in groundwater of the United States. *Environ Sci Technol* **41**(1): 74-81.

Picone S, Valstar J, van Gaans P, Grotenhuis T, Rijnaarts H (2012). Sensitivity analysis on parameters and processes affecting vapor intrusion risk. *Environ Toxicol Chem* **31**(5):1042-52.

Squillace PJ, Moran MJ (2007). Factors associated with sources, transport, and fate of volatile organic compounds and their mixtures in aquifers of the United States. *Environ Sci Technol* **41**(7):2123-30.

Williams P, Benton L, Warmerdam J, Sheehan P (2002). Comparative risk analysis of six volatile organic compounds in California drinking

water. *Environ Sci Technol* **36**(22): 4721-28.

Yao Y, Shen R, Pennell KG, Suuberg EM (2013). Examination of the Influence of Environmental Factors on Contaminant Vapor Concentration Attenuation Factors Using the U.S. EPA's Vapor Intrusion Database. *Environ Sci Technol* **47**(2):906-13.

Appendix

Weighting Matrix for Groundwater Threats

Groundwater threats from the GeoTracker database were weighted on a scale of 3 to 15 in consideration of both the site type and status. The following table shows the weights applied for each site type and status.

Sites with a status type of *Completed – Case Closed* and *Open-Referred* were excluded from the analysis.

For a given ZIP code, the weighted scores of all facilities in the area were summed.

	Status	
	Low • **Open** • **Open—Inactive Open** • **Open—Verification Monitoring**	**High** • **Open—Remediation** • **Open—Reopen** • **Open—Site Assessment** • **Open—Site Assessment & Remedial Action**
Low • **LUST Cleanup Program** • **Military Underground Storage Tanks**	**3**	**5**
Medium • **Land Disposal Site**	**6**	**10**
High • **Cleanup Program Site** • **Military Privatized Site** • **Military Cleanup Site**	**9**	**15**

Definitions*

- *Cleanup Program Site* (Site Cleanup Program): In general, Site Cleanup Program sites are areas where a release of pollutants has occurred that is not addressed in the other core regulatory programs (e.g., permitted facilities, USTs). The funding for the Program is primarily cost reimbursement from responsible parties.
- *Completed - Case Closed:* A closure letter or other formal closure decision document has been issued for the site.
- *Land Disposal Site:* The Land Disposal program regulates water quality aspects of discharges to land for disposal, treatment, or storage of waste at waste management facilities and units such as landfills, waste piles and land treatment units under California

Code of Regulations, Title 27. A land disposal unit is an area of land, or a portion of a waste management facility, at which waste is discharged.

- *Military Cleanup Site:* Military Cleanup Program sites are areas where a release of pollutants from an active or closed military facility has occurred. The military fully funds for the Program oversight.
- *Military Privatized Site:* These sites are within the Site Cleanup Program. They are unique because these sites have been transferred by the military into non-military ownership with or without further cleanup necessary.
- *Military Underground Storage Tanks (UST):* Military UST Program sites are areas where a release of pollutants from an underground storage tank has occurred at a military or former military installation. The military fully funds for the Program oversight costs.
- *Open – Eligible for Closure:* Identifies cases that meet the general and media-specific criteria established in the SWRCB Low-Threat Underground Storage Tank Policy Case Closure Policy.
- *Open – Inactive:* Identifies inactive cases where a Regional Water Quality Control Board and/or a local agency have determined a site assessment or other evaluation is required. The case may also be inactive if a responsible party appears to be recalcitrant and or has inadequate funding.
- *Open – Remediation:* Identifies sites that have on-going cleanup activities designed to remove or destroy in-place the most readily recoverable fraction of source-area mass.
- *Open – Site Assessment and Interim Remedial Action:* An interim remedial action is occurring at the site and additional activities such as site characterization, investigation, risk evaluation, and/or site conceptual model development are occurring.
- *Open – Site Assessment:* Activities such as site characterization, investigation, risk evaluation, and/or conceptual site model development are occurring.
- *Open – Verification Monitoring:* Identifies sites that have recently completed remedial actions and the RWQCB and or a local agency have requested post remediation sampling to assess the post remediation conceptual site model.

HAZARDOUS WASTE FACILITIES AND GENERATORS

Environmental Effects Indicator

Most hazardous waste must be transported from hazardous waste generators to permitted recycling, treatment, storage, or disposal facilities (TSDF) by registered hazardous waste transporters. Most shipments must be accompanied by a hazardous waste manifest. There are widespread concerns for both human health and the environment from sites that serve for the processing or disposal of hazardous waste. Many newer facilities are designed to prevent the contamination of air, water, and soil with hazardous materials, but even newer facilities may negatively affect perceptions of surrounding areas in ways that have economic, social and health impacts. The Department of Toxic Substances Control maintains data on permitted facilities that are involved in the treatment, storage, or disposal of hazardous waste as well as information on hazardous waste generators.

Indicator

Sum of weighted permitted hazardous waste facilities and hazardous waste generators within each ZIP code.

Data Source

EnviroStor Hazardous Waste Facilities Database and
Hazardous Waste Tracking System,
Department of Toxic Substances Control (DTSC)

EnviroStor is a public web site that provides access to detailed information on hazardous waste permitted facilities. Information included in the database includes the facility name and address, geographic location, facility type and status.

DTSC also maintains information on the manifests created for the transport of hazardous waste from generators in its Hazardous Waste Tracking System. Manifests include the generators' name and identification number, the transporter, the designated recipient and description of the type and quantity of waste classified by a coding system. Data are currently available for 2009.

http://www.envirostor.dtsc.ca.gov/public/data_download.asp
http://hwts.dtsc.ca.gov/

Rationale

Hazardous waste by definition that is potentially dangerous or harmful to human health or the environment. U.S. EPA and DTSC both have standards for determining when waste materials must be managed as hazardous waste. Hazardous waste can be liquids, solids, or contained gases. It can include manufacturing by-products, and discarded used or unused materials such as cleaning fluids (solvents) or pesticides. Used oil and contaminated soil generated from a site clean-up can be hazardous wastes (DTSC, Defining Hazardous Waste). In 1995, 97% of toxic chemicals released nationwide came from small generators and facilities (McGlinn, 2000). Generators of hazardous waste may treat waste onsite or send it elsewhere for disposal.

The potential health effects that come from living near hazardous waste

disposal sites have been examined in a number of studies (Vrijheid, 2000). While there is sometimes limited assessment of exposures that occur in nearby populations, there are studies that have found health effects, including diabetes and cardiovascular disease, associated with living in proximity to hazardous waste sites (Kouznetsova *et al*., 2007; Sergeev and Carpenter, 2005).

Location of hazardous waste sites in communities has long been an environmental justice concern in California. For example, a recent study of 82 hazardous waste treatment, storage, and disposal facilities in Los Angeles County found that the communities most affected by the facilities are composed of working-class and ethnic minority populations living near industrial areas (Aliyu et al, 2011). A 1997 study correlated race/ethnicity with the location of hazardous waste treatment, storage and disposal facilities for both African-American and Latino populations (Boer *et al*., 1997).

Electronic waste is defined as universal waste rather than hazardous waste by California law, and is subject to different rules for handling and transportation. However, some components of electronic devices contain hazardous materials, and facilities that collect or recycle electronic waste are potential sources of exposure to toxic chemicals (DTSC, 2010; CalRecycle, 2012).

Method

Permitted hazardous waste facilities:

- Permitted facility data were obtained from the DTSC website.
- Facilities were scored on a weighted scale in consideration of the type and permit status for the facility (See Appendix).
- Site locations were mapped or geocoded (in ArcMap).

Hazardous waste generators:

- Generator data were obtained from DTSC from the Hazardous Waste Tracking System.
- Facilities were scored on a weighted scale in consideration the type of waste (RCRA[7] waste vs. non-RCRA[8] waste) and volume generated (large quantity generator) (see Appendix).
- Class I hazardous waste facilities that did not fall within the boundaries of census ZIP codes (or within the 250 meter buffer) were assigned to the ZIP code matching the facility's postal ZIP code provided in the database.
- Site locations were mapped or geocoded (in ArcMap).

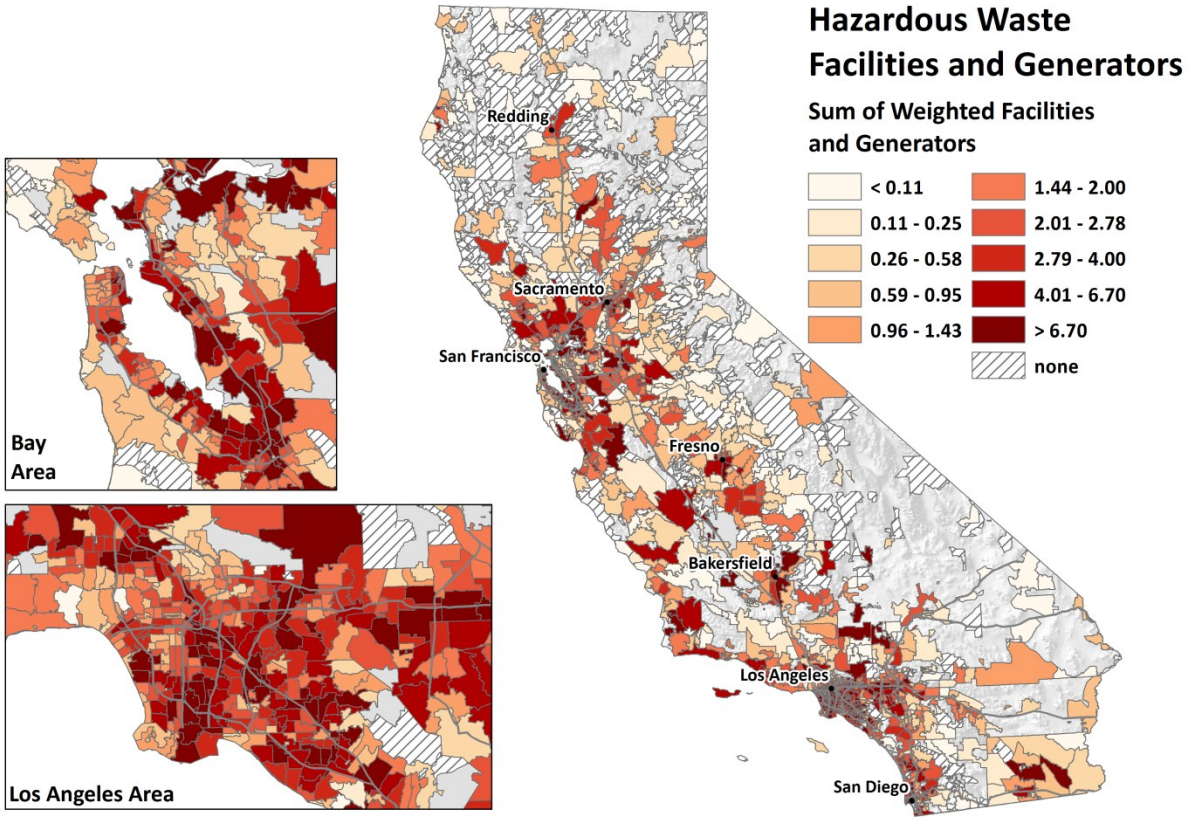
All sites were assigned a 250-meter buffer and ZIP codes were scored based on the sum of weighted sites contained in their boundaries or buffers that they intersected (in ArcMap). Summed scores were assigned

[7] RCRA: Resource Conservation and Recovery Act governs the federal management of hazardous wastes; (List of RCRA waste: http://www.epa.gov/osw/inforesources/data/br91/na_apb-p.pdf)

[8] Non-RCRA: waste streams considered hazardous in California; (List: http://www.dtsc.ca.gov/LawsRegsPolicies/Title22/upload/OEARA_REG_Title22_Ch11_AppXII.pdf)

percentiles.

Indicator Map



References

Aliyu AA, Kasim R, Martin D (2011). Siting of hazardous waste dump facilities and their correlation with status of surrounding residential neighbourhoods in Los Angeles County. *Property Management*. **29** (1): 87-102.

Boer JT, Pastor MJ, Sadd JL, Snyder LD (1997). Is there environmental racism? The demographics of hazardous waste in Los Angeles County. *Social Science Quarterly* **78**(4):793-810.

CalRecycle. "What is E-Waste?". Last updated October 26, 2012. http://www.calrecycle.ca.gov/Electronics/WhatisEwaste/. Accessed February 14, 2013.

DTSC. "Electronic Hazardous Waste (E-Waste)" 2010. http://www.dtsc.ca.gov/hazardouswaste/ewaste/. Accessed February 14, 2013.

DTSC. "Defining Hazardous Waste" 2012 http://www.dtsc.ca.gov/HazardousWaste/upload/HWMP_DefiningHW111.pdf. Accessed February 14,2013

Kouznetsova M, Huang X, Ma J, Lessner L, Carpenter DO (2007).

Increased rate of hospitalization for diabetes and residential proximity of hazardous waste sites. *Environ Health Perspect* **115**(1):75-9.

McGlinn L (2000). Spatial patterns of hazardous waste generation and management in the United States. *The Professional Geographer* **52**(1):11-22.

Sergeev AV, Carpenter DO (2005). Hospitalization rates for coronary heart disease in relation to residence near areas contaminated with persistent organic pollutants and other pollutants. *Environ Health Perspect* **113**(6):756-61.

Vrijheid M (2000). Health effects of residence near hazardous waste landfill sites: a review of epidemiologic literature. *Environmental health perspectives* **108**(Suppl 1):101.

Appendix

Weighting Matrix for Permitted Hazardous Waste Facilities and Hazardous Waste Generators

Permitted Hazardous Waste Facilities from DTSC's permitted facilities database were weighted on a scale of 1 to 12 in consideration of both facility activity and permit type. The score for any given Permitted Hazardous Waste Facility represents the sum of its Facility Activity and Permit Type.

Hazardous waste generators were weighted on a scale of 0.05 to 0.1, where all generators were given a base weight of 0.05. The score for hazardous waste generators is the sum of the based weight and any additional type of generator activity.

The following tables show the weights applied to the facilities and generators. Greater concerns were identified for permitted hazardous waste facilities that handle much of the hazardous waste generated from the ~30,000 generators in California. For this reason, weighting of generators was considerably lower than that for the handling facilities. Of the generators, higher weights were given for those that create RCRA waste or are large quantity generators (>1000 kg/month). For all ZIP codes, the weighted scores of all facilities in the area were summed.

Permitted Hazardous Waste Facilities

Category	Facility Activity	Permit Type
Permitted Hazardous Waste Facilities	**10** (Landfill) **7** (Treatment) **4** (Storage) **2** (Post-closure)	**1** (Large facilities) **1** (Non-RCRA facilities) **2** (RCRA facilities)

Hazardous Waste Generators

Category	Base weight	Generator activity
Hazardous Waste Generators	**0.05** (All generators)	**0.025** (Large quantity generator) **0.025** (RCRA waste)

IMPAIRED WATER BODIES

Environmental Effects Indicator

Contamination of California streams, rivers, and lakes by pollutants can compromise the use of the water body for drinking, swimming, fishing, aquatic life protection, and other beneficial uses. When this occurs, such bodies are considered "impaired." Information on impairments to these water bodies can help determine the extent of environmental degradation within an area.

Indicator

Summed number of pollutants across all water bodies designated as impaired within the area.

Data Source

303(d) List of Impaired Water Bodies,
State Water Resources Control Board (SWRCB)

The SWRCB provides information relevant to the condition of California surface waters. Such information is required by the Federal Clean Water Act. Every two years, State and Regional Water Boards assess the quality of California surface waters. Lakes, streams and rivers that do meet water quality standards, or are not expected to meet water quality standards, are listed as impaired under Section 303(d) of the Clean Water Act.

http://www.waterboards.ca.gov/rwqcb2/water_issues/programs/TMDLs/303dlist.shtml

Rationale

Rivers, lakes, estuaries and marine waters in California are important for many different uses. Water bodies used for recreation may also be important to the quality of life of nearby residents if subsistence fishing is critical to their livelihood (Cal/EPA, 2002). Water bodies also support abundant flora and fauna. Changes in aquatic environments can affect biological diversity and overall health of ecosystems. Aquatic species important to local economies may be impaired if the habitats where they seek food and reproduce are changed. Marine wildlife like fish and shellfish that are exposed to toxic substances may potentially expose local consumers to toxic substances as well (Cal/EPA, 2002). Excessive hardness, unpleasant odor or taste, turbidity, color, weeds, and trash in the waters are types of pollutants affecting water aesthetics (Cal/EPA, 2002), which in turn can affect nearby communities.

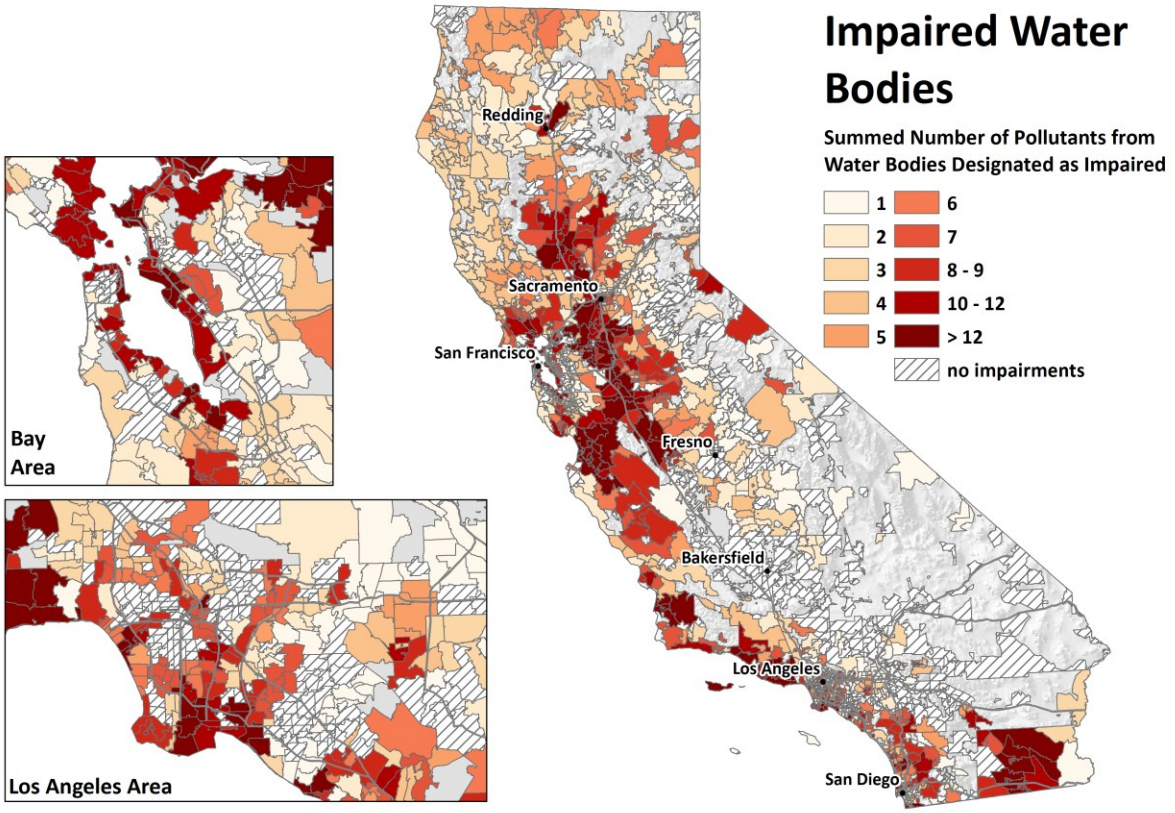
Communities of color, low-income communities, and tribes generally depend on the fish, aquatic plants, and wildlife provided by nearby surface waters to a greater extent than the general population (NEJAC, 2002). Some communities that rely on resources provided by nearby surface waters have populations of lower socioeconomic status than the general population. For example, certain fishing communities along California's northern coast have lower educational attainment and median income than California as a whole (Pomeroy *et al.*, 2010). Low-income communities in California that rely on fishing and waterfront businesses have been affected by a recent decline in the fishing

community (California State Lands Commission, 2011). Lower per capita income has been associated with increased levels of certain surface water pollutants, as have a higher percentage of minorities and people of color (Farzin and Grogan, 2012).

Method

- Data on water body type, water body ID, and pollutant type were downloaded in Excel format, and GIS data showing the visual representation of all water bodies were downloaded from the SWRCB website. http://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2010.shtml)
- All water bodies were identified in all ZIP codes in the GIS software ArcMap.
- The number of pollutants listed in streams and/or rivers that intersected a ZIP code were counted.
- The number of pollutants listed in lakes, bays, estuaries and/or shoreline that intersected or bordered a ZIP code were counted.
- The two pollutant counts were summed for every ZIP code.
- Each ZIP code was scored based on the sum of the number of individual pollutants found within and/or bordering it. For example, if two stream sections within a ZIP code were both listed for the same pollutant, the pollutant was only counted once.
- Summed ZIP code scores were assigned percentile scores.

Indicator Map



References

Cal/EPA, Agency CR (2002). Environmental Protection Indicators for California. In OEHHA (Ed.) (2002 ed., pp. 303). Sacramento: Cal/EPA. Available at URL: http://oehha.ca.gov/multimedia/epic/Epicreport.html.

California State Lands Commission (2012). Central Coastal California Seismic Imaging Project. Final Environmental Impact Report. Vol. 2. Section III. Chapter 7.

Farzin YH and Grogan KA (2012). Socioeconomic factors and water quality in California. Environmental Economics and Policy Studies. Published Online: 08 June 2012. Available at URL: http://www.feem.it/userfiles/attach/2011781234534NDL2011-051.pdf.

NEJAC (2002). National Environmental Justice Advisory Council. Fish Consumption and Environmental Justice. A Report developed from the National Environmental Justice Advisory Council Meeting of December 3-6, 2001. Available at URL: http://www.epa.gov/environmentaljustice/resources/publications/nejac/fish-consump-report_1102.pdf

Pomeroy C, Thomson CJ, Stevens MM (2010). California's North Coast Fishing Communities Historical Perspective and Recent Trends. Scripps Institution of Oceanography.SLC (2012). Available at URL: http://www-csgc.ucsd.edu/BOOKSTORE/documents/FullRept.pdf

SOLID WASTE SITES AND FACILITIES

Environmental Effects Indicator

Many newer solid waste landfills are designed to prevent the contamination of air, water, and soil with hazardous materials. However, older sites that are out of compliance with current standards or illegal solid waste sites may degrade environmental conditions in the surrounding area and pose a risk of exposure. Other types of facilities, such as composting, treatment and recycling facilities, may raise concerns about odors, vermin, and increased truck traffic. While data that describe environmental effects from the siting and operation of all types of solid waste facilities are not currently available, the California Department of Resources Recycling and Recovery (CalRecycle) maintains data on facilities that operate within the state, as well as sites that are abandoned, no longer in operation, or illegal.

Indicator

Sum of weighted solid waste sites and facilities.

Data Source

Solid Waste Information System (SWIS) and
Closed, Illegal, and Abandoned (CIA) Disposal Sites Program,
California Department of Resources Recycling and Recovery, CalRecycle

SWIS is a database which tracks solid waste facilities, operations, and disposal sites throughout California. Solid waste sites found in this database include landfills, transfer stations, material recovery facilities, composting sites, transformation facilities, waste tire sites, and closed disposal sites.

The CIA Disposal Sites Program is a subset of the SWIS database, and includes closed landfills and disposal sites that have not met minimum state standards for closure as well as illegal and abandoned sites. Sites within CIA have been prioritized to assist local enforcement agencies investigate the sites and enforce state standards.

http://calrecycle.ca.gov/SWFacilities/Directory/
http://www.calrecycle.ca.gov/SWFacilities/CIA/

Rationale

Solid waste sites can have multiple impacts on a community. Waste gases like methane and carbon dioxide can be released into the air from disposal sites for decades, even after site closure (US EPA, 2011; Ofungwu and Eget, 2005). Fires, although rare, can pose a health risk from exposure to smoke and ash (CalRecycle, 2010a; US Fire Administration, 2002). Odors and the known presence of solid waste may impair a community's perceived desirability.

Although all active solid waste sites are regulated, CalRecycle has recorded a number of old closed disposal sites and landfills that are monitored less frequently. Former abandoned disposal sites present potential for human or animal exposure to uncovered waste or burn ash. Such sites are of concern to State and local enforcement agencies (CalRecycle, 2010b).

Many of the studies that address the potential toxicity of solid waste site emissions look at the biological effects of landfill leachate on selected species of animals and plants in the laboratory. New ecological test methods have demonstrated that exposure to landfill soil containing a mixture of hazardous chemicals can cause genetic changes that are associated with adverse effects on the reproductive system (Roelofs *et al.*, 2012). In addition, an epidemiologic study of human births near landfills in Wales found an increase in the rate of birth defects after the opening or expansion of sites (Palmer *et al.*, 2005). A study conducted after an accidental fire at a municipal landfill in Greece found unacceptably high levels of dioxins in food products, primarily meat, milk and olives, from an area near the landfill (Vassiliadou *et al.*, 2009).

Method: Closed, Illegal, and Abandoned (CIA) sites:

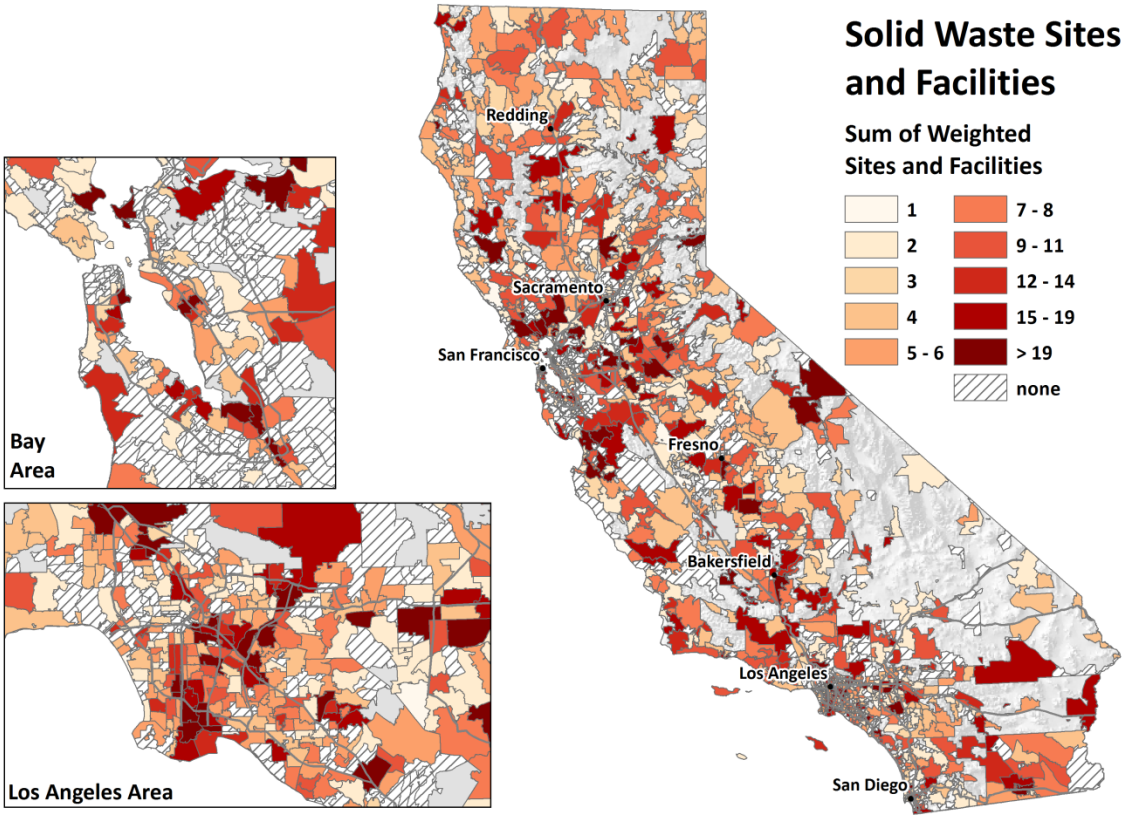
- CIA data were obtained from CalRecycle for all priorities. (Only high priority CIA sites data are available online.)
- Unconfirmed and non-solid waste sites were removed from the analysis.
- Each remaining site was scored on a weighted scale in consideration of CalRecycle's prioritization categories (see table in appendix).
- Site locations were mapped or geocoded (in ArcMap).

Active Solid Waste Information (SWIS) sites:

- SWIS data were obtained from the CalRecycle website.
- CIA records were filtered from the database because SWIS contains an inventory of both active and CIA sites.
- Of the remaining sites, Clean Closed, Absorbed, Inactive and Planned sites were not included.
- Each remaining site was scored on a weighted scale in consideration of the category type of solid waste operation (see table in appendix).
- Site locations were mapped or geocoded (in ArcMap).

All sites were assigned a 250-meter buffer and ZIP codes were scored based on the sum of weighted sites contained in their boundaries or buffers that they intersected (in ArcMap).
Solid waste facilities that scored higher than seven under the weighting matrix that did not fall within the boundaries of census ZIP codes (or within the 250 meter buffer) were assigned to the ZIP code matching the facility's postal ZIP code provided in the database.
Summed scores were assigned percentiles.

Indicator Map



References

CalRecycle. "Fire at Solid Waste Facilities". Last updated September 3, 2010. http://www.calrecycle.ca.gov/SWFacilities/Fires/. Accessed April 26, 2012.

CalRecycle. "Former Landfill and Disposal Site Investigations". Last updated October 6, 2010. http://www.calrecycle.ca.gov/Publications/Documents/Facilities%5C2010008.pdf. Accessed March 12, 2013.

Ofungwu J, Eget S (2006). Brownfields and health risks--air dispersion modeling and health risk assessment at landfill redevelopment sites. *Integr Environ Assess Manag* **2**(3):253-61.

Palmer SR, Dunstan FD, Fielder H, Fone DL, Higgs G, Senior ML (2005). Risk of congenital anomalies after the opening of landfill sites. *Environ Health Perspect* **113**(10):1362-5.

Roelofs D, de Boer M, Agamennone V, Bouchier P, Legler J, van Straalen N (2012). Functional environmental genomics of a municipal landfill soil. *Front Genet* **3**:85.

US EPA (2011). "General Information on the Link Between Solid Waste Management and Greenhouse Gas Emissions". Last updated April 14, 2011. http://www.epa.gov/climatechange/wycd/waste/generalinfo.html.

Accessed April 26, 2012.

US Fire Administration (2002). "Landfill Fires: Their Magnitude, Characteristics, and Mitigation". Prepared by TriDataCorporation: Arlington, Virginia; 2002. http://www.usfa.fema.gov/downloads/pdf/publications/fa-225.pdf. Accessed April 26, 2012.

Vassiliadou I, Papadopoulos A, Costopoulou D, Vasiliadou S, Christoforou S, Leondiadis L (2009). Dioxin contamination after an accidental fire in the municipal landfill of Tagarades, Thessaloniki, Greece. *Chemosphere* **74**(7):879-84.

Appendix

Weighting Matrix for Solid Waste Sites and Facilities

Solid Waste Sites and Facilities from the Solid Waste Information System were weighted on a scale of 1 to a maximum of 13 in consideration of both the site type and violation history. The following table shows the weights applied to the facilities and sites. The score for any given Solid Waste Site or Facility represents the sum of its 'Site or Facility Type' and 'Violations'. For all ZIP codes, the weighted scores of all facilities in the area were summed.

Category	Criteria	Site or Facility Type	Violations (any in previous 12 months) [1]
Closed, Illegal, or Abandoned Site [1]	Priority Code [2]	**6** (Priority Code A) **4** (Priority Code B) **2** (Priority Code C) **1** (Priority Code D)	NA
Solid Waste Landfill or Construction, Demolition and Inert (CDI) Debris Waste Disposal (active) [3]	Tonnage	**8** (> 10,000 tpd) **7** (> 3,000 to < 10,000 tpd) **6** (> 1,000 to < 3,000 tpd) **5** (> 100 to < 1,000 tpd) **4** (< 100 tpd)	**3** (gas) **1** (each for litter, dust, noise, vectors, and site security)
Solid Waste Disposal Site (closed, closing, inactive) [4]	Tonnage	**1** (All)	**3** (gas) **1** (each for litter, vector, site security)
Inert Debris: Engineered Fill	Regulatory Tier [5]	**2** (Notification)	**1** (each for dust, noise, vectors, site security)
Inert Debris: Type A Disposal	Regulatory Tier [5]	**3** (Permitted)	**1** (each for dust, noise, vectors, site security)
Composting	Regulatory Tier [5]	**4** (Permitted) **3** (Permitted: Chipping & Grinding, 200 to ≤500 tpd) **2** (Notification)	**1** (each for vector, odor, litter, hazard, nuisance, noise, dust, site security) **1** (fire)
Transfer/Processing	Regulatory Tier [5]	**5** (Permitted: large vol.) **3** (Permitted: medium vol.; direct transfer) **2** (Notification)	**1** (each for dust, litter, vector/bird/animal, fire, site security)
Waste Tire	Regulatory Tier [5]	**4** (Major) **2** (Minor)	**2** (each for storage, fire) **1** (each for vectors, site security)

[1] Violations: Recurring requirements ensures only facilities that exhibit a pattern and practice of non-compliance receive a higher impact score and reduces point-in-time fluctuations. Explosive gas violations have a greater potential environmental impact than dust, noise, and vectors (from SWIS and the Waste Tire Management System).

[2] CIA Sites weighted per established CIA Site Priority Code scoring methodology (A through D; additional information available at http://www.calrecycle.ca.gov/SWFacilities/CIA/forms/prioritize.htm).

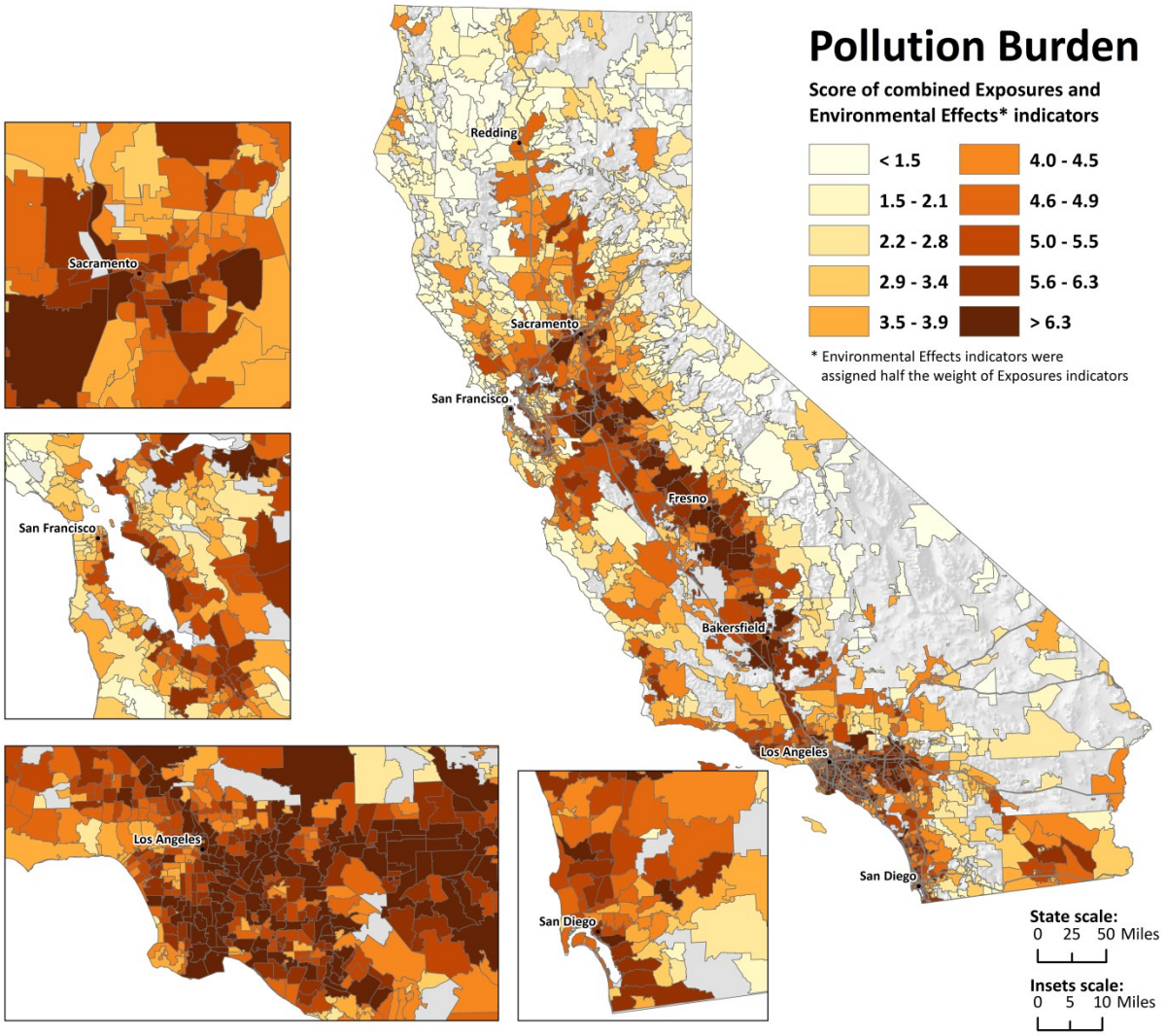
[3] Active landfills (other than Contaminated Soil Disposal Sites and Nonhazardous Ash Disposal/Monofill Facilities) are all in the Full Permit tier, so permitted tonnage (from SWIS) is used to scale impact score.

[4] Solid Waste Disposal Site (closed) means the site was closed pursuant to state closure standards that became operative in 1989. Closed sites associated with the CIA Site database were closed prior to 1989 in accordance with standards applicable at the time of closure.

[5] Regulatory Tier used to weight the site or facility. Placement within a regulatory tier accounts for the type of waste and amount of waste processed per day or onsite at any one time. See SWIS for compost and transfer/processing; Waste Tire Management System (WTMS) for waste tire sites.

SCORES FOR POLLUTION BURDEN (RANGE OF POSSIBLE SCORES: 0.1 TO 10)

Pollution Burden scores for each ZIP code are derived from the average percentiles of the six Exposures indicators (ozone and PM2.5 concentrations, diesel PM emissions, pesticide use, toxic releases from facilities, and traffic density) and the five Environmental Effects indicators (cleanup sites, impaired water bodies, groundwater threats, hazardous waste facilities and generators, and solid waste sites and facilities). Indicators from the Environmental Effects component were given half the weight of the indicators from the Exposures component. The calculated average percentile (up to 100th percentile) was divided by 10 and rounded to one decimal place for a Pollution Burden score ranging from 0.1 -10.



AGE: CHILDREN AND ELDERLY

Sensitive Populations Indicator

Children can be especially sensitive to the adverse effects of pollutants for many reasons. Children are often more susceptible to the health effects of air pollution because their immune systems and organs are still immature. Irritation or inflammation caused by air pollution is more likely to obstruct their narrow airways. Children, especially toddlers and young children, may have higher background exposures to multiple contaminants from contact with the ground, from breathing through their mouths, and from spending a significant amount of time outdoors. Further, exposure to toxic contaminants in air or other sources during infancy or childhood could affect the development of the respiratory, nervous, endocrine and immune systems, and could increase the risk of cancer later in life.

Elderly populations can also be more vulnerable to adverse health effects from exposures to pollutants than younger adults. This population is more likely to have health conditions that may worsen responses, such as weakened immune system and existing cardiovascular and respiratory disease. A history of exposure to pollutants, or interactions with medications, may influence responses.

Indicator

Percent of population under age 10 and over age 65.

Data Source

U.S. Census Bureau

As part of the 2010 decennial census, the U.S. Census Bureau questionnaire asked all census respondents for the age and date of birth of all members of the household. Datasets describing the number of individuals in different age categories are available for California at different geographic scales. The data are made available using the American FactFinder website.

http://factfinder2.census.gov/

Rationale

Sensitivity of Children

Biological differences account for children's enhanced susceptibility to environmental pollutants. Children have smaller airways, a higher oxygen demand, and lower body weight than adults. Studies have demonstrated that children under the age of two have the highest exposure to lead in soil and household dust because of hand-to-mouth behavior. Even low levels of lead in a child's blood can result in intellectual delays, attention deficit-hyperactivity disorder and behavior problems. Childhood lead poisoning is associated with poverty, recent immigrant status and lack of private health insurance (Bellinger 2004; Howarth 2012; Wright *et al.* 2008, Canfield *et al.* 2003).

Children may spend 70% of their time outdoors, where they are exposed to contaminants in outdoor air. Air pollution can contribute to asthma, aggravated by children's high breathing rates and increased particle deposition in their small airways. Because children have low

body weights and high oxygen demands, they can also ingest higher amounts of chemicals than adults in relation to their size (OEHHA, 2001).

Children have proportionately greater skin surface area than adults, allowing body heat to be lost more readily and requiring a higher rate of metabolism to maintain body temperature and fuel growth and development. The resulting higher oxygen and food requirements can lead to higher exposures to environmental contaminants in air and food (Cohen Hubal *et al.*, 2000). In addition, the skin of children, especially newborns, is softer than the skin of adults and therefore can be more readily penetrated by chemicals. Infants may have higher exposures to fat-soluble chemicals once the layer of fat underlying the skin develops at approximately 2-3 months of age, continuing through the toddler period (OEHHA, 2001). The percentage of body fat generally decreases with age (Cohen Hubal *et al.*, 2000). Once environmental chemicals have been absorbed, the infant's immature renal system is unable to eliminate them as effectively as older children and adults (Sly and Flack, 2008).

Sensitivity of the Elderly

The mechanisms of absorption, distribution, metabolism, and excretion change with age. There is a reduction in lean body mass, certain blood proteins, and total body water as we get older. In comparison to younger adult populations, there is more variation in elderly individuals' capacity to metabolize substances. Reduced metabolic rates result in decreases in blood flow, prolonging the process of chemical elimination. In addition, renal function can be reduced by 50% in the elderly (Pedersen, 1997). Heart disease, which is found in the majority of elderly populations, increases susceptibility to the effects of exposure to particulate matter and can decrease heart rate and oxygen saturation (Adler, 2003).

Researchers in Korea in the 1990s noted that an increase in air pollution resulted in an increased risk for stroke in adults over the age of 65 (Hong *et al.*, 2002). Increased prevalence of stroke has also been associated with higher concentrations of carbon monoxide, sulfur dioxide, ozone, and nitrogen oxide (Adler, 2003). A study involving senior citizens in Denver found an increased hospitalization rate for heart attacks, atherosclerosis, and pulmonary heart disease on days with high air pollution levels. Sulfur dioxide and carbon monoxide exposure have also been linked to longer hospital stays for cardiac dysrhythmias and congestive heart failure, respectively (Koken *et al.*, 2003).

Contaminants in drinking water, such as arsenic, may also pose a threat to the elderly. Arsenic accumulates in cardiovascular tissue and can trigger inflammation of the arteries, increasing the risk of atherosclerosis and vascular disease (Adler, 2003).

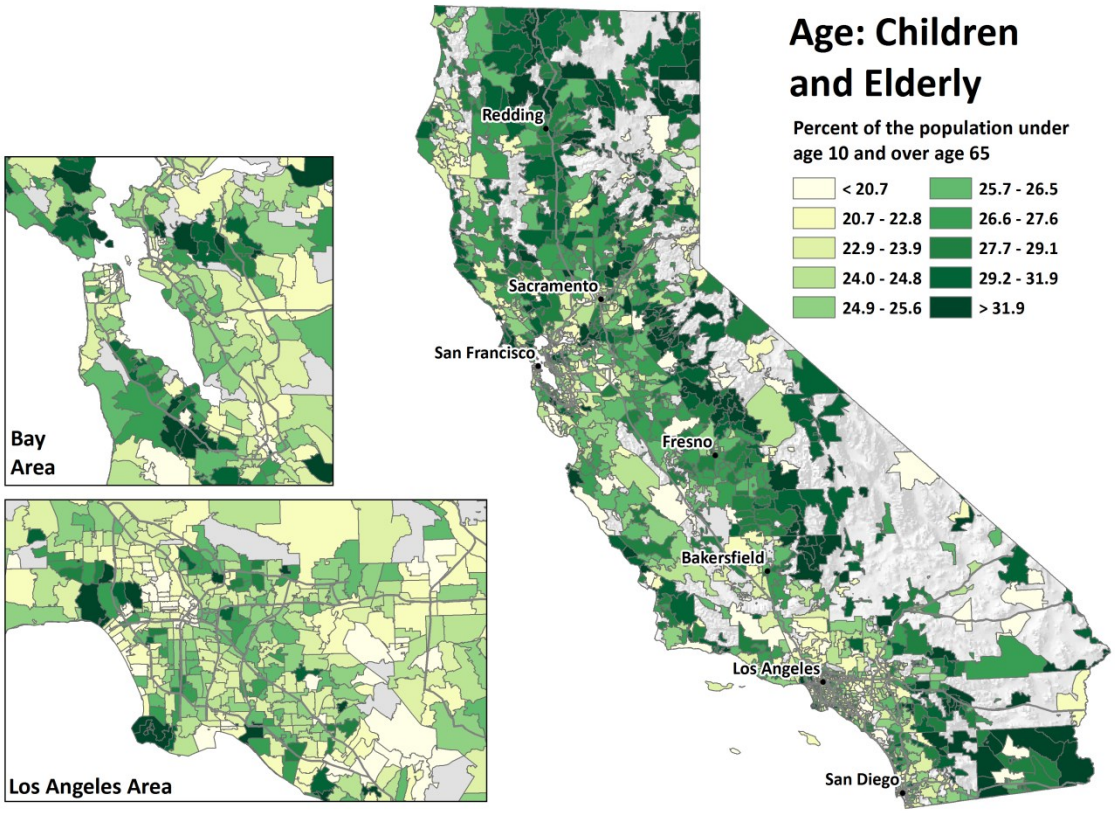
Method

- A dataset containing the number of people in different age groups by census ZIP codes was downloaded for the State.
- The percentage of children and elderly in each ZIP code was

calculated as the total number of individuals less than 10 years of age and greater than 65 years of age in the ZIP code divided by the ZIP code's total population.

- ZIP codes were ordered by this percentage. A percentile score for each ZIP code was determined by its place in the distribution of all ZIP codes.

Indicator Map



References

Adler, T (2003). Aging Research: The Future Face of Environmental Health. *Environmental Health Perspectives, 111,* 14.

Bellinger DC (2004). Lead. *Pediatrics* **113**(4 Suppl):1016-22.

Canfield RL, Henderson CR, Jr., Cory-Slechta DA, Cox C, Jusko TA, Lanphear BP (2003). Intellectual impairment in children with blood lead concentrations below 10 microg per deciliter. *N Engl J Med* **348**(16):1517-26.

Cohen Hubal EA, Sheldon LS, Burke JM, McCurdy, TR, Berry, MR, Rigas, ML, Zartarian, VG, *et al.* (2000). Children's exposure assessment: a review of factors influencing Children's exposure, and the data available to characterize and assess that exposure. *Environmental Health*

Perspectives, **108**(6):475-86.

Hong Y-C, Lee JT, Kim H, and Kwon H-J (2002). Air Pollution: A New Risk Factor in Ischemic Stroke Mortality. *Stroke* **33**(9):2165.

Howarth D (2012). Lead exposure–implications for general practice. *Aust Fam Physician* **41**(5):311-5.

Koken P JM, Piver WT, Ye F, Elixhauser A, Olsen LM, and Portier CJ (2003). Temperature, Air Pollution, and Hospitalization for Cardiovascular Diseases among Elderly People in Denver. *Environmental Health Perspectives* **111**(10):1312-1317.

Office of Environmental Health Hazard Assessment (OEHHHA). (2001, October). Prioritization of toxic air contaminants under the Children's Environmental Health Protection Act. Available from URL: http://oehha.ca.gov/air/toxic_contaminants/pdf_zip/SB25%20TAC%20prioritization.pdf

Pedersen T (1997). The Unique Sensitivity of the Elderly. UCD ExtoxNet FAQ. Available from URL: http://extoxnet.orst.edu/faqs/senspop/elder.htm

Sly PD and Flack F (2008). Susceptibility of Children to Environmental Pollutants. *Annals of the New York Academy of Sciences* **1140**(1):163-183.

Wright JP, Dietrich KN, Ris MD, Hornung RW, Wessel SD, Lanphear BP, *et al.* (2008). Association of prenatal and childhood blood lead concentrations with criminal arrests in early adulthood. *PLoS Med* **5**(5):e101.

ASTHMA

Sensitive Populations Indicator

Asthma is a chronic lung disease characterized by episodic breathlessness, wheezing, coughing, and chest tightness. While the causes of asthma are poorly understood, it is well established that exposure to traffic and outdoor air pollutants, including particulate matter, ozone, and diesel exhaust, can trigger asthma attacks. Nearly three million Californians currently have asthma and about five million have had it at some point in their lives. Children, the elderly and low-income Californians suffer disproportionately from asthma (California Health Interview Survey, 2009). Although well-controlled asthma can be managed as a chronic disease, asthma can be a life-threatening condition, and emergency department visits for asthma are a very serious outcome, both for patients and for the medical system.

Indicator

Spatially modeled, age-adjusted rate of emergency department (ED) visits for asthma per 10,000 (averaged over 2007-2009).

Data Source

California Office of Statewide Health Planning and Development (OSHPD)
California Environmental Health Tracking Program (CEHTP)
Environmental Health Investigations Branch,
California Department of Public Health

Since 2005, hospitals licensed by the state of California to provide emergency medical services are required to report all emergency department (ED) visits to OSHPD. Federally-owned facilities, including Veterans Administration and Public Health Services hospitals are not required to report. The ED dataset includes information on the principal diagnosis, which can be used to identify which patients visited the ED because of asthma.

ED utilization does not capture the full burden of asthma in a community because not everyone with asthma requires emergency care, especially if they receive preventive care, avoid asthma triggers and undertake disease maintenance. However, there is limited state-wide monitoring of other indicators, such as planned and unplanned doctor's visits, that might provide a better indication of overall disease burden. Some ED visits result in hospitalization, and OSPHD collects data on hospitalization due to asthma in addition to emergency department visits. ED visits are thought to provide a better comparative measure of asthma burden than hospitalizations and deaths because the data capture a larger portion of the overall burden and include less severe occurrences.

CEHTP used OSHPD's data to calculate age-adjusted rates of asthma ED visits for California ZIP codes. These estimates make use of ZIP-code level population estimates from a private vendor (Esri) and the U.S. 2000 Standard Population to derive age-adjusted rates. Age-adjustment takes the age distribution of a population into account and allows for meaningful comparisons between ZIP codes with different age

structures.

http://www.oshpd.ca.gov/HID/Products/EmerDeptData/
http://www.cehtp.org/p/asthma

Rationale

Asthma increases an individual's sensitivity to pollutants. Air pollutants, including particulate matter, ozone, nitrogen dioxide, and diesel exhaust, can trigger symptoms among asthmatics (Meng *et al.*, 2011). Children living near major roadways and traffic corridors in California have been shown to suffer disproportionate rates of asthma (Kim *et al.*, 2004). Particulate matter from diesel engines has been implicated as a cause of new-onset asthma (Pandya *et al*, 2002). Exposure to certain pesticides can also trigger wheezing, coughing, and chest tightness (Hernández *et al.*, 2011).

Asthma can increase susceptibility to respiratory diseases such as pneumonia and influenza (Kloepfer *et al.*, 2012). For example, one study found that when ambient particulate pollution levels are high, persons with asthma have twice the risk of being hospitalized for pneumonia compared to persons without asthma (Zanobetti *et al.*, 2000).

Asthma rates are a good indicator of population sensitivity to environmental stressors because asthma is both caused by and worsened by pollutants (CDPH, 2010). The severity of symptoms and the likelihood of needing hospital care decrease with access to regular medical care and asthma medication (Delfino *et al.*, 1998; Grineski *et al.*, 2010). Asthma-related emergency department visits provide a conservative estimate of total asthma cases because not all cases require emergency care. However, using those cases requiring emergency care as an indicator also captures some aspects of access to care and can be seen as a marker of both environmental and social stressors. Potential biases in using emergency department visits as an indicator of sensitivity include the possibility that lower socioeconomic status or more isolated rural populations may not have access to nearby health care facilities. Conversely, populations without health insurance may turn to emergency departments for care.

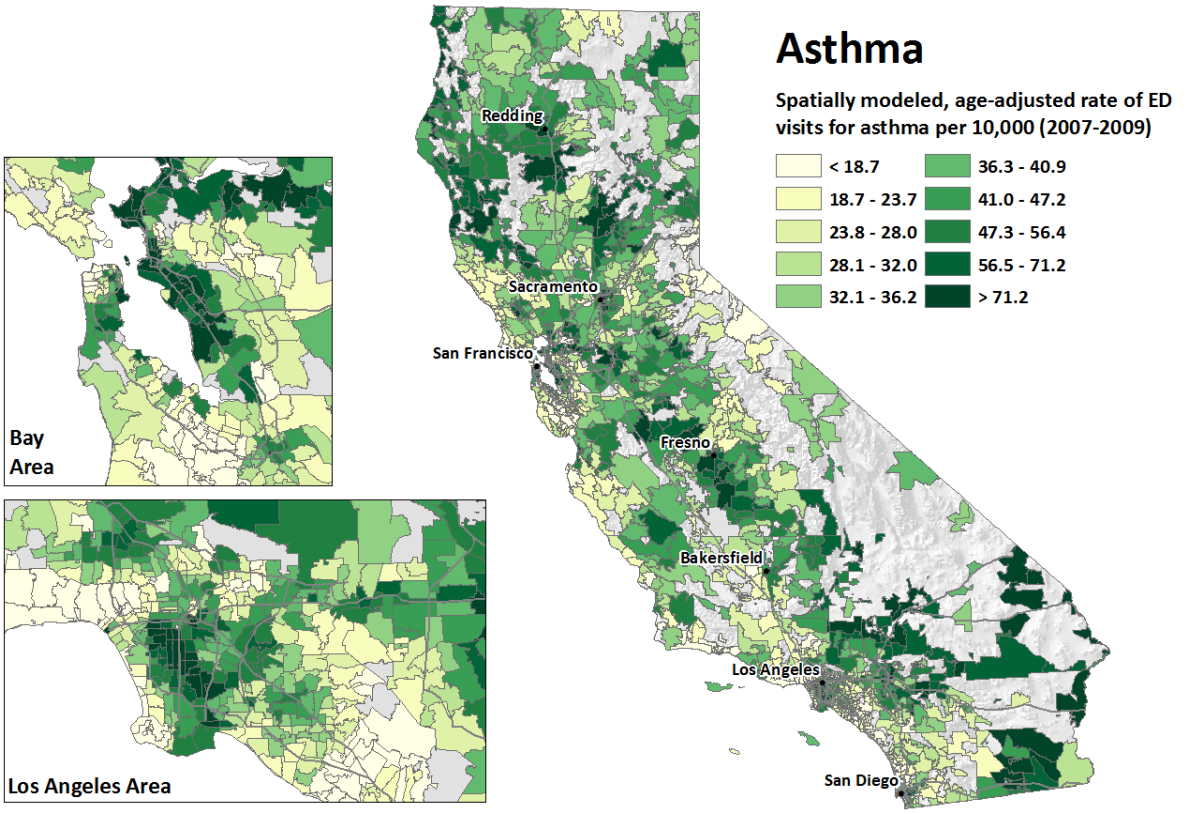
Method

- An age-adjusted rate of asthma emergency department (ED) visits was calculated for each ZIP code by CEHTP using data obtained from OSHPD.
- CEHTP obtained records for ED visits occurring during 2007-2009 from OSHPD's Emergency Department and Ambulatory Surgery files if the patient was listed as residing in California and principle diagnostic ICD-9-CM code began with the digits 493 (asthma).
- Population data used for the age-adjustment were obtained from Esri and rates reported are standardized to the 2000 U.S. population using five-year age groupings (0-4, 5-9, etc.). The rates are per 10,000 residents per year.
- The age-adjusted rates of asthma ED visits per 10,000 residents by ZIP code were then spatially modeled to provide estimates for ZIP codes with fewer than 12 ED visits and to incorporate information

about local and statewide averages into the calculations.

- A Bayesian modeling technique was used to calculate the spatially modeled rates (Mollié, 1996).
- ZIP codes without a spatially modeled rate are census ZIP codes that did not correspond to Esri ZIP codes used in the age-adjustment.
- ZIP codes were ordered by the spatially modeled rate and were assigned percentiles based on the distribution across all ZIP codes.

Indicator Map



References

California Health Interview Survey, (2009). Accessed November 2012 at http://www.chis.ucla.edu/main/default.asp

CDPH. "Asthma and the Environment." http://www.ehib.org/page.jsp?page_key=27. Last edited 9/29/2010, accessed 2/15/2013.

Delfino RJ, Zeiger RS, Seltzer JM, Street DH (1998). Symptoms in pediatric asthmatics and air pollution: differences in effects by symptom severity, anti-inflammatory medication use and particulate averaging time. *Environ Health Perspect* **106**(11):751-61.

Grineski SE, Staniswalis JG, Peng Y, Atkinson-Palombo C (2010). Children's asthma hospitalizations and relative risk due to nitrogen dioxide (NO_2): Effect modification by race, ethnicity, and insurance

status. *Environmental Research* **110**(2):178-88.

Hernández AF, Parrón T, Alarcón R (2011). Pesticides and asthma. *Current Opinion in Allergy and Clinical Immunology* **11**(2):90.

Kim JJ, Smorodinsky S, Lipsett M, Singer BC, Hodgson AT, Ostro B (2004). Traffic-related Air Pollution near Busy Roads The East Bay Children's Respiratory Health Study. *American Journal of Respiratory and Critical Care Medicine* **170**(5):520-6.

Kloepfer KM, Olenec JP, Lee WM, Liu G, Vrtis RF, Roberg KA*, et al.* (2012). Increased H1N1 infection rate in children with asthma. *Am J Respir Crit Care Med* **185**(12):1275-9.

Mollié A (1996). Bayesian mapping of disease. In: *Markov Chain Monte Carlo in Practice*. Gilks WR, Richardson S, Spiegelhalter DJ, eds. Chapman & Hall: London, pp. 359–379.

Meng Y, Wilhelm M, Ritz B, Balmes J, Lombardi C, Bueno A*, et al.* (2011). Is disparity in asthma among Californians due to higher pollution exposures, greater vulnerability, or both? In CAR Board (Ed.). Sacramento: CARB.

Pandya RJ, Solomon G, Kinner A, Balmes JR (2002). Diesel exhaust and asthma: hypotheses and molecular mechanisms of action. *Environ Health Perspect* **110**(Suppl 1):103.

Zanobetti A, Schwartz J, Gold D (2000). Are there sensitive subgroups for the effects of airborne particles? *Environ Health Perspect* **108**(9):841-5.

LOW BIRTH WEIGHT INFANTS

Sensitive Populations Indicator

Infants born weighing less than 2,500 grams (about 5.5 pounds) are classified as low birth weight (LBW), a condition that is associated with increased risk of later health problems as well as infant mortality. Most LBW infants are small because they were born early. Infants born at full term (after 37 complete weeks of pregnancy) can also be LBW if their growth was impaired during pregnancy. Nutritional status, lack of prenatal care, stress, and maternal smoking are known risk factors for LBW. Studies also suggest links with environmental exposures to lead, air pollution, toxic air contaminants, traffic pollution, pesticides, and polychlorinated biphenyls (PCBs). These children are at risk for numerous chronic health conditions and may be more sensitive to environmental exposures after birth.

Indicator

Percent low birth weight (averaged over 2007-2011).

Data Source

California Department of Public Health (CDPH)

The Health Information and Research Section of CDPH is responsible for the stewardship and distribution of birth records in the state. Medical data related to a birth, as well as demographic information related to the infant, mother, and father is collected from birth certificates. The residential ZIP code reported by the mother is also included. Birth profiles for California ZIP codes and counties can be accessed by the general public from the CDPH website. Personal identifiers are not released publicly to protect confidentiality.

http://www.cdph.ca.gov/data/statistics/Pages/BirthProfilesbyZIPCode.aspx
http://www.cdph.ca.gov/data/statistics/Pages/CountyBirthStatisticalDataTables.aspx

Rationale

LBW is considered a key marker of overall population health. Being born low weight puts individuals at higher risk of health conditions that can subsequently make them more sensitive to environmental exposures. For example, children born low weight are at increased risk of developing asthma (Nepomnyaschy and Reichman, 2006). Asthma symptoms, in turn, are worsened by exposure to air pollution. LBW can also put one at increased risk of coronary heart disease and type 2 diabetes (Barker *et al.*, 2002). These conditions can predispose one to mortality associated with particulate air pollution or excessive heat (Bateson and Schwartz, 2004; Basu and Samet, 2002). There is also evidence that children born early have lowered cognitive development and more behavioral problems compared to children born at term (Butta *et al.*, 2002), putting them at disadvantage for subsequent opportunities for good health.

Risk of LBW is increased by certain environmental exposures and social factors and can therefore be considered a marker of the combined

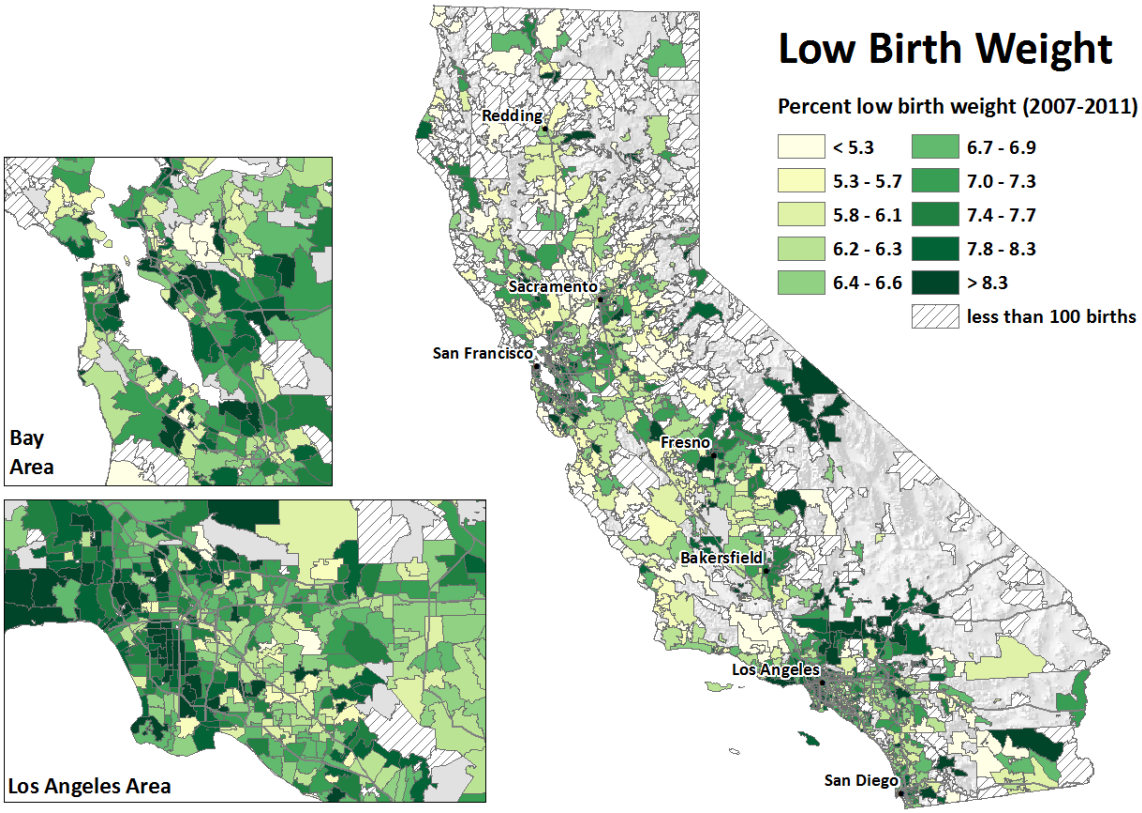
impact of environmental and social stressors. For example, exposures to traffic and to toxic air contaminants such as benzene, xylene, and toluene have been linked to LBW in California (Ghosh *et al.*, 2012). Low weight births are more common among African-American women than they are among Hispanic and non-Hispanic white women, even among those with comparable socioeconomic status, prenatal care, and behavioral risk factors (Lu and Halfon, 2003).

Living in close proximity to freeways has been associated with an increased risk for low birth weight term infants (Laurent *et al.*, 2013). Latina women exposed to pesticides in California in low-income farmworker communities were found to be at risk for low birth weight infants that were small for gestational age, with smaller than average head circumference, an indicator of brain development. (Harley *et al.*, 2011).

Method

- The average low birth weight (LBW) rate was defined as the percent of live births (including multiple births) weighing less than 2,500 grams occurring in one year.
- Estimates derived from places with few births are considered unreliable because they vary greatly from year to year. For this reason, ZIP codes with less than 100 live births during the time period considered were excluded. The average was estimated using five years of data (2007-2011) in order to minimize the number of ZIP codes that had to be excluded. It was assumed that the ZIP code geographic boundaries did not change during these five years.
- Reported ZIP codes were assigned the rate of their corresponding census ZIP code, assuming perfect geographic overlap. Reported ZIP codes that did not correspond to a census ZIP code were excluded from the analysis.
- ZIP codes that had less than 100 live births over the five years or did not correspond to a census ZIP code were excluded from the calculation of percentiles for all other ZIP codes.

Indicator Map



References

Barker DJ, Eriksson JG, Forsen T, Osmond C (2002). Fetal origins of adult disease: strength of effects and biological basis. *Int J Epidemiol* **31**(6):1235-9.

Basu R, Samet JM (2002). Relation between elevated ambient temperature and mortality: a review of the epidemiologic evidence. *Epidemiol Rev* **24**(2):190-202.

Bateson TF, Schwartz J (2004). Who is sensitive to the effects of particulate air pollution on mortality? A case-crossover analysis of effect modifiers. *Epidemiology* **15**(2):143-9.

Bhutta AT, Cleves MA, Casey PH, Cradock MM, Anand KJ (2002). Cognitive and behavioral outcomes of school-aged children who were born preterm: a meta-analysis. *JAMA* **288**(6):728-37.

Ghosh JKC, Wilhelm M, Su J, Goldberg D, Cockburn M, Jerrett M, *et al.* (2012). Assessing the Influence of Traffic-related Air Pollution on Risk of Term Low Birth Weight on the Basis of Land-Use-based Regression Models and Measures of Air Toxics. *American Journal of Epidemiology* **175**(12):1262-74.

Harley KG, Huen K, Schall RA, Holland NT, Bradman A, Barr DB, *et al.* (2011). Association of organophosphate pesticide exposure and

paraoxonase with birth outcome in Mexican-American women. *PloS one* **6**(8):e23923.

Laurent O, Wu J, Li L, Chung J, Bartell S (2013). Investigating the association between birth weight and complementary air pollution metrics: a cohort study. *Environ Health* **12**(1):18.

Lu MC, Halfon N (2003). Racial and ethnic disparities in birth outcomes: a life-course perspective. *Matern Child Health J* **7**(1):13-30.

Nepomnyaschy L, Reichman NE (2006). Low birthweight and asthma among young urban children. *Am J Public Health* **96**(9):1604-10.

EDUCATIONAL ATTAINMENT

Socioeconomic Factors Indicator

Educational attainment is an important element of socioeconomic status and a social determinant of health. Numerous studies suggest education can have a protective effect from exposure to environmental pollutants that damage health. Information on educational attainment is collected annually in the U.S. Census Bureau's American Community Survey (ACS). In contrast to the decennial census, the ACS surveys a small sample of the U.S. population to estimate more detailed economic and social information for the country's population.

Indicator

Percent of the population over age 25 with less than a high school education (5-year estimate, 2007-2011).

Data Source

American Community Survey
U.S. Census Bureau

The American Community Survey (ACS) is an ongoing survey of the U.S. population conducted by the U.S. Census Bureau and has replaced the long form of the decennial census. Unlike the decennial census, which attempts to survey the entire population and collects a limited amount of information, the ACS releases results annually based on a sub-sample of the population and includes more detailed information on socioeconomic factors such as educational attainment. Multiple years of data are pooled together to provide more reliable estimates for geographic areas with small population sizes. The most recent results available at the census ZIP code are the 5-year estimates for 2007-2011. The data are made available using the American FactFinder website.

http://www.census.gov/acs/www/
http://factfinder2.census.gov/

Rationale

Educational attainment is an important independent predictor of health (Cutler and Lleras-Muney, 2006). As a component of socioeconomic status, education is often inversely related to the degree of exposure to indoor and outdoor pollution. Several studies have associated educational attainment with susceptibility to the health impacts of environmental pollutants. For example, individuals without a high school education appear to be at higher risk of mortality associated with particulate air pollution than those with a high school education (Krewski *et al.*, 2000). There is also evidence that the effects of air and traffic-related pollution on respiratory illness, including childhood asthma, are more severe in communities with lower levels of education (Cakmak *et al.*, 2006; Shankardass *et al.*, 2009; Neidell, 2004).

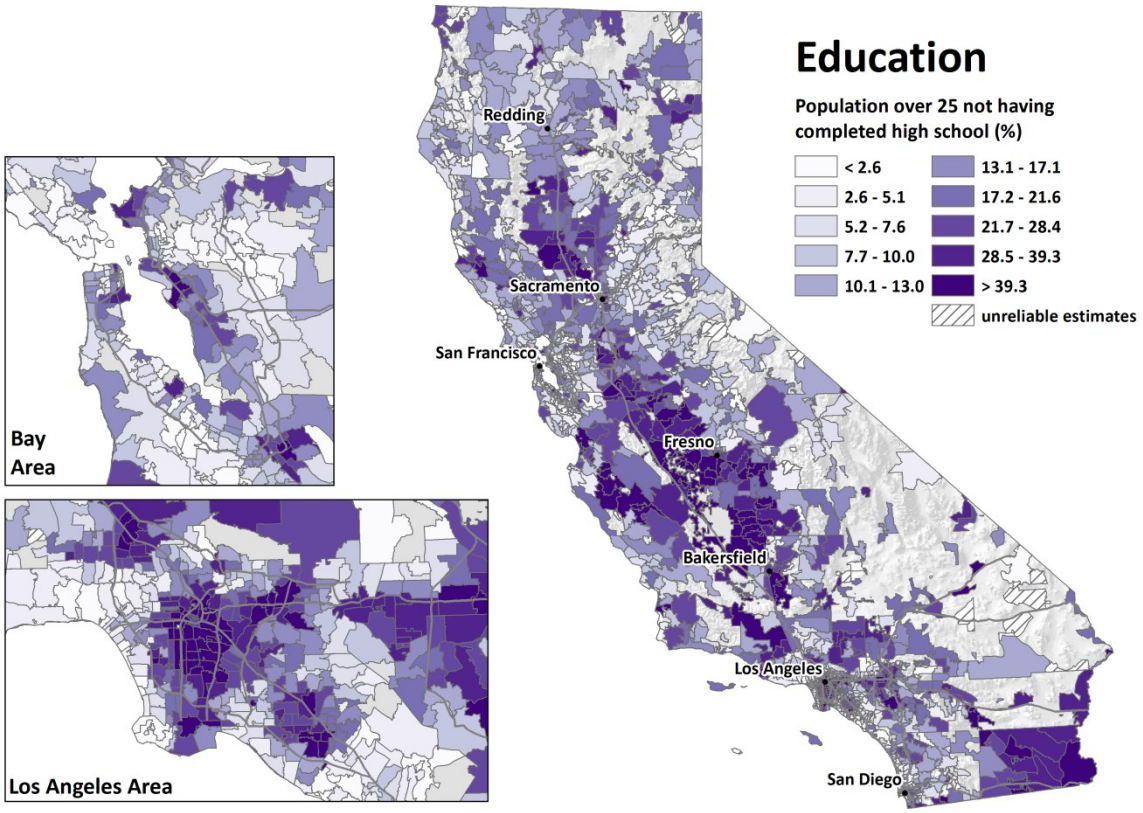
The ways in which lower educational attainment can decrease health status are not completely understood, but may include economic hardship, stress, fewer occupational opportunities, lack of social support, and reduced access to health-protective resources such as medical care, prevention and wellness initiatives, and nutritious food. In a study of pregnant women in Amsterdam, smoking and exposure to environmental

tobacco smoke were more common among women with less education. These women also were at significantly increased risk of preterm birth, low birth weight and small for gestational age infants (van den Berg *et al.*, 2012). A review of studies tying social stressors with the effects of chemical exposures on health found that level of education was related to mortality and incidence of asthma and respiratory diseases from exposure to particulate air pollution and sulfur dioxide (Lewis *et al.*, 2011).

Method

- From the 2007-2011 American Community Survey estimates, a dataset containing the percentage of the population over age 25 with a high school education or higher was downloaded by census ZIP codes for the state of California.
- This percentage was subtracted from 100 to obtain the proportion of the population with less than a high school education by census ZIP code.
- Due to small sampling size or small population size within a ZIP code, not all estimates of the educational attainment are reliable. The margin of error (MOE) reported in the ACS was used to evaluate the reliability estimates. The MOE is the difference between an estimate and its upper or lower confidence bound. All ACS-published margins of error are based on a 90 percent confidence level.
- All ZIP codes in which the ratio of the MOE to the estimate was less than 66.6 percent (two-thirds) were retained. Of the remaining estimates, the MOE was larger than 20.6, which corresponds to the 33.3 percentile (tertile) of all-percent high school education estimates. These estimates were also removed.
- ZIP codes meeting this criteria were ordered by percent of population over age 25 with less than a high school education and percentiles were assigned to each based on the distribution across all ZIP codes.

Indicator Map



References

Cakmak S, Dales RE, Judek S (2006). Respiratory health effects of air pollution gases: modification by education and income. *Archives of Environmental & Occupational Health* **61**(1):5-10.

Cutler DM, Lleras-Muney A (2006). Education and Health: Evaluating Theories and Evidence. *National Bureau of Economic Research Working Paper Series* **No. 12352**.

Krewski D, Burnett RT, Goldberg MS, Hoover K, Siemiatycki J, Jerrett M, *et al*. (2000). Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of particulate air pollution and mortality. *Cambridge, MA: Health Effects Institute*.

Lewis AS, Sax SN, Wason SC, Campleman SL (2011). Non-chemical stressors and cumulative risk assessment: an overview of current initiatives and potential air pollutant interactions. *Int J Environ Res Public Health* **8**(6):2020-73.

Neidell MJ (2004). Air pollution, health, and socio-economic status: the effect of outdoor air quality on childhood asthma. *Journal of Health Economics* **23**(6):1209-36.

Shankardass K, McConnell R, Jerrett M, Milam J, Richardson J, Berhane K (2009). Parental stress increases the effect of traffic-related air

pollution on childhood asthma incidence. *Proc Natl Acad Sci U S A* **106**(30):12406-11.

van den Berg G, van Eijsden M, Vrijkotte TG, Gemke RJ (2012). Educational inequalities in perinatal outcomes: the mediating effect of smoking and environmental tobacco exposure. *PLoS One* **7**(5):e37002.

LINGUISTIC ISOLATION

Socioeconomic Factors Indicator

According to the most recent U.S. Census Bureau's 2007-2011 American Community Survey (ACS), nearly 43% of Californians speak a language at home other than English, about 20% of the state's population speaks English "not well" or "not at all," and 10% of all households in California are linguistically isolated. The U.S. Census Bureau uses the term "linguistic isolation" to measure households where all members 14 years of age or above have at least some difficulty speaking English. A high degree of linguistic isolation among members of a community raises concerns about access to health information and public services, and effective engagement with regulatory processes. Information on language use is collected annually in the ACS. In contrast to the decennial census, the ACS surveys a small sample of the U.S. population to estimate more detailed economic and social information for the country's population.

Indicator

Percentage of households in which no one age 14 and over speaks English "very well" or speaks English only.

Data Source

American Community Survey
U.S. Census Bureau

The American Community Survey (ACS) is an ongoing survey of the U.S. population conducted by the U.S. Census Bureau and has replaced the long form of the decennial census. Unlike the decennial census, which attempts to survey the entire population and collects a limited amount of information, the ACS releases results annually based on a sub-sample of the population and includes more detailed information on socioeconomic factors such as linguistic isolation. Multiple years of data are pooled together to provide more reliable estimates for geographic areas with small population sizes. The most recent results available at the census ZIP code are the 5-year estimates for 2007-2011. The data are made available using the American FactFinder website.

http://www.census.gov/acs/www/
http://factfinder2.census.gov/

Rationale

From 1990 to 2000 the number of households in the U.S. defined as "linguistically isolated" rose by almost 50% (Shin and Bruno, 2003). While the percentage of immigrant households in California that are linguistically isolated is comparable to the national percentage, according to the 2009 American Community Survey (Hill, 2011), California has a higher proportion of immigrants than any other state and the immigrant population has increased by 400% since 1970 (Johnson, 2011). The inability to speak English well can affect an individual's communication with service providers and his or her ability to perform daily activities. People with limited English are less likely to have regular medical care and are more likely to report difficulty getting medical information or advice than English speakers. Communication is essential for many steps in the process of obtaining health care, and limited English speakers may delay care because they

lack important information about symptoms and available services (Shi *et al*. 2009). Non-English speakers are also less likely to receive mental health services when needed, and because in California non-English speakers are concentrated in minority ethnic communities, limited English proficiency may contribute to further ethnic and racial disparities in health status and disability (Sentell *et al*. 2007). Linguistic isolation is also an indicator of a community's ability to participate in decision-making processes and the ability to navigate the political system.

Lack of proficiency in English often results in racial discrimination, and both language difficulties and discrimination are associated with stress, low socioeconomic status and reduced quality of life (Gee and Ponce, 2010). Linguistic isolation hampers the ability of the public health sector to reduce racial and ethnic disparities because non-English-speaking individuals participate in public health surveillance studies at very low rates, even when there is translation available (Link *et al*., 2006).

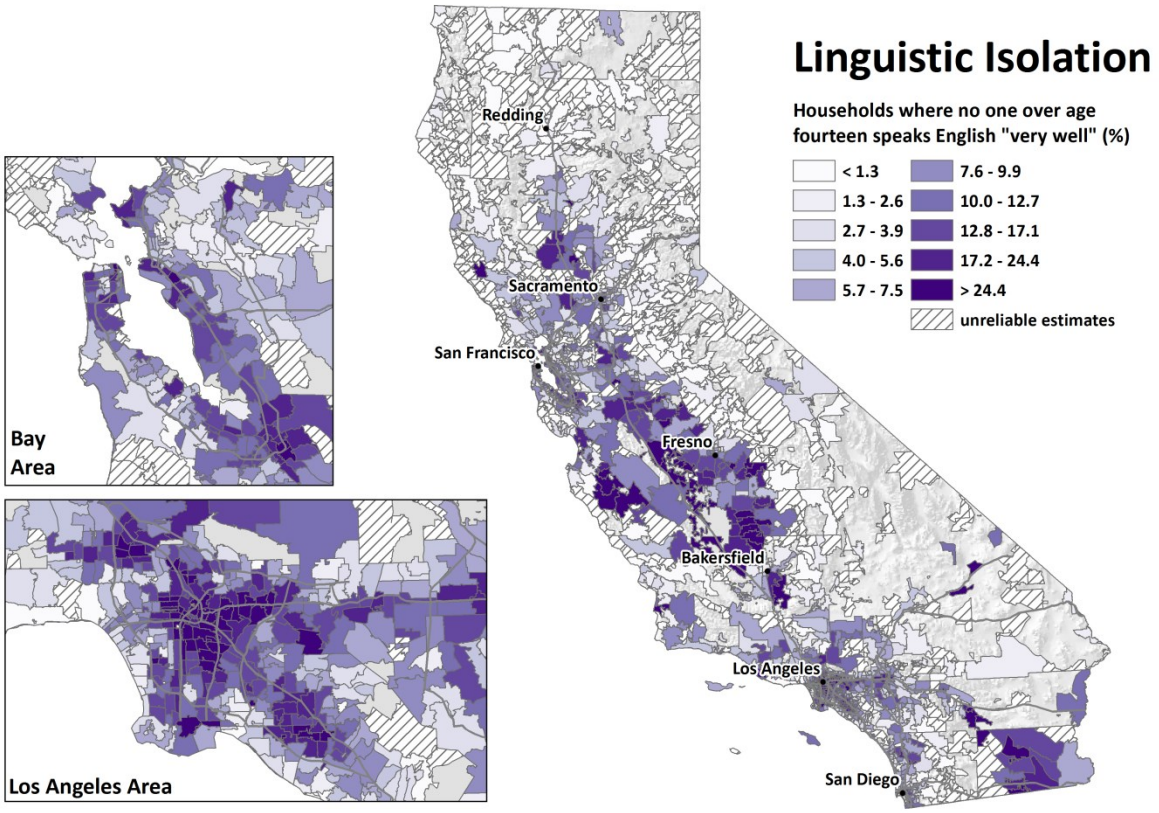
In the event of an emergency, such as an accidental chemical release or a spill, households that are linguistically isolated may not receive timely information on evacuation or shelter-in-place orders, and may therefore experience health risks that those who speak English can more easily avoid. Additionally, linguistic isolation was independently related to both proximity to a Toxic Release Inventory (TRI) facility and cancer risks by the National-Scale Air Toxics Assessment (NATA) in an analysis of the San Francisco Bay Area, suggesting that linguistically isolated communities may bear a greater share of health risks from air pollution hazards (Pastor *et al*,. 2010).

Method

- From the 2007-2011 American Community Survey, a dataset containing the average percent of household in which no one age 14 and over speaks English "very well" or speaks English only was downloaded by census ZIP codes for the state of California. This variable is referred to as "linguistic isolation" and measures households where no one speaks English well.
- Due to small sampling size or small population size within a ZIP code, not all estimates are reliable. The margin of error (MOE) reported in the ACS was used to evaluate the reliability of each estimate. The margin of error is the difference between an estimate and its upper or lower confidence bound. All ACS-published margins of error are based on a 90 percent confidence level. The following criteria were used:
  - All estimates where the ratio of the MOE to the estimate was less than 66.6 percent (two-thirds) were included.
  - The distribution of all the ZIP codes was considered. The 33.3 percentile (lower tertile) was 4.2% and the 66.6 percentile (upper tertile) was 11.2%.
  - For estimates below 4.2%, if the upper bound was greater or equal to 4.2%, then the estimate was retained.
  - For estimates between 4.3% and 11.2%, if the lower bound was greater than 4.3% and the upper bound was less than 11.2%,

then the estimate was retained.
  - For estimates greater than 11.3%, if the lower bound was greater than 4.3%, then the estimate was retained.
- ZIP codes meeting this criteria were ordered by the percent linguistically isolated and percentiles were assigned to each based on the distribution across all ZIP codes.

Indicator Map



References

Gee GC, Ponce N (2010). Associations between racial discrimination, limited English proficiency, and health-related quality of life among 6 Asian ethnic groups in California. *Am J Public Health* **100**(5):888-95.

Hill, Laura (2011). English Proficiency of Immigrants. Fact Sheet. Public Policy Institute of California, March 2011. 2 pp. Accessed 1/30/2013. http://www.ppic.org/content/pubs/jtf/JTF_EnglishProficiencyJTF.pdf

Johnson, Hans (2011). Immigrants in California. Fact Sheet. Public Policy Institute of California, April 2011. 2 pp. Accessed 1/30/2013. http://www.ppic.org/content/pubs/jtf/JTF_ImmigrantsJTF.pdf

Link MW, Mokdad AH, Stackhouse HF, Flowers NT (2006). Race, ethnicity, and linguistic isolation as determinants of participation in public health surveillance surveys. *Prev Chronic Dis* **3**(1):A09.

Pastor M, Morello-Frosch R, Sadd J (2010). *Air pollution and*

environmental justice: integrating indicators of cumulative impact and socio-economic vulnerability into regulatory decision-making: California Environmental Protection Agency, Air Resources Board, Research Division.

Sentell T, Shumway M, Snowden L (2007). Access to mental health treatment by English language proficiency and race/ethnicity. *J Gen Intern Med* **22 Suppl 2**:289-93.

Shi L, Lebrun LA, Tsai J (2009). The influence of English proficiency on access to care. *Ethn Health* **14**(6):625-42.

Shin HB, Bruno R (2003). Language Use and English-Speaking Ability: 2000. In US Dept of Commerce (Ed.) (pp. 1-11). Washington, DC: U.S. Census Bureau.

POVERTY

Socioeconomic Factors Indicator

Poverty is an important social determinant of health. Numerous studies have suggested that impoverished populations are more likely than wealthier populations to experience adverse health outcomes when exposed to environmental pollution. Information on poverty is collected annually in the U.S. Census Bureau's American Community Survey (ACS). In contrast to the decennial census, the ACS surveys a small sample of the U.S. population to estimate more detailed economic and social information for the country's population.

Indicator

Percent of the population living below two times the federal poverty level (5-year estimate, 2007-2011).

Data Source

American Community Survey
U.S. Census Bureau

The American Community Survey (ACS) is an ongoing survey of the U.S. population conducted by the U.S. Census Bureau and has replaced the long form of the decennial census. Unlike the decennial census, which attempts to survey the entire population and collects a limited amount of information, the ACS releases results annually based on a sub-sample of the population and includes more detailed information on socioeconomic factors such as poverty. Multiple years of data are pooled together to provide more reliable estimates for geographic areas with small population sizes. The most recent results available at the census ZIP code are the 5-year estimates for 2007-2011. The data are made available using the American FactFinder website.

The Census Bureau uses income thresholds that are dependent on family size to determine a person's poverty status during the previous year. For example, if a family of four with two children has a total income less than $21,938 during 2010, everyone in that family is considered to live below the federal poverty line. A threshold of twice the federal poverty level was used in this analysis because the federal poverty thresholds have not changed since the 1980s despite increases in the cost of living, and because California's cost of living is higher than many other parts of the country.

http://www.census.gov/acs/www/
http://factfinder2.census.gov/

Rationale

Wealth influences health because it helps determine one's living conditions, nutrition, occupation, and access to health care and other health-promoting resources. For example, studies have shown a stronger effect of air pollution on mortality (Forastiere *et al.*, 2007) and childhood asthma (Lin *et al.*, 2004, Meng *et al.*, 2011) among low income communities. A multi-city study in Canada found that the effect of nitrogen dioxide on respiratory hospitalizations was increased among lower income households compared to those with higher incomes (Cakmak *et al.*, 2006). Other studies have found that neighborhood-level

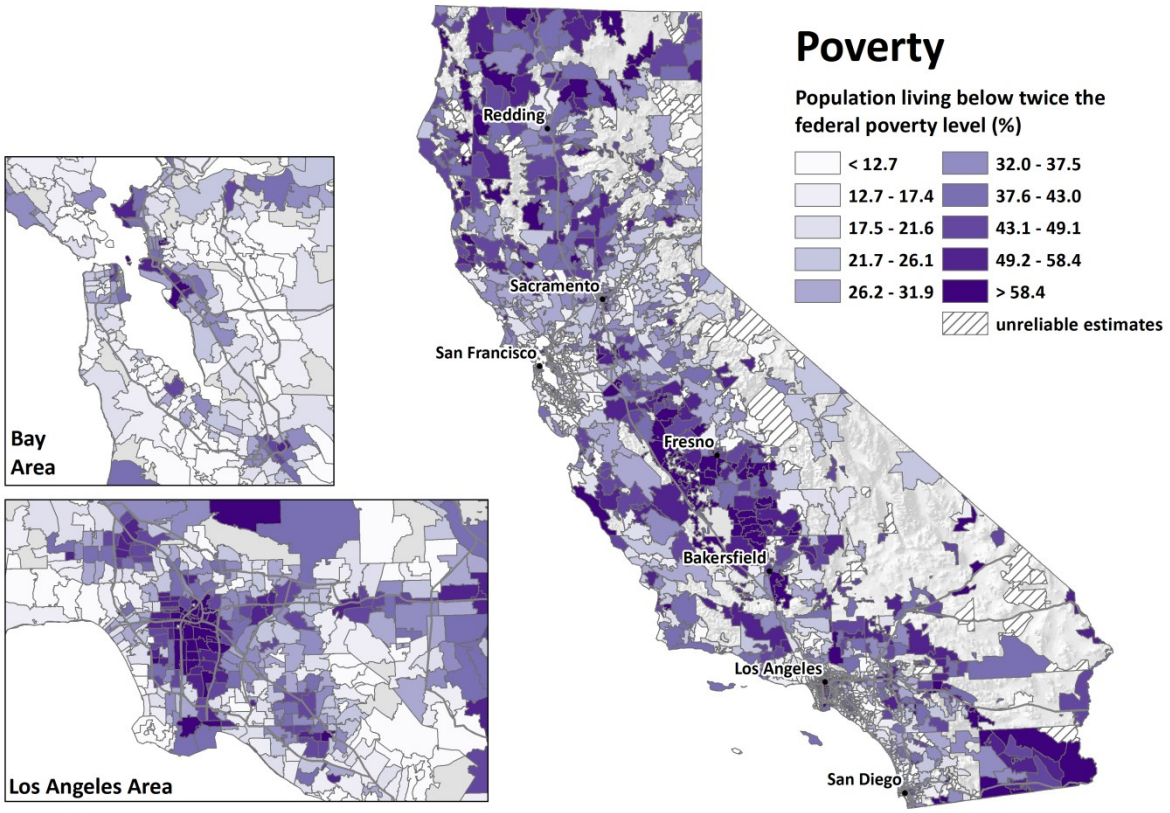
income modifies the relationship between particulate air pollution and preterm birth (Yi *et al.,* 2010) as well as traffic and low birth weight (Zeka *et al.,* 2008), with mothers living in low income neighborhoods having higher risk of both outcomes.

One way by which poverty may lead to greater susceptibility is from the effects of chronic stress on the body (Wright *et al.*, 1999; Brunner and Marmot, 2006). Differential underlying burdens of pre-existing illness and co-exposure to multiple pollutants are other possible factors (O'Neill *et al.,* 2003).

Method

- From the 2007-2011 American Community Survey, a dataset containing the number of individuals below 200 percent of the federal poverty level was downloaded by census ZIP codes for the state of California.
- The number of individuals below the poverty level was divided by the total population for whom poverty status was determined to obtain a percent.
- The margin of error (MOE) reported in the ACS was used to evaluate the reliability of each estimate. Due to small sampling size or small population size within a ZIP code, not all estimates are reliable. The MOE is the difference between an estimate and its upper or lower confidence bound. All ACS-published margins of error are based on a 90 percent confidence level.
- MOEs are reported on the total population (for whom poverty status was determined). The MOE was used to evaluate the reliability of each estimate. If the ratio of MOE) to the total population was greater 66.6 percent (two-thirds), the estimate was excluded.
- ZIP codes meeting this criteria were ordered by the percentage of the population below twice (or 200 percent of) the federal poverty level. A percentile score for a ZIP code was determined by its place in the distribution of all ZIP codes.

Indicator Map



References

Brunner E and Marmot M (2006). Social organization, stress and health. In: *Social Determinants of Health* (2nd edition). Marmot M and Wildinson RG, eds. Oxford, UK: Oxford University Press, p. 7-30.

Cakmak S, Dales RE, Judek S (2006). Respiratory health effects of air pollution gases: modification by education and income. *Archives of Environmental & Occupational Health* **61**(1):5-10.

Forastiere F, Stafoggia M, Tasco C, Picciotto S, Agabiti N, Cesaroni G, *et al.* (2007). Socioeconomic status, particulate air pollution, and daily mortality: differential exposure or differential susceptibility. *American Journal of Industrial Medicine* **50**(3):208-16.

Lin M, Chen Y, Villeneuve PJ, Burnett RT, Lemyre L, Hertzman C, *et al.* (2004). Gaseous air pollutants and asthma hospitalization of children with low household income in Vancouver, British Columbia, Canada. *American Journal of Epidemiology* **159**(3):294-303.

Meng Y, Wilhelm M, Ritz B, Balmes J, Lombardi C, Bueno A, *et al.* (2011). Is disparity in asthma among Californians due to higher pollution exposures, greater vulnerability, or both? In CAR Board (Ed.). Sacramento: CARB.

O'Neill MS, Jerrett M, Kawachi I, Levy JI, Cohen AJ, Gouveia N, *et al.*

(2003). Health, wealth, and air pollution: advancing theory and methods. *Environmental Health Perspectives* **111**(16):1861.

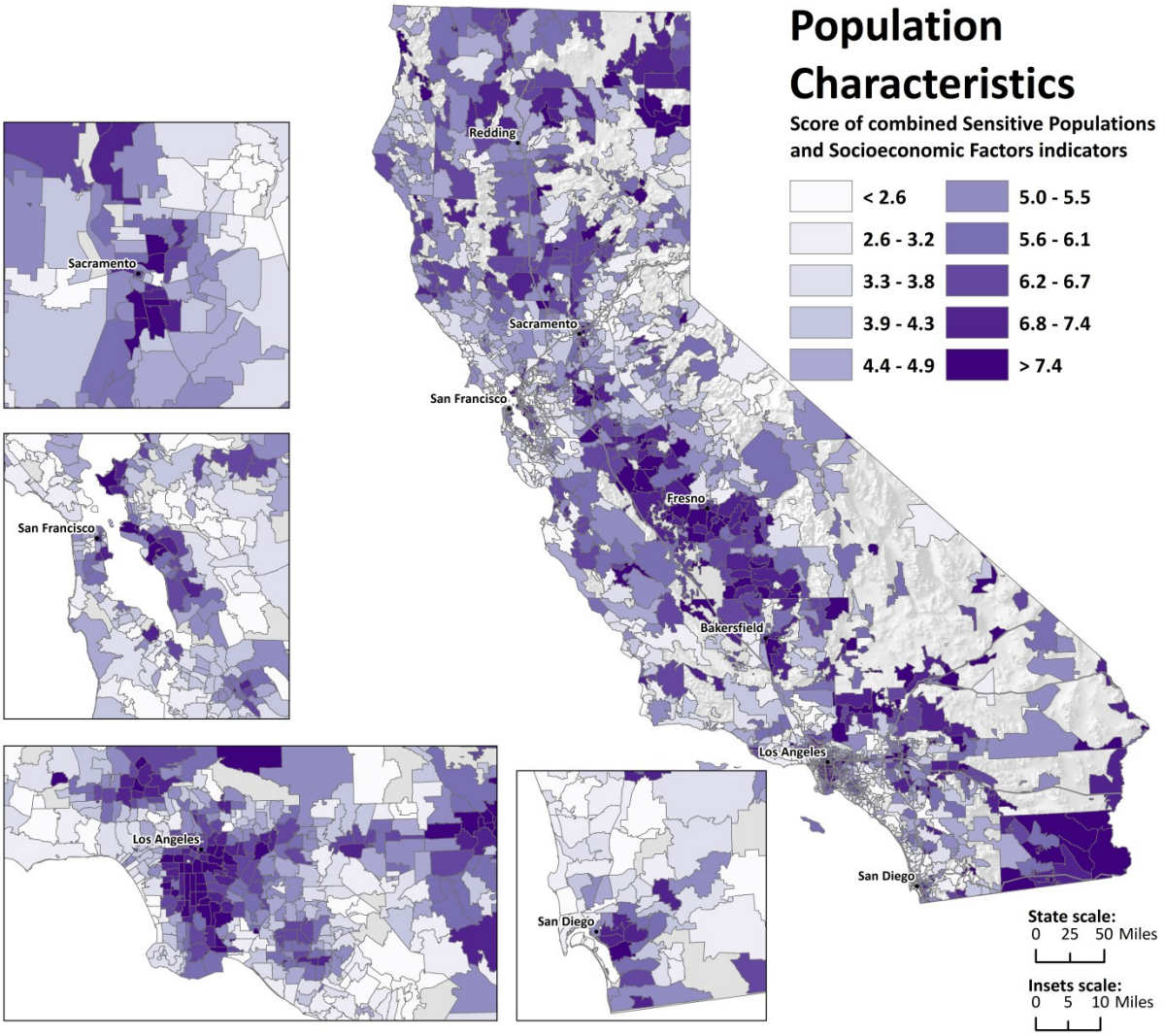
Wright RJ, Rodriguez M, Cohen S (1998). Review of psychosocial stress and asthma: an integrated biopsychosocial approach. *Thorax* **53**(12):1066-74.

Yi O, Kim H, Ha E (2010). Does area level socioeconomic status modify the effects of PM10 on preterm delivery? *Environmental Research* **110**(1):55-61.

Zeka A, Melly SJ, Schwartz J (2008). The effects of socioeconomic status and indices of physical environment on reduced birth weight and preterm births in Eastern Massachusetts. *Environ Health* **7**:60.

SCORES FOR POPULATION CHARACTERISTICS (RANGE OF POSSIBLE SCORES: 0.1 TO 10)

Population Characteristics scores for each ZIP code are derived from the average percentiles for the three Sensitive Populations indicators (children/elderly, low birth weight, and asthma) and the three Socioeconomic Factors indicators (educational attainment, linguistic isolation, and poverty). The calculated average percentile divided by 10 for a Population Characteristic score ranging from 0.1 -10.



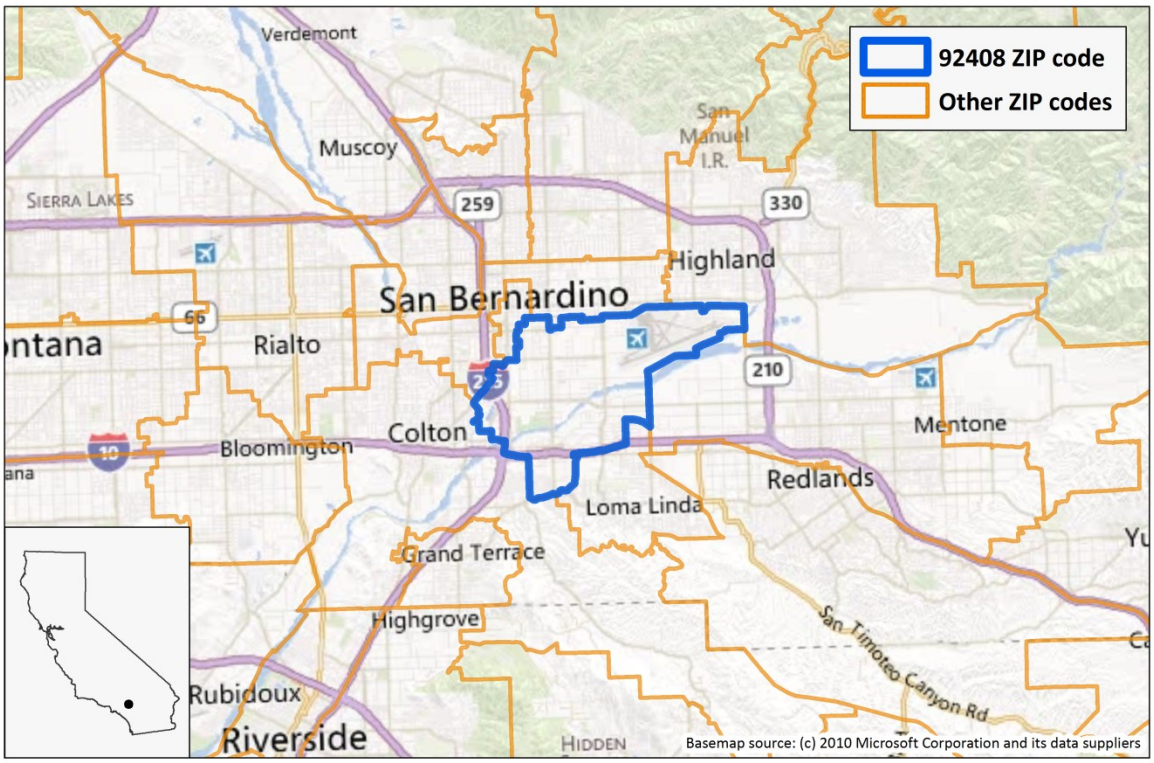
EXAMPLE ZIP CODE:

INDICATOR RESULTS AND CALENVIROSCREEN SCORE

EXAMPLE: 92408, SAN BERNARDINO POPULATION 15,271

One example ZIP code was selected to illustrate how an overall CalEnviroScreen score is calculated using the California Communities Environmental Health Screening Tool. Shown below are:

- An area map for the ZIP code and surrounding ZIP codes.
- Tables for the indicators of Pollution Burden and Population Characteristics with percentile scores for each of the indicators.
- A table showing how a CalEnviroScreen score would be calculated for the example area, based on the data in this report.



Exposure Indicators						
Indicator	Ozone (concentration)	PM2.5 (concentration)	DieselPM (emissions)	Pesticide Use (lbs/sq. mi.)	Toxic Releases (weighted lbs)	Traffic (density)
Raw Value	0.81	14.0	22.65	0.35	576964	1,725
Percentile	98.26	83.28	84.68	29.88	78.50	80.92

Environmental Effects Indicators					
Indicator	Cleanup Sites (weighted sites)	Groundwater Threats (weighted sites)	Hazardous Waste Facilities/ Generators (weighted sites)	Impaired Water Bodies (number of pollutants)	Solid Waste Sites/Facilities (weighted sites and facilities)
Raw Value	91	110	5.95	1	24
Percentile	90.75	75.09	88.87	14.50	97.41

Sensitive Population Indicators			
Indicator	Children (<10) and Elderly (>65) (percent)	Asthma (rate per 10,000)	Low Birth Weight (percent)
Raw Value	23.2	73.26	8.11
Percentile	22.74	90.65	87.68

Socioeconomic Factor Indicators			
Indicator	Educational Attainment (percent)	Linguistic Isolation (percent)	Poverty (percent)
Raw Value	31.5	18.5	55.4
Percentile	83.51	83.36	87.22

CALCULATION OF CALENVIROSCREEN SCORE FOR 92408

	Pollution Burden		Population Characteristics	
	Exposures *(6 indicators)*	**Environmental Effects*** *(5 indicators)*	**Sensitive Populations** *(3 indicators)*	**Socioeconomic Factors** *(3 indicators)*
Indicator Percentiles	98.26 +83.28 +84.68 +29.88 +78.50 +80.92	+ (0.5 × 90.75) + (0.5 × 75.09) + (0.5 × 88.87) + (0.5 × 14.50) + (0.5 × 97.41)	22.74 + 90.65 + 87.68	+ 83.51 + 83.36 + 87.22
Average Percentile	638.83 ÷ (6 + (0.5 × 5)) = 75.16		455.16 ÷ 6 = 75.86	
Score (Range 0.1 – 10)	7.5		7.6	
CalEnviroScreen Score	7.5 x 7.6 = 57 (57 is in the top 5% of CalEnviroScreen ZIP codes statewide)			

* Indicators from the Environmental Effects component were given half the weight of the indicators from the Exposures component

CALENVIROSCREEN TOP 10% AND STATEWIDE RESULTS

The maps on the following pages depict the top 10 percent of statewide ZIP codes using the CalEnviroScreen methodology described in this report. The first set of maps depicts the top 5 and 10 percent scoring ZIP Codes in the state.

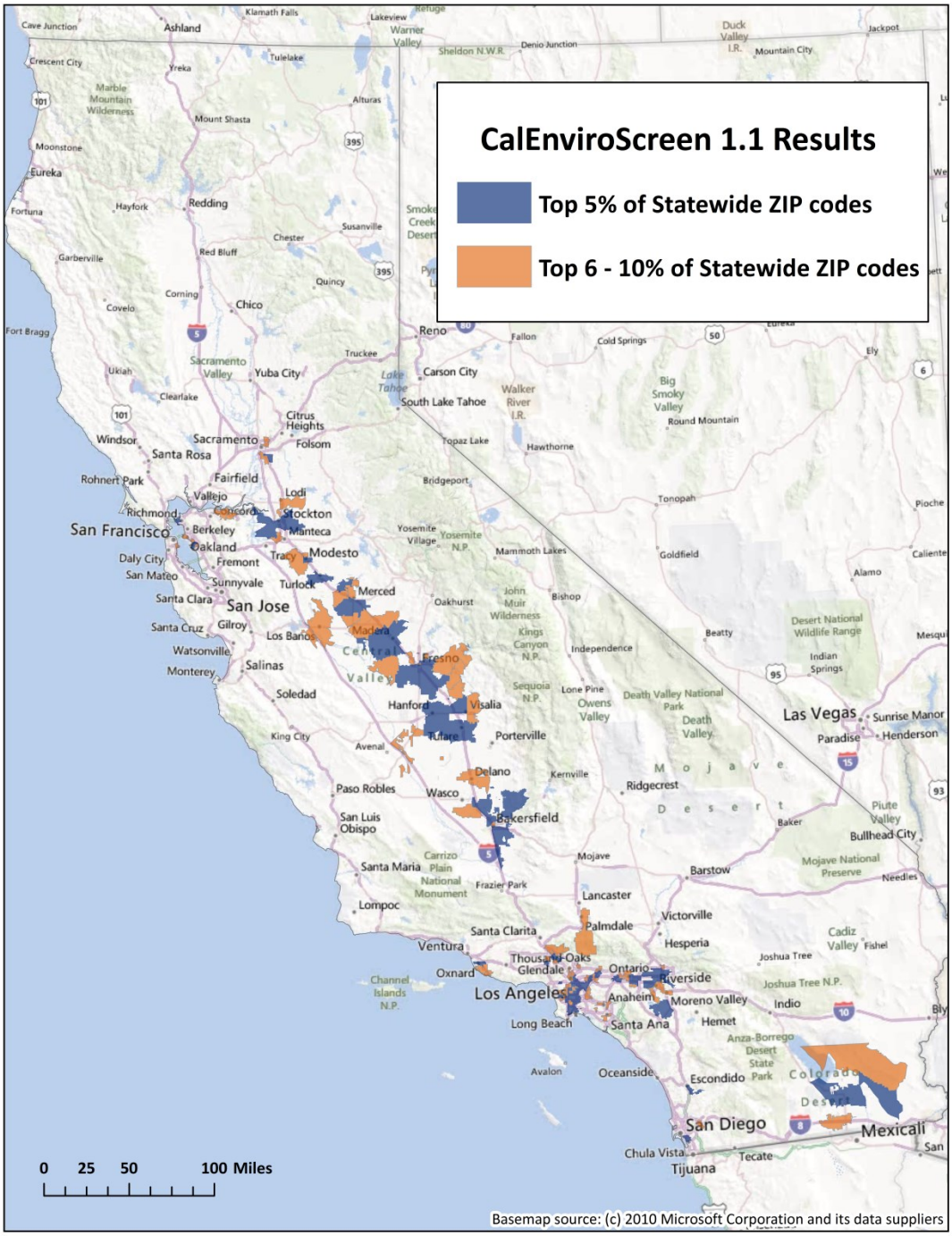
The second set of maps depicts the relative scoring of California's census ZIP codes. ZIP codes with darker colors have the higher CalEnviroScreen scores and therefore have relatively high pollution burdens and population sensitivities. ZIP codes with lighter colors have lower scores, and correspondingly lower pollution burdens and sensitivities.

The maps of specific regions of the state (Los Angeles, San Francisco, San Diego, San Joaquin Valley, Sacramento and the Coachella and Imperial Region) are "close-ups" of the statewide map and are intended to provide greater clarity on the relative scoring of census ZIP codes in those regions. Colors on these maps reflect the relative statewide scoring of individual ZIP codes.

Numerical scores for each ZIP code, as well as the individual indicator scores for each ZIP code, may be found online at OEHHA's web site at (http://www.oehha.ca.gov/ej/). The information is available both in a Microsoft Excel spreadsheet format, and will be available as an online mapping application.

TOP 10% HIGHEST SCORING CENSUS ZIP CODES

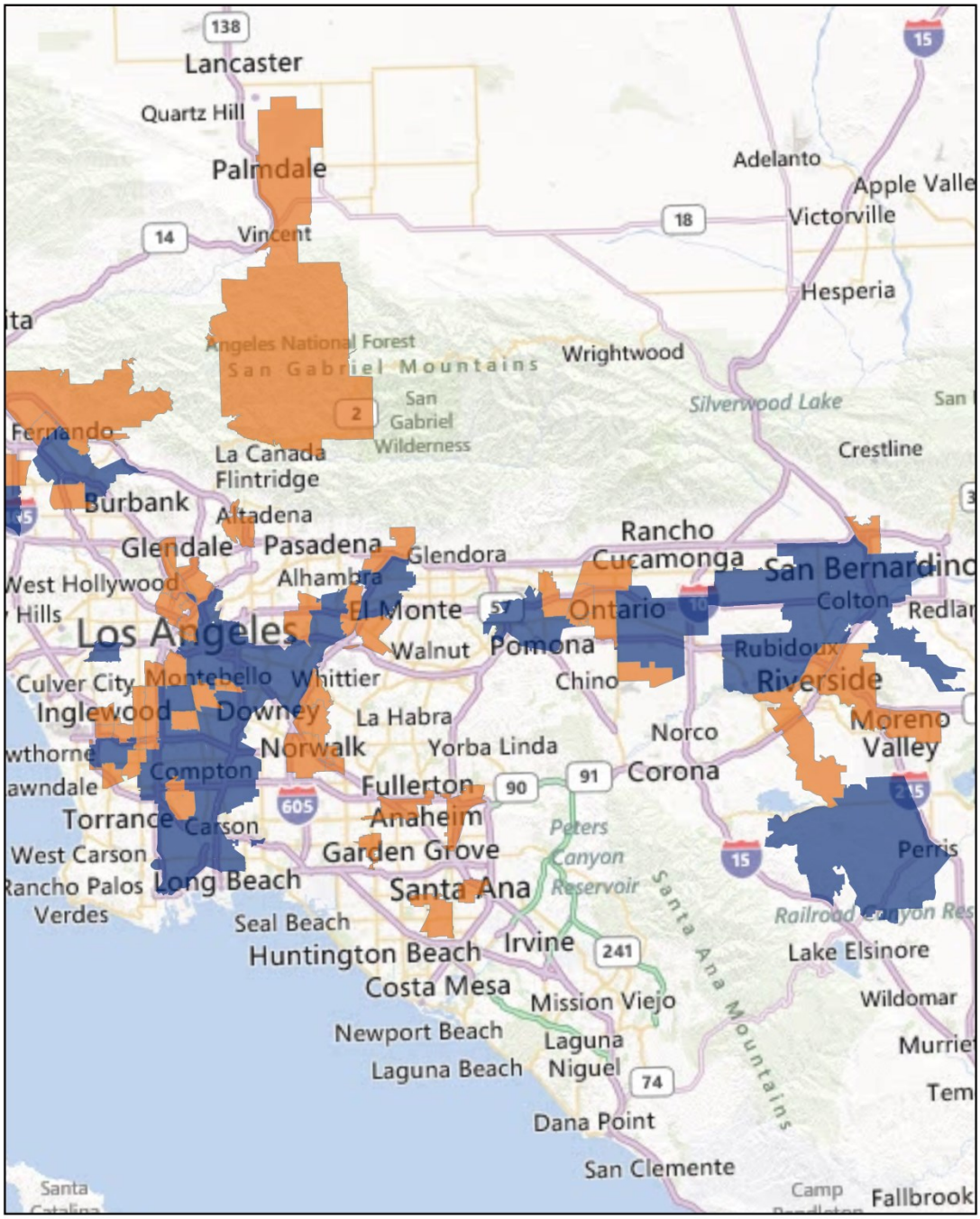
Using the CalEnviroScreen scores for all the census ZIP codes across the State, the 10% of the ZIP codes with the highest scores were identified. This represents 176 of the 1769 ZIP codes in the State. Because of variation in the number of people living in different ZIP codes, the population represented in these 10% of ZIP codes is about 7.8 million, or about 21% of the 37 million people living in California.



CalEnviroScreen 1.1 Results

Top 5% of Statewide ZIP codes

Top 6 - 10% of Statewide ZIP codes



Los Angeles Area

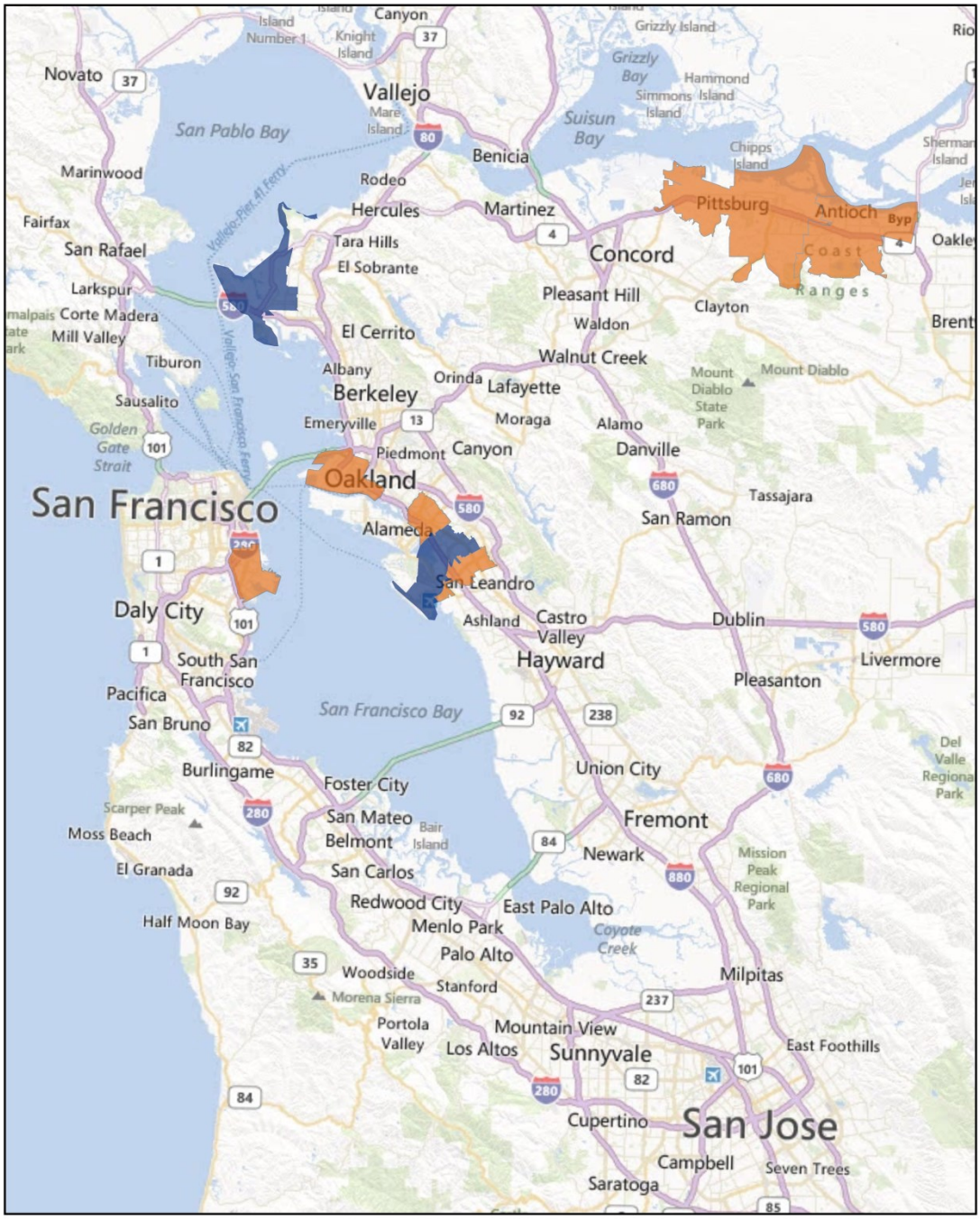
0 5 10 20 Miles

Basemap source: (c) 2010 Microsoft Corporation and its data suppliers

CalEnviroScreen 1.1 Results

Top 5% of Statewide ZIP codes

Top 6 - 10% of Statewide ZIP codes



San Francisco Area

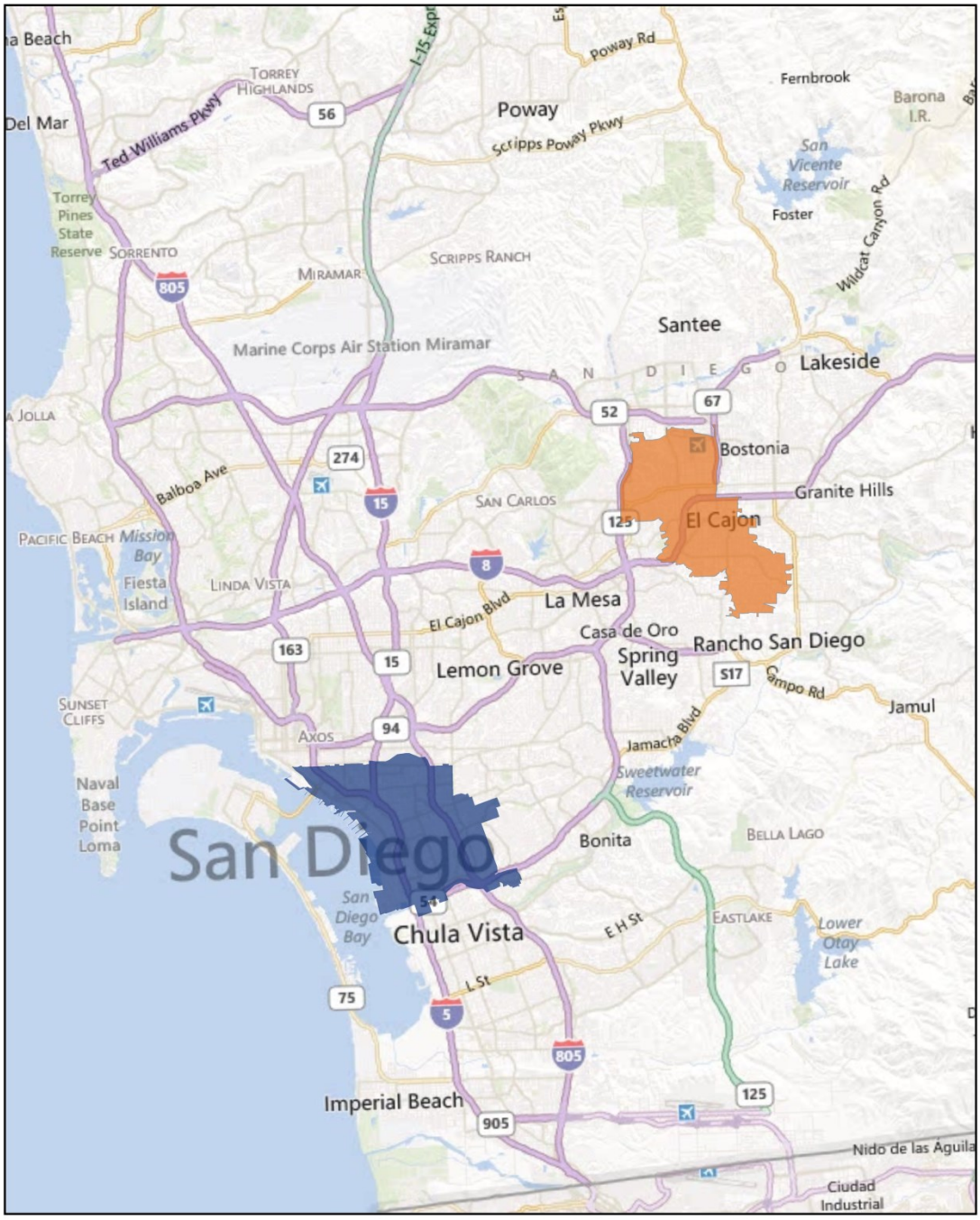
0 2.5 5 10 Miles

Basemap source: (c) 2010 Microsoft Corporation and its data suppliers

CalEnviroScreen 1.1 Results

Top 5% of Statewide ZIP codes

Top 6 - 10% of Statewide ZIP codes



San Diego Area

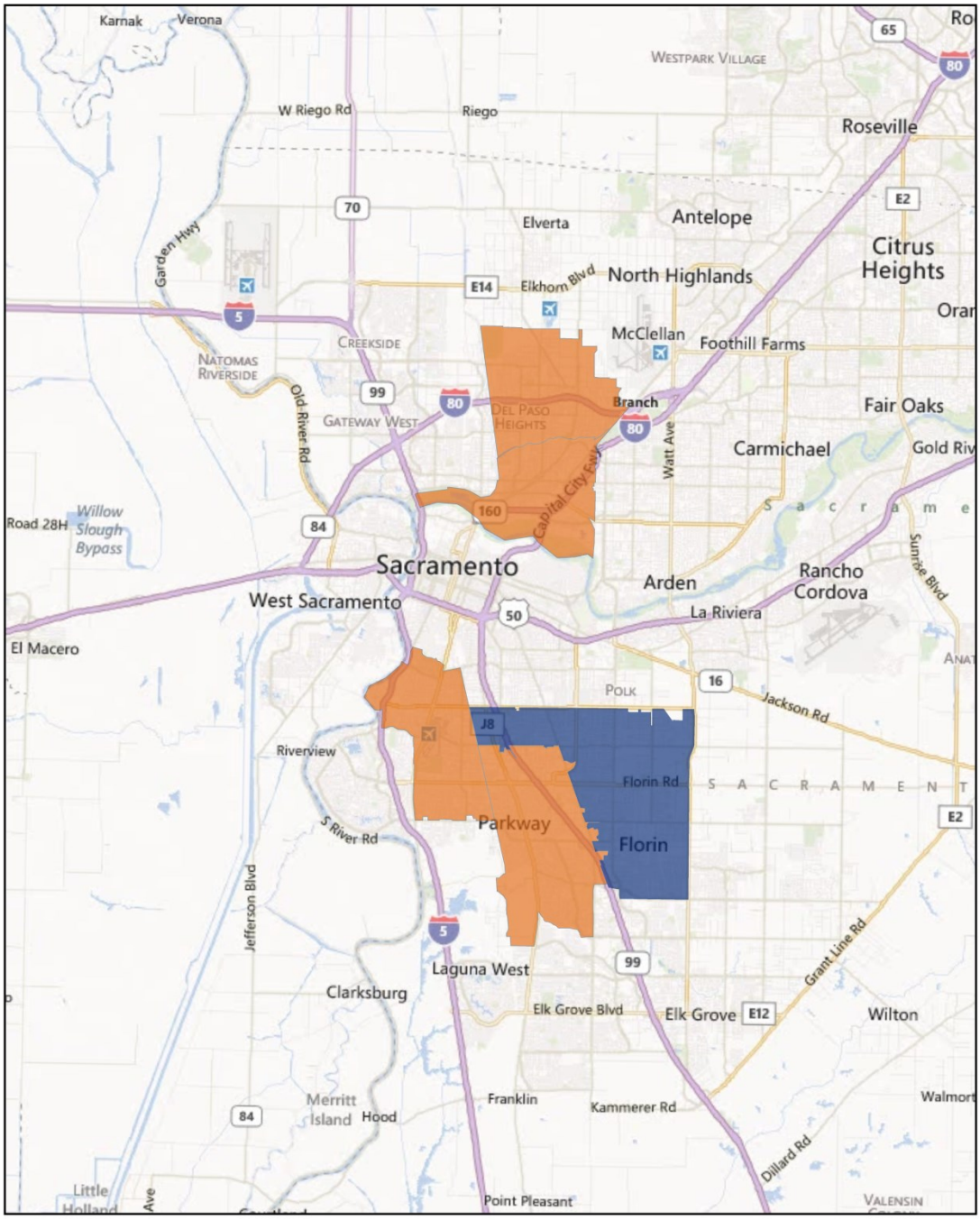
0 2.5 5 10 Miles

Basemap source: (c) 2010 Microsoft Corporation and its data suppliers

CalEnviroScreen 1.1 Results

Top 5% of Statewide ZIP codes

Top 6 - 10% of Statewide ZIP codes



Sacramento Area

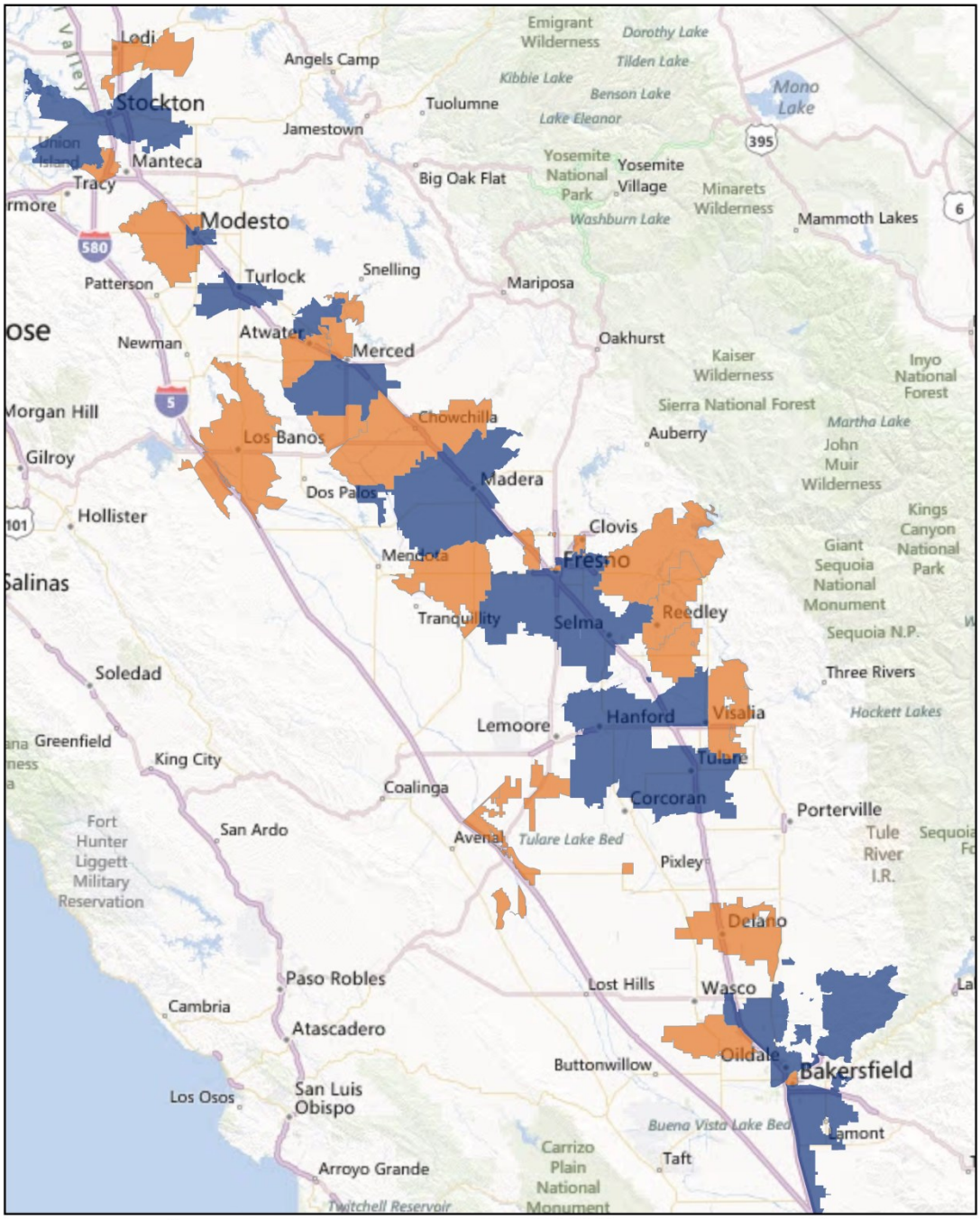
0 2.5 5 10 Miles

Basemap source: (c) 2010 Microsoft Corporation and its data suppliers

CalEnviroScreen 1.1 Results

Top 5% of Statewide ZIP codes

Top 6 - 10% of Statewide ZIP codes



San Joaquin Valley

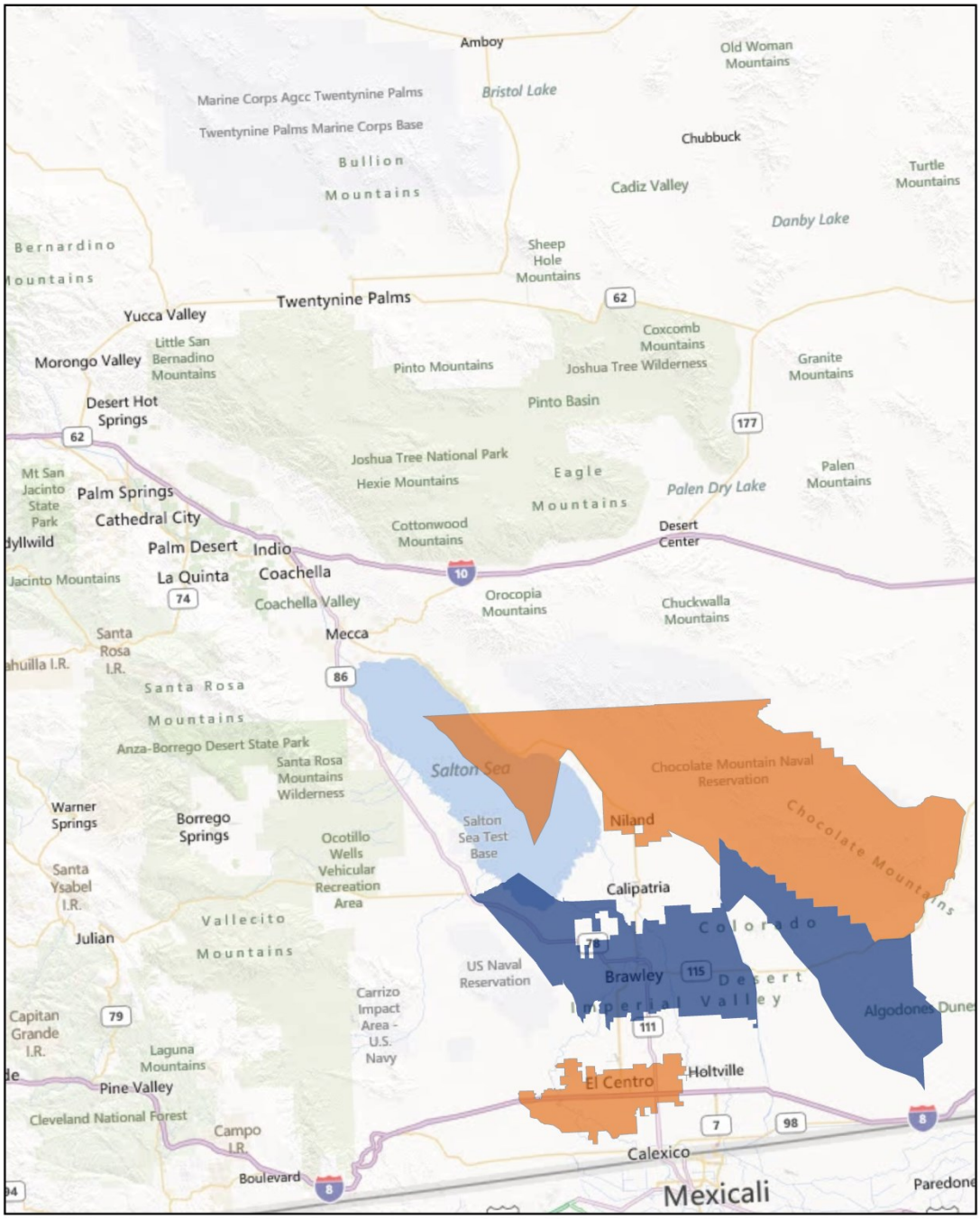
0 10 20 40 Miles

Basemap source: (c) 2010 Microsoft Corporation and its data suppliers

CalEnviroScreen 1.1 Results

Top 5% of Statewide ZIP codes

Top 6 - 10% of Statewide ZIP codes

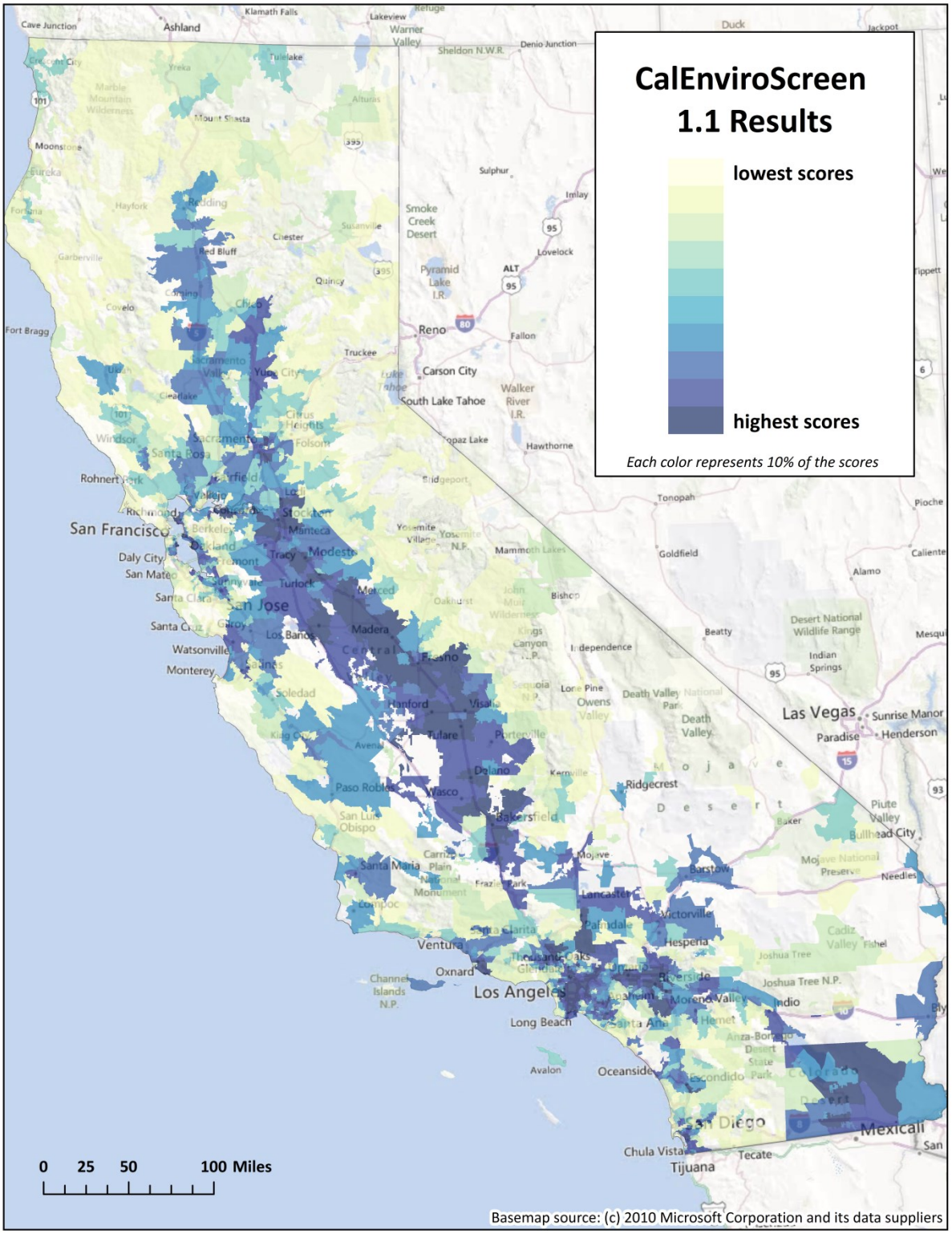


Coachella & Imperial Region

0 5 10 20 Miles

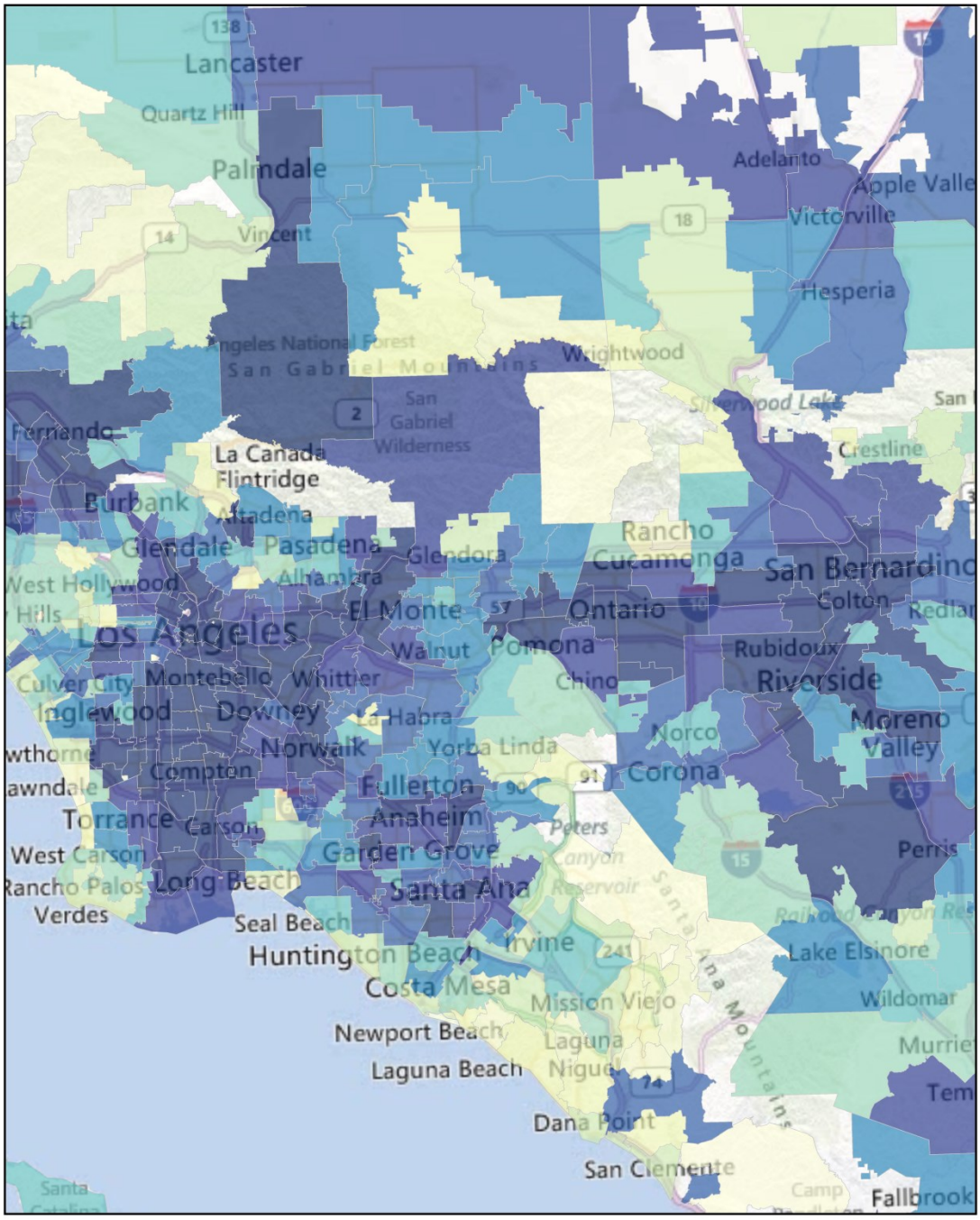
Basemap source: (c) 2010 Microsoft Corporation and its data suppliers

CALENVIROSCREEN STATEWIDE RESULTS



CalEnviroScreen 1.1 Results

Each color represents 10% of the scores



Los Angeles Area

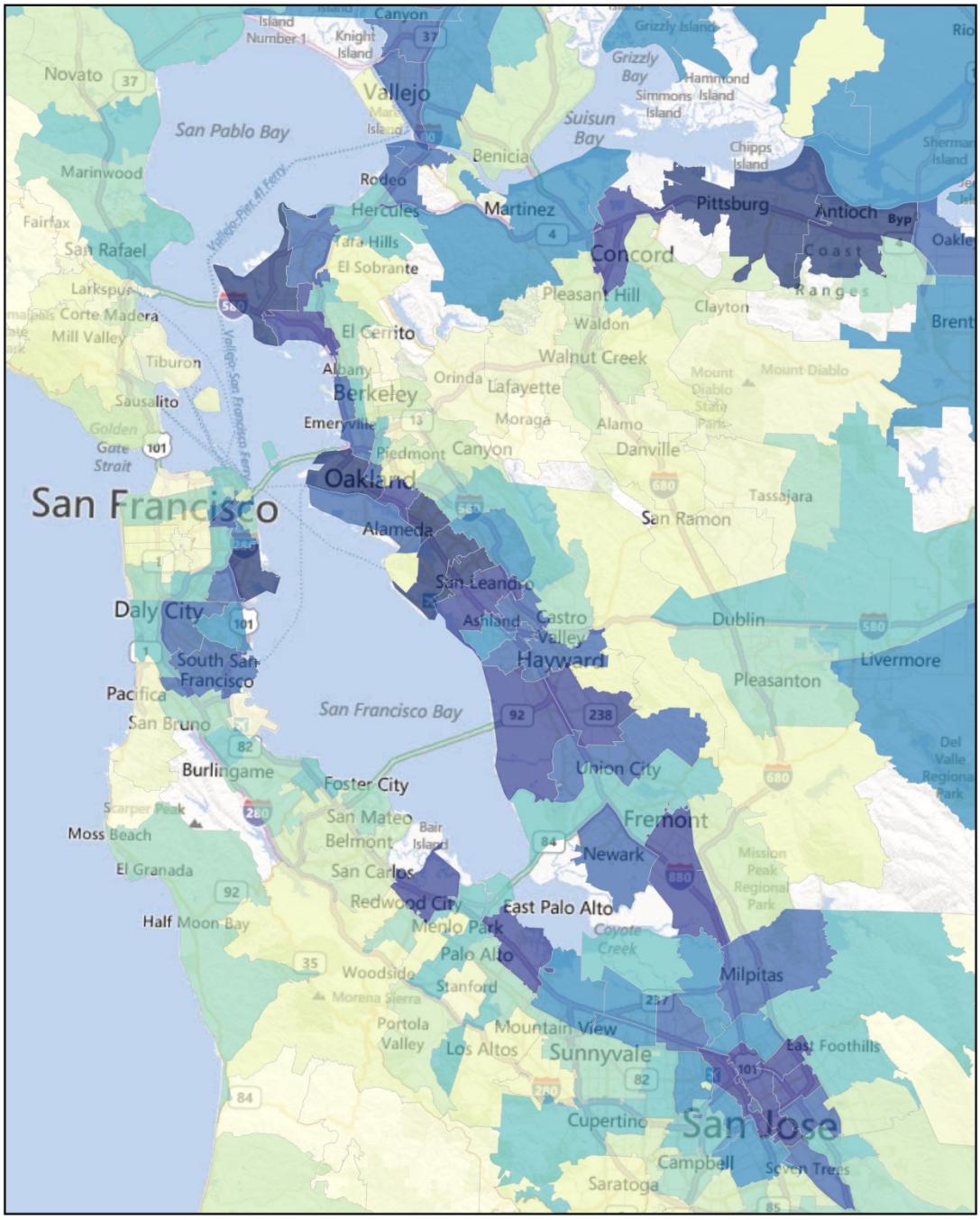
0 5 10 20 Miles

Basemap source: (c) 2010 Microsoft Corporation and its data suppliers

CalEnviroScreen 1.1 Results

lowest scores — **highest scores**

Each color represents 10% of the scores



San Francisco Area

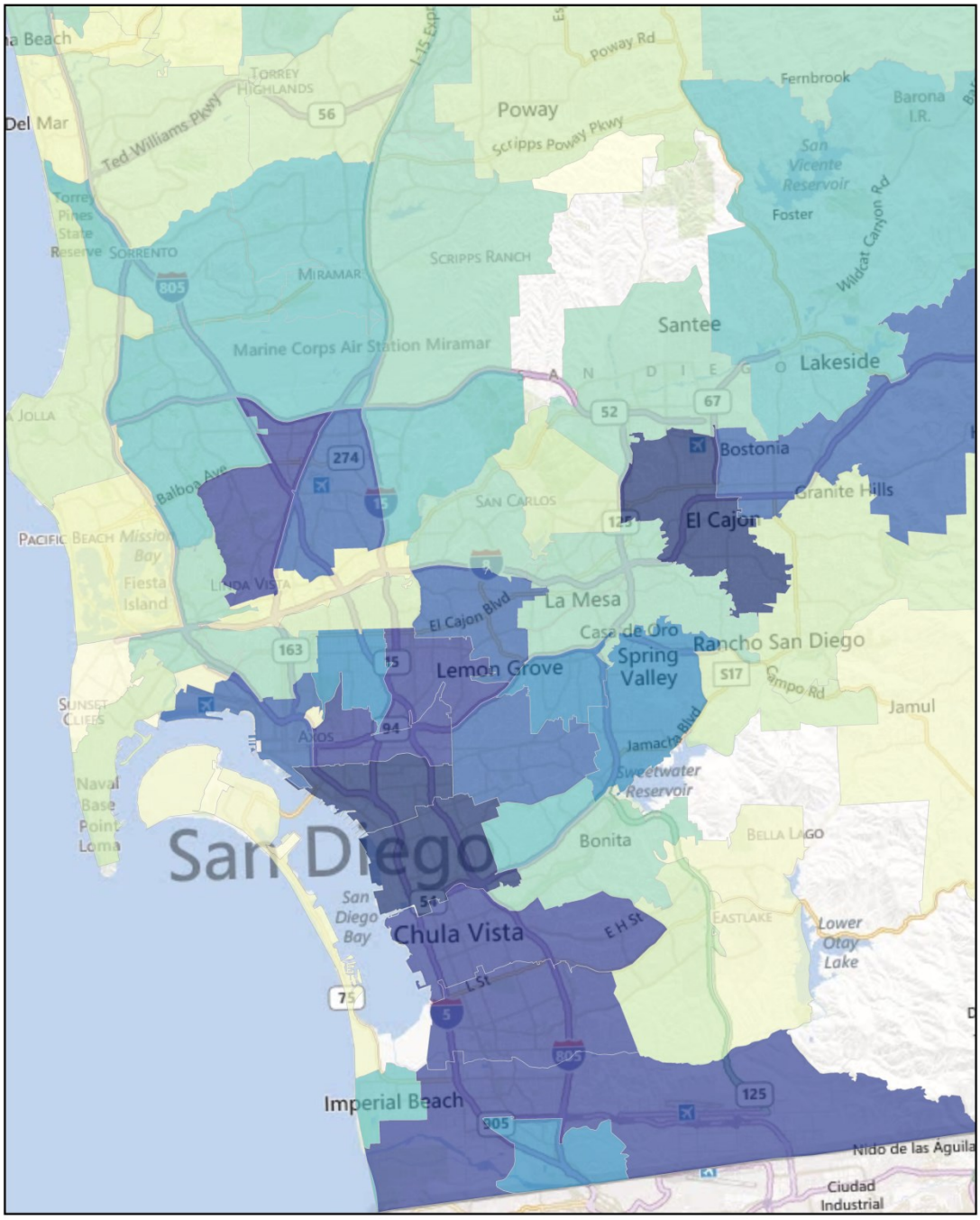
0 2.5 5 10 Miles

Basemap source: (c) 2010 Microsoft Corporation and its data suppliers

CalEnviroScreen 1.1 Results

lowest scores — **highest scores**

Each color represents 10% of the scores



San Diego Area

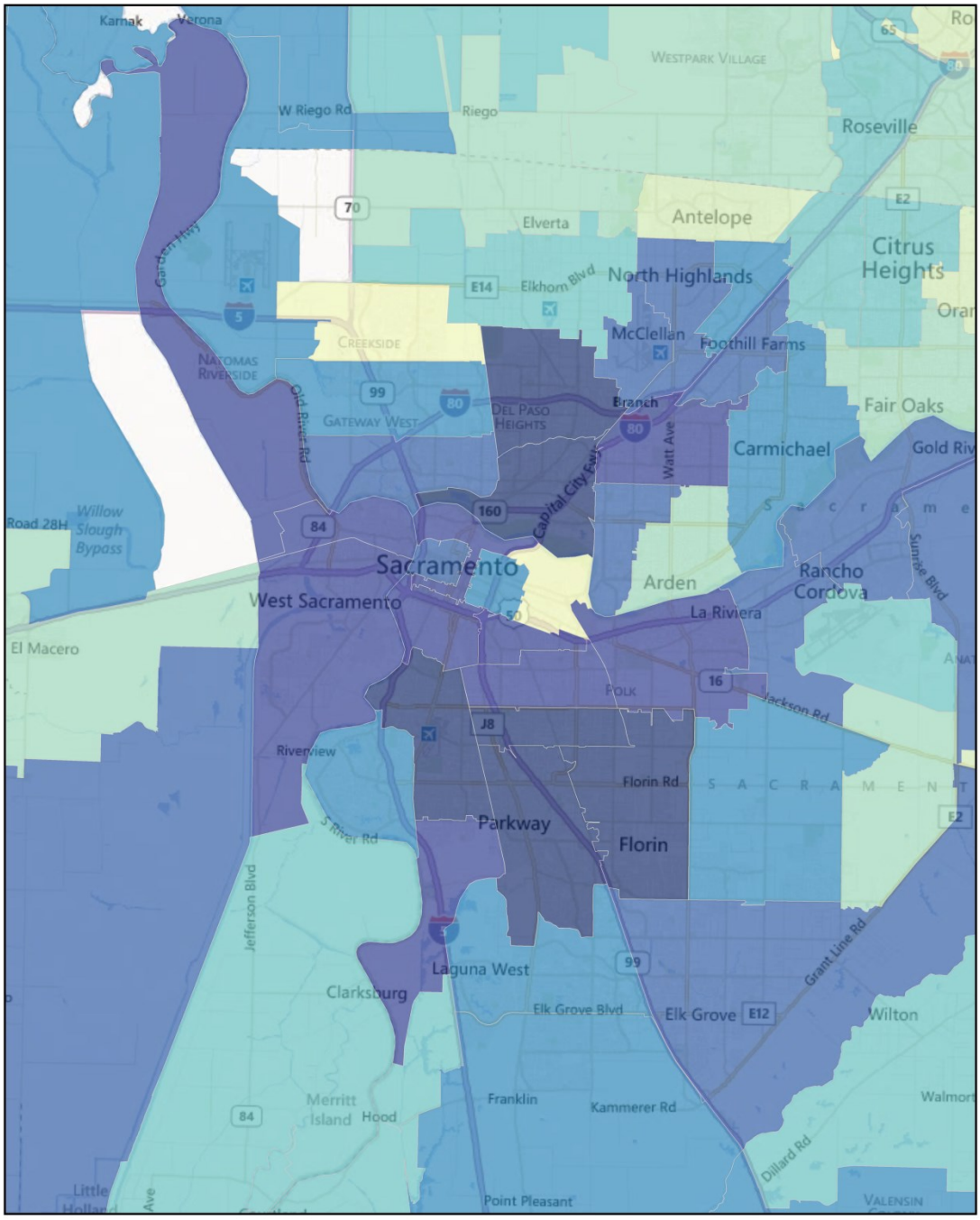
0 2.5 5 10 Miles

Basemap source: (c) 2010 Microsoft Corporation and its data suppliers

CalEnviroScreen 1.1 Results

lowest scores — highest scores

Each color represents 10% of the scores



Sacramento Area

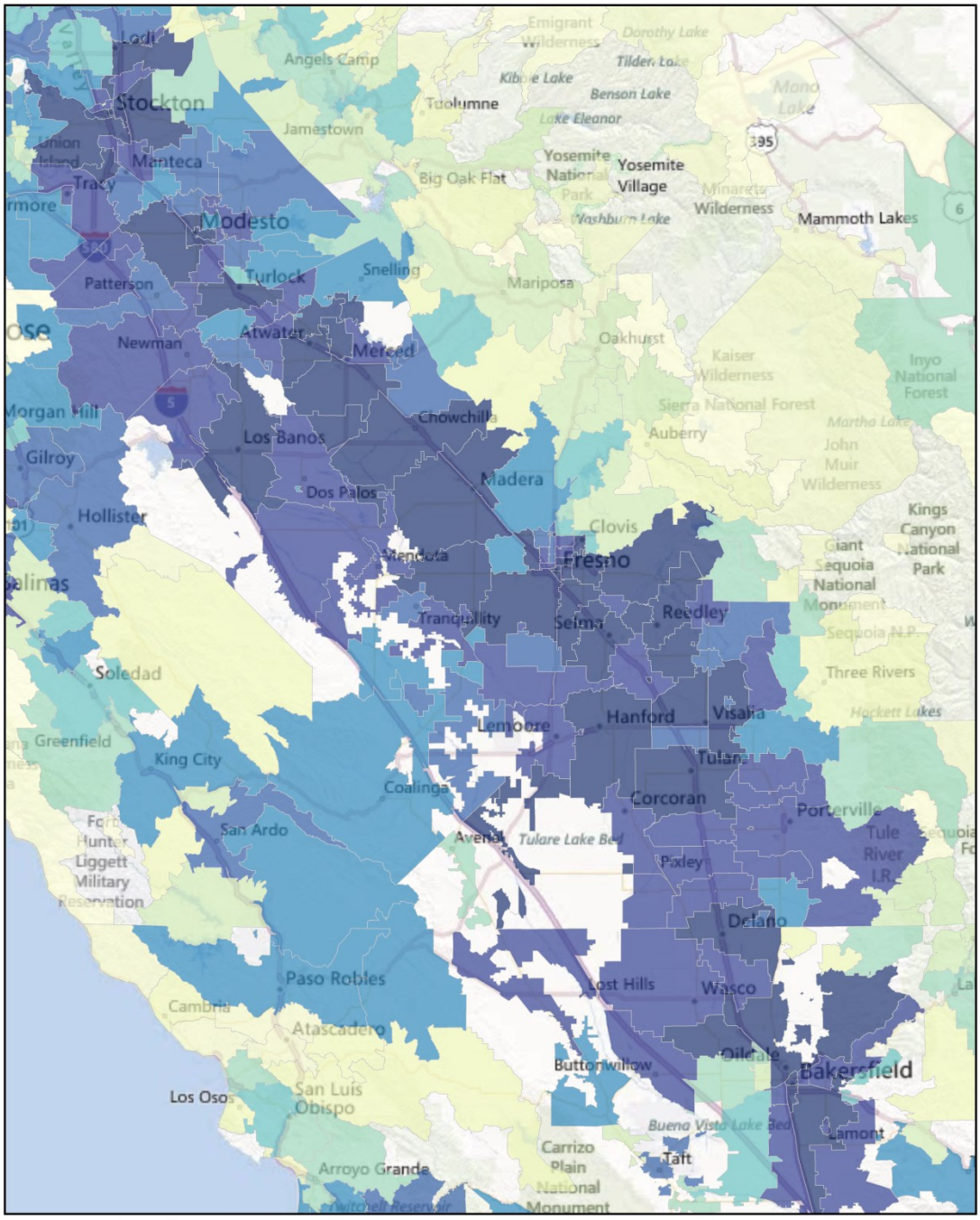
0 2.5 5 10 Miles

Basemap source: (c) 2010 Microsoft Corporation and its data suppliers

CalEnviroScreen 1.1 Results

lowest scores — highest scores

Each color represents 10% of the scores



San Joaquin Valley

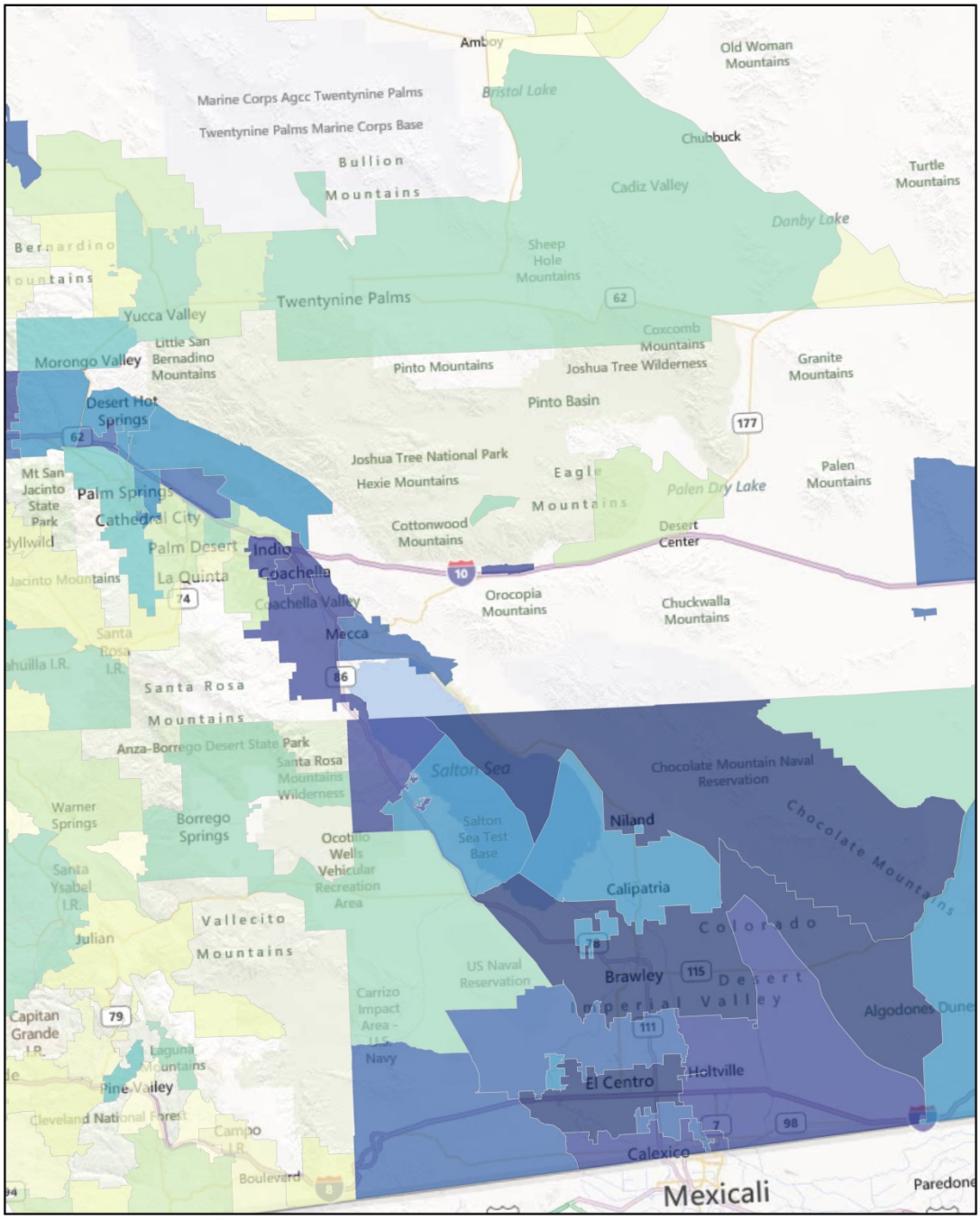
0 10 20 40 Miles

Basemap source: (c) 2010 Microsoft Corporation and its data suppliers

CalEnviroScreen 1.1 Results

lowest scores — **highest scores**

Each color represents 10% of the scores



Coachella & Imperial Region

0 5 10 20 Miles

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ANALYSIS OF CALENVIROSCREEN 1.1 SCORES AND RACE/ETHNICITY

The CalEnviroScreen 1.1 scores represent a combined measure of pollution and the potential vulnerability of a population to the effects of pollution. Unlike CalEnviroScreen 1.0, Version 1.1 scores do not include a measure of race/ethnicity in the calculation of the CalEnviroScreen score. The removal of race/ethnicity from the score does not minimize the importance of examining this issue in the context of environmental impacts and vulnerability. This section presents some of the scientific evidence related to the vulnerability to pollution of some racial/ethnic groups, and provides an analysis of the relationship between CalEnviroScreen scores and race/ethnicity.

Scientific research indicates that the relationship between pollutant exposure, stress, and health outcomes can vary based on the race and ethnicity of a population. For example, studies have shown that maternal exposure to particulate pollution results in a greater reduction in infant birth weight among African-American mothers than white mothers (Bell *et al.*, 2007). Another study found that African-American mothers of low socioeconomic status exposed to traffic-related air pollution had twice the likelihood of delivering a preterm infant compared to white mothers of low socioeconomic status (Ponce *et al.*, 2005). A study of traffic exposure and spontaneous abortion also found a greater effect for African-American women than other racial and ethnic groups (Green *et al.*, 2009).

For children, a study of the effects of nitrogen dioxide (NO_2) on children without health insurance in Phoenix found that Hispanic children had twice the risk of hospitalization for asthma from NO_2 exposure as white children. Black children showed about twice the risk of asthma hospitalization from NO_2 exposure as Hispanic children, regardless of insurance status (Grineski *et al.*, 2010).

Differences have also been observed for the effect of PM2.5 exposure on emergency department visits for asthma among patients of different races. The effect was found to be significant and greater in African American populations compared to Caucasians for the first three days following exposure (Glad *et al.*, 2012). Additionally, higher mortality has been observed among African-American populations exposed to ozone than other populations exposed to the same levels (Medina-Ramon and Schwartz, 2008).

In Native American children, rates of overweight and obesity are higher than among non-Native populations, potentially due in part to psychosocial stressors, lack of access to healthy food, and exposure to environmental obesogens (Schell and Gallo, 2012). Native Americans have lower life expectancy and higher rates of certain chronic diseases than the U.S. population as a whole.

The mechanisms by which differences in race or ethnicity may lead to differences in health status and response to pollutants are complex and are not well understood. Some studies have explored

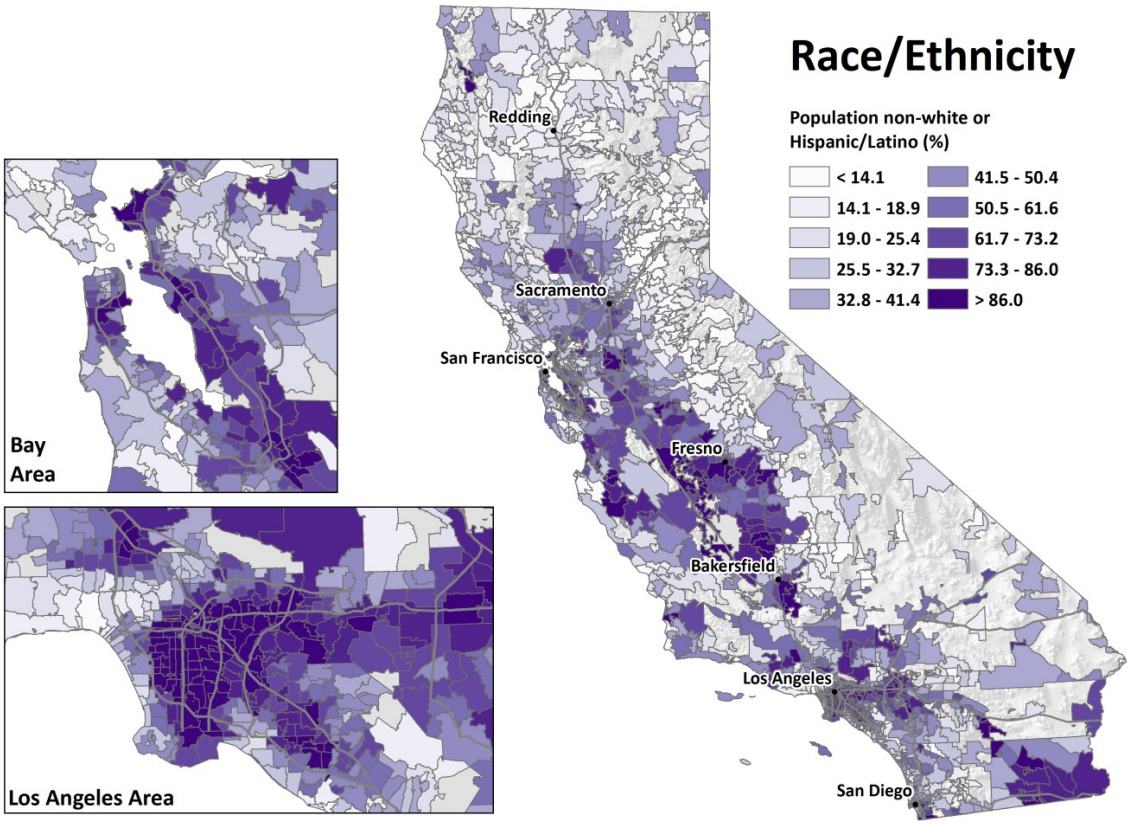
the relationship between the experience of racism as a form of chronic stress and human health (Paradies, 2006; Kwate *et al*., 2003), while others have looked at racial discrimination as an aspect of socioeconomic disadvantage, along with residential crowding, noise, poor housing quality, reduced access to health care, and exposure to violence (Evans and Marcynyszyn, 2004; Geronimus, 1996; Mertz and Grumbach, 2001, Williams and Williams-Morris, 2000; Clark *et al*., 1999). A study of the effect of blood lead level on blood pressure found that there are significant racial and ethnic disparities, with the strongest association occurring in African Americans with symptoms of depression (Hicken *et al*., 2013). The authors suggest that this finding presents evidence for the role that social stressors play in determining vulnerability to the health impacts of environmental exposures.

We evaluated potential associations between race/ethnicity and CalEnviroScreen 1.1 scores using data from the 2010 decennial census. The U.S. Census Bureau questionnaire asked all census respondents to identify if they were of Hispanic, Latino or Spanish origin and in a separate question, their race. Datasets describing the number of individuals in different race and ethnicity categories are available for California at different geographic scales. The data are made available using the American FactFinder website (http://factfinder2.census.gov/). Differences in racial and ethnic composition across California can be estimated using these data.

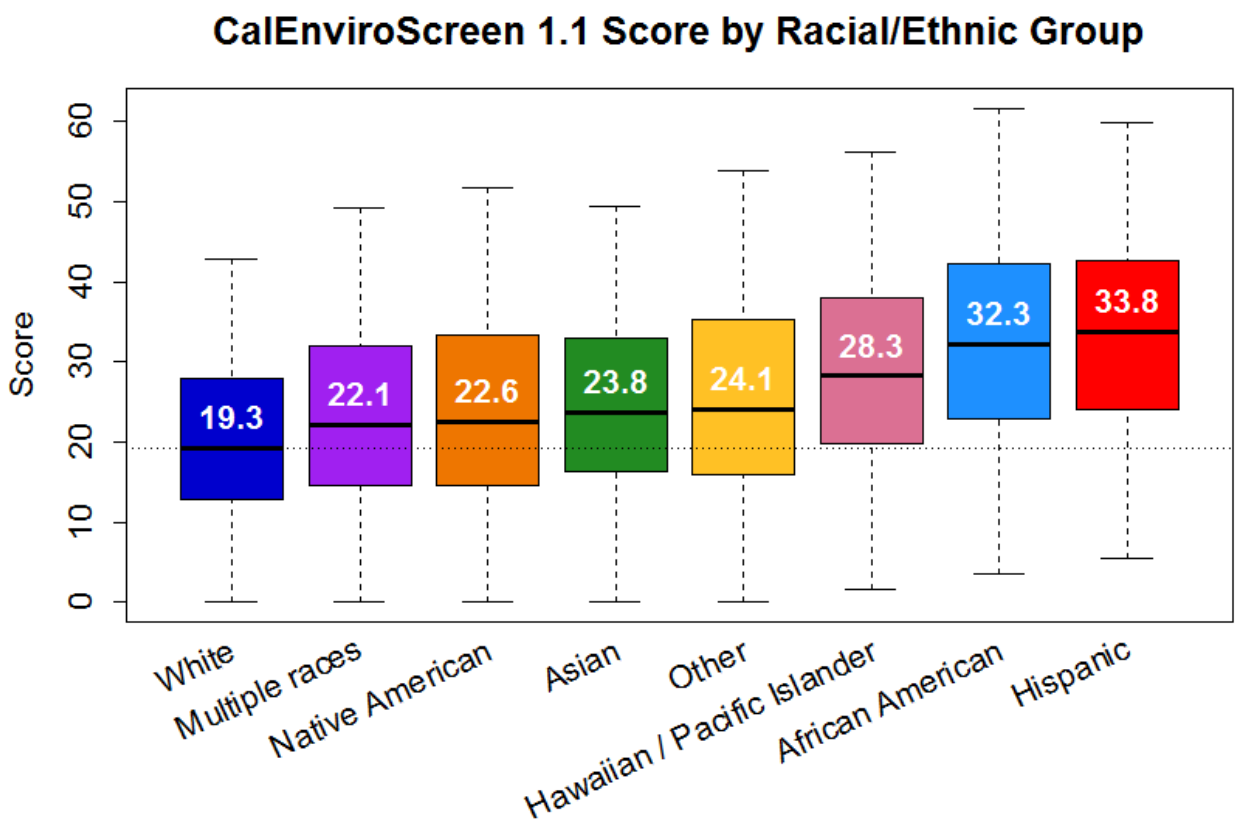
Our analysis examined race/ethnicity using the following steps:

- A dataset containing the number of people by race/ethnicity was downloaded by census ZIP codes for the State.
- The non-white percentage of the population in each ZIP code was calculated as the total number of people identified as non-white or Hispanic/Latino in the ZIP code divided by the total population of the ZIP code.
- ZIP codes were ordered by the percentage of the population that is non-white or Hispanic/ Latino). A percentile score for a ZIP code was determined by its place in the distribution of all ZIP codes.

The mapping results of the statewide analysis of race/ethnicity are shown below:



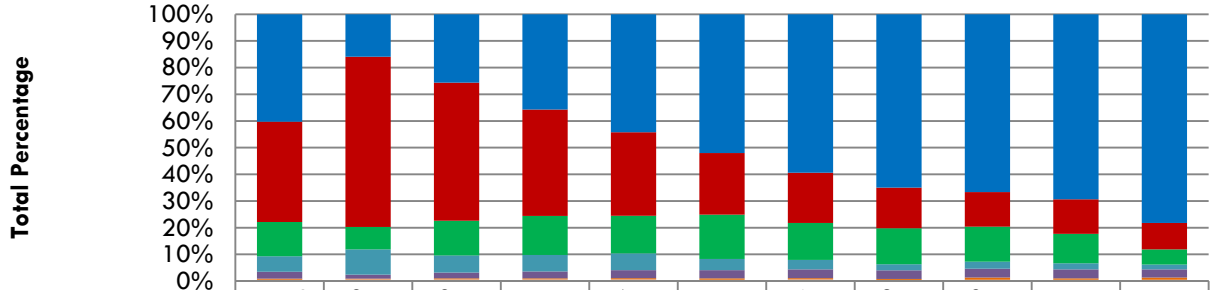
The following chart shows the typical range of CalEnviroScreen 1.1 scores pertaining to Californians of different races and ethnicities. The dark horizontal lines in each box plot, and the numbers above them, indicate the median (average) CalEnviroScreen score for each racial or ethnic group. The shaded boxes correspond to the "Interquartile Range" (IQR), or the range of values between the 25th to 75th percentile. The dashed vertical lines coming off each box show extreme values experienced by the groups.



The chart below examines how the racial/ethnic composition of ZIP codes varies by CalEnviroScreen scores. ZIP codes across the state were divided into ten categories with equal numbers of ZIP codes (deciles), sorted from highest (91-100 percentile) to lowest CalEnviroScreen scores (1-10 percentile). The overall racial/ethnic composition of the California population is represented by the first vertical bar on the left side of the chart. The second vertical bar represents the ten percent of ZIP codes with the highest CalEnviroScreen scores, the third vertical bar represents the ten percent of ZIP codes with the next highest CalEnviroScreen scores, and so on. The percent of the population of different races/ethnicities in each decile is shown in the column below each bar.

If all racial/ethnic groups were equal in terms of CalEnviroScreen score, the proportion of each group in each decile would be equal to its overall proportion in the California population. That is, an even distribution of pollution burden and population vulnerability across racial and ethnic groups would mean that all the bars would resemble the left-most bar in the chart. However it is clear from the chart that this in not the case, implying that pollution burden and population vulnerability are not distributed evenly across different racial/ethnic groups.

Race-Ethnicity Proportions of California ZIP Codes by CalEnviroScreen 1.1 Deciles



	Total CA	91-100%*	81-90%	71-80%	61-70%	51-60%	41-50%	31-40%	21-30%	11-20%	1-10%
White	40.2	15.9	25.6	35.7	44.2	52	59.4	64.9	66.7	69.4	78.2
Hispanic	37.6	63.8	51.7	39.9	31.3	23.1	18.8	15.2	13	13	9.9
Asian American	12.8	8.4	13	14.6	14.1	16.6	13.9	13.5	13.1	11	5.7
African-American	5.8	9.5	6.4	6.2	6.3	4.2	3.5	2.3	2.7	2.3	1.8
Multi	2.6	1.5	2.2	2.6	3	3.1	3.3	3.2	3.3	3.4	3.1
Native American	0.4	0.3	0.4	0.4	0.5	0.5	0.5	0.4	0.8	0.5	0.8
Native Hawaiian	0.3	0.4	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2
Other	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.3	0.3

* The "91-100%" column shows the population composition of the ZIP codes with the highest CalEnviroScreen 1.1 scores. The 1-10% column represents those ZIP codes in the lowest scores.

These results also show broad trends in differences by race/ethnicity across CalEnviroScreen scores. Hispanic, African-American, and to some extent Native Hawaiian /Pacific Islander populations tend to have higher CalEnviroScreen 1.1 scores than other groups and are proportionally overrepresented in the highest scoring ZIP codes (81-90 and 91-100 percentiles) relative to their proportion of the California population. The white population tends to have a lower score and is underrepresented in the highest scoring ZIP codes relative to its proportion of the statewide population.

References

Bell ML, Ebisu K, Belanger K (2007). Ambient air pollution and low birth weight in Connecticut and Massachusetts. *Environ Health Perspect* **115**(7):1118-24.

Clark R, Anderson NB, Clark VR, Williams DR (1999). Racism as a stressor for African Americans. A biopsychosocial model. *Am Psychol* **54**(10):805-16.

Evans GW, Marcynyszyn LA (2004). Environmental justice, cumulative environmental risk, and health among low- and middle-income children in upstate New York. *Am J Public Health* **94**(11):1942-4.

Geronimus AT (1996). Black/white differences in the relationship of maternal age to birthweight: a population-based test of the weathering hypothesis. *Soc Sci Med* **42**(4):589-97.

Glad JA, Brink LL, Talbott EO, Lee PC, Xu X, Saul M, and Rager J (2012). The relationship of ambient ozone and PM2. 5 levels and asthma emergency department visits: Possible influence of gender and ethnicity. *Archives of Environmental & Occupational Health* **67**(2): 103-108.

Green RS, Malig B, Windham GC, Fenster L, Ostro B, and Swan S (2009). "Residential exposure to traffic and spontaneous abortion." *Environmental Health Perspectives* 117(12):1939.

Kwate NO, Valdimarsdottir HB, Guevarra JS, Bovbjerg DH (2003). Experiences of racist events are associated with negative health consequences for African American women. *J Natl Med Assoc* **95**(6):450-60.

Medina-Ramón M, Schwartz J (2008). Who is more vulnerable to die from ozone air pollution? *Epidemiology* **19**(5):672-9.

Mertz EA, Grumbach K (2001). Identifying communities with low dentist supply in California. *Journal of Public Health Dentistry* **61**(3):172-7.

Paradies Y (2006). A systematic review of empirical research on self-reported racism and health. *Int J Epidemiol* **35**(4):888-901.

Ponce NA, Hoggatt KJ, Wilhelm M, Ritz B (2005). Preterm birth: the interaction of traffic-related air pollution with economic hardship in Los Angeles neighborhoods. *Am J Epidemiol* **162**(2):140-8.

Schell LM, Gallo MV (2012). Overweight and obesity among North American Indian infants, children, and youth. *Am J Hum Biol* **24**(3):302-13.

Williams DR, Williams-Morris R (2000). Racism and mental health: the African American experience. *Ethn Health* **5**(3-4):243-68.