Update to the California Communities Environmental Health Screening Tool

Proposed CalEnviroScreen 3.0

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OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

OEHHA Authors:

John Faust
Laura August
Komal Bangia
Rose Schmitz
Vanessa Galaviz
Julian Leichty
Shankar Prasad
Andrew Slocombe
Robbie Welling
Walker Wieland
Lauren Zeise

OEHHA Editors:

Allan Hirsch
David Siegel

CalEPA Reviewers:

Arsenio Mataka
Gina Solomon

DEDICATION

This version of CalEnviroScreen is dedicated to the memory of Dr. George Alexeeff, who served as OEHHA's director from 2011 until shortly before his passing in June 2015. Dr. Alexeeff played a critical role in the development of CalEnviroScreen and believed strongly in the importance of identifying California communities with signficiant pollution burdens and vulnerabilities. CalEnviroScreen is one of the most visible of Dr. Alexeeff's many accomplishments in the fields of public health and environmental protection.

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PREFACE TO VERSION 3.0

CalEnviroscreen 3.0 is the latest iteration of the California Communities Environmental Health Screening Tool. This proposed version of CalEnviroScreen incorporates recent data for nearly all indicators and improvements in the way some indicators are calculated to better reflect environmental conditions or a population's vulnerability to environmental pollutants. Two new indicators -- cardiovascular disease and rent-adjusted income -- have been added to help reflect health and socioeconomic vulnerability to pollution. These indicators were included partially in response to public comments that Version 2.0 did not include enough health indicators, and did not sufficiently account for variations in the cost of living around the state. The children-and-elderly indicator has been removed to address the concern that the indicator does not provide a good measure of the vulnerable elderly and children across the state. Instead, children and elderly are highlighted in a separate analysis, as well as in demographic data for each census tract. Additional explanation of these changes and all other updates to this draft are provided in the accompanying Summary of Changes document.

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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. CalEnviroScreen uses a science-based method for evaluating multiple pollution sources in a community while accounting for a community's vulnerability to pollution's adverse effects.

In 2014, over 9.3 million Californians lived in communities that were identified as "disadvantaged" by CalEPA due to the environmental conditions and vulnerability of people living in those communities. The designation of those communities was based on the results of CalEnviroScreen 2.0 that was finalized and released in October 2014. The Air Resources Board, other California Environmental Protection Agency (CalEPA) boards and departments, and other state agencies used these designations to allocate resources and make policy decisions intended to benefit these disadvantaged communities.

This update uses current methods and data to identify California's most burdened and vulnerable communities.

Statewide Evaluation

The Office of Environmental Health Hazard Assessment (OEHHA) has updated its statewide analysis of communities in California. Similar to previous versions of CalEnviroScreen, this version also identifies communities most burdened by pollution from multiple sources and most vulnerable to its effects, taking into account the socioeconomic and health status of people living in those communities. In doing so, CalEnviroScreen continues to:

- Produce a *relative*, rather than absolute, measure of pollution's impacts and vulernablities in California communities.
- Provide a baseline assessment and methodology that has been expanded and updated with additional information
- Evaluate multiple pollution sources, and stressors that measure a community's vulnerability to pollution.

Many factors, often referred to as stressors, contribute to a community's pollution burden and vulnerability. Integration of these multiple factors into a risk assessment is not currently feasible. Risk assessments are primarily designed to quantify health risks from a single pollutant or source at a time, often in one specific medium (e.g., air or water). Occasionally, groups of related contaminants can be considered together or aggregated. However, some community groups and scientists have criticized this approach as failing to adequately consider the totality of the health risks facing an individual community.

People in real life are simultaneously exposed to multiple contaminants from multiple sources and also have multiple stressors based on their health status as well as living conditions. Thus, the resulting cumulative health risk is also often influenced by nonchemical factors such as socioeconomic and health status of the people living in a community. In such situations, risk assessment has a limited ability to quantify the resulting cumulative risk because it requires extensive characterization of the chemicals present, the routes and levels of exposure, and the dose-response relationship for hundreds of chemicals for which data is neither currently available nor likely to be generated in the foreseeable future.

In addition, a methodology does not exist to fully integrate geographic factors (such as proximity to sources), intrinsic factors (health status), and extrinsic factors (socioeconomic status) into risk assessment. Hence, OEHHA and CalEPA developed CalEnviroScreen to conduct statewide evaluations of community-scale impacts through this screening tool.

Impact vs. Risk

A core purpose of developing CalEnviroScreen is to characterize "*impacts"* of pollution in communities with respect to factors that are not routinely included in risk assessment. Often, the terms *risk* and *impact* are used synonymously, suggesting that they describe the same outcome. However, the term *risk* means a probability of an injury or loss, while *impact* in this context refers more broadly to stressors that can affect health and quality of life. While risk assessment suggests a quantitative approach to evaluating injury or loss, impact assessment implies integrating both quantitative factors and those less readily measured or estimated, but that may increase the magnitude of adverse effects.

Public Review and Input

Recognizing the importance of transparency and public input into government's decision making, and that the primary goal of CalEnviroScreen is a step towards achieving environmental justice, this draft of CalEnviroScreen 3.0 is being released for public review and comment. In addition, OEHHA is hosting regional public workshops to share the proposed updates to the tool, answer questions, and take public comment.

This report follows the same format as previous CalEnviroScreen versions beginning with methodology, selection criteria for the 20 indicators, calculation of CalEnvioScreen score for an individual census tract followed by how the data for each indicator were selected and analyzed. The scores of each indicator and the final CalEnviroScreen scores for different areas of the state are presented as maps. The report concludes by providing the overall results of the statewide analysis, presented as maps showing the census tracts with highest CalEnviroScreen scores.

This draft update to CalEnviroScreen continues to:

- Provide a broad picture of the burdens and vulnerabilities that communities confront from environmental pollutants.
- Rely on the use of indicators that are measured or estimated and affect the resulting impact score.
- Analyze the data and present results at the census tract scale.

CalEnviroScreen 3.0 contains a number of important improvements over previous versions. The major changes and improvements include the following:

- Updating all indicators with the most recent available information.
- Improvements in the way some indicators are calculated to better reflect environmental conditions or population vulnerability.

- Adding a new health vulnerability indicator that reflects differences in cardiovascular disease rates.
- Adding a new socioeconomic factor to address concerns regarding the effects of differences in housing costs across the state.
- Removal of the *Age: Children and Elderly* indicator due to concerns that the indicator did not provide a good measure of the vulnerability of children and elderly. The indicator used in CalEnviroScreen 2.0 was the percent of the population under age 10 and over age 65. However, this measure emphasized census tracts with large retired populations, and did not address vulnerable elderly populations experiencing early mortality. The measure, as constructed, emphasized elderly over children in part because there is less variability across tracts in the percentage of children. Children and elderly were inversely correlated with each other. When CalEnviroScreen 2.0 data were evaluated, excluding the Age indicator did not result in significant changes in the percent children, elderly, and different racial/ethnic groups of the most highly-scoring census tracts. Additional information on the decision to remove the indicator of children and elderly, and the alternative approach to addressing age vulnerability is described in the accompanying Summary of Changes document.

METHOD

THE CALENVIROSCREEN MODEL

Definition of Cumulative Impacts

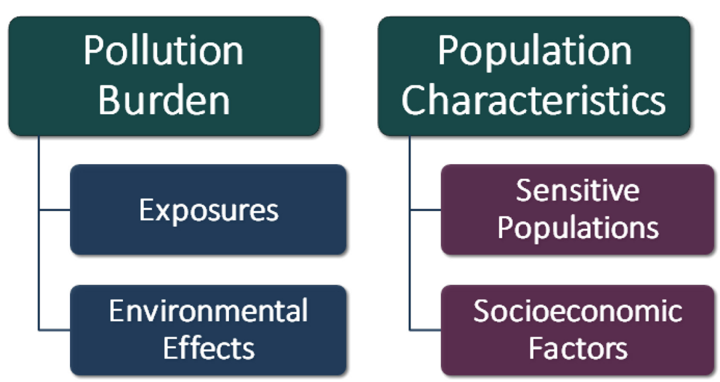
CalEPA adopted the following working definition of cumulative impacts in 2005:

> *"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 CalEPA 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.



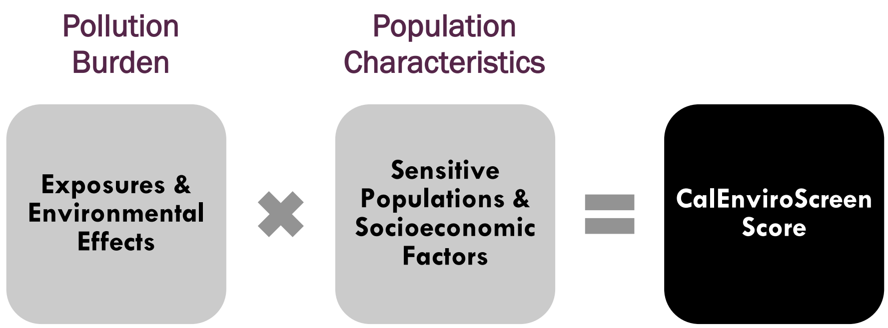
Model Characteristics

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.

2. *Risk Assessment Principles*: Some people (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)**

* Enough decimal places were retained in the calculation to eliminate ties.

Notes on Scoring System

In the CalEnviroScreen model, the Population Characteristics are 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. The final ordering of the communities is independent of the magnitude of the scale chosen for the Population Characteristics (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

CalEnviroScreen 3.0 uses the census tract scale as the unit of analysis. Census tract boundaries are available from the Census Bureau. These were updated in 2010. There are approximately 8,000 census tracts in California, representing a relatively fine scale of analysis. Census tracts are made up of multiple census blocks, which are the smallest geographic unit for which population data are available. Some census blocks have no people residing in them (unpopulated blocks).

CalEnviroScreen Scores and Race/Ethnicity, Young and Elderly Populations

The relationship between the calculated CalEnviroScreen score and race/ethnicity and children and elderly populations will be examined with the final data and will be released with the final version of this update.

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].

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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].

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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

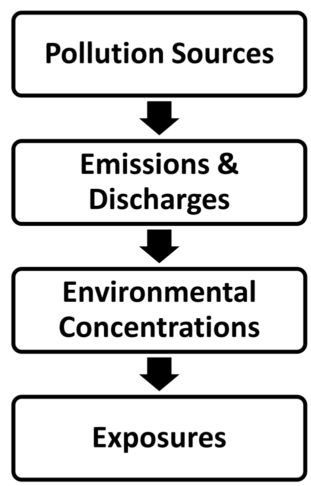
- An indicator should provide a measure that is relevant to the component it represents, in the context of the 2005 CalEPA cumulative impacts definition.
- Indicators should represent widespread concerns related to pollution in California.
- The indicators taken together should provide a good representation of each component.
- Pollution burden indicators should relate to issues that may be potentially actionable by CalEPA 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 census tract level geographical unit or translatable to the census tract 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. CalEnviroScreen uses data relating to pollution sources, releases, and environmental concentrations as indicators of potential human exposures to pollutants. Seven indicators were identified and found consistent with criteria for exposure indicator development. They are:



- Ozone concentrations in air
- PM 2.5 concentrations in air
- Diesel particulate matter emissions
- Drinking water contaminants 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 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. The environmental effects of pollution can also affect people by limiting their ability 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 with impaired physiological conditions, such as people with 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, 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 sensitive populations affected by toxic chemical exposures were identified and found consistent with criteria for development of these indicators:

- Asthma emergency department visits
- Cardiovascular disease (emergency department visits for heart attacks)
- 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
- Rent-adjusted income
- Unemployment

Indicator and Component Scoring

The indicator values for the census tracts 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 percentile averages are scaled so that they have a maximum value of 10 and a possible range of 0 to 10. Each average was divided by the maximum value observed in the state and then multiplied by 10 (see example calculation on Page 16). The scaling ensures that the pollution component and population component contribute equally to the overall CalEnviroScreen score.

* When a geographic area has no indicator value (for example, the census tract has no hazardous waste generators or facilities), it is excluded from the percentile calculation and assigned a score of zero for that indicator. When data are unreliable or missing for a geographic area, 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.

Pollution Burden

Exposures

- Ozone Concentrations
- PM2.5 Concentrations
- Diesel PM Emissions
- Drinking Water Contaminants
- Pesticide Use
- Toxic Releases from Facilities
- Traffic Density

Environmental Effects

- Cleanup Sites
- Groundwater Threats
- Hazardous Waste
- Impaired Water Bodies
- Solid Waste Sites and Facilities

Population Characteristics

Sensitive Populations

- Asthma Emergency Department Visits
- Cardiovascular Disease (Emergency Department visits for Heart Attacks)
- Low Birth-Weight Infants

Socioeconomic Factors

- Educational Attainment
- Linguistic Isolation
- Poverty
- Rent-Adjusted Income
- Unemployment

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 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 census tracts of the state. Maps are also developed highlighting the census tracts 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. 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 provide a meaningful measure of the pollution burden or population vulnerability.
- 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, uncertainties may arise because environmental conditions change over time, or large databases may contain errors or be incomplete, 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.
- Highly uncertain measurements have been excluded from the analysis (for example, socioeconomic measures with high margins of error).

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

- How well data on chemical uses or emissions 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 15 and 20 percent, is expected to be the most suitable application of the CalEnviroScreen results.

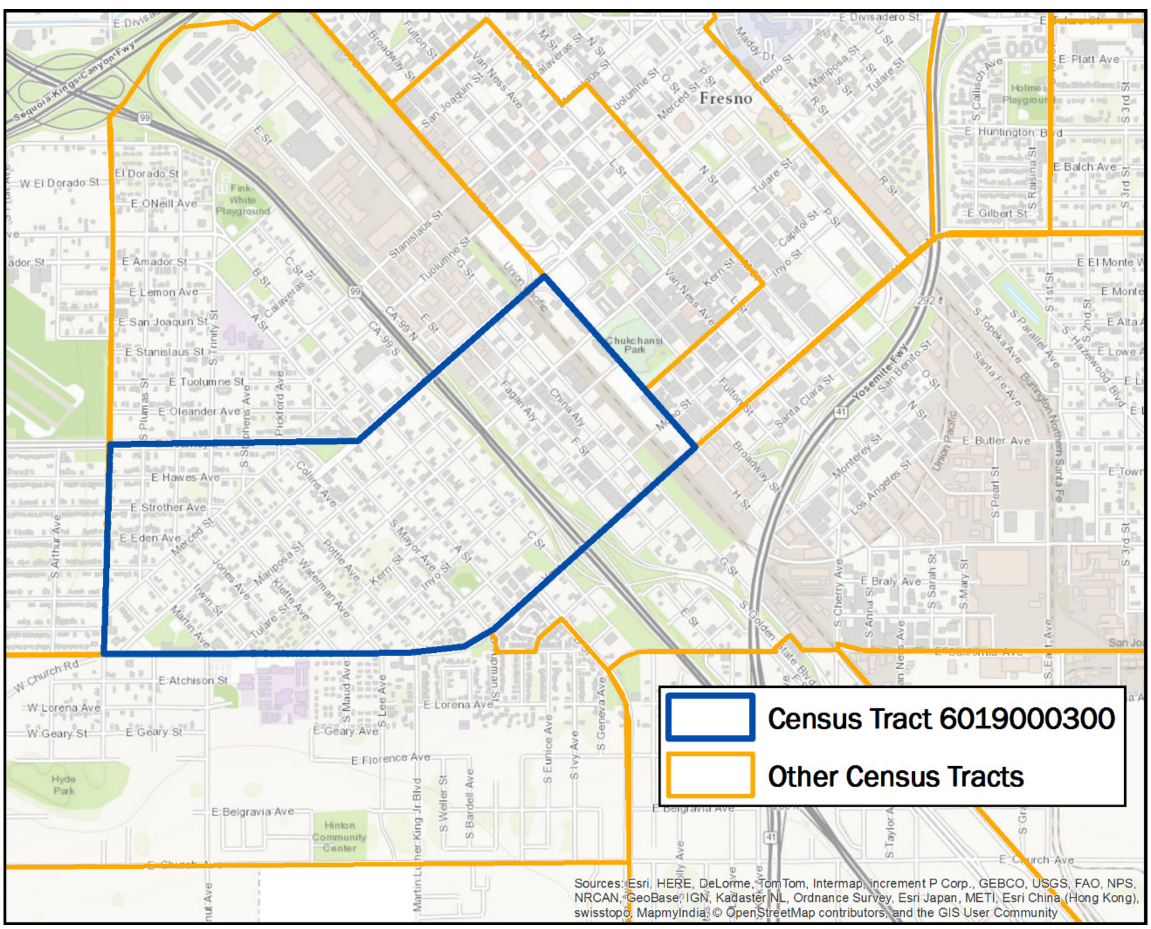
Reference Meehan August L, Faust JB, Cushing L, Zeise L, Alexeeff, GV (2012). Methodological Considerations in Screening for Cumulative Environmental Health Impacts: Lessons Learned from a Pilot Study in California. *Int J Environ Res Public Health 9(9):* 3069-3084.

EXAMPLE CENSUS TRACT: INDICATOR RESULTS AND CALENVIROSCREEN SCORE

One example census tract in western Fresno was selected to illustrate how an overall CalEnviroScreen score is calculated using the California Communities Environmental Health Screening Tool. Its census tract number is 6019000300.

Shown below are:

- An area map for the census tract and surrounding tracts.
- 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 was calculated for the example area, using CalEnviroScreen 3.0.



Exposure Indicators		
Indicator	Raw Value	Percentile
Ozone (concentration)	0.06	**98.18**
PM2.5 (concentration)	15.40	**97.22**
DieselPM (emissions)	53.07	**96.34**
Pesticide Use (lbs/sq. mi.)	26.78	**66.79**
Toxic Releases (RSEI toxicity-weighted releases)	35,783.10	**99.15**
Traffic (density)	434.57	**24.21**
Drinking Water (index)	682.29	**80.86**

Environmental Effects Indicators		
Indicator	Raw Value	Percentile
Cleanup Sites (weighted sites)	23.50	**80.68**
Groundwater Threats (weighted sites)	22.00	**73.71**
Hazardous Waste Factilities/ Generators (weighted sites)	0.01	**8.55**
Impaired Water Bodies (number of pollutants)	0.00	**0**
Solid Waste Sites/Facilities (weighted sites and facilities)	0.75	**28.37**

Sensitive Population Indicators		
Indicator	Raw Value	Percentile
Asthma (rate per 10,000)	142.28	98.42
Cardiovascular Disease (heart attacks per 10,000)	14.96	97.67
Low Birth Weight (percent)	8.12	97.04

Socioeconomic Factor Indicators		
Indicator	Raw Value	Percentile
Educational Attainment (percent)	27.0	72.14
Linguistic Isolation (percent)	14.4	72.55
Poverty (percent)	76.2	96.67
Rent-adjusted income ($)	15,862	95.87
Unemployment (percent)	10.7	52.51

Calculation of CalEnviroScreen Score for tract 6019000300

	Pollution Burden		Population Characteristics	
	Exposure Indicators (7)	Environmental Effects Indicators* (5)	Sensitive Population Indicators (3)	Socioeconomic Factor Indicators (5)
Indicator Percentile	98.18	(0.5 x 80.68)	98.42	72.14
	97.22	(0.5 x 73.71)	97.67	72.55
	96.34	(0.5 x 8.55)	97.04	96.67
	66.79	(0.5 x 0.00)		95.87
	99.15	(0.5 x 28.37)		52.51
	24.21			
	80.86			
Average Percentile	658.41 ÷ (7 + (0.5 x 5)= **69.31** *The percentiles for the pollution burden indicators are averaged with the environmental effects indicators half weighted.*		682.87 ÷ 7= **85.36** *The percentiles for the population characteristics indicators are averaged.*	
Scaled Component Scores (Range 0-10)	(69.31 ÷ 80.46**) x 10 = **8.61** *The average percentile is scaled by the statewide maximum pollution burden percentile.*		(85.36 ÷96.83***) x 10 = **8.82** *The average percentile is scaled by the statewide maximum population characteristics percentile.*	
CalEnviroScreen Score	8.61 x 8.82= **75.94** A score of **75.94** puts this census tract in the 95-100 percentile or **top 5%** of all CalEnviroScreen scores statewide.			

* Indicators from the Environmental Effects component were given half the weight of the indicators from the Exposures component.
** The tract with the highest average percentile for Pollution Burden in the state had a value of 80.46.
*** The tract with the highest average percentile for Population Characteristics in the state had a value of 96.83.

INDIVIDUAL INDICATORS: DESCRIPTION AND ANALYSIS

Pollution Burden: Exposure and Environmental Effect Indicators

AIR QUALITY: OZONE

Ozone pollution causes numerous adverse health effects, including respiratory irritation and exacerbation of 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

Mean of summer months (May-October) of the daily maximum 8-hour ozone concentration (ppm), averaged over three years (2012 to 2014).

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

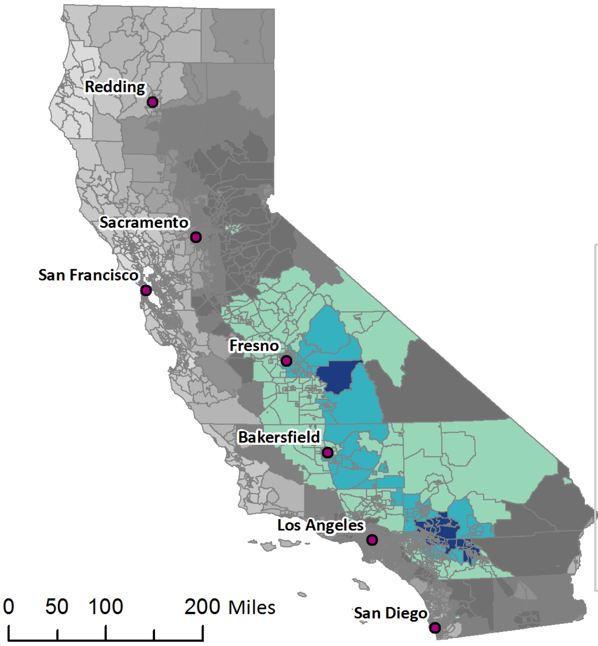
Schwartz 2011). A long-term study in southern California found that rates of asthma hospitalization for children increased during warm season episodes of high ozone concentration (Moore *et al.* 2008). Additional studies have shown that the increased risk is higher among children under 2 years of age, 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). A study in New Mexico found an association between ozone and both cardiovascular and respiratory emergency room visits during spring and summer months when ambient ozone concentrations are highest (Rodopoulou *et al*., 2014). 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).

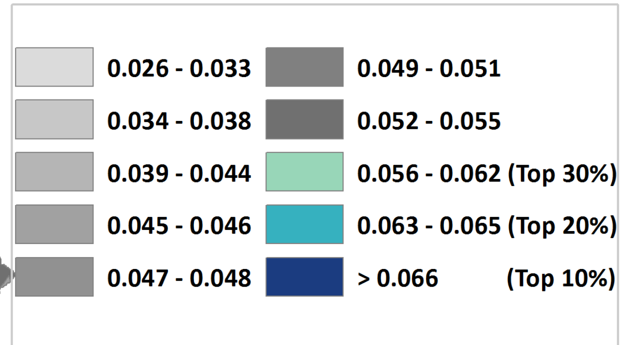
Method

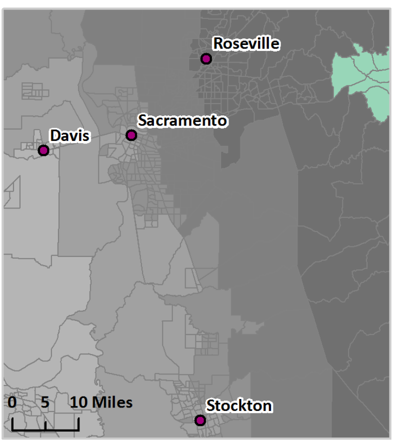
- Daily maximum 8-hour average concentrations for all monitoring sites in California were extracted from CARB's air monitoring network database for the summer months (May to October) for the years 2012-2014.
- The mean of summer months (May-October) were calculated by averaging all of the daily maximum 8-hour ozone concentration, during those months over three years (2012 to 2014).
- The mean concentrations from the monitoring stations were used to model ozone concentrations across the state of California. A modeling technique called Inverse Distance Weighting (IDW) was used. The basis of IDW is that the ozone concentrations measured at nearby monitors influence the estimated concentration at a given location more than ozone concentrations measured at monitors further away.
- Using the IDW model, daily maximum 8-hour concentration were estimated for the center of each census tract. These were averaged to obtain a single value for each census tract.
- Ozone values at census tracts with centers more than 50 km from the nearest monitor were not estimated using the model. For these tracts, the ozone value of the nearest air monitor was used.
- Census tracts were ordered by ozone concentration values and assigned a percentile based on the statewide distribution of values.

Ozone

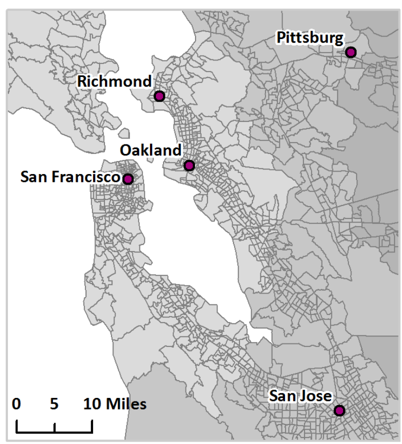
8-hour ozone concentrations, ppm (2011-2013)



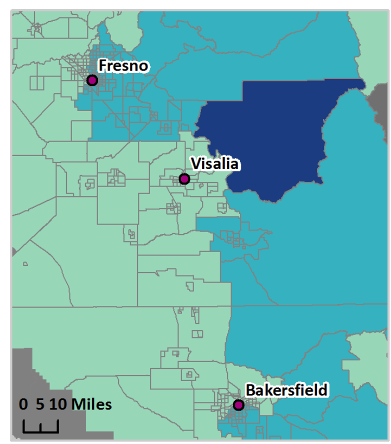




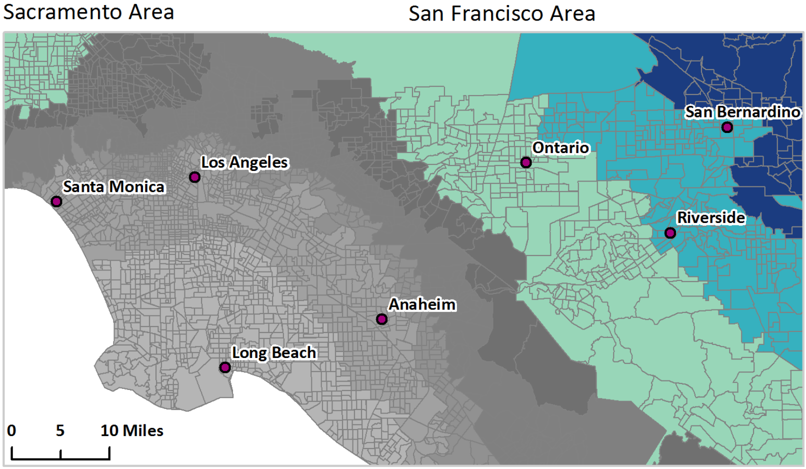
Sacramento Area



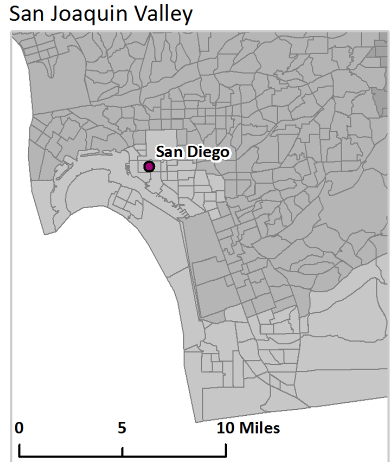
San Francisco Area



San Joaquin Valley



Greater Los Angeles Area



San Diego Area

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AIR QUALITY: PM2.5

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, $\mu g/m^3$), over three years (2012 to 2014).

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 seven counties nationwide will have PM2.5 concentrations that exceed this standard. All are in California (US EPA, 2012b).

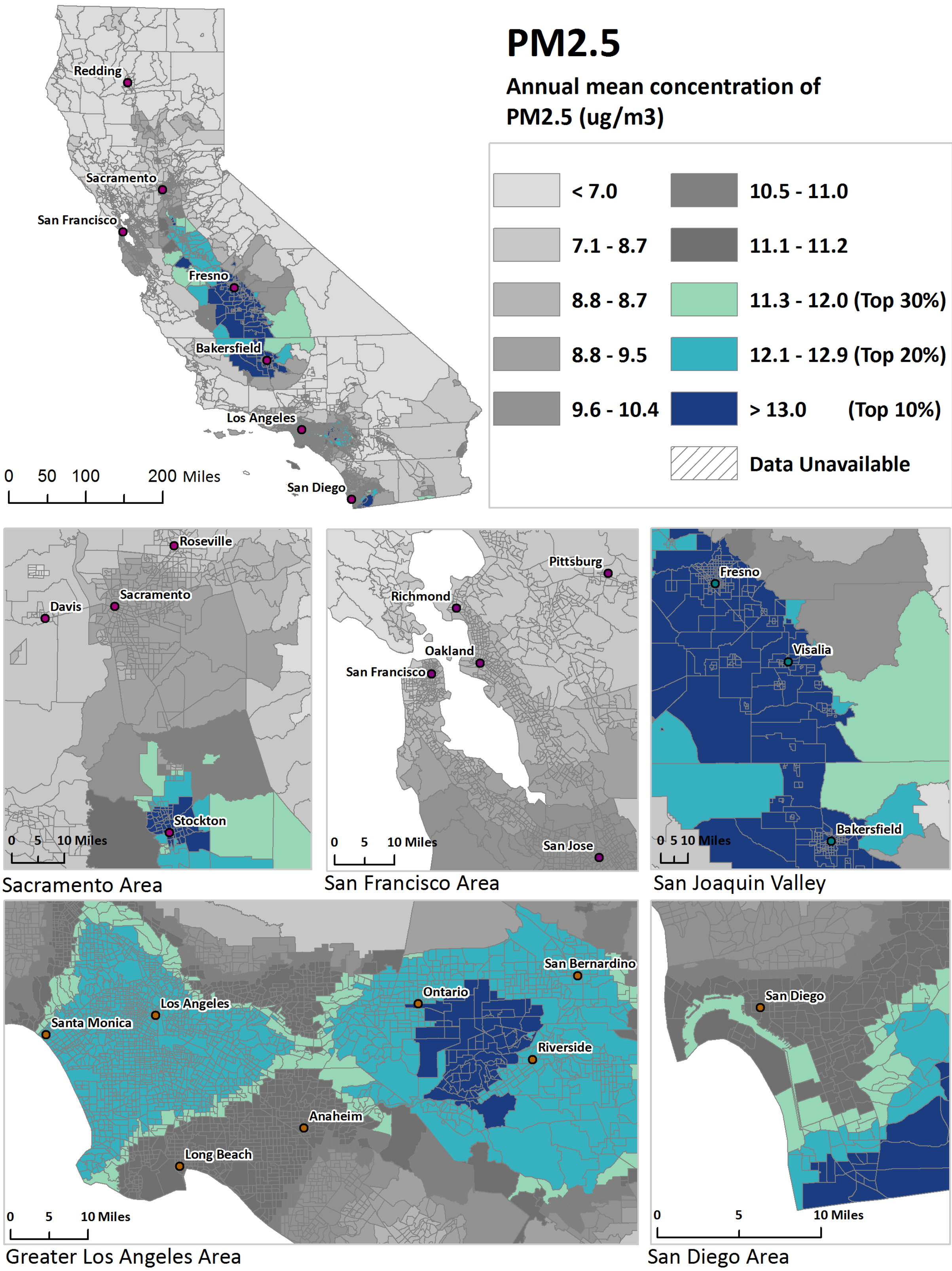
In children, researchers associated high ambient levels of PM2.5 in Southern California with adverse effects on lung development (Gauderman *et al.,* 2004). Another study in California found an association between components of PM2.5 and increased hospitalizations for several childhood respiratory diseases (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). A large study in six US communities, including Los Angeles, found an association between increased PM2.5 concentration and an increased risk of stroke (Adar *et al.*, 2013). A California study of long term PM2.5 exposure in women found significant associations with biomarkers of inflammation that can indicate increased risk of cardiovascular disease (Ostro *et al.,* 2014). 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 2012-2014 with the exception of the monitors at San Ysidro and Otay Mesa where only 2015 monitored data is available. For San Ysidro and Otay Mesa, estimated 2012-2014 values were developed based on a factor derived from nearby monitors.

- For all measurements in the time period, the mean concentrations were estimated at the geographic center of the census tract 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.
- PM2.5 values for census tracts with centers more than 50 kilometers from the nearest monitor were assigned a concentration based on satellite observations for the years 2006-2012, with the exception of the monitor in Portola (Plumas County), California. Satellite data was used for areas beyond 10 kilometers from the Portola monitor due to the localized nature of the pollution in Portola.
- Census tracts were ordered by the PM2.5 concentration values and assigned a percentile based on the statewide distribution of values.


PM2.5
Annual mean concentration of PM2.5 (ug/m3)
< 7.0
7.1 - 8.7
8.8 - 8.7
8.8 - 9.5
9.6 - 10.4
10.5 - 11.0
11.1 - 11.2
11.3 - 12.0 (Top 30%)
12.1 - 12.9 (Top 20%)
> 13.0 (Top 10%)
Data Unavailable
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 50 100 200 Miles
Roseville
Davis
Sacramento
Stockton
0 5 10 Miles
Sacramento Area
Pittsburg
Richmond
Oakland
San Francisco
San Jose
0 5 10 Miles
San Francisco Area
Fresno
Visalia
Bakersfield
0 5 10 Miles
San Joaquin Valley
San Bernardino
Ontario
Los Angeles
Santa Monica
Riverside
Anaheim
Long Beach
0 5 10 Miles
Greater Los Angeles Area
San Diego
0 5 10 Miles
San Diego Area

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DIESEL PARTICULATE MATTER

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 2012 summer day in July (kg/day).

Data Source

California Air Resources Board (CARB)
San Diego Association of Governments (SANDAG)

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 2012 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 (US EPA, 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 (US EPA, 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). A recent study of diesel exhaust inhalation by healthy non-smoking adults found an increase in blood pressure and other potential triggers of heart attack and stroke (Krishnan *et al.,* 2013)

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 2012 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 4 km-by-4 km 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.

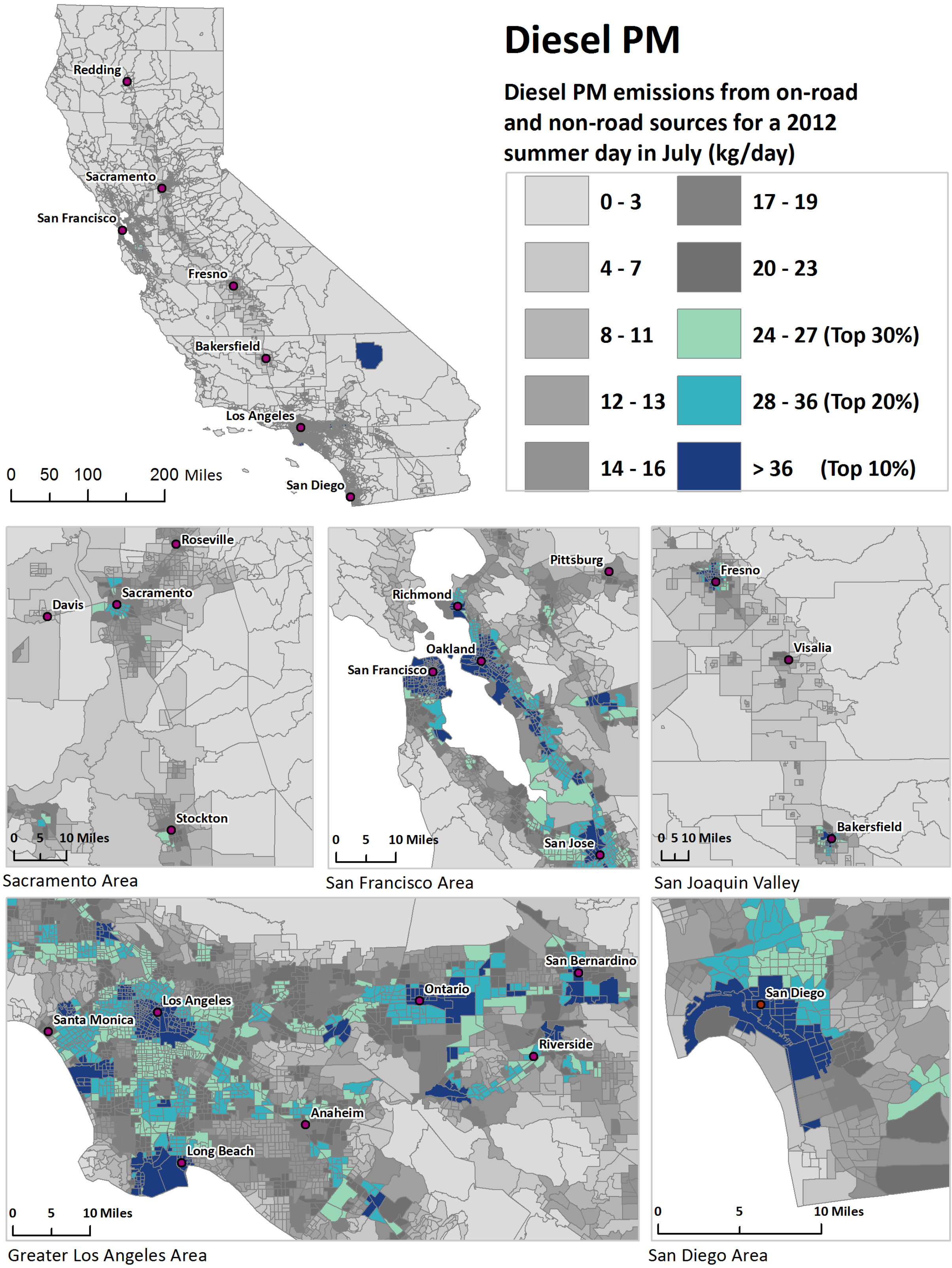
Gridded diesel PM from non-road sources were calculated as follows:

- 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; Forest Land; Military Bases; Non-irrigated Pasture Land; Rail Lines; Non-Urban Land; Commercial Airports; and Ports.

Adjustment for emissions at the US-Mexico border:

- To account for additional diesel PM emissions from sources on the Mexico side of the U.S.-Mexico border, CARB compared the results of its gridded diesel PM calculation with estimated diesel PM measurements at the Calexico and Otay Mesa monitors using measured nitrogen oxides (NO_X) as a surrogate. The measured NO_x concentration at the Calexico monitor indicated that the diesel PM emissions were underestimated. The diesel PM emissions estimates were adjusted to reflect the higher levels that occur at this location . The NO_x concentrations at the Otay Mesa monitor matched the estimated diesel PM emissions more closely and did not require any adjustment.

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 census tracts in ArcMap using a weighted average where the proportion of a grid-cell intersecting the populated portion (populated census blocks) of each census tract is used as the weight. The resulting census tract totals are assigned a percentile based on the statewide distribution of values.


Diesel PM
Diesel PM emissions from on-road and non-road sources for a 2012 summer day in July (kg/day)
0 - 3
4 - 7
8 - 11
12 - 13
14 - 16
17 - 19
20 - 23
24 - 27 (Top 30%)
28 - 36 (Top 20%)
> 36 (Top 10%)
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 50 100 200 Miles
Roseville
Davis
Sacramento
Stockton
0 5 10 Miles
Sacramento Area
Pittsburg
Richmond
Oakland
San Francisco
San Jose
0 5 10 Miles
San Francisco Area
Fresno
Visalia
Bakersfield
0 5 10 Miles
San Joaquin Valley
San Bernardino
Ontario
Los Angeles
Santa Monica
Riverside
Anaheim
Long Beach
0 5 10 Miles
Greater Los Angeles Area
San Diego
0 5 10 Miles
San Diego Area

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DRINKING WATER CONTAMINANTS

Californians receive their drinking water from a wide variety of sources and distribution systems. An estimated 98% of Californians received their water from public sources in 2013 (SOR, 2015). In 2014, approximately 97% of Californians using public systems received water that met all federal and state drinking water standards (SWRCB, 2016).

However, drinking water quality varies with location, water source, treatment method, and the ability of the water purveyor to remove contaminants before distribution. Because water is universally consumed, drinking water contamination has the potential to result in widespread exposures. Contaminants may be introduced into drinking water sources in many ways, such as by natural occurrence, accidents, industrial releases, and agricultural runoff.

California water systems have a high rate of compliance with drinking water standards. In 2014, systems serving only about 2.9 percent of the state's population were in violation of one or more drinking water standards (SWRCB, 2016). The drinking water contaminant index used in CalEnviroScreen 3.0 is not a measure of compliance with these standards. The drinking water contaminant index is a combination of contaminant data that takes into account the relative concentrations of different contaminants and whether multiple contaminants are present. The indicator does not indicate whether water is safe to drink.

Certain assumptions, data gaps and limitations within the indicator score methodology may affect the calculation of scores. For example, the indicator score is calculated using average contaminant concentrations over one compliance cycle (2005-2013). Therefore, those average concentrations may not be representative of current concentrations in treated drinking water. The indicator results do not provide a basis for determining when differences between scores are significant in relation to human health. Census tracts can encompass multiple public drinking water systems, and therefore, their scores may represent a combination of water contaminant data from several public drinking water systems and groundwater sources. As such, the drinking water contaminant score may not reflect the water that an *individual* resident of that tract is drinking. For a location within a census tract, more specific local water quality data may be available from the public water system serving that area. Public water systems are required to prepare annual Consumer Confidence Reports that provide detailed, system-specific information on water quality, health impacts and compliance with drinking water standards. These Consumer Confidence Reports provide drinking water quality information directly to the public. The U.S. Environmental Protection Agency offers guidance on finding water quality data in California: http://water.epa.gov/drink/local/ca.cfm

Indicator *Drinking water contaminant index for selected contaminants*

Data Source Drinking Water Systems Geographic Reporting Tool, California Environmental Health Tracking Program, California Department of Public Health (CDPH)
http://cehtp.org/page/water/water_system_map_viewer

Public Water System Location Data Permitting/Inspections/Compliance/Monitoring/Enforcement (PICME) database, California Department of Public Health

Safe Drinking Water Information System, U.S. Environmental Protection Agency
http://water.epa.gov/scitech/datait/databases/drink/sdwisfed/index.cfm

Water Quality Monitoring Database, CDPH
http://www.cdph.ca.gov/certlic/drinkingwater/Pages/EDTlibrary.aspx

Domestic Well Project, Groundwater Ambient Monitoring and Assessment (GAMA) Program, State Water Resources Control Board
http://www.waterboards.ca.gov/water_issues/programs/gama/domestic_well.shtml

Priority Basin Project, GAMA Program, State Water Resources Control Board and U.S. Geological Survey
http://www.waterboards.ca.gov/water_issues/programs/gama/priority_basin_projects.shtml

Rationale Low income and rural communities, particularly those served by small community water systems, can be disproportionately exposed to contaminants in their drinking water (VanDerslice, 2011; Balazs *et al.*, 2011).

Much of California relies on groundwater for drinking. In agricultural areas, nitrate from fertilizer application or animal waste can leach to groundwater and cause contamination of drinking water wells, although the distribution of nitrate occurrence and concentrations varies with soil type and crops planted (Lockhart *et al.,* 2013). Rural residents of the San Joaquin Valley receive water primarily from shallow domestic wells,. Elevated levels of nitrate in drinking water are associated with methemoglobinemia (blue baby syndrome), and may be associated with birth defects and miscarriages (Ruckart *et al.*, 2007). Perchlorate, a groundwater contaminant that can come from geologic, industrial and agricultural sources, is common in drier regions of the state (Fram & Belitz, 2011). Although for most people, ingested perchlorate comes primarily from food, on average, across all age groups, 20 percent comes from drinking water (Huber *et al.,* 2011). Perchlorate exposure during pregnancy appears to affect thyroid hormone levels in newborns, which can disrupt normal development (Hershman 2005, Steinmaus *et al.,* 2010). A study of bladder cancer in the U.S. found that drinking surface water was associated with an increased risk of mortality, and the authors suspected a link to low-level pesticide contamination (Colli & Kolettis, 2010).

Arsenic, a known human carcinogen, is a naturally occurring contaminant often found in groundwater in arid and semiarid regions, particularly in the San Joaquin Valley. Exposure to arsenic through drinking water is associated with elevated lung and bladder cancer rates, especially with early-life exposures (Steinmaus *et al.,* 2013). Balazs et al. (2012) found that communities with more low socioeconomic-status residents were more likely to be exposed to arsenic in their drinking water and more likely to receive water from systems with high numbers of water quality compliance violations. In an earlier study of nitrate concentrations and socioeconomic characteristics of water consumers, they found that small community water systems serving Latinos and renters supplied drinking water with higher levels of nitrate than systems serving fewer Latinos and a higher proportion of homeowners (Balasz *et al.*, 2011).

Method

A drinking water contaminant metric was calculated for each census tract through four broad steps (detailed more fully below):

1. Drinking water system boundaries were identified based upon established boundaries or, where necessary, the boundaries were approximated.
2. Drinking water contaminant data were associated with each water system and average concentrations were calculated for each contaminant and system.
3. The systems' average water contaminant concentration was re-allocated from the system boundaries to census tracts. The census tracts were then ranked to obtain a percentile score for each contaminant and tract.
4. A census tract contaminant index was calculated as the sum of the percentiles for all contaminants.

Drinking Water System Boundaries

- Water system boundaries were downloaded from the CDPH Environmental Health Investigation Branch's Drinking Water Systems Geographic Reporting Tool.
- If the system boundaries were not available, but system source locations were available, boundaries were approximated based on their locations and the population served by the system.
- For areas without known water systems and source locations, township boundaries from the Public Land Survey System

(approximately 6 miles square) were treated as the boundaries for the purpose of assigning water quality to people living in that area.

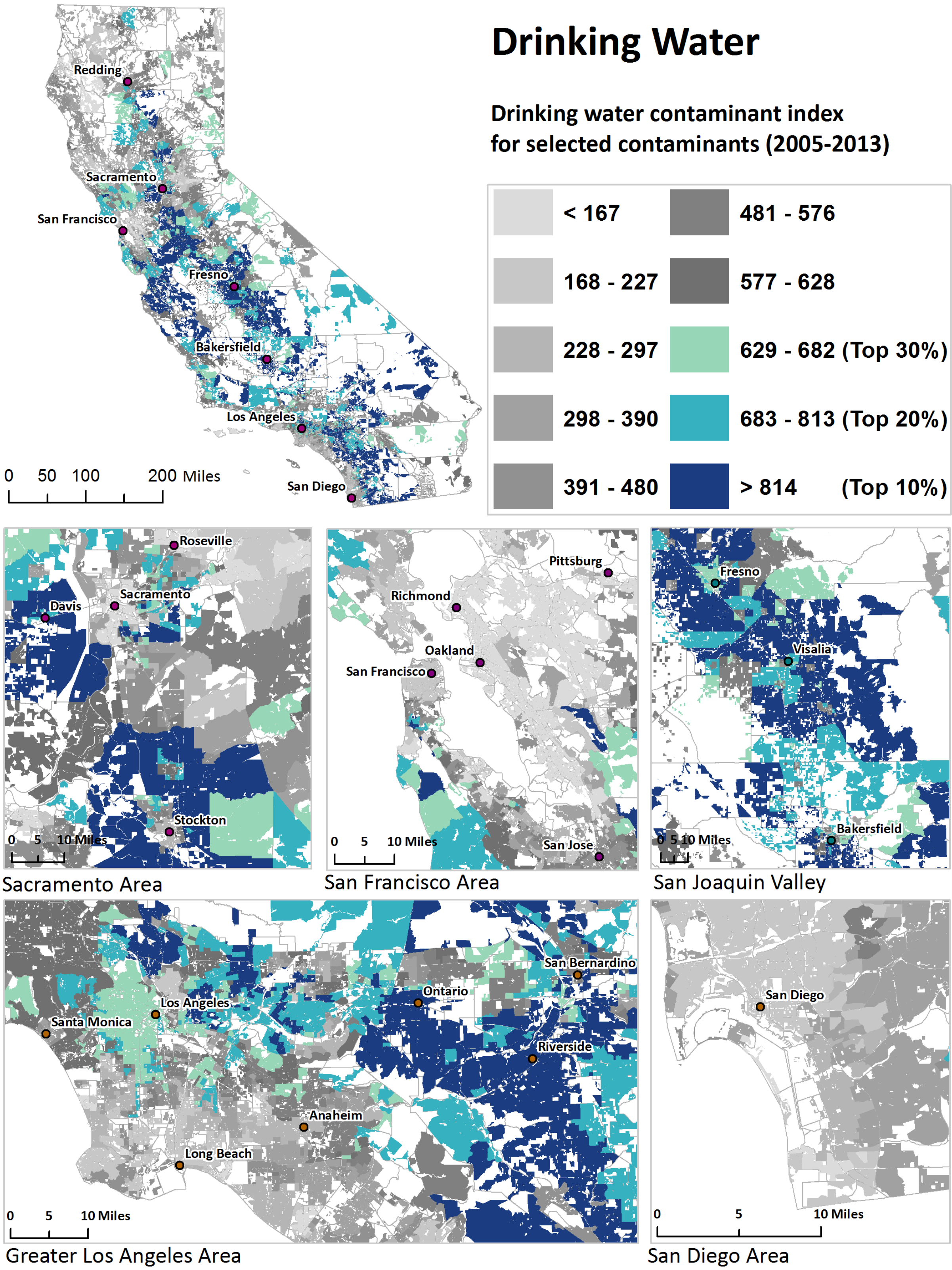
Drinking Water Contaminant Metric Calculation

- A subset of contaminants tested in drinking water across California was selected for the analysis (see Appendix) based on frequency of testing and detection in California drinking water. Monitoring data for these chemicals were obtained from CDPH's Water Quality Monitoring database from 2005-2013, the three most recent compliance periods. Water quality data representing treated/delivered water were associated with their water system first. If no treated/delivered water quality data for a system was available, but the system purchased water from wholesalers, the wholesaler's water quality was associated with the system. If no treated/delivered water data were reported in that time period for a given contaminant and system, water quality data from untreated or raw sources were used for that contaminant and system.
- For large water systems serving more than 100,000 people that rely on local sources of water and purchase water from wholesalers, the fraction of water that was purchased was identified from publicly available information (*e.g.*, water quality reports). If no information was found on fraction purchased, it was assumed that half of the water was purchased (including all systems serving less than 100,000 people that purchase water from wholesalers).
- Time-weighted average concentrations of each contaminant were calculated for each year for each sample source within a system. The average yearly concentrations were then averaged to create a source concentration. Then, the source concentrations within a system were averaged to calculate one concentration value for each chemical in each system. If purchased water from wholesalers was included, the calculation was adjusted by the fraction purchased.
- Areas without system or sample source data were assigned the average groundwater quality data for sources in the township in which they were located (raw or untreated community or non-community water system data, Domestic Well Project water quality data, and Priority Basin water quality data). People in these areas were assumed to drink groundwater.
- Violations of the Maximum Contamination Level for any chemical contaminant and Total Coliform rule were also

summed for each water system, serving as a basis for a "violation index."

Re-allocation from Water System Boundaries to Census Tracts

- Census *blocks* were assigned the contaminant concentration or violation index of the systems in which they fell. Partial census blocks were apportioned by area.
- Census tract concentration estimates for each contaminant were calculated as the population-weighted sum of the contaminant concentration for the census blocks (or partial blocks) within the tract. Violation index data were similarly calculated.
- The census tracts were ordered by the value of their contaminant concentrations or violation index. Percentiles were calculated.
- The overall drinking water contaminant score for a census tract is the sum of its percentiles for all contaminants and violations.



Note: This map displays only the populated portions of census tracts in California.

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Appendix

Contaminants Evaluated

Contaminant	Public Health Goal	Maximum Contaminant Level
Arsenic	0.004 µg/l	10 µg/l
Cadmium	0.04 µg/l	5 µg/l
Chromium, Hexavalent	0.02 µg/l	10 µg/l
Dibromochloropropane (DBCP)	0.0017 µg/l	0.2 µg/l
Lead	0.2 µg/l	15 µg/l
Nitrate (NO_3)	45 mg/l	45 mg/l
Perchlorate	6 µg/l	6 µg/l
Radium 226 and Radium 228 [Combined]	0.05 pCi/l 0.019 pCi/l	5 pCi/l
Total Trihalomethanes (THM)	---	80 µg/l
Tetrachloroethylene (PCE)	0.06 µg/l	5 µg/l
Trichloroethylene (TCE)	1.7 µg/l	5 µg/l
1,2,3-Trichloropropane	0.0007 µg/l	0.005 µg/l*
Uranium	0.43 pCi/l	20 pCi/l

* Notification level.

Violation Types Evaluated

Violation Type
MCL Violation
Total Coliform Rule Violation

PESTICIDE USE

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, averaged over three years (2012 to 2014).

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).

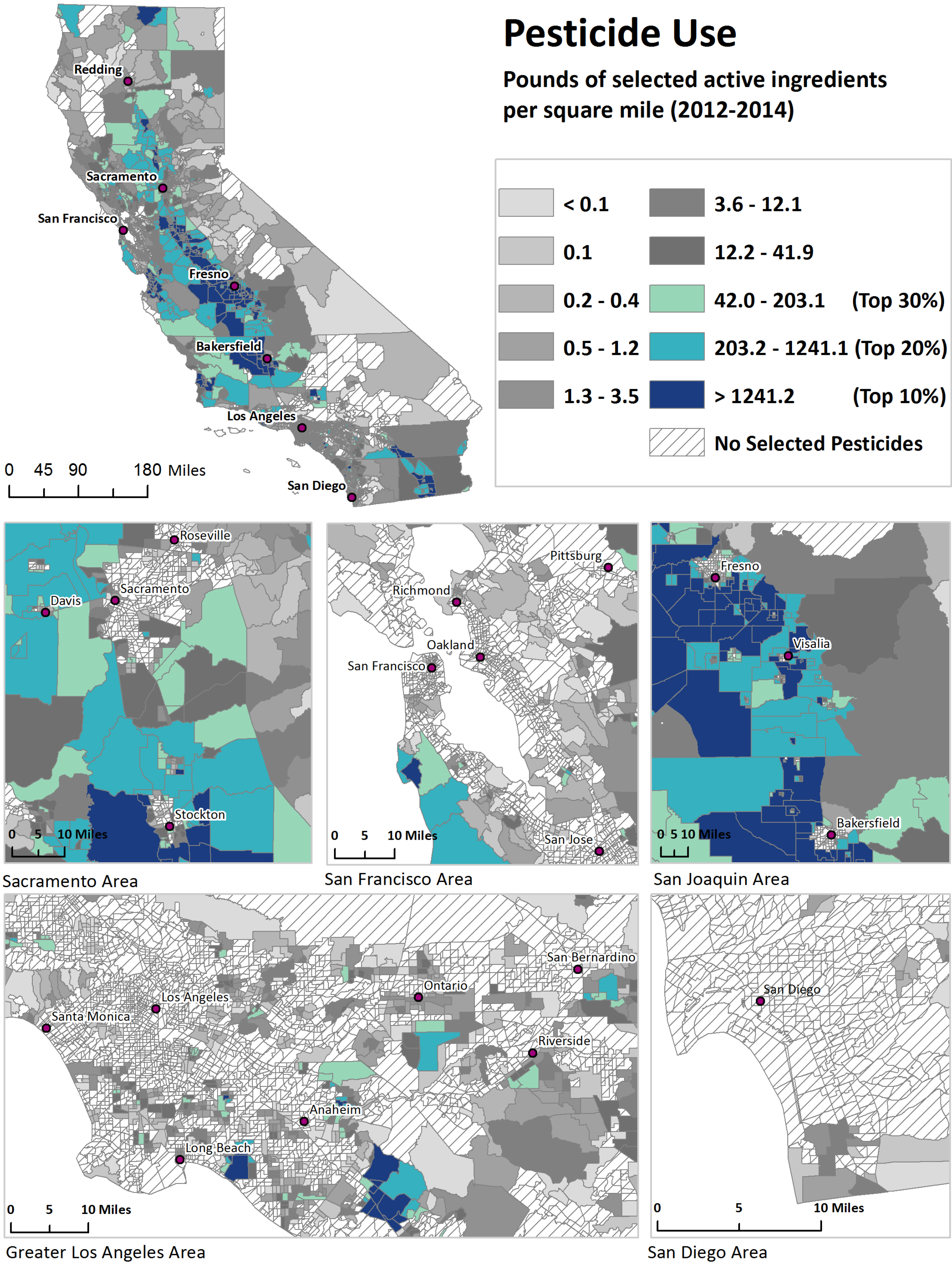
A large cohort study of male pesticide applicators found a significant association between the use of four specific insecticides and aggressive prostate cancer (Koutros *et al.*, 2012). Prenatal exposure to the organophosphate chlorpyrifos has been associated with abnormalities in brain structure in 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 70 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 2012, 2013, and 2014.

- Production pesticide use (total pounds of selected active ingredient) for MTRS records were matched to census tracts using a match file created in the GIS software ArcMap.
- Production pesticide use for each census tract was divided by each census tract's area.


Pesticide Use
Pounds of selected active ingredients per square mile (2012-2014)
< 0.1
0.1
0.2 - 0.4
0.5 - 1.2
1.3 - 3.5
3.6 - 12.1
12.2 - 41.9
42.0 - 203.1 (Top 30%)
203.2 - 1241.1 (Top 20%)
> 1241.2 (Top 10%)
No Selected Pesticides
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 45 90 180 Miles
Roseville
Davis
Sacramento
Stockton
0 5 10 Miles
Sacramento Area
Pittsburg
Richmond
Oakland
San Francisco
San Jose
0 5 10 Miles
San Francisco Area
Fresno
Visalia
Bakersfield
0 5 10 Miles
San Joaquin Area
San Bernardino
Ontario
Los Angeles
Santa Monica
Riverside
Anaheim
Long Beach
0 5 10 Miles
Greater Los Angeles Area
San Diego
0 5 10 Miles
San Diego Area

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 70 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*
- *Dimethyl disulfide (Paladin)*
- *Endosulfan**
- *Ethalfluralin*
- *Ethoprop*
- *Ethylene glycol*
- *Fenamiphos*
- *Fenpropathrin*
- *Fenthion*
- *Fludioxonil*
- *Flumioxazin*
- *Fosthiazate*
- *Hydrogen cyanamide*
- *Imazalil*
- *Linuron*
- *Malathion*
- *Metalaxyl*
- *Metam-sodium*
- *Methamidophos (Monitor)*
- *Methidathion*
- *Methomyl*
- *Methyl bromide*
- *Methyl isothiocyanate*
- *Methyl parathion*
- *Metrafenone*
- *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).*

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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

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 (US EPA) 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. US EPA has a computer-based screening tool called Risk Screening Environmental Indicators (RSEI) that analyzes these releases and models potential toxic exposures.

Indicator

Toxicity-weighted concentrations of modeled chemical releases to air from facility emissions and off-site incineration (averaged over 2011 to 2013).

Data Source

Risk Screening Environmental Indicators (RSEI)
U.S. Environmental Protection Agency (US EPA)
Toxic Release Inventory (TRI)
Mexico Registry of Emissions and Pollutant Transfer (RETC)

The TRI program was created by the federal Emergency Planning and Community Right-to-Know Act (EPCRA) and Pollution Prevention Act. The program maintains a database of emissions and other releases for certain toxic chemicals. The database is updated annually and includes:

- Chemicals identified in EPCRA Section 313 (593 individually listed chemicals and 30 chemical categories including three 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).

The Registry of Emissions and Pollutant Transfer (RETC) is Mexico's national database, similar to U.S. EPA's TRI, with information on pollutants released into the environment, including air, water, and soil. Current Mexican environmental regulations include a list of 200 chemicals that have mandatory reporting requirements to RETC, with their respective reporting thresholds.

RSEI is a computer-based screening tool that analyzes factors related to toxic releases that may result in chronic human health risks. RSEI analyzes these factors and calculates a numeric score. To give the score meaning, it must be ranked against other RSEI scores. RSEI combines TRI release data with toxicity estimates and models the dispersion of chemicals in air by incorporating physicochemical properties, weather and geography. US EPA gives each chemical release and potential exposure pathway is given a toxic weight. The toxicity weights are drawn from various programs of the US EPA, CalEPA, and the Agency for Toxic Substances and Disease Registry and consider both cancer and non-cancer endpoints. The resulting measure of exposure is additive across chemicals.

For all air releases, an EPA plume model is used to estimate long-term pollutant concentrations downwind of a stack or area source. The air releases resulting from incineration of waste after transfers to off-site facilities are modeled in the same manner. RSEI assigns the toxicity weighted concentrations to an 810 m by 810 m grid cell system. The total concentration based hazard scores for the entire grid cell system are available from US EPA as RSEI Geographic Microdata.

http://www.epa.gov/opptintr/rsei/pubs/rsei_methodology_v2.3.1.pdf

http://www.epa.gov/opptintr/rsei/pubs/rsei_users_manual_v2.3.1.pdf

http://www.epa.gov/tri/index.htm

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

http://www.semarnat.gob.mx/temas/gestion-ambiental/calidad-del-aire/registro-de-emisiones-y-transferencia-de-contaminantes-retc

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.

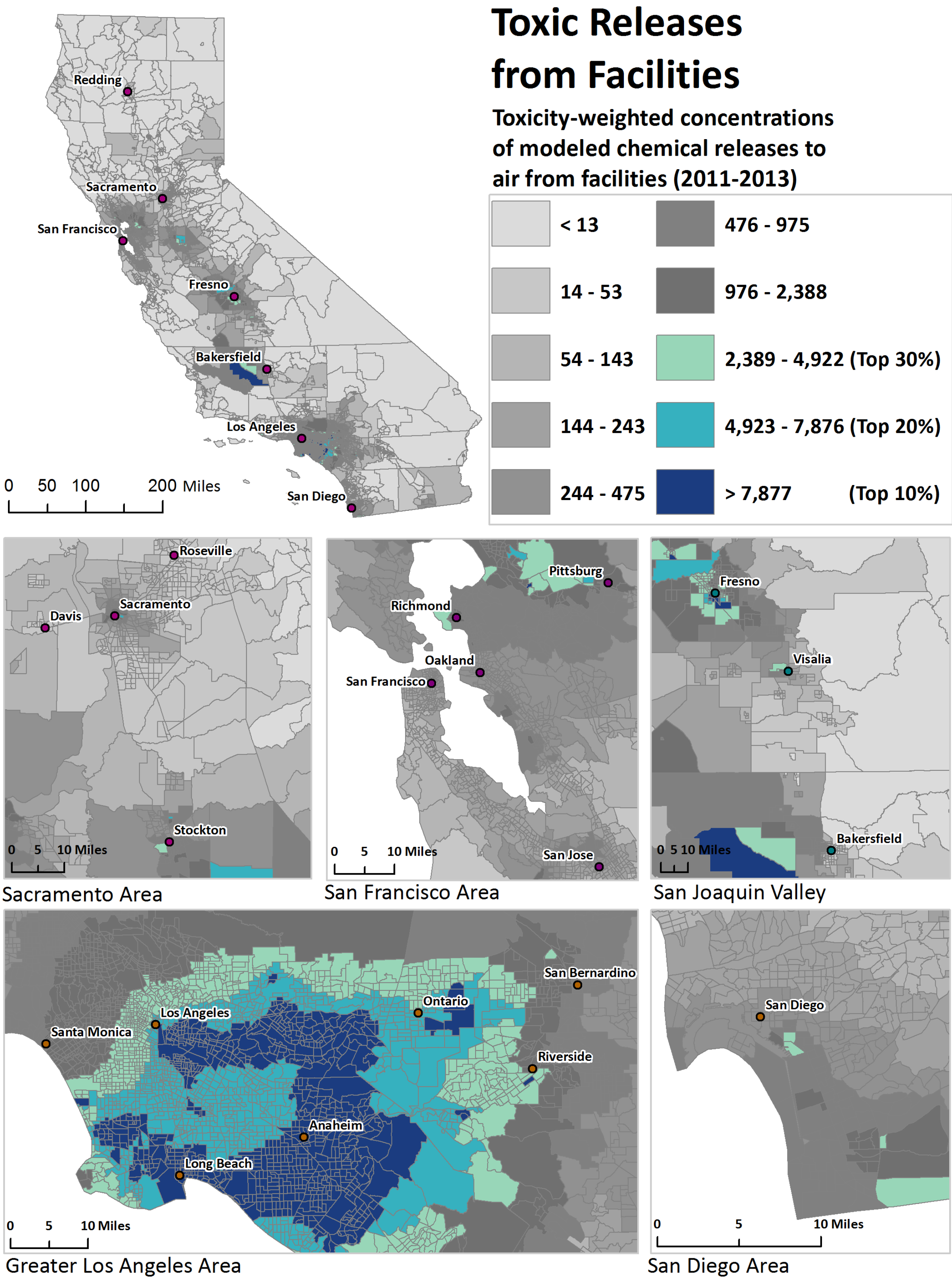
In addition to routine chemical releases, some communities located near TRI facilities are at risk from exposure to accidental chemical releases. A study of self-reported accident rates at U.S. chemical facilities over a five year period reported that 1,205 facilities (7.8% of facilities in the database) 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). A study that compared county-level TRI releases and health data found that increased chemical releases to air were significantly associated with higher total mortality as well as mortality from cardiovascular disease (Hendryx *et al.,* 2014).

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

- California TRI air releases for years 2011 through 2013 were modeled to RSEI by Abt Associates, US EPA contractors for the RSEI program (Releases to land and water were not included.)
- Emissions reported to RETC for the years 2011 to 2013 from Mexican facilities within 49 kilometers of the California border were also provided to Abt Associates for inclusion in the RSEI model.
- Census tract-level estimates for RSEI hazard-weighted concentrations were made by taking a land-area weighted average of the block-level values for each tract. Land area information was obtained from a 2010 Census Tiger Line block shapefile.
- The average of the 2011 to 2013 toxicity weighted concentration estimates for census tracts were sorted and assigned a percentile based on their position in the distribution.



Toxic Releases from Facilities
Toxicity-weighted concentrations of modeled chemical releases to air from facilities (2011-2013)
< 13
14 - 53
54 - 143
144 - 243
244 - 475
476 - 975
976 - 2,388
2,389 - 4,922 (Top 30%)
4,923 - 7,876 (Top 20%)
> 7,877 (Top 10%)
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 50 100 200 Miles
Roseville
Davis
Sacramento
Stockton
0 5 10 Miles
Sacramento Area
Pittsburg
Richmond
Oakland
San Francisco
San Jose
0 5 10 Miles
San Francisco Area
Fresno
Visalia
Bakersfield
0 5 10 Miles
San Joaquin Valley
San Bernardino
Ontario
Los Angeles
Santa Monica
Riverside
Anaheim
Long Beach
0 5 10 Miles
Greater Los Angeles Area
San Diego
0 5 10 Miles
San Diego Area

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TRAFFIC DENSITY

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 census tract boundary (2013)

Data Source

California Environmental Health Tracking Program (CEHTP), California Department of Public Health
US Department of Transportation and US Customs and Border Protection
San Diego Association of Governments (SANDAG)

Data on the amount of traffic traveling on major roadways statewide are available. Traffic data was complied and analyzed by CEHTP. The data on traffic volumes were purchased from TrafficMetrix, Information on current traffic volumes up to the year 2013 was purchased from the operator of the TrafficMetrix database, which includes CalTrans traffic monitoring data as well as other sources of local traffic data. Digital road data were purchased separately from TeleAtlas, a mapping company.

For this analysis, CEHTP developed a traffic linkage program using the data on traffic counts and road segments and modeled traffic for road segments with missing counts. CEHTP's program calculates traffic density within a 150 meter buffer of the census tract boundary. Traffic density was calculated as the sum of all road length-adjusted traffic volumes per hour divided by the total road length in and within 150 meters of each census tract.

The most recent year of traffic volumes are from 2013 and when available, 2013 or the most recent volumes were selected.

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). A U.S. Centers for Disease Control and Prevention study based on the 2010 Census found that Latinos, non-whites, foreign born and people who speak a language other than English at home were most likely to live within 150 meters of a major highway (Boehmer *et al*., 2013). 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).

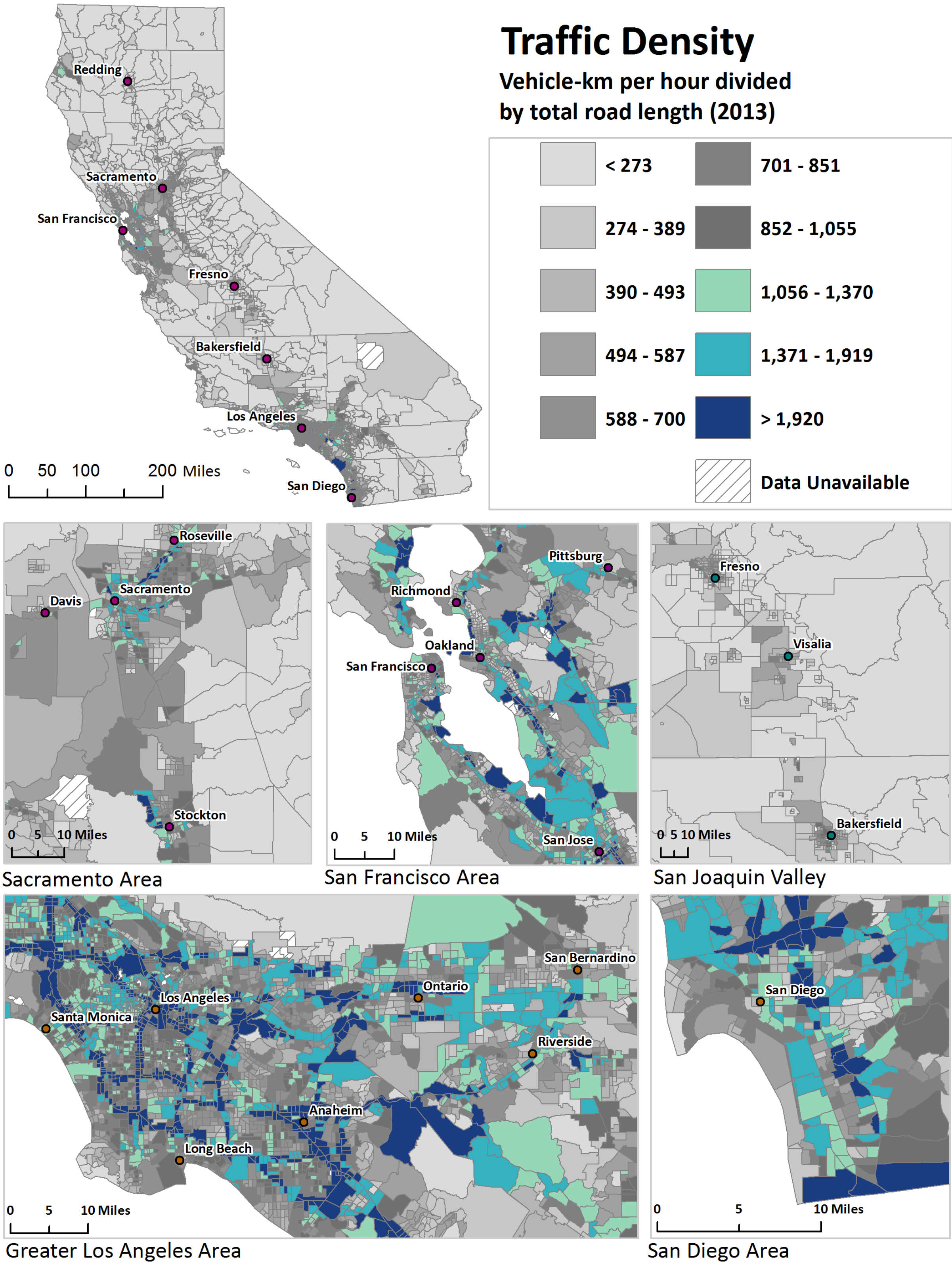
Exposure to air pollutants from vehicle emissions has been linked to adverse birth outcomes, such as low birth weight and preterm birth (Ghosh *et al*., 2012; Ritz *et al.* 2007). A recent study of children in Los Angeles found that those with the highest prenatal exposure to traffic-related pollution 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 2010 census tracts in California and the area of the buffered census tract was calculated by CEHTP. A buffer was chosen to account for roadways near census tract 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 traffic volume data (from TrafficMetrix) was linked to the corresponding road segment (from TeleAtlas) in a geographic information system (GIS).
- The buffered cenus tracts were intersected with the linked data on traffic volumes and roads. For each road within the buffer, a length-adjusted volume was calculated and summed for all roads in the buffer. The total amount of road length within the buffered census tract was also calculated.
- Due to differences in the length of road segments across the state, a length-adjusted traffic volume metric was selected. This metric multiplies traffic volumes by the length of the road segment.
- Traffic density was then calculated by dividing the sum of all length-adjusted traffic volumes within the buffered census tract (vehicle-km/hr) by the sum of the length of all road segments within the buffered census tract (km).
- Traffic density (vehicles-km/hr/km) is represented as the number of vehicles (adjusted by road segment lengths in kilometers) per hour per kilometer of roadways within the buffered census tract.
- Traffic density from roads in Mexico within 150 meters of the US-California border were also included in the indicator. Traffic data on major Mexican roadways within 150 meters of the border was provided by SANDAG for the Tijuana area. Information on parallel roads near other border crossings, such as Mexicali, was not available at the time of this update.
- Data on the number of vehicles crossing the six ports of entry into the United States as well as traffic on Mexican roadways within 150 meters of the border were also included. This data came from the US Department of Transportation based on data from the US Customs and Border Protection. Border crossing counts at the six ports of entry into the US were summed for the number of trucks, busses and personal vehicles coming into the US in 2013. These counts were multipled by two to account for vehicles leaving the US, since this data is not collected.
- Census tracts were sorted by traffic density and assigned percentiles based on the distribution.


Traffic Density
Vehicle-km per hour divided by total road length (2013)
< 273
274 - 389
390 - 493
494 - 587
588 - 700
701 - 851
852 - 1,055
1,056 - 1,370
1,371 - 1,919
> 1,920
Data Unavailable
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 50 100 200 Miles
Roseville
Davis
Sacramento
Stockton
0 5 10 Miles
Sacramento Area
Pittsburg
Richmond
Oakland
San Francisco
San Jose
0 5 10 Miles
San Francisco Area
Fresno
Visalia
Bakersfield
0 5 10 Miles
San Joaquin Valley
San Bernardino
Ontario
Los Angeles
Santa Monica
Riverside
Anaheim
Long Beach
0 5 10 Miles
Greater Los Angeles Area
San Diego
0 5 10 Miles
San Diego Area

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CLEANUP SITES

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 census tract.
(Data downloaded May 2016)

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. Weights were also adjusted based on proximity to populated census blocks.

Data Source

EnviroStor Cleanup Sites Database,
Department of Toxic Substances Control (DTSC)

US Environmental Protection Agency, Region 9
Region 9 NPL Sites (Superfund Sites) Polygons

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."

US EPA 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 or the estimated extent of contamination.

http://www.envirostor.dtsc.ca.gov/public/

https://edg.epa.gov/clipship/

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.

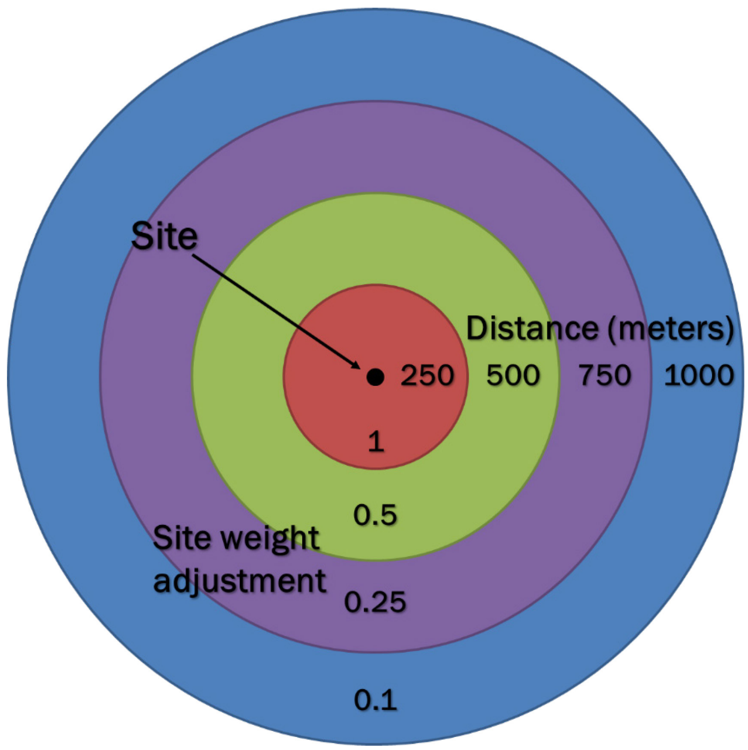
It generally takes many years for a site to be certified as clean, and cleanup work is often delayed due to cost, litigation, concerns about liability or detection of previously unrecognized contaminants. Contaminated sites also have the potential to degrade nearby wildlife habitats, resulting in potential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

Method

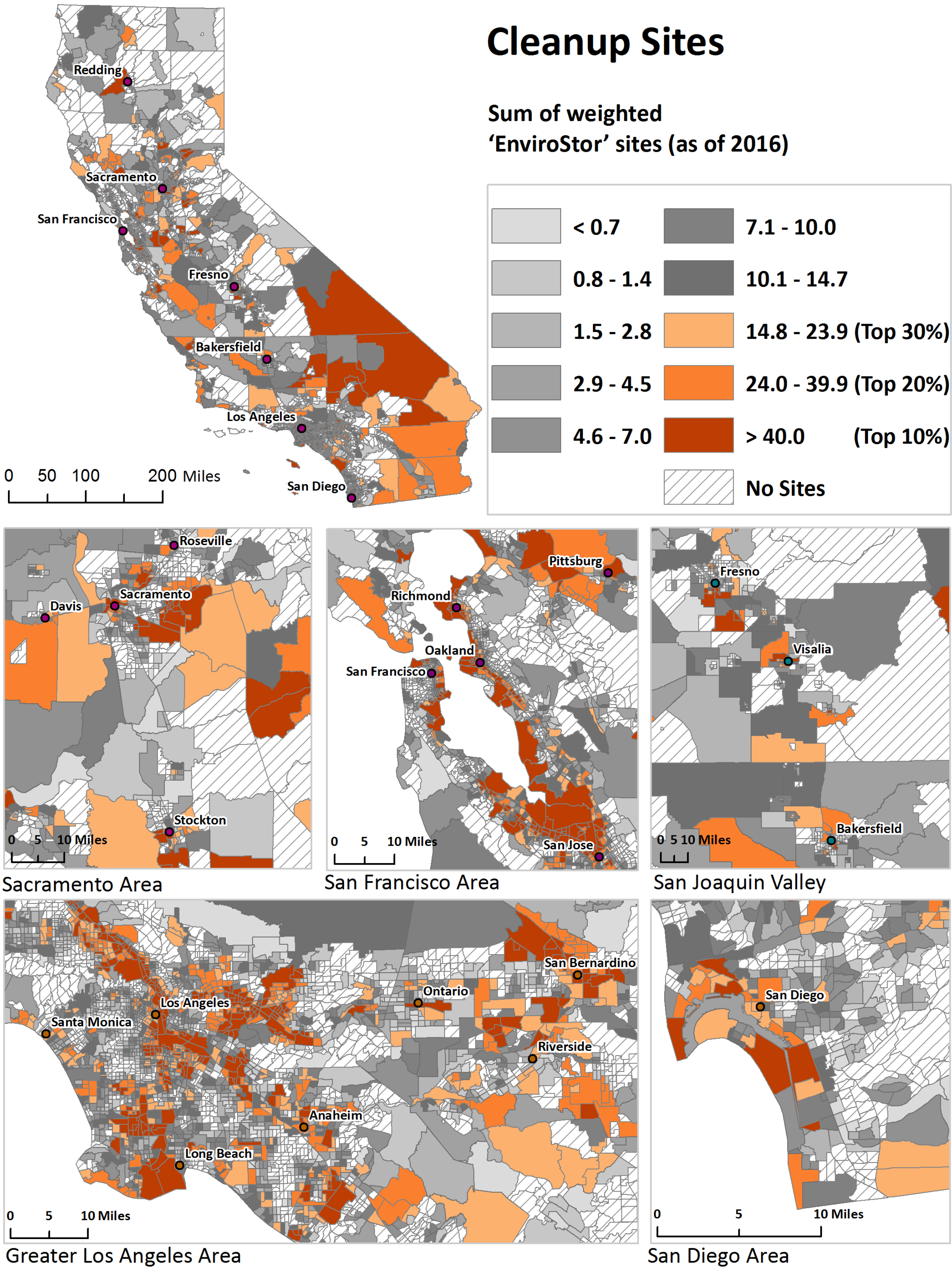
- Data on cleanup site type, status, and location (coordinate or address) for the entire state were obtained from DSTC's EnviroStor database.
- Sites with a valid latitude and longitude were mapped and sites with address only were geocoded in ArcMap. Sites without a valid latitude and longitude or unrecognizable address were excluded from the analysis.
- US EPA Region 9 National Priority List (NPL) polygon shapefile boundary data were downloaded from the Environmental Dataset Gateway.
- Polygon boundaries of California NPL sites were identified. Sites were assigned a score of 10 or 12 (as a federal Superfund site).
- EnviroStor sites with a NPL polygon representation were used instead of points.
- 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 0 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.

- The weights for all sites were adjusted based on the distance they fell from populated census blocks. Sites further than 1000m from any populated census block were excluded from the analysis.
- Site weights were adjusted by multiplying the weight by 1 for sites less than 250m, 0.5 for sites 250-500m, 0.25 for sites 500-750m, and 0.1 for sites 750-1000m from the nearest populated census blocks within a given tract.



- Each census tract was scored based on the sum of the adjusted weights (in ArcMap).
- Summed census tract scores were ordered and assigned percentiles.


Cleanup Sites
Sum of weighted
'EnviroStor' sites (as of 2016)
< 0.7
0.8 - 1.4
1.5 - 2.8
2.9 - 4.5
4.6 - 7.0
7.1 - 10.0
10.1 - 14.7
14.8 - 23.9 (Top 30%)
24.0 - 39.9 (Top 20%)
> 40.0 (Top 10%)
No Sites
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 50 100 200 Miles
Roseville
Davis
Sacramento
Stockton
0 5 10 Miles
Sacramento Area
Pittsburg
Richmond
Oakland
San Francisco
San Jose
0 5 10 Miles
San Francisco Area
Fresno
Visalia
Bakersfield
0 5 10 Miles
San Joaquin Valley
San Bernardino
Ontario
Los Angeles
Santa Monica
Riverside
Anaheim
Long Beach
0 5 10 Miles
Greater Los Angeles Area
San Diego
0 5 10 Miles
San Diego Area

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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 table below 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 census tract, 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).
- *Tiered CA Permit Sites*: These facilities manage waste not regulated under RCRA, but regulated as a hazardous waste by the State of California. These facilities include but are not limited to recyclers, oil transfer stations, and precious metals recyclers.
- *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)

Number of Cleanup Sites in CalEnviroScreen 3.0: Approximately 5,700

Site Type	% of Sites
Military Evaluation	20%
Voluntary Cleanup	20%
Tiered Permit	15%
State Response	14%
Evaluation	10%
Corrective Action	8%
Historical	6%
School Cleanup	5%
National Priorities List (NPL) (with boundaries)	1%
Federal Superfund (boundaries unavailable)	1%

GROUNDWATER THREATS

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 census tract. (Data downloaded June 2016)

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). The indicator takes into account information about the type of site, its status, and its proximity to populated census blocks.

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, produced water ponds, 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, Division of Oil, Gas & Geothermal 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

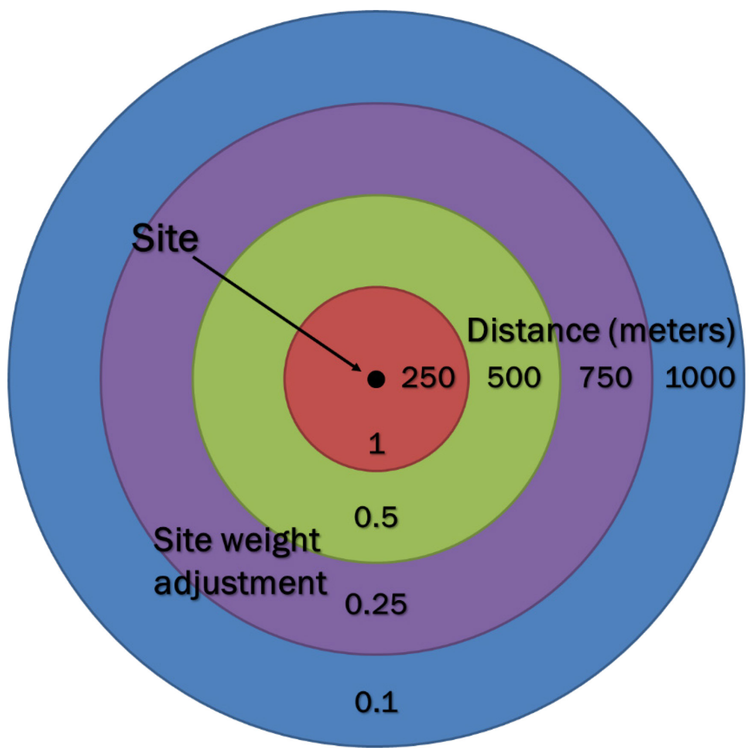
Common groundwater pollutants found at LUST and cleanup sites in California include gasoline and diesel fuels, chlorinated solvents and other volatile organic compounds (VOCs) such as benzene, toluene, and methyl tert-butyl ether (MTBE); heavy metals such as lead, chromium and arsenic; polycyclic aromatic hydrocarbons (PAHs); persistent organic pollutants like polychlorinated biphenyls (PCBs); DDT and other insecticides; and perchlorate (SWRCB, 2012; DPR, 2011; US EPA, 2002). An assessment of benzene exposure from a fuel leak concluded that soil and groundwater contamination could put nearby residents at risk and could have caused adverse health effects (Santos *et al.,* 2013). 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

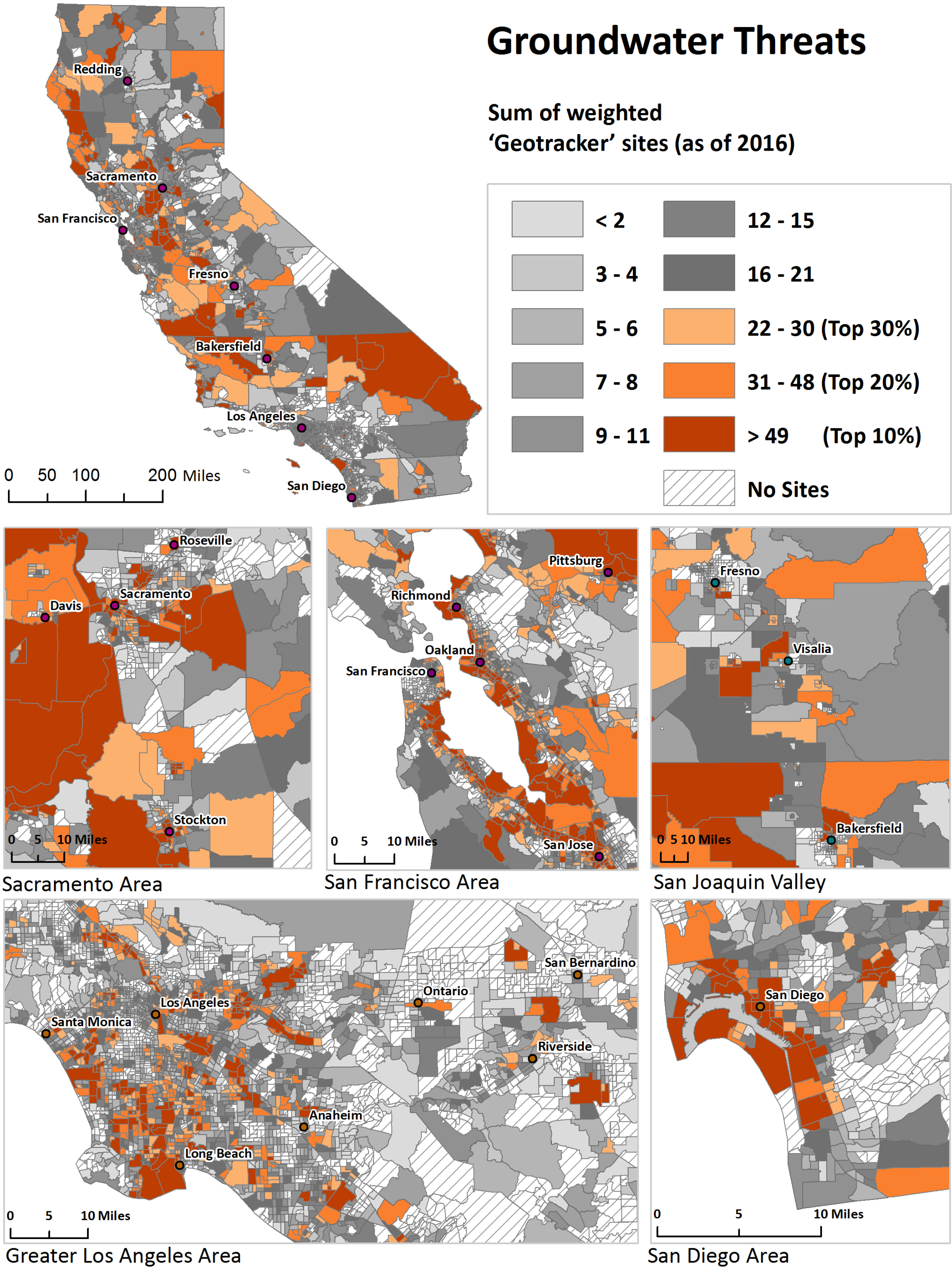
- Data on cleanup site type, status, and location (coordinate or address) for the entire state were downloaded from GeoTracker (http://geotracker.waterboards.ca.gov/data_download.asp; GeoTracker Cleanup Sites).
- Sites with a valid latitude and longitude were mapped and sites with address only were geocoded in ArcMap. Sites without a valid latitude and longitude or unrecognizable address were excluded from the analysis.
- 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 1 to 15 in consideration of both the site type and status. (See Appendix.)

- The weights for all sites, except LUST Cleanup Program and military UST sites, were adjusted based on the distance they fell from populated census blocks. Sites further than 1000m from any populated census block were excluded from the analysis. LUST Cleanup Program and military UST sites were not adjusted, but if these sites fell further than 250m from populated census blocks, they were excluded.
- Site weights were adjusted by multiplying the weight by 1 for sites less than 250m, 0.5 for sites 250-500m, 0.25 for sites 500-750m, and 0.1 for sites 750-1000m from the nearest populated census blocks within a given tract. Sites outside of a census tract, but less than 1000m from one of that tract's populated blocks were similarly adjusted based on the distance to the nearest block from that tract (See image below).



- Each census tract was scored based on the sum of the adjusted weights for sites it contains or is near (in ArcMap).
- Census tracts were ordered based on their summed scores and were assigned percentiles.


Groundwater Threats
Sum of weighted
'Geotracker' sites (as of 2016)
< 2
3 - 4
5 - 6
7 - 8
9 - 11
12 - 15
16 - 21
22 - 30 (Top 30%)
31 - 48 (Top 20%)
> 49 (Top 10%)
No Sites
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 50 100 200 Miles
Roseville
Davis
Sacramento
Stockton
0 5 10 Miles
Sacramento Area
Pittsburg
Richmond
Oakland
San Francisco
San Jose
0 5 10 Miles
San Francisco Area
Fresno
Visalia
Bakersfield
0 5 10 Miles
San Joaquin Valley
San Bernardino
Ontario
Los Angeles
Santa Monica
Riverside
Anaheim
Long Beach
0 5 10 Miles
Greater Los Angeles Area
San Diego
0 5 10 Miles
San Diego Area

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Appendix

Weighting Matrix for Groundwater Threats

Groundwater threats from the GeoTracker database were weighted on a scale of 1 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 because they are completed or were referred and tracked by another agency.

For a given census tract, the weighted scores of all facilities in the area were summed after adjusting for proximity to populated census blocks.

Site Type	Status	Weight
Land Disposal Sites [Military Privatized Site*]	Open – Remediation	10
	Open - Assessment & Interim Remedial Action	10
	Open - Site Assessment	6
	Open	3
	Open – Operating	3
	Open - Verification Monitoring	3
	Open - Closed / Monitoring	2
	Open – Inactive	2
	Open - Eligible for Closure	Exclude
	Open – Proposed	Exclude
Produced Water Ponds	Active	5
	Inactive	2
LUST Sites [Military UST Site*]	Open – Remediation	3
	Open - Assessment & Interim Remedial Action	3
	Open - Site Assessment	2
	Open - Verification Monitoring	2
	Open – Inactive	1
	Open - Eligible for Closure	Exclude
Cleanup Program Sites [Military Cleanup Site*]	Open - Assessment & Interim Remedial Action	15
	Open – Remediation	15
	Open - Site Assessment	10
	Open - Reopen Case	10
	Open - Verification Monitoring	6
	Open – Inactive	3
	Open - Eligible for Closure	Exclude

*Military sites have unique site types, but receive the same weights as their Land Disposal, Cleanup, and LUST site types of the same status.

Site Type 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.
- *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.
- *Produced Water Ponds:* Produced water is the water that is produced as a byproduct during oil and gas extraction. The major constituents in produced water are salts, oil, inorganic and organic chemicals, and sometimes heavy metals or traces of naturally-occurring radioactive materials. The Regional Water Quality Control Boards require waste discharge permits for produced water ponds.
- *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.

Status Definitions for Land Disposal Sites*:

- *Open - Operating:* A land disposal site that is accepting waste. These sites have been issued waste discharge requirements by the appropriate Regional Water Quality Control Board.
- *Open - Proposed:* A land disposal site that is in the process of undergoing the permit process from several agencies. These sites have not been issued waste discharge requirements by the appropriate Regional Water Quality Control Board, and are not accepting waste.
- *Open – Closing/with Monitoring:* A land disposal site that is no longer accepting waste and is undergoing all operations necessary to prepare the site for post-closure maintenances in accordance with an approved plan for closure.
- *Open – Closed/with Monitoring:* A land disposal site that has ceased accepting waste and was closed in accordance with applicable statutes, regulations, and local ordinances in effect at time of closure. Land disposal site in post closure maintenance period as waste could have an adverse effect on the quality of the waters of the state. Site has waste discharge requirements.
- *Open – Inactive:* A land disposal site that has ceased accepting waste but has not been formally closed or is still within the post closure monitoring period. Site does

not pose a significant threat to water quality and does not have groundwater monitoring. Site may or may not have waste discharge requirements.

- *Completed – Case Closed/No Monitoring:* A land disposal site that ceased accepting waste and was closed in accordance with applicable statutes, regulations, and local ordinances in effect at time of closure. The land disposal site was monitored for at least 30 years and Water Board staff has determined that wastes no longer pose a threat to water quality. Site does not have waste discharge requirements.

Status Definitions for Other Site Types*:

- *Completed – Case Closed*: A closure letter or other formal closure decision document has been issued for the site.
- *Open – Assessment & 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 – Inactive*: No regulatory oversight activities are being conducted by the Lead Agency.
- *Open – Remediation*: An approved remedy or remedies has/have been selected for the impacted media at the site and the responsible party (RP) is implementing one or more remedy under an approved cleanup plan for the site. This includes any ongoing remedy that is either passive or active, or uses a combination of technologies. For example, a site implementing only a long term groundwater monitoring program, or a "monitored natural attenuation" (MNA) remedy without any active groundwater treatment as part of the remedy, is considered an open case under remediation until site closure is completed.
- *Open – Site Assessment*: Site characterization, investigation, risk evaluation, and/or site conceptual model development are occurring at the site. Examples of site assessment activities include, but are not limited to, the following: 1) identification of the contaminants and the investigation of their potential impacts; 2) determination of the threats/impacts to water quality; 3) evaluation of the risk to humans and ecology; 4) delineation of the nature and extent of contamination; 5) delineation of the contaminant plume(s); and 6) development of the Site Conceptual Model.
- *Open – Verification Monitoring* (use only for UST, Chapter 16 regulated cases): Remediation phases are essentially complete and a monitoring/sampling program is occurring to confirm successful completion of cleanup at the Site. (e.g. No "active" remediation is considered necessary or no additional "active" remediation is anticipated as needed. Active remediation system(s) has/have been shut-off and the potential for a rebound in contaminant concentrations is under evaluation).
- *Open – Reopen Case* (available selection only for previously closed cases): This is not a case status. This field should be selected to record the date that the case was reopened for further investigation and/or remediation. A case status should immediately be selected from the list of case status choices after recording this date.

- *Open – Eligible for Closure*: Corrective action at the Site has been determined to be completed and any remaining petroleum constituents from the release are considered to be low threat to Human Health, Safety, and the Environment. The case in GeoTracker is going through the process of being closed.

** Available through Geotracker website: http://geotracker.waterboards.ca.gov/ (except the Produced Water Pond definition available at http://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/oil_field_produced/index.shtml).*

Number of Groundwater Threat Sites: Approximately 13,000

Facility Type	% of Total
Cleanup Program Site	40%
LUST Site	25%
Military Cleanup Site	15%
Land Disposal Site	12%
Military UST Site	4%
Produced Water Pond	3%
Military Privatized Site	<1%

HAZARDOUS WASTE GENERATORS AND FACILITIES

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 census tract.
(Permitted hazardous waste facilities was downloaded June 2016., Hazardous waste data is from 2012-2014.)

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 2012 - 2014.

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. US 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).

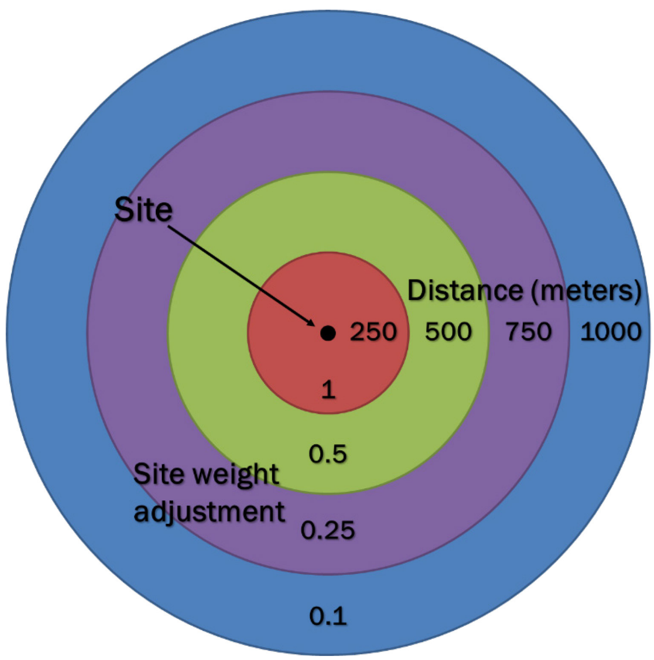
Hazardous waste generators:

- Generator data were obtained from DTSC from the Hazardous Waste Tracking System for 2012 to 2014.

- Only large quantity generators (producing over 1,000 kg of waste per month[1] for at least one of the three years) and generators producing RCRA waste[2] were included.
- Facilities were scored on a weighted scale in consideration of the volume of waste generated (see Appendix).
- Site locations were mapped or geocoded (in ArcMap).

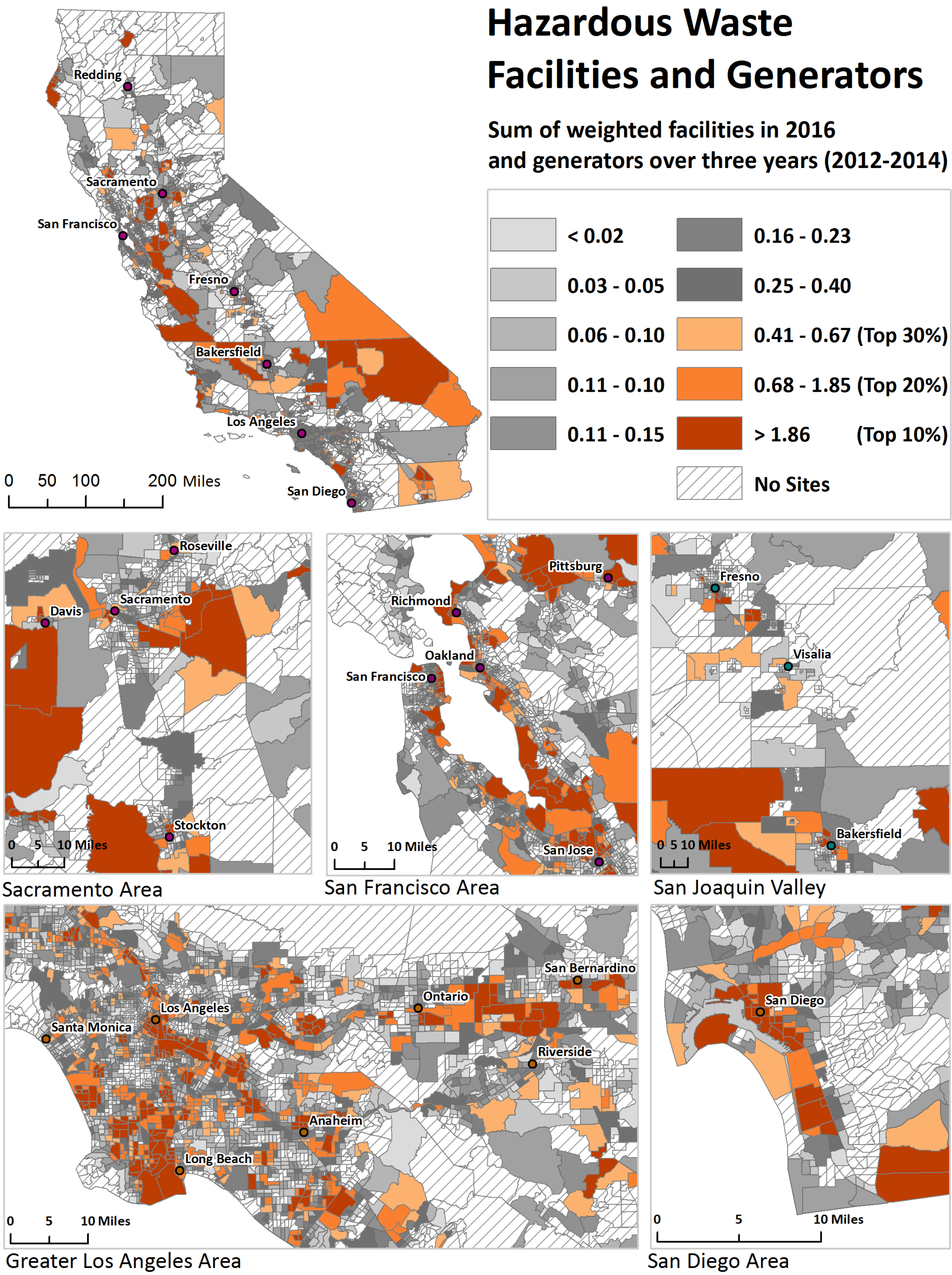
Proximity Adjustment:

- The weights for facilities (permitted and generators) were adjusted based on the distance they fell from populated census blocks. All facilities further than 1,000m from any populated census block were excluded from the analysis.
- Site weights were adjusted by multiplying the weight by 1 for facilities less than 250m, 0.5 for sites 250-500m, 0.25 for sites 500-750m, and 0.1 for sites 750-1000m from the nearest populated census blocks within a given tract. Facilities outside of a census tract, but less than 1000m from one of that tract's populated blocks were similarly adjusted based on the distance to the nearest block from that tract (See image below).



- Each census tracts was scored based on the sum of the adjusted weights for sites it contains or is near (in ArcMap).
- Census tracts were ordered based on their summed scores and were assigned percentiles.

[1] Corresponds to over 13.1 tons per year
[2] 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)


Hazardous Waste Facilities and Generators
Sum of weighted facilities in 2016
and generators over three years (2012-2014)
< 0.02
0.03 - 0.05
0.06 - 0.10
0.11 - 0.10
0.11 - 0.15
0.16 - 0.23
0.25 - 0.40
0.41 - 0.67 (Top 30%)
0.68 - 1.85 (Top 20%)
> 1.86 (Top 10%)
No Sites
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 50 100 200 Miles
Roseville
Davis
Sacramento
Stockton
0 5 10 Miles
Sacramento Area
Pittsburg
Richmond
Oakland
San Francisco
San Jose
0 5 10 Miles
San Francisco Area
Fresno
Visalia
Bakersfield
0 5 10 Miles
San Joaquin Valley
San Bernardino
Ontario
Los Angeles
Santa Monica
Riverside
Anaheim
Long Beach
0 5 10 Miles
Greater Los Angeles Area
San Diego
0 5 10 Miles
San Diego Area

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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.

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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 15 in consideration of the 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 0.1 to 2 based on the yearly amount of waste generated.

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. Only large quantity generators (> 1,000 kg per month or >13.1 tons per year) that produce RCRA waste were included due to the large number of hazardous waste generators producing small amounts of less hazardous types of waste. In 2012 to 2014 this represents about 4,500 generators. Higher weights were given to generators that produced larger volumes of waste. For all census tract codes, the weighted and proximity adjusted scores of all facilities and generators in the area were summed.

Permitted Hazardous Waste Facilities

	Weight	Activity or Status
Facility Activity (base weight)	10	Landfill
	7	Treatment
	4	Storage
	2	Post-closure
Permit Type *(additional weight)*	1	Large facilities
	1	Non-RCRA facilities
	2	RCRA facilities

Hazardous Waste Generators

Generator Type	Weight	Quantity of Waste
Large Quantity Hazardous Waste Generators (> 13.1 tons per year)	0.1	< 100 tons/yr
	0.5	100 – 1,000 tons/yr
	2	>1,000 tons/yr

Number of Hazardous Waste Generators and Permitted Facilities: Approximately 4,600

Facility Type	% of Total
Large hazardous waste generator with RCRA waste	98%
Permitted hazardous waste storage facility	2%*

**Permitted storage facilities are weighted much higher than generators.*

IMPAIRED WATER BODIES

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 (2012).

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 (CalEPA, 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 (CalEPA, 2002). Excessive hardness, unpleasant odor or taste, turbidity, color, weeds, and trash in the waters are types of pollutants affecting water aesthetics (CalEPA, 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). In addition, a study in the Sacramento-San Joaquin Delta found that fish consumption for certain subsistence fishers was higher than rates used for planning and regulation of polluted waters, and that mercury consumption from fish was significantly above US EPA advisory levels (Shilling *et al.,* 2010).

Two studies, one in England and one in San Antonio, Texas, found that people who lived near water bodies with significant impairments were more likely to believe that the water bodies were safe, and therefore to visit them more often, than people who lived further away (Georgiou *et al.,* 2000; Brody *et al.,* 2004).

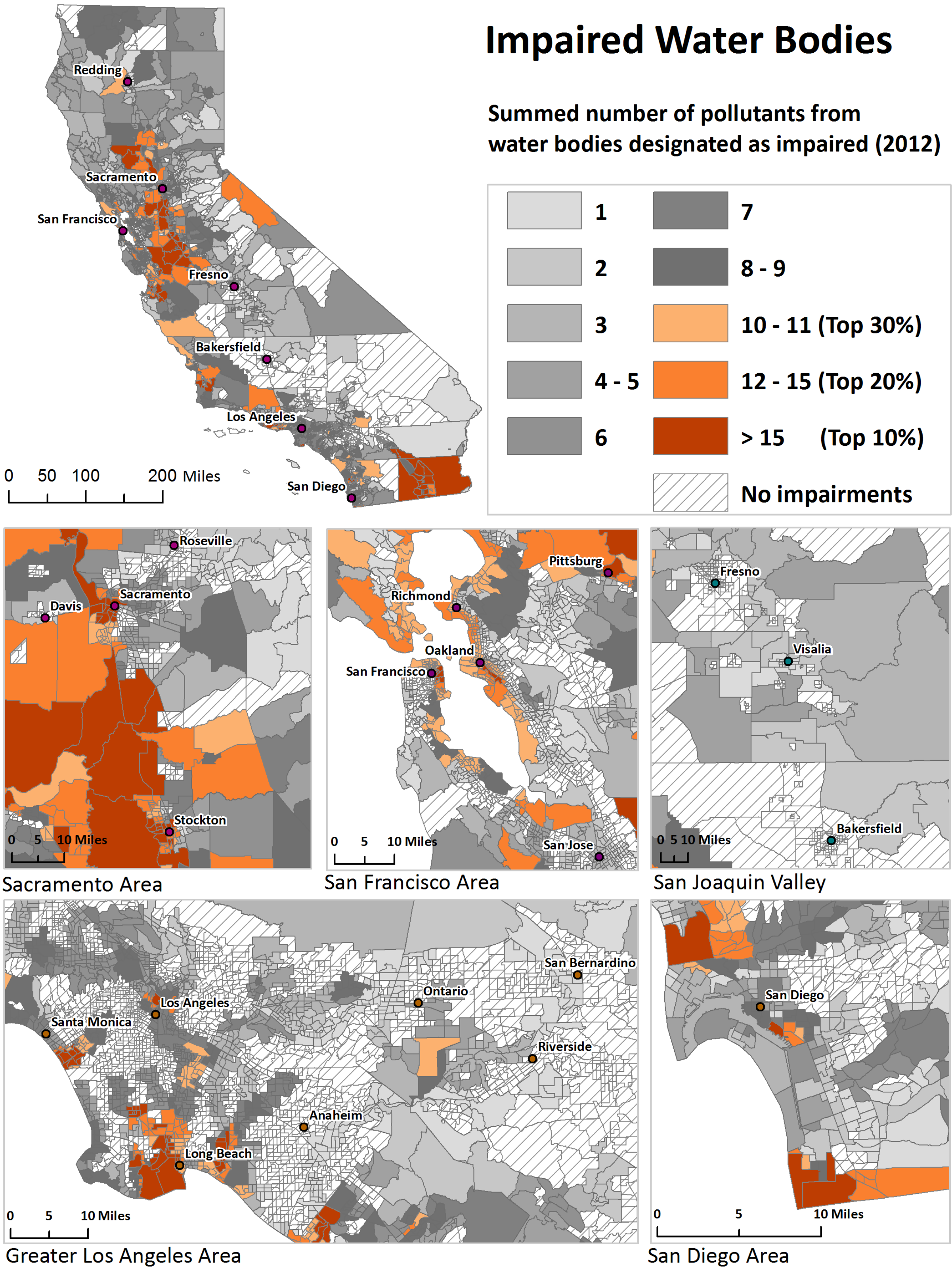
Method

- 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/integrated2012.shtml

- All water bodies were identified in all census tracts in the GIS software ArcMap.
- The number of pollutants listed in streams or rivers that fell within 1 kilometer (km) or 2 km of a census tract's populated blocks were counted. The 2 km buffer distance was applied to major rivers (>100 km in length, plus the Los Angeles River and Imperial Valley canals and drainage ways). The 1 km buffer distance was applied to all smaller streams/rivers.
- The number of pollutants listed in lakes, bays, estuaries or shoreline that fell within 1 km or 2 km of a census tract's populated blocks were counted. The 2 km buffer distance was applied to major lakes or bays greater than 25 square kilometers in size, plus all the Sacramento/San Joaquin River Delta waterways. The 1 km buffer distance was applied for all other lakes/bays.
- The two pollutant counts were summed for every census tract.

- Each census tract 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 census tract were both listed for the same pollutant, the pollutant was only counted once.
- Census tracts were ordered based on their summed scores and were assigned percentiles.


Impaired Water Bodies
Summed number of pollutants from water bodies designated as impaired (2012)
1
2
3
4 - 5
6
7
8 - 9
10 - 11 (Top 30%)
12 - 15 (Top 20%)
> 15 (Top 10%)
No impairments
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 50 100 200 Miles
Roseville
Davis
Sacramento
Stockton
0 5 10 Miles
Sacramento Area
Pittsburg
Richmond
Oakland
San Francisco
San Jose
0 5 10 Miles
San Francisco Area
Fresno
Visalia
Bakersfield
0 5 10 Miles
San Joaquin Valley
San Bernardino
Ontario
Los Angeles
Santa Monica
Riverside
Anaheim
Long Beach
0 5 10 Miles
Greater Los Angeles Area
San Diego
0 5 10 Miles
San Diego Area

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Shilling F, White A, Lippert L, Lubell M (2010). Contaminated fish consumption in California's Central Valley Delta. *Environ Res* **110**(4):334-44.

SOLID WASTE SITES AND FACILITIES

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 (as of June 2016).

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 and affect the health and quality of life of nearby residents (Heaney *et al*., 2011).

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). A recent cohort study of people living within 5 kilometers of a landfill in Italy found associations between exposure to hydrogen sulfide, a marker of airborne contamination from landfills, and slight increases in mortality and morbidity from respiratory diseases (Mataloni *et al.* 2016).

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).

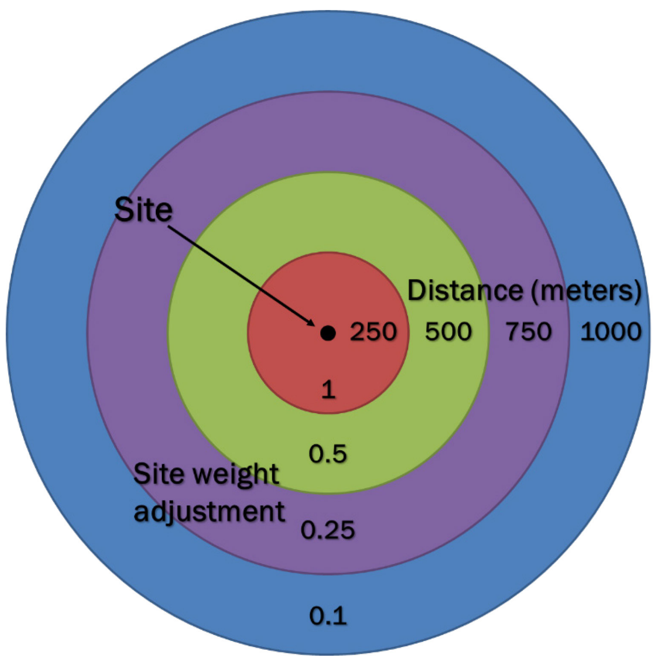
Active Solid Waste Information (SWIS) sites:

- 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).

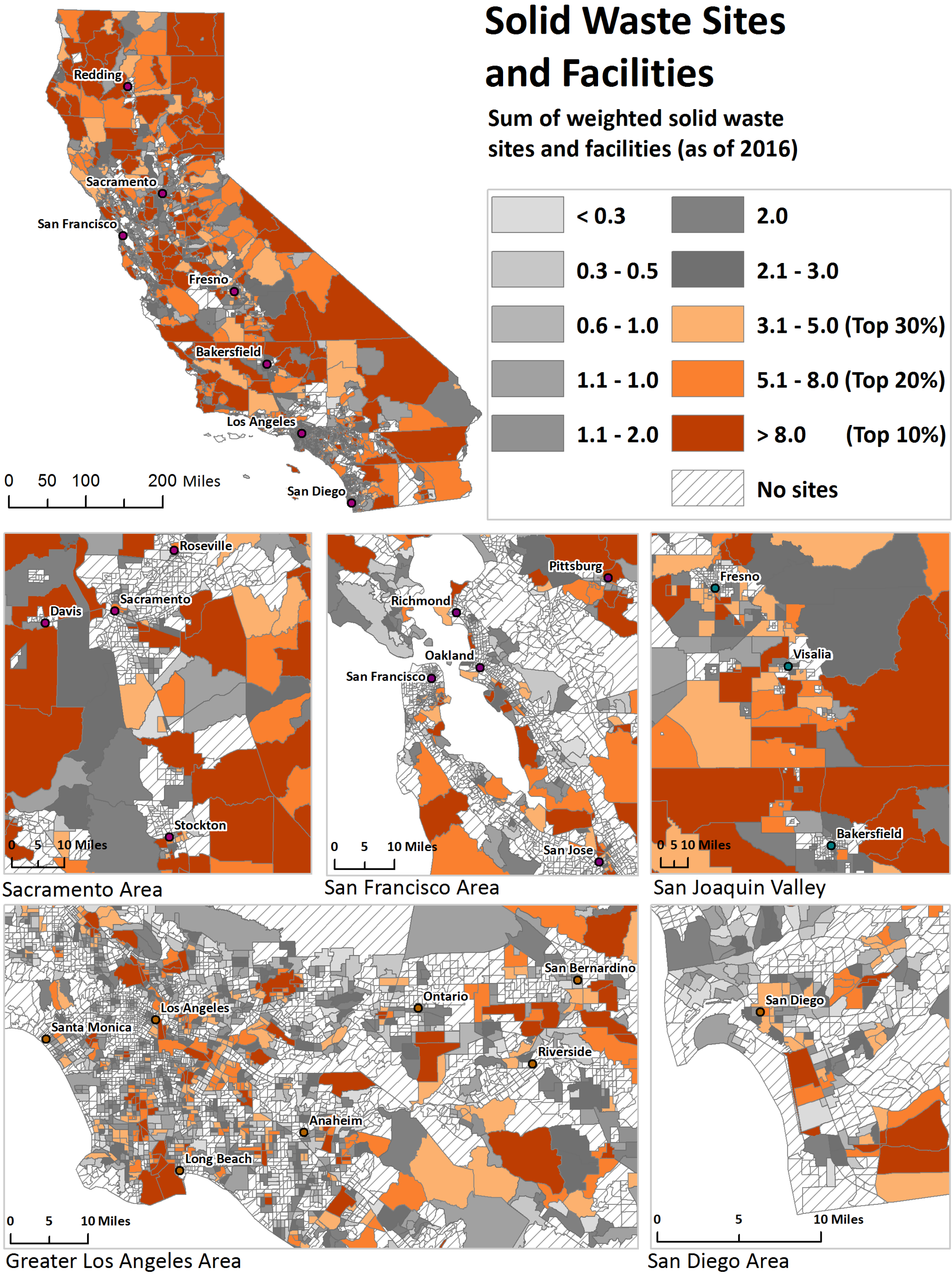
- Site locations were mapped or geocoded (in ArcMap).
- CalRecycle provided site boundaries (based on parcel boundaries and aerial photo inspection) for most of the solid waste landfills in the SWIS database. These boundaries were used in the analysis in place of point location, when applicable.

All sites:

- The weights for all sites, including the large landfill perimeters, were adjusted based on the distance they fell from populated census blocks. Sites further than 1000m from any populated census block were excluded from the analysis.
- Site weights were adjusted by multiplying the weight by 1 for sites less than 250m, 0.5 for sites 250-500m, 0.25 for sites 500-750m, and 0.1 for sites 750-1000m from the nearest populated census blocks within a given tract. Sites outside of a census tract, but less than 1000m from one of that tract's populated blocks were similarly adjusted based on the distance to the nearest block from that tract.



- Each census tract was scored based on the sum of the adjusted weights for sites it contains or is near.
- Census tracts were ordered based on their summed scores and were assigned percentiles.


Solid Waste Sites and Facilities
Sum of weighted solid waste sites and facilities (as of 2016)
< 0.3
0.3 - 0.5
0.6 - 1.0
1.1 - 1.0
1.1 - 2.0
2.0
2.1 - 3.0
3.1 - 5.0 (Top 30%)
5.1 - 8.0 (Top 20%)
> 8.0 (Top 10%)
No sites
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 50 100 200 Miles
Roseville
Davis
Stockton
0 5 10 Miles
Sacramento Area
Pittsburg
Richmond
Oakland
San Jose
San Francisco Area
Visalia
0 5 10 Miles
San Joaquin Valley
San Bernardino
Ontario
Los Angeles
Santa Monica
Riverside
Anaheim
Long Beach
Greater Los Angeles Area
San Diego Area

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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 census tracts, the weighted scores of all facilities in the area were summed after adjusting for proximity to populated census blocks.

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.

Number of Solid Waste Sites and Facilities in CalEnviroScreen 2.0: Approximately 2,800

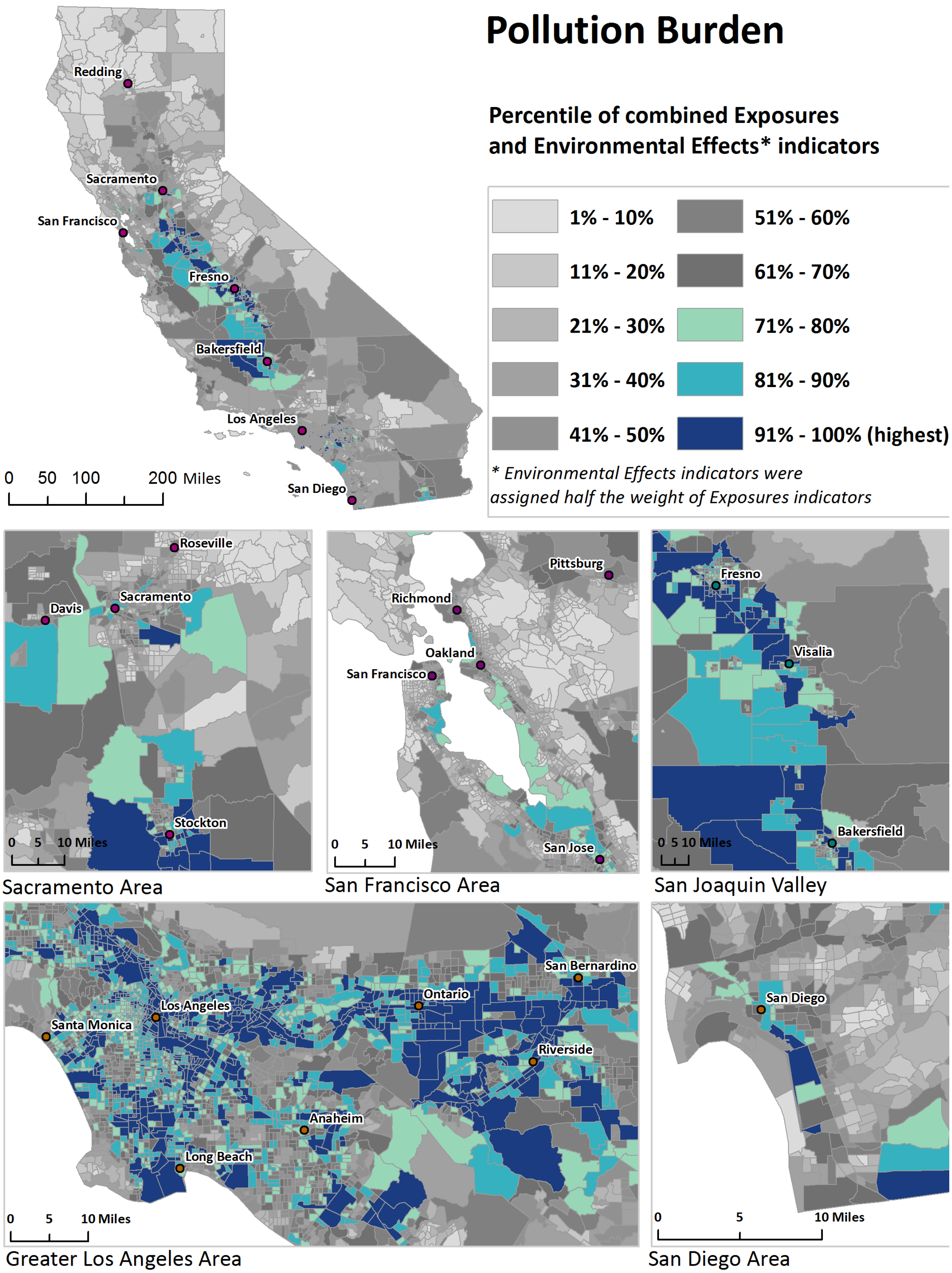
Facility Type	% of Total
Disposal (closed)	49%
Transfer/Processing (open)	25%
Composting	13%
Disposal (active)	11%
Waste Tire	2%
Transfer/Processing (closed)	<1%

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

Pollution Burden scores for each census tract are derived from the average percentiles of the seven Exposures indicators (ozone and PM2.5 concentrations, diesel PM emissions, drinking water contaminants, 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 pollution buden score (average of the indicators) was divided by 10 and rounded to one decimal place for a Pollution Burden score ranging from 0.1 -10.

Note: The map on the following page shows pollution scores divided into deciles.


Pollution Burden
Percentile of combined Exposures and Environmental Effects* indicators
1% - 10%
11% - 20%
21% - 30%
31% - 40%
41% - 50%
51% - 60%
61% - 70%
71% - 80%
81% - 90%
91% - 100% (highest)
* Environmental Effects indicators were assigned half the weight of Exposures indicators
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 50 100 200 Miles
Roseville
Davis
Stockton
0 5 10 Miles
Sacramento Area
Pittsburg
Richmond
Oakland
San Jose
San Francisco Area
Visalia
San Joaquin Valley
San Bernardino
Ontario
Santa Monica
Riverside
Anaheim
Long Beach
Greater Los Angeles Area
San Diego Area

Population Characteristics: Sensitive Population and Socioeconomic Factor Indicators

ASTHMA

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 2011-2013).

Data Source

California Office of Statewide Health Planning and Development (OSHPD)
California Environmental Health Tracking Program (CEHTP)
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. ZIP code estimates are assigned to 2010 census blocks using areal apportionment. Population-weighted census block estimates are then combined to arrive at a census tract estimate.

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

Rationale

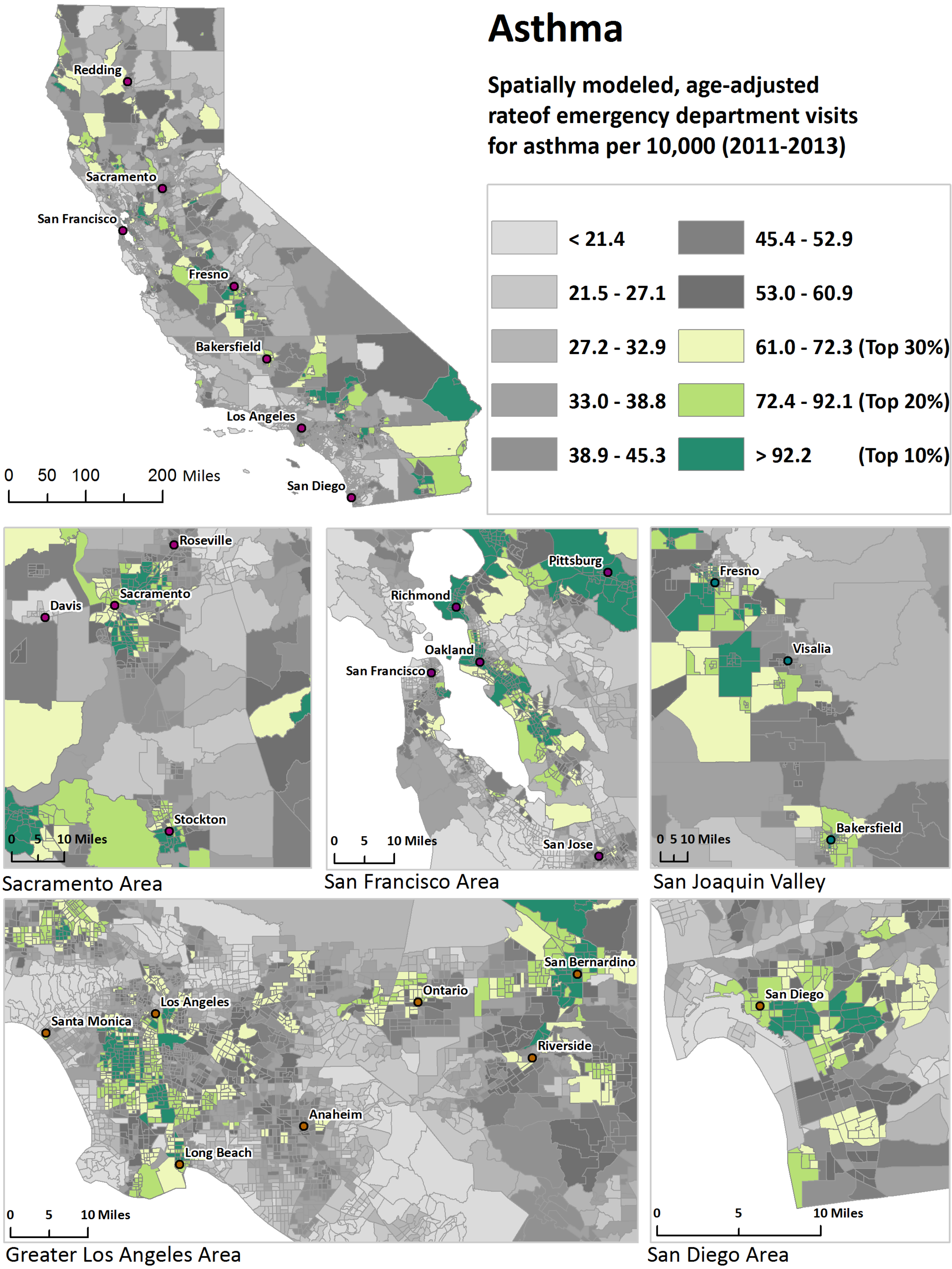
Asthma increases an individual's sensitivity to pollutants. Air pollutants, including particulate matter, ozone, nitrogen dioxide, and diesel exhaust, can trigger symptoms among asthmatics (Meng *et al.*, 2011). Children living near major roadways and traffic corridors in California have been shown to 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). A study of low income children who developed asthma found that there was an increase in asthma diagnosis following increases in ambient air pollution (Wendt *et al.,* 2014). 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

- CEHTP obtained records for ED visits occurring during 2011-2013 from OSHPD's Emergency Department and Ambulatory Surgery files for patients listed as residing in California and principle diagnostic ICD-9-CM code that begins with the digits 493, which identifies asthma.
- An age-adjusted rate of asthma emergency department (ED) visits was calculated for each ZIP code by CEHTP using data obtained from OSHPD. ZIP code rates were then reapportioned to census tract rates (see below).
- Population data used for the age-adjustment were obtained from Esri and rates reported are standardized to the 2000 US population using five-year age groupings (0-4, 5-9, etc.). The rates are per 10,000 residents per year.
- CEHTP spatially modeled the age-adjusted rates to provide estimates for ZIP codes with fewer than 12 ED visits, which are are considered statistically unreliable. A modeling technique that incorporates information about both local and statewide rates into the calculations was used (Mollié, 1996).
- Census blocks were assigned the average rate of the ZIP code they intersected using areal apportionment. Census tract rates were then estimated by the population-weighted average of the rates of the census blocks that it contains.
- Census tracts were ordered by the spatially modeled apportioned rate and were assigned percentiles based on the distribution across all census tracts.


Asthma
Spatially modeled, age-adjusted rateof emergency department visits for asthma per 10,000 (2011-2013)
< 21.4
21.5 - 27.1
27.2 - 32.9
33.0 - 38.8
38.9 - 45.3
45.4 - 52.9
53.0 - 60.9
61.0 - 72.3 (Top 30%)
72.4 - 92.1 (Top 20%)
> 92.2 (Top 10%)
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 50 100 200 Miles
Roseville
Davis
Sacramento
Stockton
0 5 10 Miles
Sacramento Area
Pittsburg
Richmond
Oakland
San Francisco
San Jose
0 5 10 Miles
San Francisco Area
Fresno
Visalia
Bakersfield
0 5 10 Miles
San Joaquin Valley
San Bernardino
Ontario
Los Angeles
Santa Monica
Riverside
Anaheim
Long Beach
0 5 10 Miles
Greater Los Angeles Area
San Diego
0 5 10 Miles
San Diego Area

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CARDIOVASCULAR DISEASE

Cardiovascular disease (CVD) refers to conditions that involve blocked or narrowed blood vessels that can lead to a heart attack or other heart problems. CVD is the leading cause of death both in California and the United States. Acute myocardial infarction (AMI), commonly known as a heart attack, is the most common cardiovascular event. Although many people survive and return to normal life after a heart attack, quality of life and long term survival may be reduced, and these people are highly vulnerable to future cardiovascular events.

There are many risk factors for developing CVD including diet, lack of exercise, smoking, and air pollution. In scientific statements made by the American Heart Association, there is strong evidence that air pollution contributes to cardiovascular morbidity and mortality (Pope et al. 2006; Brook et al. 2010).

Short term exposure to air pollution, and specifically particulate matter, has been shown to increase the risk of cardiovascular mortality shortly following a heart attack. There is also growing evidence that long term exposure to air pollution may result in premature death for people that have had a heart attack. In addition to people with a previous AMI, the effects of pollution on cardiovascular disease may be more pronounced in the elderly and people with other preexisting health conditions.

Indicator

Spatially modeled, age-adjusted rate of emergency department (ED) visits for AMI per 10,000 (averaged over 2011-2013).

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 a heart attack.

ED visits for heart attacks do not capture the full burden of people living with CVD because not everyone with CVD has a heart attack. However, there is limited information on people with CVD, and therefore ED visits for a heart attack was selected as a good indicator of CVD. The selection of ED visits for AMI is likely to capture virtually the full burden of heart attacks because the abrupt nature and severity of the event would cause most individuals to visit the ED.

CEHTP used OSHPD's data to calculate age-adjusted rates of AMI ED visits for California ZIP codes. These estimates make use of 2013 ZIP code scale population estimates from a private vendor (ESRI) and the US 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. ZIP code estimates are assigned to 2010 census blocks using areal apportionment. Population-weighted census block estimates are then combined to arrive at a census tract estimate.

http://www.oshpd.ca.gov/HID/Products/EmerDeptData/
http://www.cehtp.org/page/heart_attack/

Rationale

Recent studies have shown that individuals with preexisting heart disease or an AMI respond differently to the effects of pollution than individuals without heart disease. Specifically, individuals who have had an AMI may have a higher risk of dying after exposure to both short- and long-term increases in air pollution.

An early paper on the subject of air pollution effects on sensitive subpopulations found the relative risk of dying on days with high levels of pollution was higher for people with chronic obstructive pulmonary disease (COPD), pneumonia, and existing heart disease or stroke (Schwartz 1994).

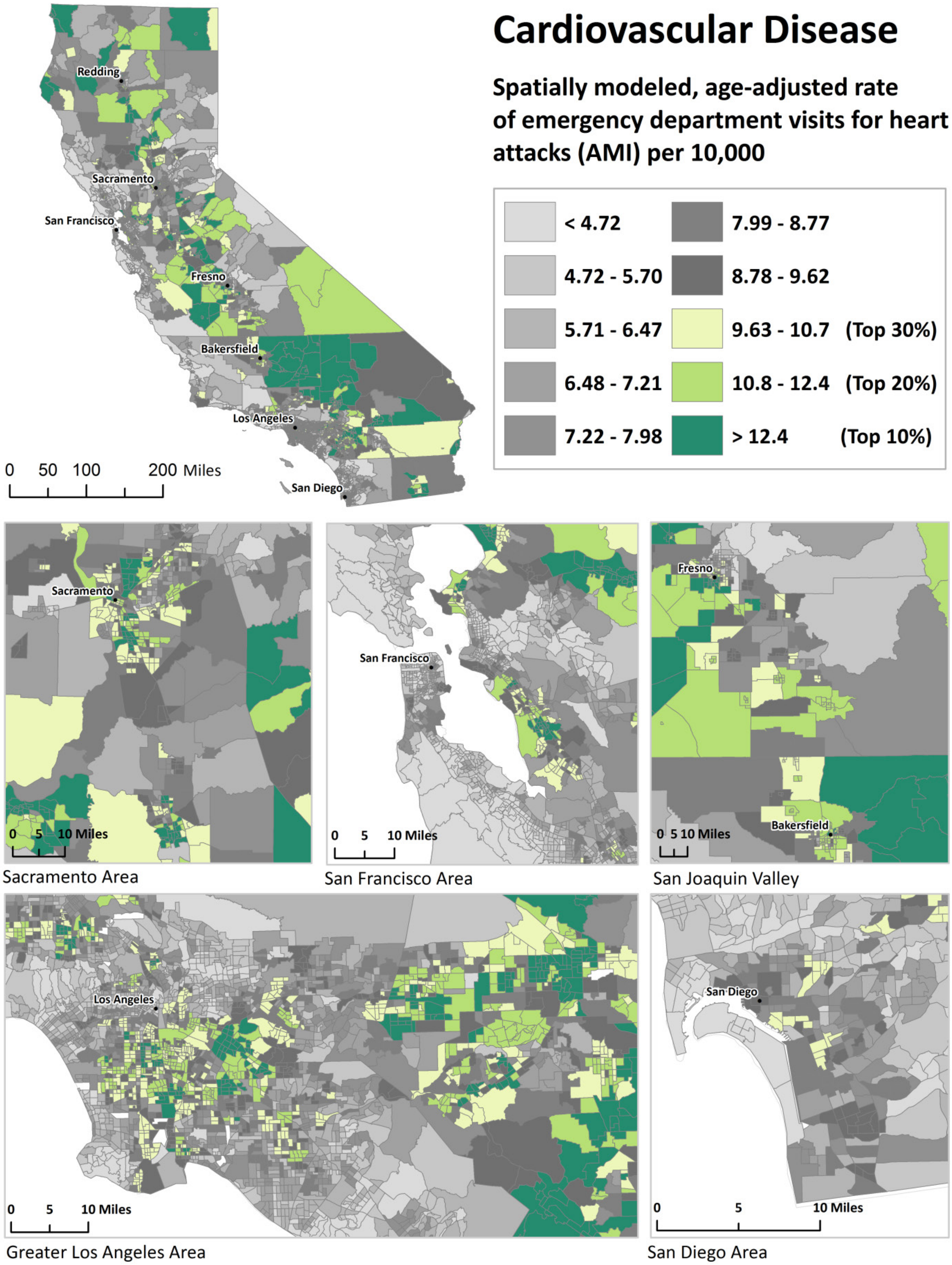
Multiple studies have found exposure to high levels of air pollution increased the risk of dying following an AMI. The effects of short-term exposure to PM 10 or traffic-related air pollution following an AMI significantly increased the risk of death in a cohort study of almost 4,000 people in Massachusetts (von Klot et al. 2009), in a multi-city European study of over 25,000 people (Berglind et al. 2009), and among over 65,000 elderly residents in Illinois (Bateson and Schwartz 2004).

The influence of long-term exposure to pollution on survival following an AMI has also been examined, although the research is less conclusive. A recent cohort study examined mortality over 10 years for almost 9,000 patients with a previous AMI and found significant increases in non-accidental mortality for each 10 $\mu g/m^3$ increase in PM 2.5. This suggests that long-term exposure to particulate matter may play a role in the likelihood of survival following a heart attack (Chen 2016).

Several of these studies on the effects of air pollution on AMI survivors have examined whether different effects are observed by race or ethnicity. To date, no significant differences have been found.

Method

- CEHTP obtained records for ED visits occurring during 2011-2013 from OSHPD's Emergency Department and Ambulatory Surgery files for patients listed as residing in California and with a principal diagnostic ICD-9-CM code that begins with the digits 410, which identifies AMI.
- An age-adjusted rate of AMI emergency department (ED) visits was calculated for each ZIP code by CEHTP using data obtained from OSHPD. ZIP code rates were then reapportioned to census tract rates (see below).
- Population data used for the age-adjustment were obtained from ESRI and rates reported are standardized to the 2000 US population using five-year age groupings. The rates are per 10,000 residents per year.
- CEHTP spatially modeled the age-adjusted rates to provide estimates for ZIP codes with fewer than 12 ED visits, which are are considered statistically unreliable. A modeling technique that incorporates information about both local and statewide rates into the calculations was used (Mollié, 1996).
- Census blocks were assigned the average rate of the ZIP code they intersected using areal apportionment. Census tract rates were then estimated by the population-weighted average of the rates of the census blocks that it contains.
- Census tracts were ordered by the spatially modeled apportioned rate and were assigned percentiles based on the distribution across all census tracts.


Cardiovascular Disease
Spatially modeled, age-adjusted rate of emergency department visits for heart attacks (AMI) per 10,000
< 4.72
4.72 - 5.70
5.71 - 6.47
6.48 - 7.21
7.22 - 7.98
7.99 - 8.77
8.78 - 9.62
9.63 - 10.7 (Top 30%)
10.8 - 12.4 (Top 20%)
> 12.4 (Top 10%)
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 50 100 200 Miles
0 5 10 Miles
Sacramento Area
San Francisco Area
San Joaquin Valley
Greater Los Angeles Area
San Diego Area

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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.

Pope CA, Muhlestein JB, May HT, Renlund DG, Anderson JL, Horne BD (2006). Ischemic heart disease events triggered by short-term exposure to fine particulate air pollution. *Circulation* **114**(23):2443-8.

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LOW BIRTH WEIGHT INFANTS

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 restricted 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 chronic health conditions that may make them more sensitive to environmental exposures after birth.

Indicator

Percent low birth weight, (averaged over 2006-2012).

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. Personal identifiers are not released publicly to protect confidentiality.

Information about the geographic location of births was used by OEHHA in compliance with the State of California Committee for the Protection of Human Subjects. The data was analyzed by the California Environmental Health Tracking Program (CEHTP) of CDPH's Environmental Health Investigation Branch.

http://www.cdph.ca.gov/data/dataresources/requests/Pages/BirthandFetalDeathFiles.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.

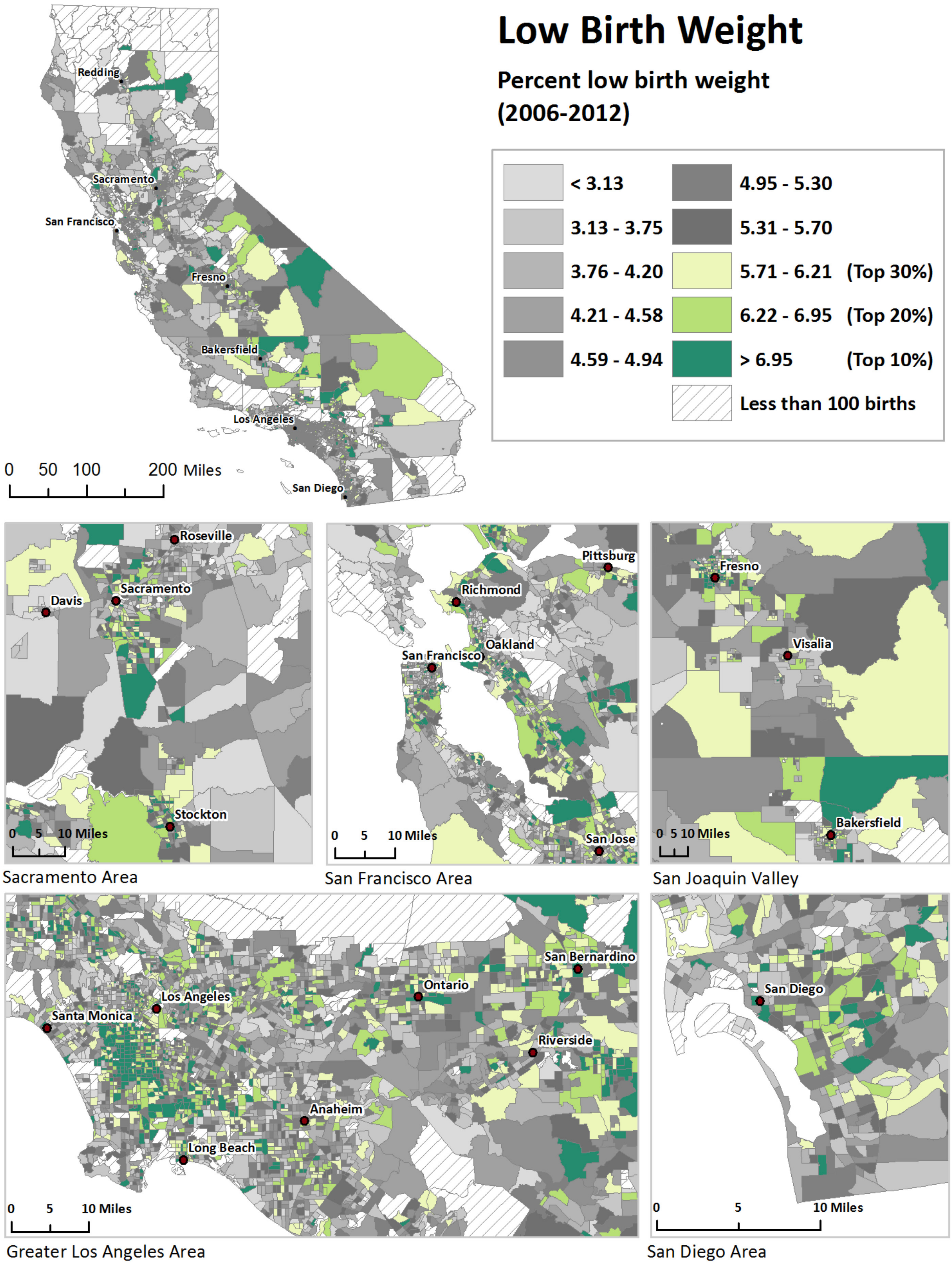
Risk of LBW is increased by certain environmental exposures and social factors and can therefore be considered a marker of the combined impact of environmental and social stressors. For example, exposures to fine particulate matter, heavy traffic and to toxic air contaminants such as benzene, xylene, and toluene have been linked to LBW in California (Ghosh *et al.*, 2012, Basu *et al.,* 2014). 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 LBW 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 LBW infants that were small for gestational age, with smaller than average head circumference, an indicator of brain development (Harley *et al.*, 2011).

Method

- The low birth weight (LBW) rate was calculated from California birth records as the percent of live, singleton births during the 2006-2012 period weighing less than 2,500 grams.
- Multiple births (non-singletons) and births with an improbable combination of gestational age and birth weight were excluded (Alexander, 1996). Out-of-state births, and births with no known residential address (including P.O. boxes) were also excluded. These exclusions lead to a lower statewide LBW rate than that reported by other organizations who do not apply this criterion.
- Births were geocoded based on the mother's residential address at the time of birth by CEHTP. A small number (less than 1%) of addresses could not be geocoded and were excluded.
- Estimates derived from places with few births are considered unreliable because they often produce extreme values much higher or lower than expected and can vary greatly from year to year. For this reason, census tracts with fewer than 100 live births during seven years were excluded. The average low birth weight rate was estimated using seven years of data (2006-2012) in order to minimize the number of excluded census tracts,

- Each census tract was assigned a percentile based on its relative ranking of spatially modeled LBW compared to all other tracts.


Low Birth Weight
Percent low birth weight
(2006-2012)
< 3.13
3.13 - 3.75
3.76 - 4.20
4.21 - 4.58
4.59 - 4.94
4.95 - 5.30
5.31 - 5.70
5.71 - 6.21 (Top 30%)
6.22 - 6.95 (Top 20%)
> 6.95 (Top 10%)
Less than 100 births
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 50 100 200 Miles
Roseville
Davis
Sacramento
Stockton
0 5 10 Miles
Sacramento Area
Pittsburg
Richmond
Oakland
San Francisco
San Jose
0 5 10 Miles
San Francisco Area
Fresno
Visalia
Bakersfield
0 5 10 Miles
San Joaquin Valley
San Bernardino
Ontario
Los Angeles
Santa Monica
Riverside
Anaheim
Long Beach
0 5 10 Miles
Greater Los Angeles Area
San Diego
0 5 10 Miles
San Diego Area

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EDUCATIONAL ATTAINMENT

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, 2010-2014).

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 tract scale are the 5-year estimates for 2010-2014. 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).

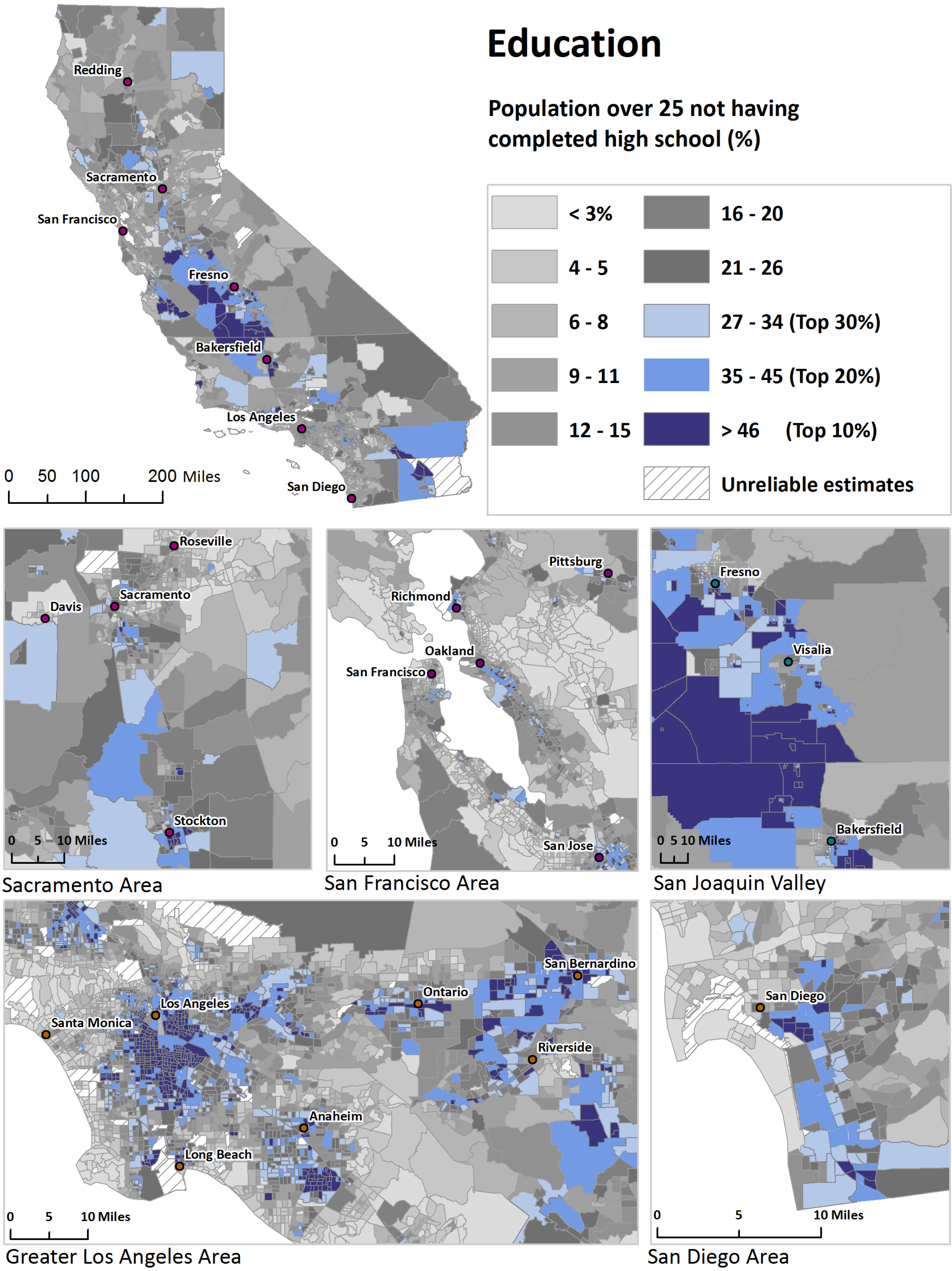
The ways in which lower educational attainment can decrease health status are not completely understood, but may include economic hardship, stress, fewer occupational opportunities, lack of social support, and reduced access to health-protective resources such as medical care, prevention and wellness 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). A study of older adults, aged 70 to 79, found that those with less than a high school education had significantly shorter leukocyte telomere length, a genetic marker linked to stress, than those with more education (Adler *et al.*, 2013)

Method

- From the 2010-2014 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 tracts 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.
- Unlike the U.S. Census, ACS estimates come from a sample of the population and may be unreliable if they are based on a small sample or population size. The standard error (SE) and relative standard error (RSE) were used to evaluate the reliability of each estimate.
- The SE was calculated for each census tract by dividing the margin of error (MOE) reported in the ACS by 1.645, a statistical value associated with a 90 percent confidence interval. The MOE is the difference between an estimate and the upper or lower bounds of its confidence interval. All ACS-published MOEs are based on a 90 percent confidence interval.
- The RSE is calculated by dividing a tract's SE by its estimate of educational attainment, and taking the absolute value of the result.
- Census tract estimates that met either of the following criteria were considered reliable and included in the analysis:

1. RSE less than 50 (meaning the SE was less than half of the estimate) OR
2. SE was less than the mean SE of all California census tract estimates for education.

- Census tracts with unreliable estimates received no score for the indicator (null). The indicator was not factored into that tract's overall CalEnviroScreen score.
- Census tracts that met the inclusion criteria were ordered by the percentage of the population over age 25 with less than a high school education and percentiles were assigned to each based on the distribution across all census tracts.


Education
Population over 25 not having completed high school (%)
< 3%
4 - 5
6 - 8
9 - 11
12 - 15
16 - 20
21 - 26
27 - 34 (Top 30%)
35 - 45 (Top 20%)
> 46 (Top 10%)
Unreliable estimates
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 50 100 200 Miles
Roseville
Davis
Sacramento
Stockton
0 5 10 Miles
Sacramento Area
Pittsburg
Richmond
Oakland
San Francisco
San Jose
0 5 10 Miles
San Francisco Area
Fresno
Visalia
Bakersfield
0 5 10 Miles
San Joaquin Valley
San Bernardino
Ontario
Los Angeles
Santa Monica
Riverside
Anaheim
Long Beach
0 5 10 Miles
Greater Los Angeles Area
San Diego
0 5 10 Miles
San Diego Area

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LINGUISTIC ISOLATION

According to the most recent U.S. Census Bureau's 2010-2014 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, 2010-2014).

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 tract scale are the 5-year estimates for 2010-2014. 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).

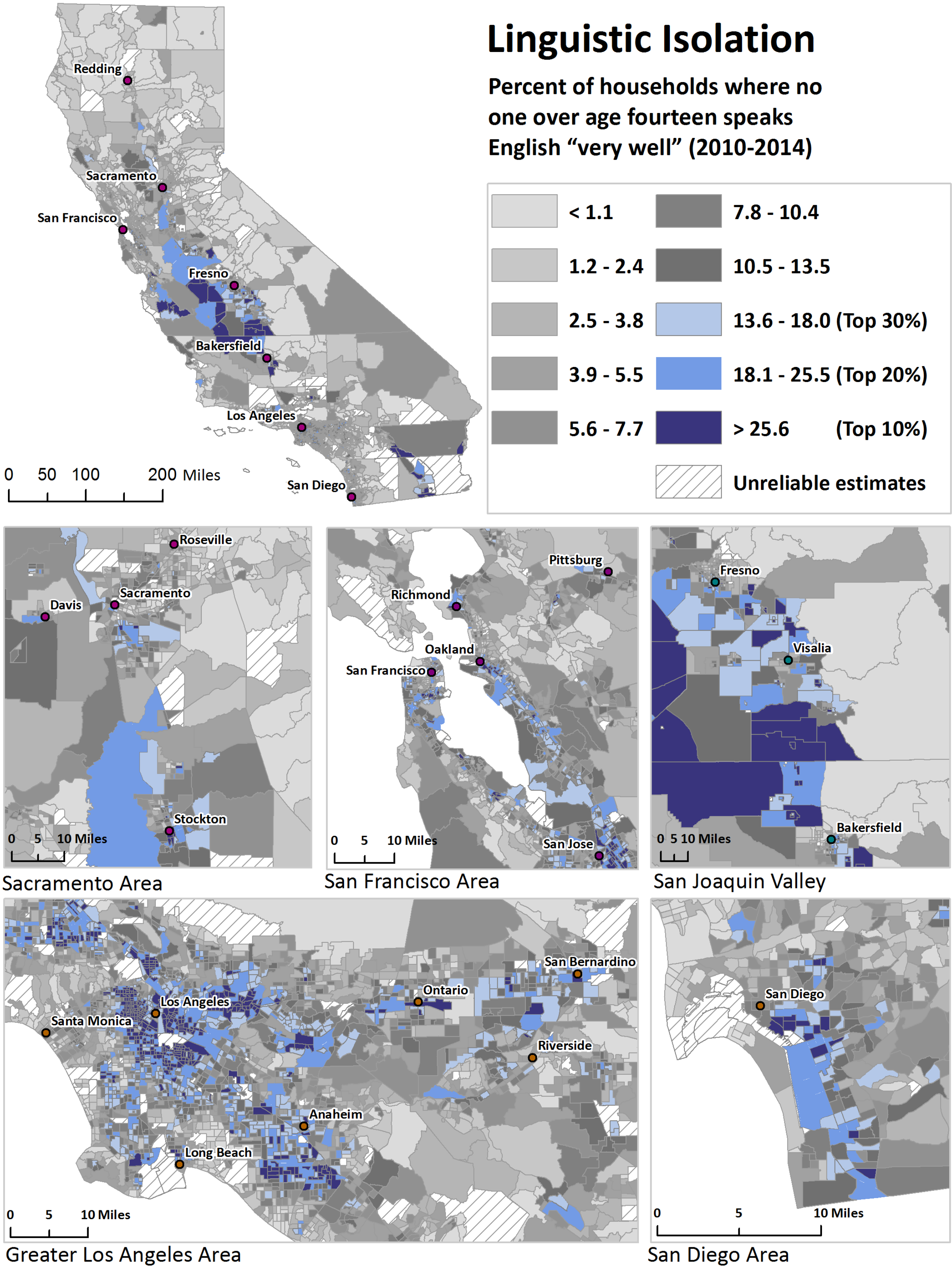
In the event of an emergency, such as an accidental chemical release or a spill, households that are linguistically isolated may not receive timely information on evacuation or shelter-in-place orders, and may therefore experience health risks that those who speak English can more easily avoid. Additionally, 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 2010-2014 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 tracts for the state of California. This variable is referred to as "linguistic isolation" and measures households where no one speaks English well.
- Unlike the U.S. Census, ACS estimates come from a sample of the population and may be unreliable if they are based on a small sample or population size. The standard error (SE) and

relative standard error (RSE) were used to evaluate the reliability of each estimate.

- The SE was calculated for each census tract by dividing the margin of error (MOE) reported in the ACS by 1.645, a statistical value associated with a 90 percent confidence interval. The MOE is the difference between an estimate and the upper or lower bounds of its confidence interval. All ACS-published MOEs are based on a 90 percent confidence interval.
- The RSE is calculated by dividing a tract's SE by its estimate of the percent of linguistically isolated households, and taking the absolute value of the result.
- Census tract estimates that met either of the following criteria were considered reliable and included in the analysis:
    1. RSE less than 50 (meaning the SE was less than half of the estimate) OR
    2. SE was less than the mean SE of all California census tract estimates for linguistic isolation.
- Census tracts with unreliable estimates received no score for the indicator (null). The indicator was not factored into that tract's overall CalEnviroScreen score.
- Census tracts that met the inclusion criteria were ordered by the percent linguistically isolated and percentiles were assigned to each based on the distribution across all tracts.


Linguistic Isolation
Percent of households where no one over age fourteen speaks English "very well" (2010-2014)
< 1.1
1.2 - 2.4
2.5 - 3.8
3.9 - 5.5
5.6 - 7.7
7.8 - 10.4
10.5 - 13.5
13.6 - 18.0 (Top 30%)
18.1 - 25.5 (Top 20%)
> 25.6 (Top 10%)
Unreliable estimates
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 50 100 200 Miles
Roseville
Davis
Sacramento
Stockton
0 5 10 Miles
Sacramento Area
Pittsburg
Richmond
Oakland
San Francisco
San Jose
0 5 10 Miles
San Francisco Area
Fresno
Visalia
Bakersfield
0 5 10 Miles
San Joaquin Valley
San Bernardino
Ontario
Los Angeles
Santa Monica
Riverside
Anaheim
Long Beach
0 5 10 Miles
Greater Los Angeles Area
San Diego
0 5 10 Miles
San Diego Area

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POVERTY

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, 2010-2014).

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 tract scale are the 5-year estimates for 2010-2014. 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

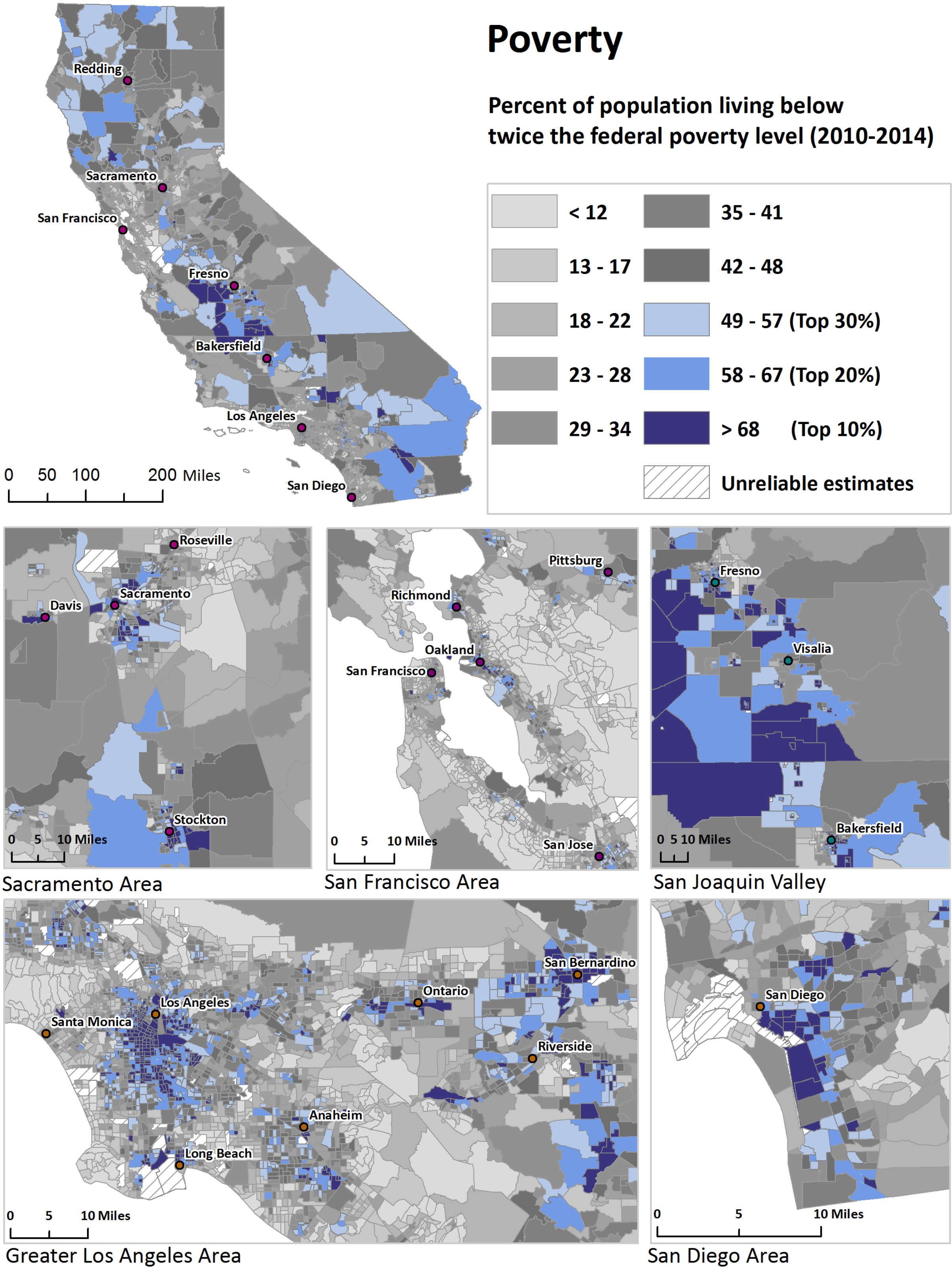
Wealth influences health because it helps determine one's living conditions, nutrition, occupation, and access to health care and other health-promoting resources. For example, studies have shown a stronger effect of air pollution on mortality (Forastiere *et al.,* 2007) and childhood asthma (Lin *et 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 2010-2014 American Community Survey, a dataset containing the number of individuals below 200 percent of the federal poverty level was downloaded by census tracts 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.
- Unlike the U.S. Census, ACS estimates come from a sample of the population and may be unreliable if they are based on a small sample or population size. The standard error (SE) and relative standard error (RSE) were used to evaluate the reliability of each estimate.
- The SE was calculated for each census tract using the formula for approximating the SE of proportions provided by the ACS (American Community Survey Office, 2013, pg. 13, equation 4). When this approximation could not be used, the formula for approximating the SE of ratios (equation 3) was used instead.
- The RSE is calculated by dividing a tract's SE by its estimate of the percentage of the population living below twice the federal poverty level, and taking the absolute value of the result.
- Census tract estimates that met either of the following criteria were considered reliable and included in the analysis:
  1. RSE less than 50 (meaning the SE was less than half of the estimate) OR
  2. SE was less than the mean SE of all California census tract estimates for poverty.

- Census tracts with unreliable estimates received no score for the indicator (null). The indicator was not factored into that tract's overall CalEnviroScreen score.
- Census tracts that met the inclusion criteria were ordered by the percentage of the population below twice the federal poverty level. A percentile score for a census tract was determined by its place in the distribution of all census tracts.


Poverty
Percent of population living below
twice the federal poverty level (2010-2014)
< 12
13 - 17
18 - 22
23 - 28
29 - 34
35 - 41
42 - 48
49 - 57 (Top 30%)
58 - 67 (Top 20%)
> 68 (Top 10%)
Unreliable estimates
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 50 100 200 Miles
Roseville
Davis
Sacramento
Stockton
0 5 10 Miles
Sacramento Area
Pittsburg
Richmond
Oakland
San Francisco
San Jose
0 5 10 Miles
San Francisco Area
Fresno
Visalia
Bakersfield
0 5 10 Miles
San Joaquin Valley
San Bernardino
Ontario
Los Angeles
Santa Monica
Riverside
Anaheim
Long Beach
0 5 10 Miles
Greater Los Angeles Area
San Diego
0 5 10 Miles
San Diego Area

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RENT-ADJUSTED INCOME

The cost and availability of housing is an important determinant of well-being. Households with lower incomes spend a larger proportion of their income on housing. The inability of households to afford necessary non-housing goods after paying for shelter is known as housing-induced poverty. California has very high housing costs relative to much of the country, making it difficult for many to afford adequate housing. Within California, the cost of living varies significantly and is largely dependent on housing cost, availability, and demand.

Areas where households may be stressed by high housing cost relative to income can be identified by subtracting each census tract's median gross rent from median household income. Information on both household income and cost of rent for housing is collected annually in the US Census Bureau's American Community Survey (ACS).

Indicator

Rent-adjusted income. Median household income minus median gross rent (5-year estimates, 2010-2014)

Data Source

American Community Survey
US Census Bureau

The American Community Survey (ACS) is an ongoing survey of the US population conducted by the US 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 household income and rent costs. 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 tract scale are the 5-year estimates for 2010-2014. The data are made available using the American FactFinder website.

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

Rationale

Housing affordability is an important part of the framework of social and economic conditions that shape the health and well-being of individuals (Braubach, 2011; Commission on Social Determinants of Health, 2008). Socioeconomic variables may influence response to pollutants or modify the effect of exposure to pollution. Several scientific studies have examined the relationship between income level, pollution exposures, and health outcomes. Individuals with low income exposed to high levels of air pollution had higher mortality rates than higher income individuals (Finkelstein *et al*., 2003). Children of low-income families had greater asthma hospitalization rates when exposed to air pollutants (Lin *et al*., 2004).

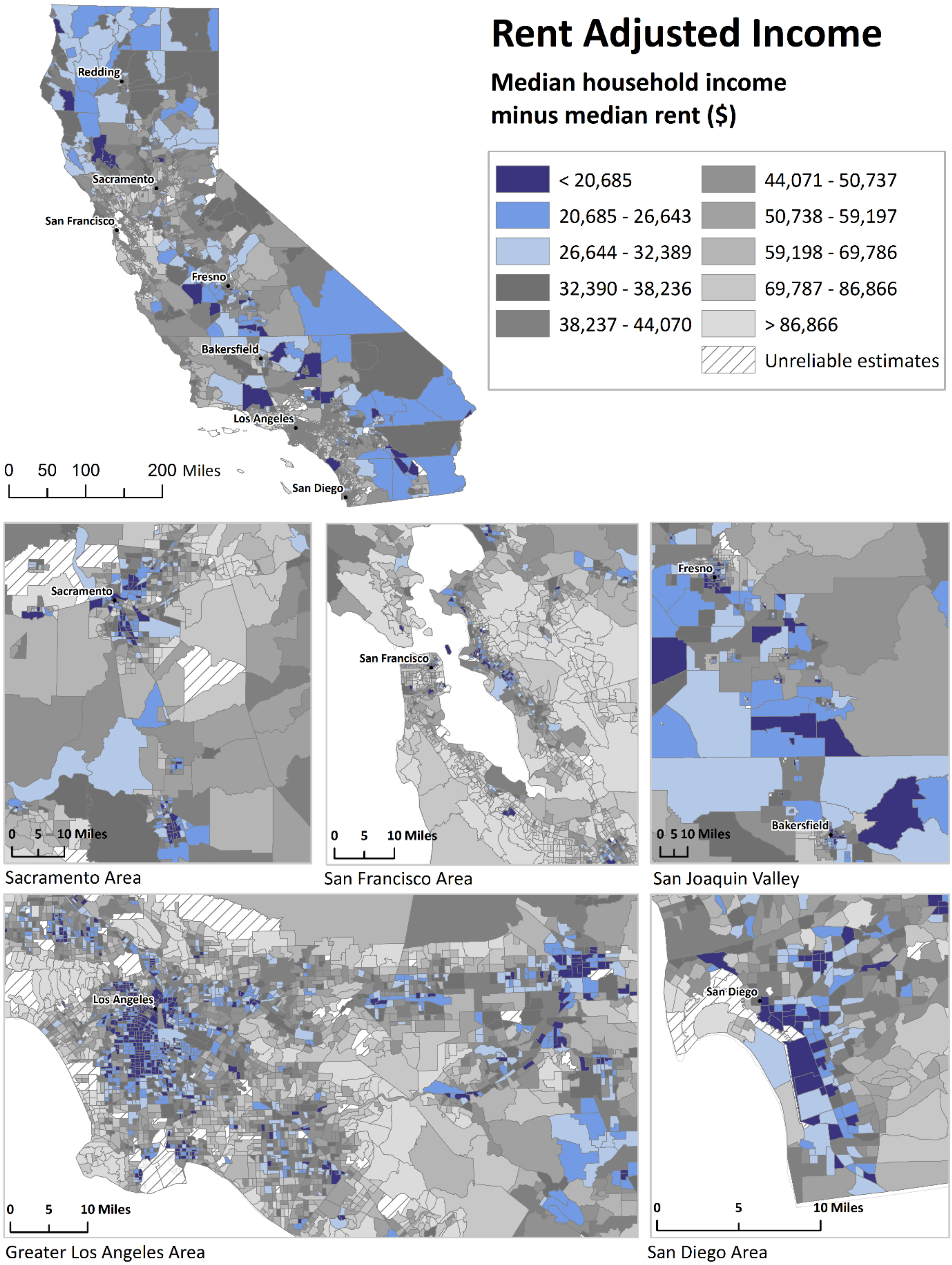
Low-income and financially vulnerable households that face high costs for housing can potentially suffer from health impacts (Beer *et al*., 2006; Slatter and Beer, 2003). Households that experience high rent burden for longer periods of time are associated with greater disadvantage (Susin, 2007). Studies have shown that high rent burden can mean a higher likelihood of postponing medical services for financial reasons. High rent burden is also associated with worse self-reported health conditions (Meltzer and Schwartz, 2015). High housing cost burdens and unaffordable housing situations can also contribute to residential instability, increase vulnerability to acute and chronic health problems, worsen stress and depression, and can lead to poor educational outcomes for children (Anderson et al. 2003; Harkness 2005; Pollack *et al*., 2010; Meltzer 2015).

The fraction of low-income households paying greater than 30 percent of their income to housing expenditures has been on the rise in the US since 1970 (Quigley and Raphael, 2004). Greulich et al. reported that the poorest fifth of households spend 55 percent of their income on housing, up from 50 percent in 1970 (Greulich, 2004). Geographic differences in housing costs are not accounted for in the official poverty measure calculated by the U.S. Census Bureau. California has some of the highest housing costs in the nation as well as substantial differences in housing costs within the state (LAO, 2015).

Measures of affordable housing often use a ratio of housing costs to income as a measure of rent burden or owner-cost burden. However, housing-cost burden measures of affordability do not consider whether the income available after the housing expenditure is adequate to meet non-housing needs (Kutty, 2005). The residual income approach here focuses on the income remaining after housing expenditures and has been used in research studies as an alternative to a measure based on a ratio (Kutty, 2005; McConnell, 2012). Rent costs reflect the price paid for housing per unit of time and are considered a superior measure to home value when determining differences in costs of living (Winters, 2009). A rent adjusted income measure helps account for differences in housing costs across different areas of California.

Method

- From the 2010-2014 American Community Survey, a dataset containing median household income was downloaded by census tracts for the State of California.
- A dataset containing the median gross rent amounts was also downloaded by census tracts for the State of California from the same database.
- For each census tract the value of annual median gross rent was subtracted from annual median household income to yield a rent-adjusted income score.
- Unlike the US Census, ACS estimates come from a sample of the population and may be unreliable if they are based on a small sample or population size. The standard error (SE) and relative standard error (RSE) were used to evaluate the reliability of each estimate.
- The SE was calculated for each census tract by dividing the margin of error (MOE) reported in the ACS by 1.645, a statistical value associated with a 90 percent confidence interval. The MOE is the difference between an estimate and the upper or lower bounds of its confidence interval. All ACS-published MOEs are based on a 90 percent confidence interval.
- The RSE is calculated by dividing a tract's SE by its estimate of median household income or median gross rent, and taking the absolute value of the result.
- Census tract estimates that met either of the following criteria were considered reliable and included in the analysis:
    1. RSE less than 50 (meaning the SE was less than half of the estimate) OR
    2. SE was less than the mean SE of all California census tract estimates for median household income or median gross rent.
- Census tracts with unreliable estimates receive no score for the indicator (null). The indicator is not factored into that tract's overall CalEnviroScreen score.
- Census tracts that met the inclusion criteria for both the median household income and median gross rent data were ordered by the rent-adjusted income. The census tracts were assigned percentiles based on the distribution across all tracts.


Rent Adjusted Income
Median household income minus median rent ($)
< 20,685
20,685 - 26,643
26,644 - 32,389
32,390 - 38,236
38,237 - 44,070
44,071 - 50,737
50,738 - 59,197
59,198 - 69,786
69,787 - 86,866
> 86,866
Unreliable estimates
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 50 100 200 Miles
0 5 10 Miles
Sacramento Area
San Francisco Area
San Joaquin Valley
Greater Los Angeles Area
San Diego Area

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Lin M, *et al*. (2004). Gaseous air pollutants and asthma hospitalization of children with low household income in Vancouver, British Columbia, Canada. *Am J Epidemiol* **159**(3): 294-303.

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UNEMPLOYMENT

Because low socioeconomic status often goes hand-in-hand with high unemployment, the rate of unemployment is a factor commonly used in describing disadvantaged communities. On an individual level, unemployment is a source of stress, which is implicated in poor health reported by residents of such communities. Lack of employment and resulting low income often oblige people to live in neighborhoods with higher levels of pollution and environmental degradation.

Indicator

Percent of the population over the age of 16 that is unemployed and eligible for the labor force. Excludes retirees, students, homemakers, institutionalized persons except prisoners, those not looking for work, and military personnel on active duty (5-year estimate, 2010-2014).

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. 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 unemployment. 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 tract level are the 5-year estimates for 2010-2014. The data are available on the American FactFinder website.

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

Rationale

There is evidence that an individual's health is at least partly determined by neighborhood and regional factors. Unemployment is frequently used as a surrogate for neighborhood deprivation, which is associated with pollution exposure as well as poor health (Voigtlander *et al.*, 2010). Studies of neighborhood socioeconomic factors have found stress to be a major factor in reported poor health among residents of disadvantaged communities, and both financial and emotional stress are direct results of unemployment (Turner, 1995).

The unemployed tend to have higher annual illness rates, lack health insurance and access to health care, and have an increased risk of death compared to those who are employed. In addition, poor health also affects a person's ability to obtain and retain employment (Athar *et al.* 2013). Unemployment, along with low income and low educational attainment, has been associated with increased incidence of irritable bowel syndrome (Farzaneh *et al.*, 2013), childhood asthma (Hafkamp-de Groen *et al.,* 2013), poor mental health (Kan, 2013), and decreased quality of life among cervical cancer survivors (Yoo *et al.,* 2013). A study of 4301 men and women in 3 cities in Germany found that men living in high-unemployment neighborhoods were at higher risk of emergent coronary artery disease than men living in areas of low unemployment (Dragano *et al.,* 2009). In a study of unemployment and mortality, the authors found that job loss was associated with an increased hazard of death compared to that of employed individuals, equivalent to aging 10 years (Tapia Granados *et al.*, 2014). Unemployment has been shown to be associated with the biological effects of stress. Stress resulting from early-life experiences and current domestic stress are linked with shorter leukocyte telomere length (LTL). Among men, long-term unemployment (more than 500 days during three years) in early adulthood was associated with having shorter LTL, compared to being continuously employed (Ala-Mursula *et al.,* 2013). Stress, in turn, may lead to poor health, increased susceptibility to toxic effects of pollution, and reduced capacity to cope and recover from adverse effect of environmental exposures (Defur *et al.*, 2007).

Premji *et al.* (2007) studied the relationship between pollutant emissions and socioeconomic variables in 27 Canadian communities and found that pollution levels were positively associated with the unemployment rate. In a study of statewide unemployment levels as well as trucking industry data in New Jersey, Davis *et al.* (2010) found that high unemployment was associated with high coefficient of haze, a measure of diesel particulate pollution.

Method

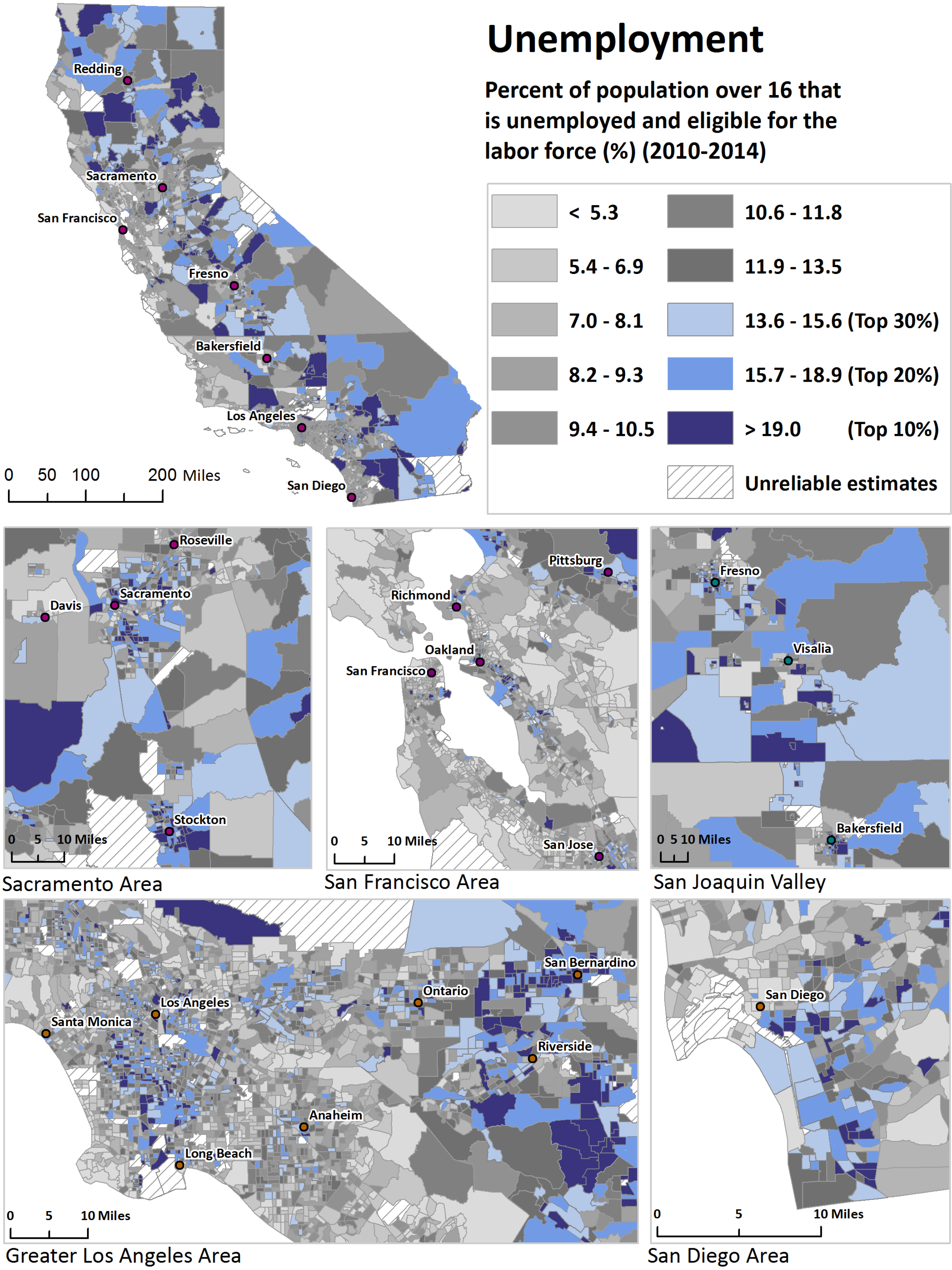
- From the 2010-2014 American Community Survey, a dataset containing the unemployment rate was downloaded by census tracts for the state of California.
- The Census Bureau calculates an unemployment rate by dividing the 'Population Unemployed in the Civilian Labor Force' by 'Population in the Civilian Labor Force' and then converting to a percentage.
- Unlike the U.S. Census, ACS estimates come from a sample of the population and may be unreliable if they are based on a small sample or population size. The standard error (SE) and

relative standard error (RSE) were used to evaluate the reliability of each estimate.

- The SE was calculated for each census tract using the formula for approximating the SE of proportions provided by the ACS (American Community Survey Office, 2013, pg. 13, equation 4). When this approximation could not be used, the formula for approximating the SE of ratios (equation 3) was used instead.
- The RSE is calculated by dividing a tract's SE by its estimate of unemployment rate, and taking the absolute value of the result.
- Census tract estimates that met either of the following criteria were considered reliable and included in the analysis:
    1. RSE less than 50 (meaning the SE was less than half of the estimate) OR
    2. SE was less than the mean SE of all California census tract estimates for unemployment rate.
- Census tracts with unreliable estimates received no score for the indicator (null). The indicator was not factored into that tract's overall CalEnviroScreen score.
- Census tracts that met the inclusion criteria were ordered by unemployment rate. A percentile score for a census tract was determined by its place in the distribution of all census tracts.

Unemployment

Percent of population over 16 that is unemployed and eligible for the labor force (%) (2010-2014)



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SCORES FOR POPULATION CHARACTERISTICS

(RANGE OF POSSIBLE SCORES: 0.1 TO 10)

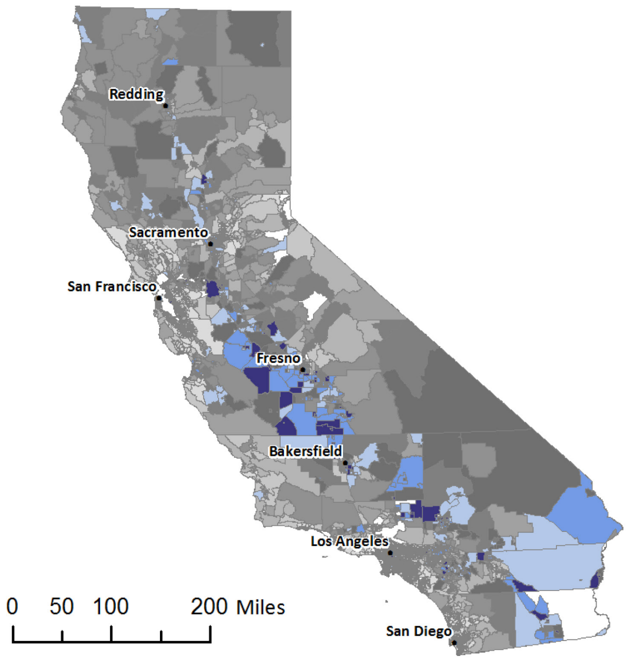
Population Characteristics scores for each census tract are derived from the average percentiles for the three Sensitive Populations indicators (asthma, cardiovascular disease, and low birth weight,) and the five Socioeconomic Factors indicators (educational attainment, linguistic isolation, poverty, rent-adjusted income, and unemployment). The calculated average percentile divided by 10 for a Population Characteristic score ranging from 0.1 -10.

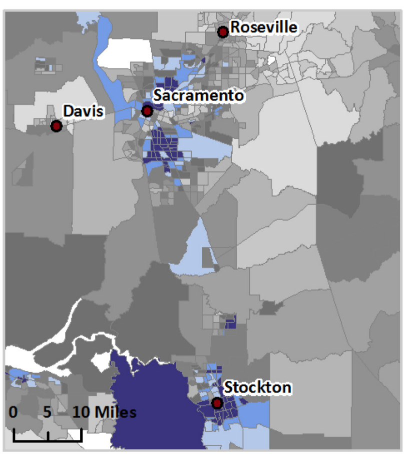
Note: The map on the following page shows population characteristic scores divided into deciles.

Population Characteristics

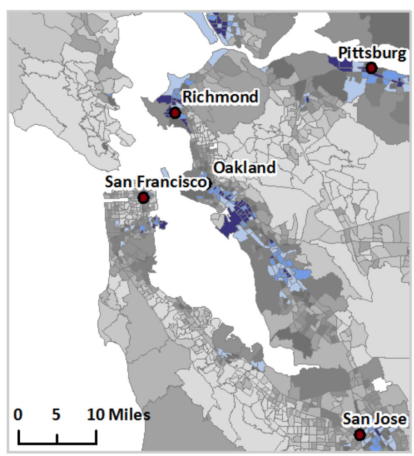
Percentile of combined Sensitive Populations and Socioeconomic Factors indicators

1% - 10%	51% - 60%
11% - 20%	61% - 70%
21% - 30%	71% - 80%
31% - 40%	81% - 90%
41% - 50%	91% - 100% (highest)

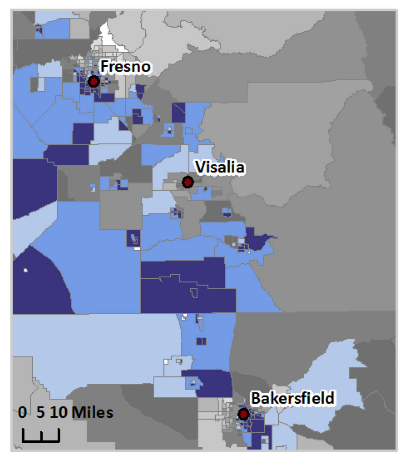




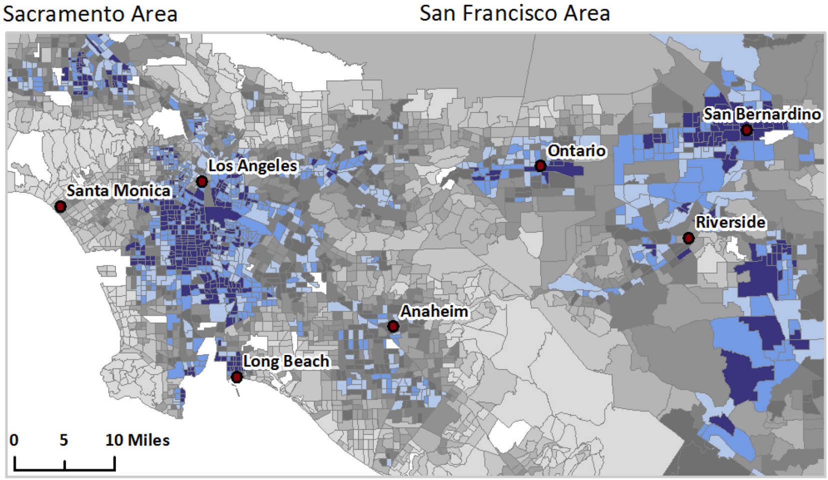
Sacramento Area



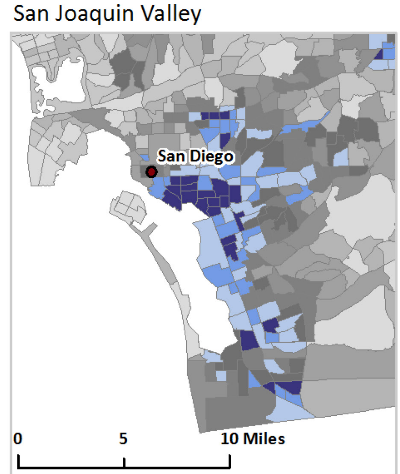
San Francisco Area



San Joaquin Valley



Greater Los Angeles Area



San Diego Area

RESULTS

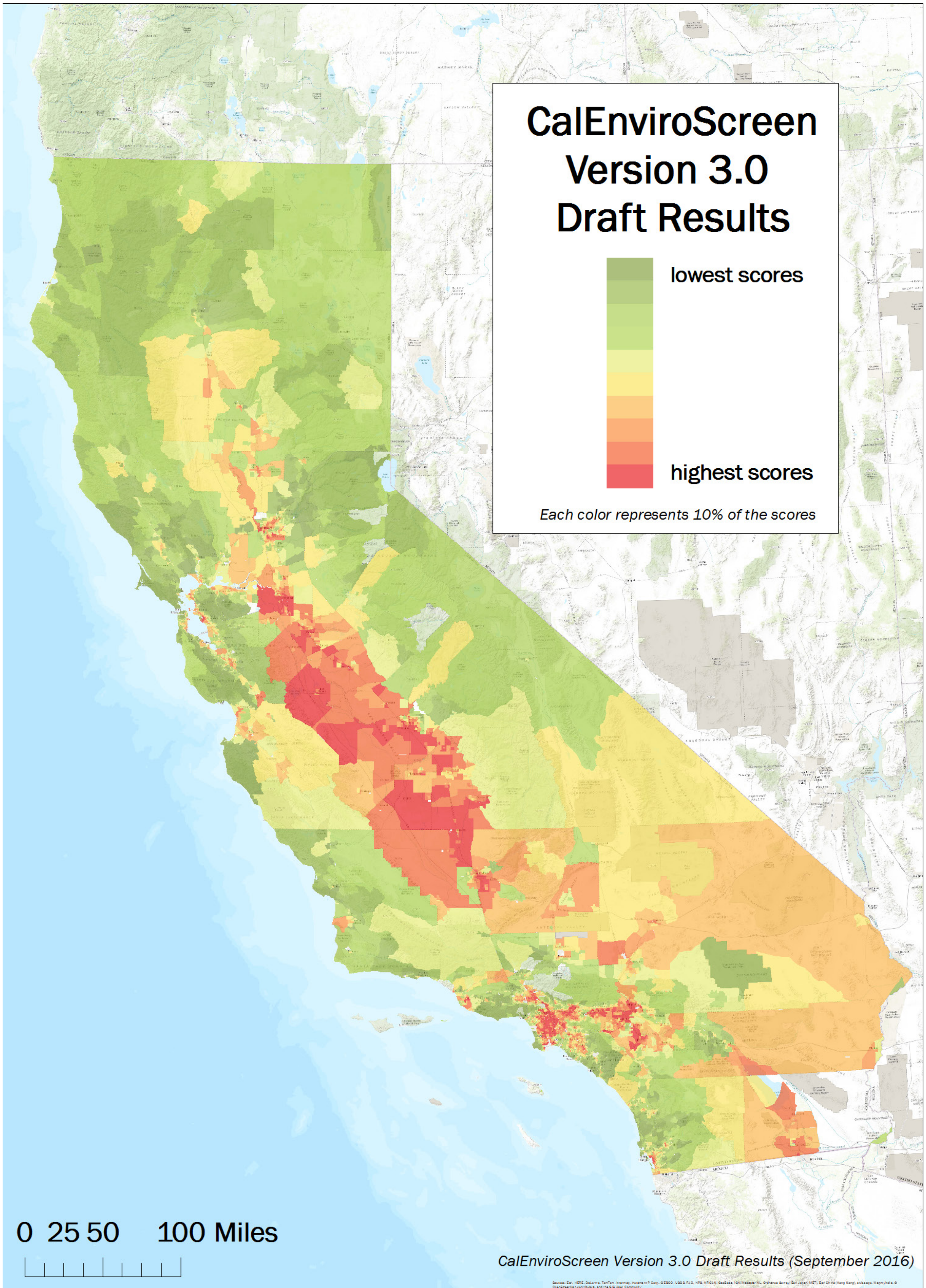
CALENVIROSCREEN STATEWIDE RESULTS

The maps on the following pages depict the relative scoring of California's census tracts using the CalEnviroScreen methodology described in this report. Census tracts with darker red colors have the higher CalEnviroScreen scores and therefore have relatively high pollution burdens and population sensitivities. Census tracts with lighter green 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 tracts in those regions. Colors on these maps reflect the relative statewide scoring of individual census tracts.

Numerical scores for each census tract, as well as the individual indicator scores for each census tract, may be found online at OEHHA's web site (http://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30-draft). The information is available both in a Microsoft Excel spreadsheet format and as an online mapping application.

CALENVIROSCREEN STATEWIDE RESULTS

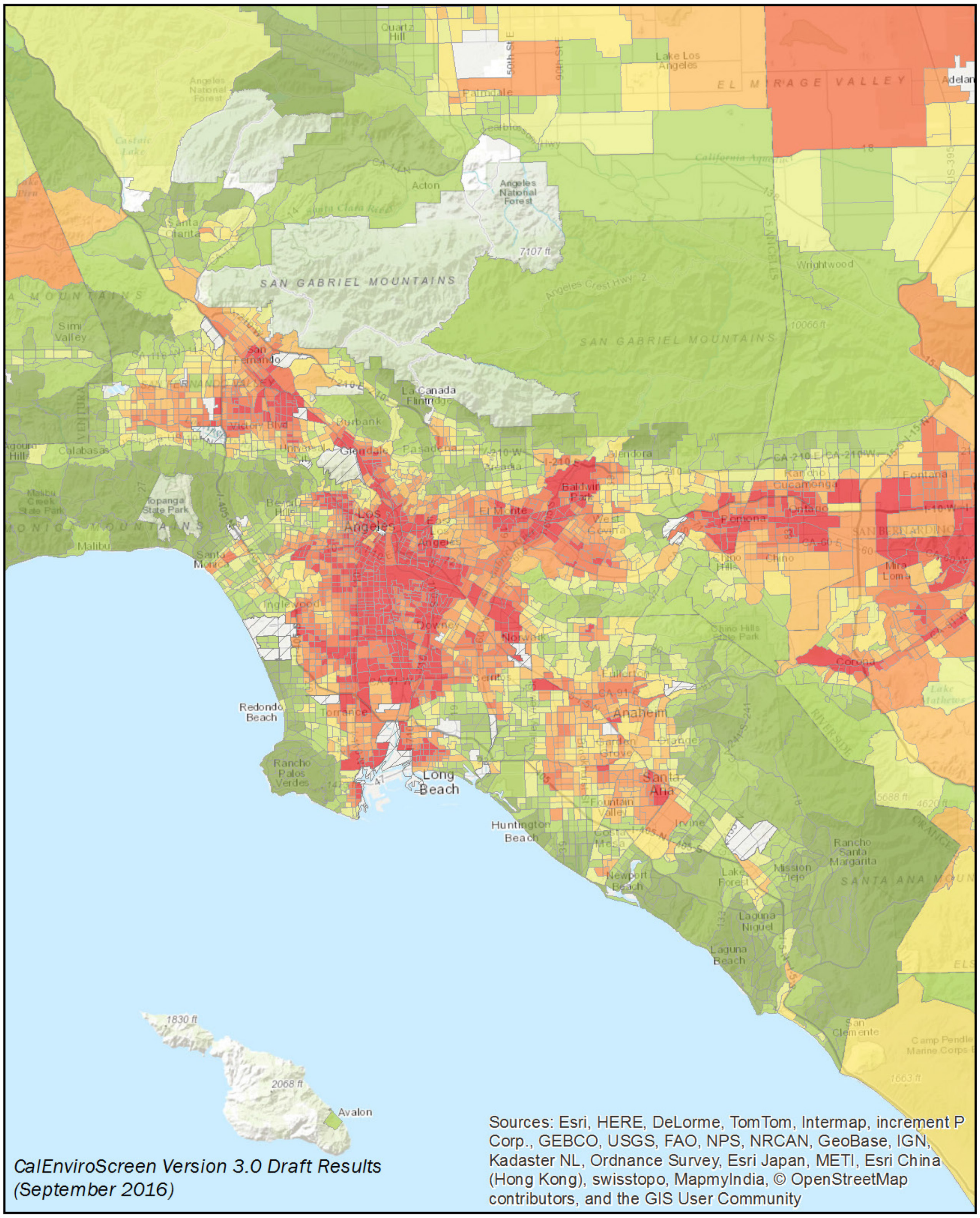

CalEnviroScreen
Version 3.0
Draft Results
lowest scores
highest scores
Each color represents 10% of the scores
0 25 50 100 Miles
CalEnviroScreen Version 3.0 Draft Results (September 2016)

CalEnviroScreen Version 3.0 Draft Results

Top 20% pollution, no CalEnviroScreen score

lowest scores — highest scores

Each color represents 10% of the scores



Los Angeles Area

0 5 10 20 Miles

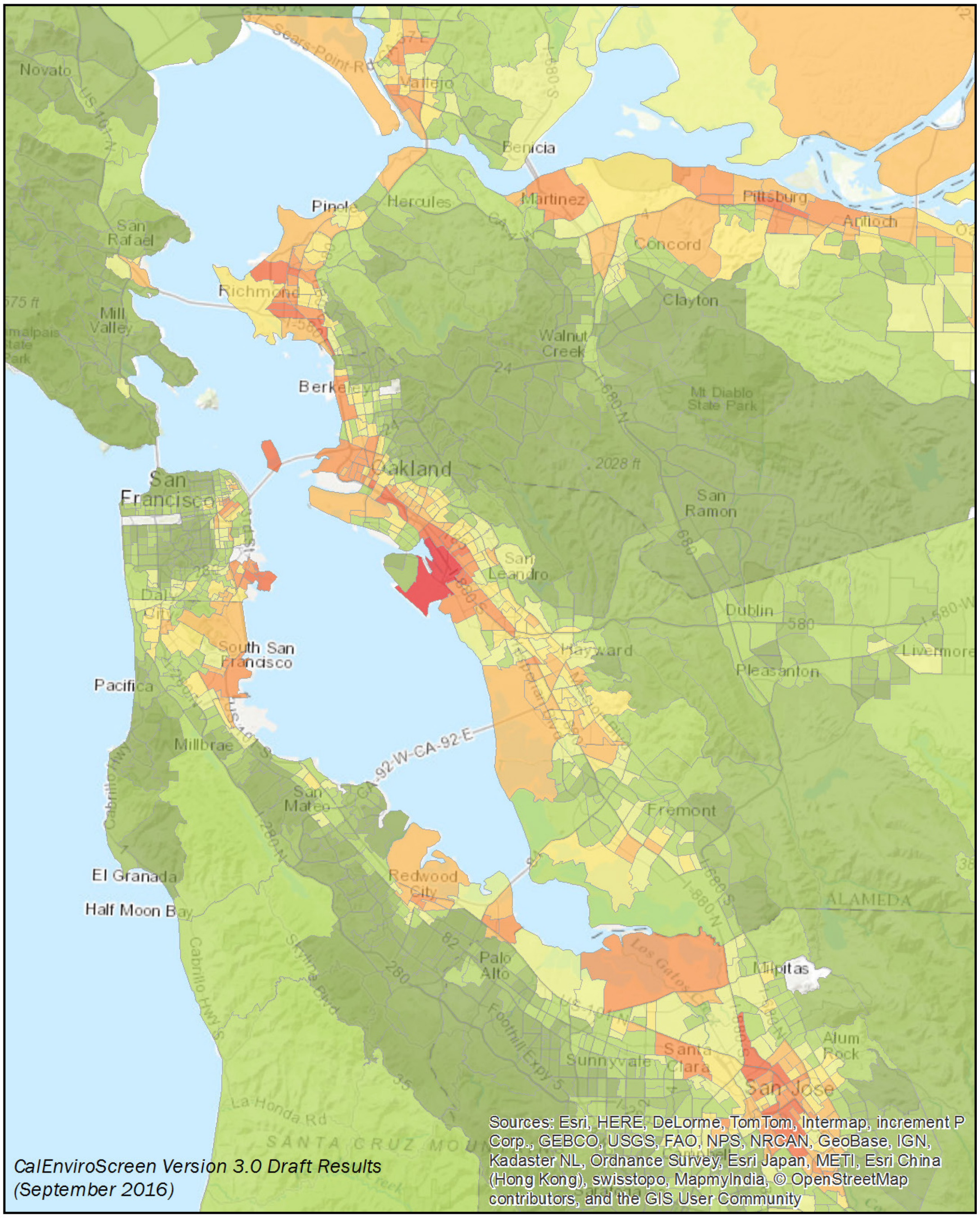
CalEnviroScreen Version 3.0 Draft Results

Top 20% pollution, no CalEnviroScreen score

lowest scores

highest scores

Each color represents 10% of the scores



San Francisco Area

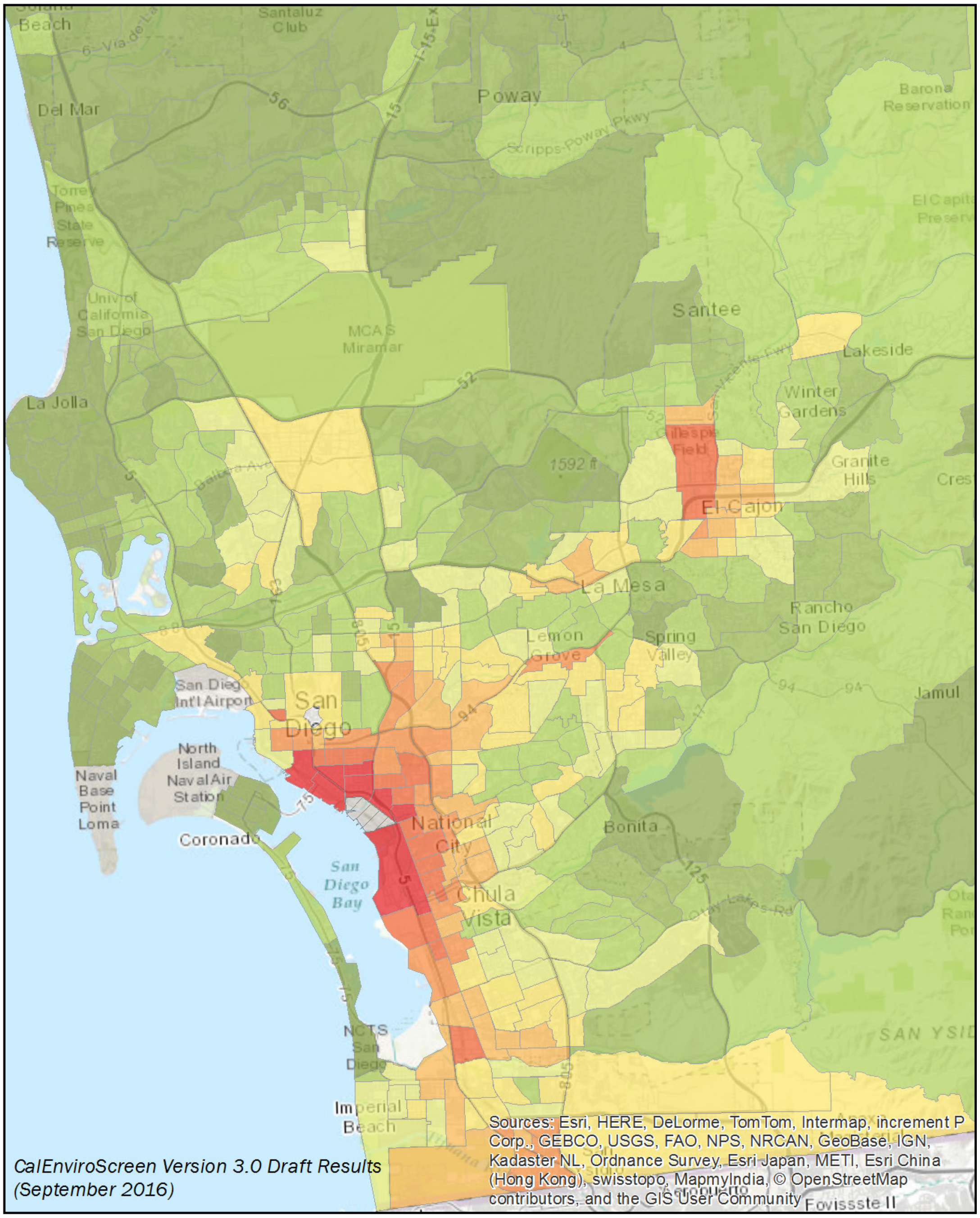
0 2.5 5 10 Miles

CalEnviroScreen Version 3.0 Draft Results

Top 20% pollution, no CalEnviroScreen score

lowest scores — highest scores

Each color represents 10% of the scores



San Diego Area

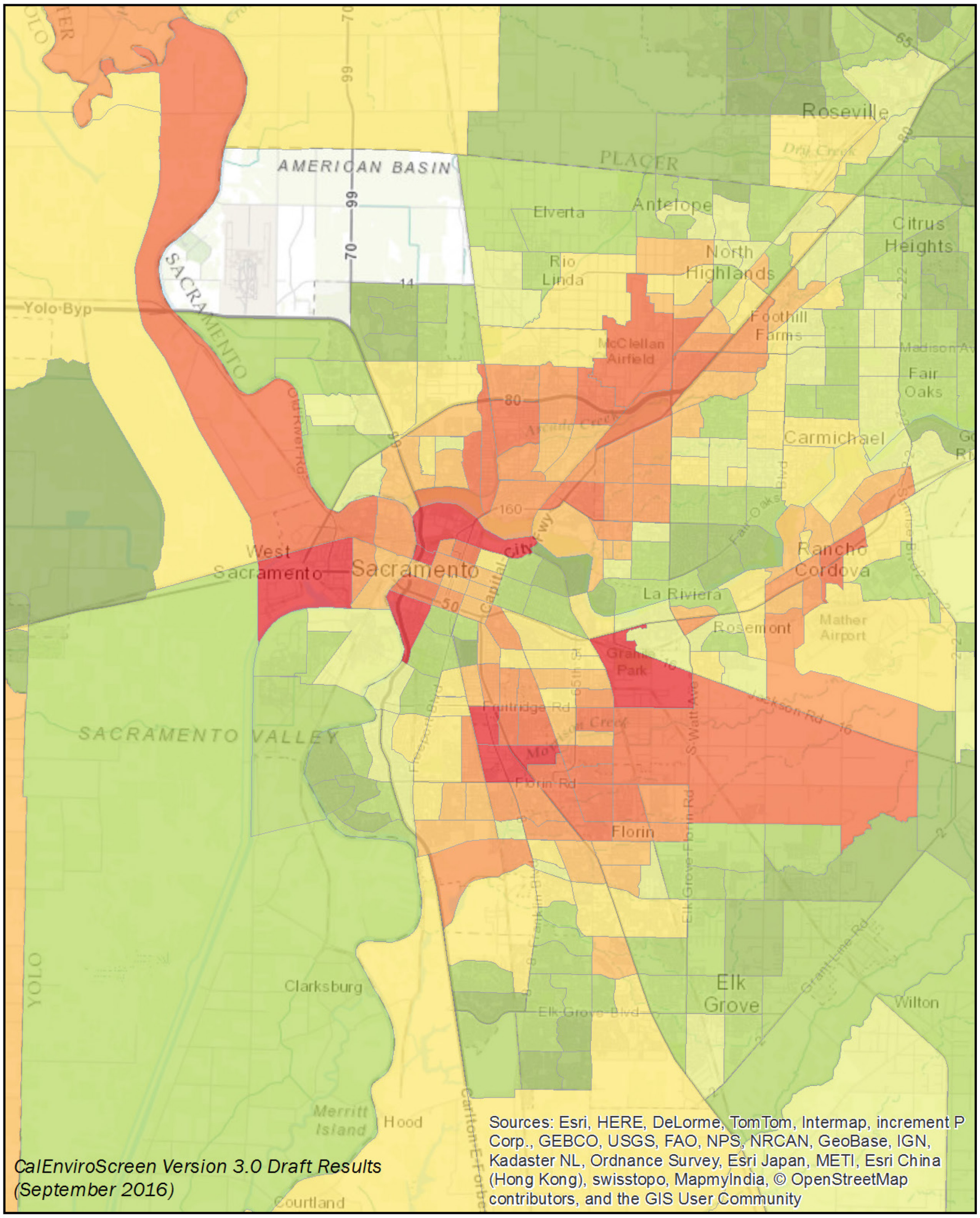
0 2.5 5 10 Miles

CalEnviroScreen Version 3.0 Draft Results

Top 20% pollution, no CalEnviroScreen score

lowest scores — highest scores

Each color represents 10% of the scores



Sacramento Area

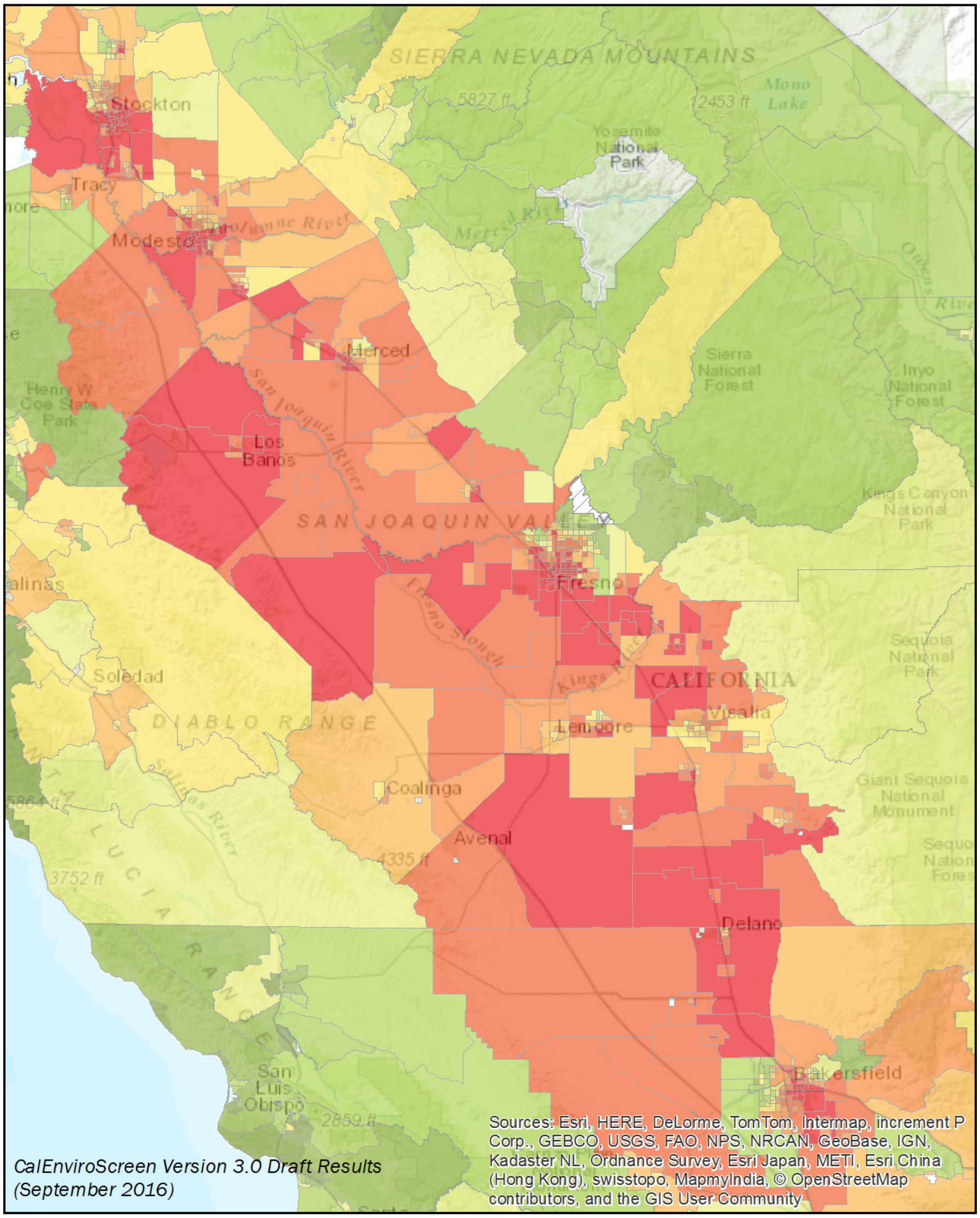
0 2.5 5 10 Miles

CalEnviroScreen Version 3.0 Draft Results

Top 20% pollution, no CalEnviroScreen score

lowest scores — highest scores

Each color represents 10% of the scores



San Joaquin Valley

0 10 20 40 Miles

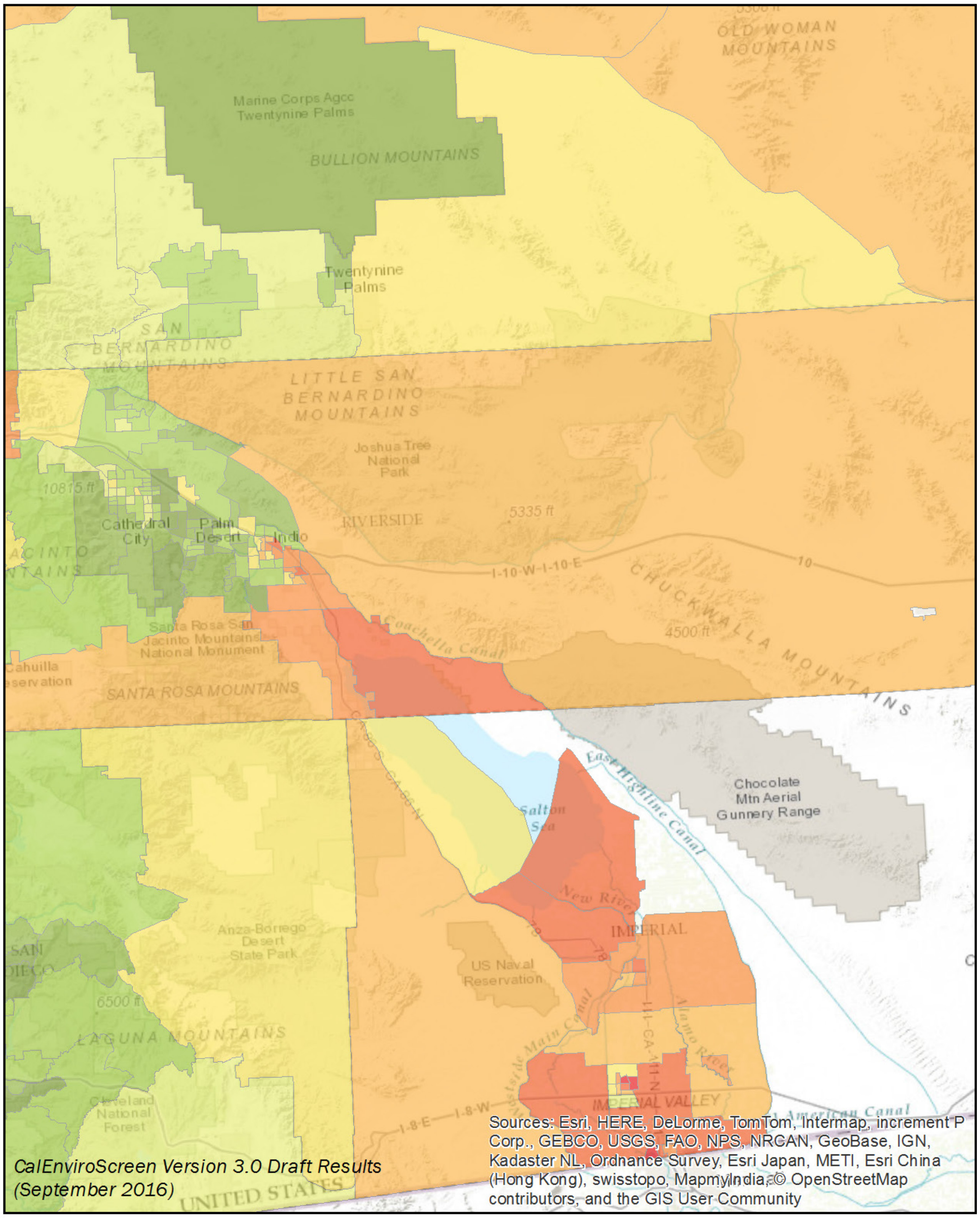
CalEnviroScreen Version 3.0 Draft Results

Top 20% pollution, no CalEnviroScreen score

lowest scores

highest scores

Each color represents 10% of the scores



Imperial Area

0 5 10 20 Miles