Community Air Risk Evaluation Program

Phase I Findings and Policy Recommendations Related to Toxic Air Contaminants in the San Francisco Bay Area

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1. INTRODUCTION

1.1 Background

In the San Francisco Bay Area toxic air contaminants* (TAC) are a serious concern, as they are in other major metropolitan areas. The California Air Resources Board (ARB) lists 189 compounds as TAC, including particulate matter (PM) specifically from diesel internal combustion engines; benzene, a constituent of gasoline and a product of incomplete combustion; and 1-3 butadiene and formaldehyde, also products of incomplete combustion. Health risks posed by these compounds include cancer risks; chronic, non-cancer risks, such as diseases of the lungs, liver, and kidneys; and acute risks, such as eye and respiratory irritations. A distinction is made between TAC and criteria pollutants, such as ozone and PM from all sources. Though both types of pollutants can have serious health effects, the regulatory frameworks for controlling them differ.

The Bay Area Air Quality Management District (Air District) currently implements a variety of programs that reduce TAC emissions and exposures. Under State law, the Air District's primary mission is to regulate stationary sources and indirect sources, and, through its regulatory, enforcement, and permit programs, the Air District reduces criteria pollutant and toxic emissions from these sources. Through its grant and incentive programs, the Air District allocates approximately $40 million in annual funding to provide incentives to reduce criteria pollutant and toxics emissions from on-road and off-road mobile sources. In addition, the Air District has an advisory role on air quality issues related to development, housing, and transportation. The Air District also supports and sponsors legislation to reduce criteria pollutant and toxic emissions from on-road and off-road mobile sources and other sources; develops model ordinances to reduce criteria and toxic pollutant emissions from on-road and off-road mobile sources and area sources; and conducts public information campaigns to increase public awareness of and involvement in pollution reduction programs.

High TAC emissions often occur near communities where, due to age (youth or seniors), high rates of asthma or other medical conditions, lack of medical services, and other socio-economic factors, residents may be particularly sensitive to the effects of TAC. These concerns led to State legislation (AB 1390, Lowenthal) which requires that California air districts with more than one million residents distribute at least 50% of their Carl Moyer Grant funding in such a manner that directly benefits communities with the most significant exposures. These concerns have also underscored the need for the Air District to develop improved tools to map and assess TAC emissions and exposures throughout the region in order to identify areas where emission reduction activities should be focused.

1.2 The Community Air Risk Evaluation Program

The goal of the Community Air Risk Evaluation (CARE) program is to identify locations with high toxic emissions and sensitive populations, and to use the information to help the Air District establish policies for the use of its incentive funding, regulatory authority, and other programs to reduce toxic emissions in areas with high TAC exposures and sensitive populations.

* Key words and phrases are defined in an appended glossary.

In Phase I of the CARE Program, the Air District and its consultants* – with input from CARE Task Force members, including scientists, community groups, and industry representatives – developed a preliminary emissions inventory of TAC and compiled demographic and health-statistics data to help identify locations with high levels of TAC and populations who are especially sensitive to TAC. The TAC emissions inventory is an annual inventory for year 2000 derived using emissions models and engineering calculations. The TAC inventory was displayed on a map of the Bay Area to indicate locations where emissions are highest.

To support the development, refinement, and evaluation of the Bay Area toxic inventory, a number of additional studies were undertaken in Phase I, including a telephone survey of residential wood burning, a carbon-14 analysis to determine new versus old carbon fractions in the ambient air, a chemical mass balance (CMB) study to estimate the source contributions to various ambient PM compounds, and a CMB analysis of organic PM compounds. Such measurement-based studies are helpful to verify that the TAC emissions estimates are realistic. Findings from Phase I are described in Section 2.

Findings from the technical studies will be used to help design measures to reduce exposure to toxic compounds, especially for sensitive populations. Activities to reduce exposure will begin being implemented immediately, as further technical analysis proceeds in Phases II and III. In Phase I, for example, the Air District included in the procedures for its Carl Moyer Program a method to target areas with high PM and sensitive populations. Additional policy recommendations are described in Section 3.

In Phase II of the CARE Program, with continued input from the Task Force, the Air District will work to improve the TAC inventory and begin preliminary modeling to estimate concentrations of TAC in the Bay Area. In Phase III, the modeling of TAC concentrations will be refined and more detailed assessments of exposure will be made using measurements and modeling. Phases II and III are outlined in Section 4.

1.3 Scope and Audience

This document summarizes the findings of Phase I of the CARE Program and presents policy recommendations aimed at reducing health risks from TAC in the Bay Area. This document targets a general audience with concerns about TAC in the Bay Area, as well as policy makers, communities, and industry groups who can use this information to help design effective TAC control strategies. In addition to summarizing Phase I findings and policy recommendations, this document also outlines the goals for Phases II and III of the CARE Program.

* The Air District worked with Sonoma Technology Inc. (STI) to develop a gridded emissions inventory of toxic air contaminants.

2. FINDINGS – PHASE I

2.1 Emissions of Toxic Air Contaminants in the San Francisco Bay Area

In Phase I of the CARE program, an annual emissions inventory of TAC was developed for a 2 by 2 kilometer (approx. 1 square mile) grid system covering the Bay Area. This gridded inventory represents emission levels in year 2000 and includes emissions from individual facilities (point sources), on-road mobile sources, and off-road mobile and other distributed sources (area sources). The compounds included in the TAC inventory are those defined by ARB, including diesel PM and other toxic compounds such as benzene and formaldehyde. In addition to mapping and evaluating them directly, the emissions of each toxic compound were weighted by their toxicity. For example, benzene has a higher cancer risk than MTBE, so it receives a higher weight. The risk-weighted emissions can be compared on the basis of their relative risks.

In the Bay Area, diesel PM accounts for about 80% of the cancer risk from airborne toxics (Figure 1a). This finding is consistent with the findings made by the South Coast Air Quality Management District in the MATES I and II studies and with statewide findings made by ARB. Diesel PM consists of primarily fine particles. In addition to the toxic effects of diesel PM, all fine particulate matter also aggravates heart and respiratory disease, including asthma. Major sources of diesel PM include on-road and off-road heavy duty diesel trucks and construction equipment (Figure 1b). The highest diesel PM emissions occur in the urban core areas of eastern San Francisco, western Alameda, and northwestern Santa Clara Counties (Figure 2a).

The major contributor to acute (short term) non-cancer health effects in the Bay Area is acrolein, a chemical formed from the combustion of fossil fuels and photochemical reactions in the atmosphere. The major contributor to chronic (long term) non-cancer health effects in the Bay Area is also acrolein. Major sources of acrolein in the Bay Area include on-road mobile sources and aircraft (Figure 1c-f). Areas with high acrolein emissions are near commercial and military airports and freeways (Figure 2b).

The emissions inventory of TAC and associated potential health risks estimated in Phase I are the best available estimates for the Bay Area. However, the inventory and estimates of risk should be considered preliminary because they are subject to change as further analysis is carried out in Phases II and III.

2.2 Supporting Studies

To support the development of the Bay Area TAC inventory and to assist in its evaluation, the Air District conducted a number of additional studies. A telephone survey of residential wood burning provided an estimation of total wood burning in the Bay Area that is consistent with previous estimates; however, the study indicated that much less wood burning occurs in San Francisco County than previously estimated and more occurs in Alameda, Contra Costa, and North Bay Counties. A carbon-14 analysis showed that during both summer and winter new carbon (wood burning, forest fires, food preparation) and old carbon (fossil fuel combustion) each contribute about half the total carbon collected on PM filter samples in the Bay Area. Confirming this result and reconciling it with emissions inventory estimates will be important future steps. A chemical mass balance (CMB) study was conducted to estimate the source

contributions of various sources to ambient particulate matter. Similarly, a CMB analysis of organic PM compounds is underway to apportion the organic portion of observed PM concentrations. These types of studies are important since diesel PM cannot be measured directly.

2.3 Demographic and Health Statistics Geospatial Data

Many children (under 18), seniors (over 64), and low-income families (below 185% of U.S. poverty level) live in core urban areas of the Bay Area. These populations, as well as the total population of the Bay Area, were gridded in the same 2 x 2 kilometer grid used for the TAC emissions (Figure 3a-c). As a group, children and seniors are more sensitive to the harmful effects of TAC. In addition, low income residents often have less access to health care compared to the overall population of the Bay Area.

Western Alameda County and eastern San Francisco County have high hospitalization rates for childhood (under 14) asthma (Figure 3d). Studies have shown that children living near freeways are more likely to develop asthma and are likely to be more sensitive to the effects of TAC[*]. While no attempt is being made here to establish a causative link between the asthma hospitalization rates shown in Figure 3d and TAC emissions, it is clear that areas with high rates of childhood asthma are important targets for reductions in TAC emissions. Comparison of the maps of demographic and health data (Figures 3a-d) to TAC emissions (Figures 2a-b) reveals that high TAC emissions occur near areas with low-income and sensitive populations.

2.4 Population-weighted Emissions

In order to identify areas with both high emissions and sensitive populations, the Air District developed maps of emissions weighted by total population, or by sensitive populations (Figure 4a-d). For example, Figure 4 shows diesel PM emissions weighted by demographic and health data: diesel PM was weighted by population under 18 (4a), population over 64 (4b), family income less than 185% of federal poverty level (4c), and age-adjusted asthma rates for children 14 and under (4d).

3. POLICY RECOMMENDATIONS

3.1 Targeted Mitigation

One of the objectives of the CARE Program is that information gained at each phase of the program be used to help direct mitigation strategies. The Air District intends to use Phase I findings to target appropriate mitigation measures in areas with high TAC emissions and sensitive populations, that is, population-weighted TAC emissions can be used as a surrogate for TAC exposures. The Air District recognizes that population-weighted emissions are not a perfect surrogate for exposure; however, they are a reasonable indicator of where mitigation efforts should be focused while more refined technical analysis proceeds. The CARE program is

[*] For example, the East Bay Children's Respiratory Health Study, published by J. J. Kim, S. Smorodinsky, M. Lipsett, B. C. Singer, A. T. Hodgson, and B. Ostro in 2004, conducted a school-based investigation of "Traffic-related Air Pollution near Busy Roads."

committed to following up with more sophisticated techniques for evaluating exposure in Phases II and III.

In the following sections a number of potential policy responses are outlined that adapt existing mitigation strategies and target them using Phase I emissions and demographic data to achieve the goals of the CARE program.

3.2 Grant and Incentive Programs

Through the Carl Moyer Program, the Transportation Fund for Clean Air, the Mobile Source Incentive Fund and other grant programs, the Air District distributes approximately $40 million per year in incentive funding to reduce emissions from on-road and off-road sources. Data from Phase I of the CARE program will help the Air District focus grants and incentives in areas with high TAC emissions and sensitive populations. Combining gridded emissions of diesel PM and other TAC with population and health effects data is an example of how these data can be used.

The Air District has already focused certain grant programs in this way. Gridded emission information for fine PM has already been incorporated into the policies and procedures for awarding past grant cycles of Carl Moyer Funds. Following this precedent, Air District staff intends to recommend to the Board of Directors that the CARE Program Phase I gridded toxic emissions, population and health effects information be incorporated into the policies and procedures for awarding other Air District grant and incentive funds.

Model year 2007 and later on-road heavy-duty diesel (HDD) vehicles have substantially lower PM emissions than older vehicles. However because of the relatively low turnover rate and high mileage accumulation for HDDs, it will be many years before substantial emission reductions are achieved by fleet turnover alone. Off-road diesel sources, including construction equipment, ships, cargo handling equipment, trains, etc., which are not subject to the same stringent emission standards as on-road HDDs, contribute an increasingly larger fraction of total diesel PM emissions. In addition, the high per vehicle cost (about $5,000 to $25,000) of reducing diesel PM emissions from existing sources through retrofits or replacement means that only a small fraction of the existing high emitting diesel PM sources can be cleaned up or replaced each year. Thus, there is a need to use these limited resources as effectively as possible.

3.3 Public Involvement

The Air District conducts public information campaigns to increase public involvement in pollution reduction programs. The Air District works with local Resource Teams in communities including West Oakland, West Contra Costa County, and East Palo Alto to encourage public involvement, and holds numerous meetings throughout the Bay Area on local air quality concerns. For example, the Air District was integrally involved in efforts to enforce the State's new anti-idling rules for diesel trucks that service the Port of Oakland area. Several workshops were held to explain these new regulations to local residents. The Phase I findings will provide critical information to Air District staff and to community members as the Air District continues to work with Bay Area communities.

3.4 Collaboration with Other Government Agencies

The Air District has worked closely with Cal/EPA and others on statewide efforts to reduce air quality impacts from goods movement. The Air District is also collaborating with the Metropolitan Transportation Commission, the Port of Oakland, and other stakeholders to reduce emissions from goods movement in the Bay Area. The Air District is also working closely with ARB and two railroads to implement the statewide Railroad Memorandum of Understanding. The CARE Program Phase I findings will provide critical technical support for these efforts.

The Air District also has an advisory role on air quality issues related to land use development, housing, and transportation. The Air District reviews and comments on local general plans and environmental documents. Air District staff will incorporate Phase I findings into outreach to cities and counties regarding TACs, buffer zones, and incompatible land uses.

Although the State and federal governments regulate mobile sources, the largest sources of diesel PM and other TACs, the Air District works closely with ARB to achieve stringent mobile source regulations. In 2005 the Air District supported ARB regulations on Cargo Handling Equipment at Ports and Railyards and Auxiliary Engines on Ocean-Going Vessels. The Phase I findings will help the Air District and Bay Area communities to advocate for additional regulations from ARB.

3.5 Model Ordinances

The Air District develops model ordinances to reduce criteria and toxic pollutant emissions that are adopted and enforced by local governments. For example, the Air District has developed a model ordinance to limit residential wood burning that many local jurisdictions have adopted. Similarly, the Phase I findings will aid the Air District as we explore other such model ordinances, such as local ordinances to limit idling of diesel equipment.

3.6 Regulations

The Air District has authority to regulate criteria pollutant and toxic emissions from stationary sources and indirect sources. The CARE Program Phase I findings will help identify priorities for TAC reductions in new or modified Air District regulations. Initial emphasis will likely be placed on stationary sources. The Air District also has authority to regulate indirect sources, however, so the Air District may also consider regulatory programs focused on large indirect sources of TAC, for example facilities that attract large numbers of diesel vehicles.

3.7 New Legislation

The Air District sponsors and supports legislation to reduce criteria pollutant and toxic emissions from on-road and off-road mobile sources and other sources. For example, in 2006 the Air District supported SB 1601 (Lowenthal), which would have required Best Available Control Technology to reduce emissions at California ports. In 2005, the Air District supported several bills related to the reduction of TAC, including AB 694 (Chan), which the Air District sponsored to expand the use of Transportation Fund for Clean Air (TFCA) funding to clean up Bay Area

heavy duty diesel vehicles that are not part of public agency fleets[*]. Phase I findings will help identify and advocate for additional legislation.

4. NEXT STEPS

4.1. Future Work

Future phases of the CARE program will build on work in Phase I to refine the preliminary TAC inventory, apply air quality models to estimate TAC concentrations, and collect supplemental measurements of TAC concentrations (Phase II). Measurement-based and model-based concentrations will be used in combination with exposure models to more realistically estimate actual population exposures (Phase III). Additional TAC mitigation strategies will also be defined. The outlines below begin to summarize future phases of the CARE program. More details will be developed in a CARE protocol document.

4.2. Phase II

In Phase II the Air District will:

- Further develop the TAC emissions inventory, including a reevaluation of diesel PM emissions from construction equipment;
- Conduct preliminary modeling, at both regional and local scales during a summer and a winter season to estimate TAC concentrations;
- Participate with ARB and the Port of Oakland to conduct a *health risk assessment* (HRA) for the port;
- Work with ARB to conduct an HRA for the West Oakland community;
- Carry out measurement studies (already in planning phase) of organic and elemental carbon to estimate diesel PM in cooperation with ARB;
- Refine and implement mitigation strategies identified in Phase I.

4.3. Phase III

Phase III tasks are still preliminary, and may include the following:

- Further develop the TAC emissions inventory;
- Refine regional and local scale modeling;
- Apply tools developed during the Port of Oakland HRA to other communities;
- Conduct exposure analyses, including micro-scale analyses, to estimate actual population exposures;
- Refine and implement mitigation strategies identified in Phases I and II.

[*] Public agency fleets were already eligible.

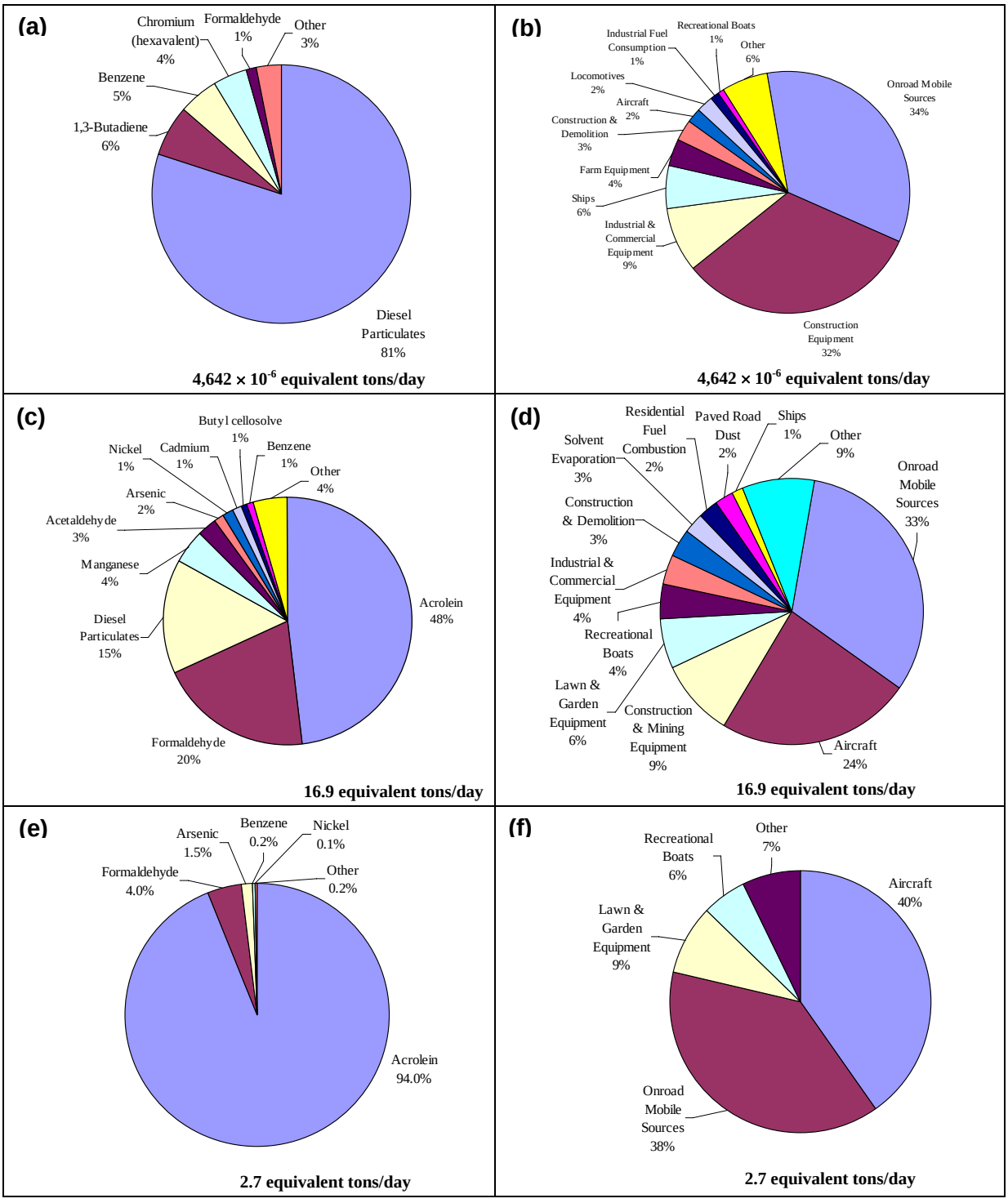

Figure1. Contributions to Bay Area-wide toxicity-weighted emissions, broken down by TAC and by emissions source category: (a) cancer toxicity-weighted emissions by pollutant; (b) cancer toxicity-weighted emissions by source category; (c) chronic toxicity-weighted emissions by pollutant; (d) chronic toxicity-weighted emissions by source category; (e) acute toxicity-weighted emissions by pollutant; (f) acute toxicity-weighted emissions by source category.

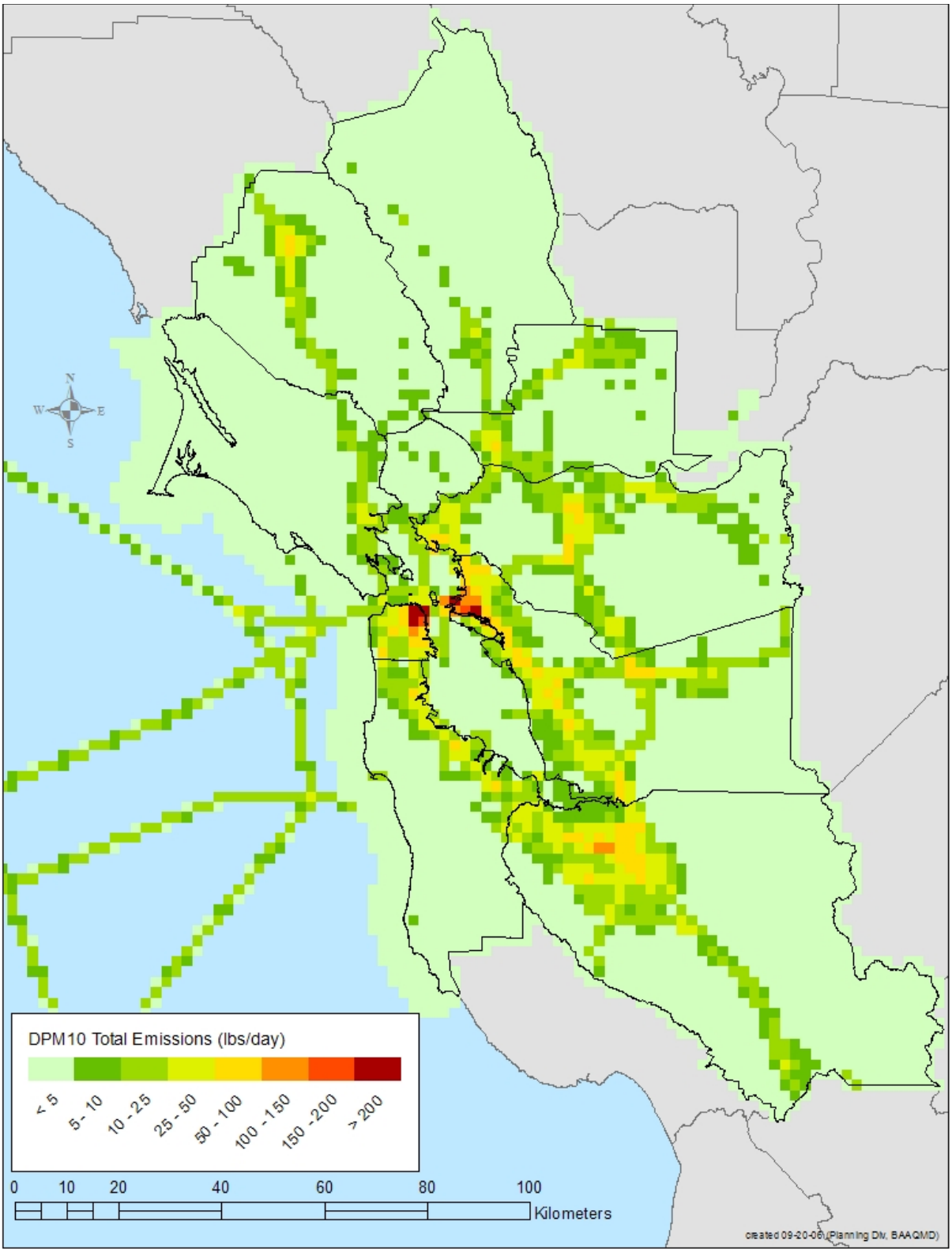

Figure 2a. Emission density plot of diesel particulate emissions.

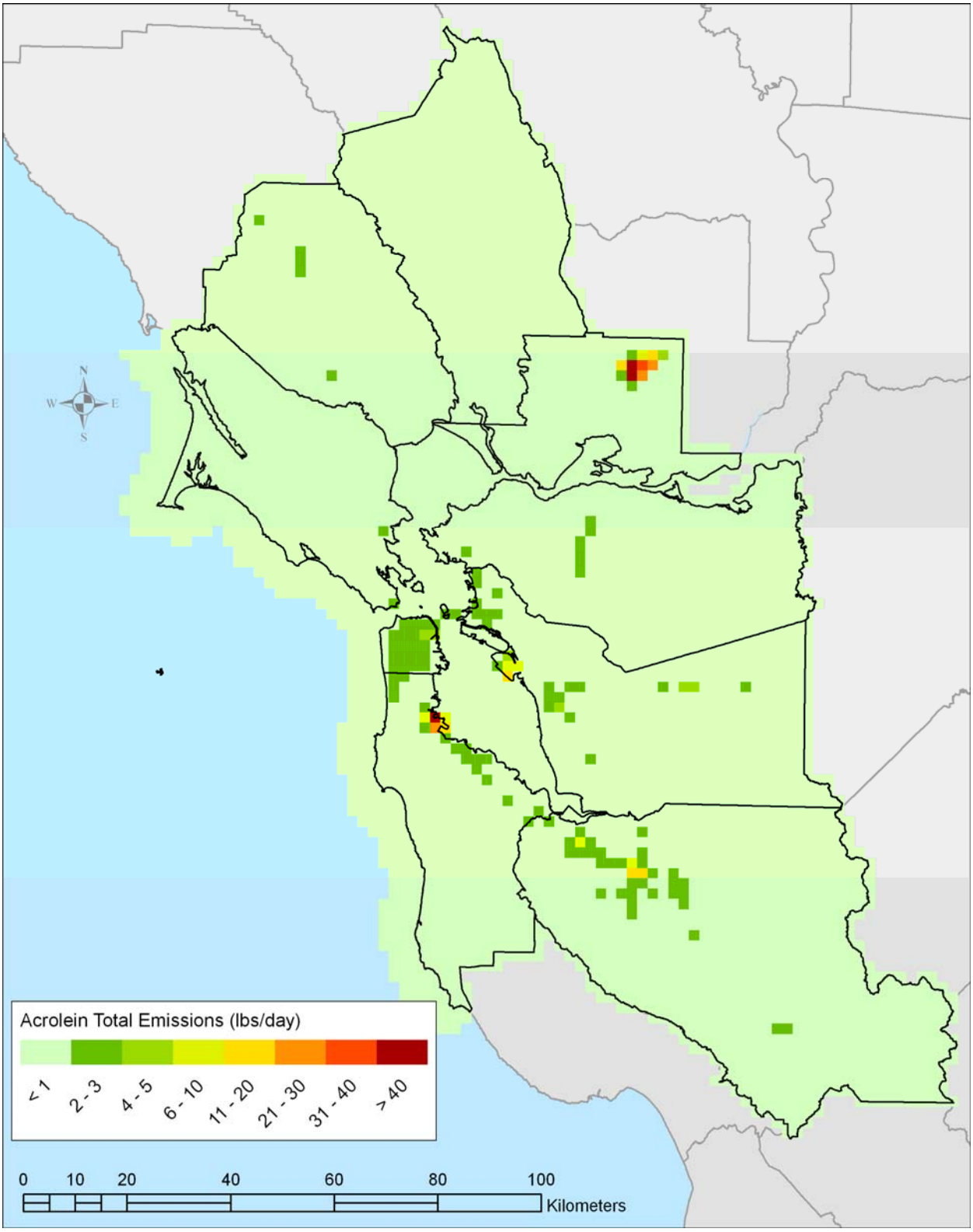

Figure 2b. Emission density plot of acrolein emissions.

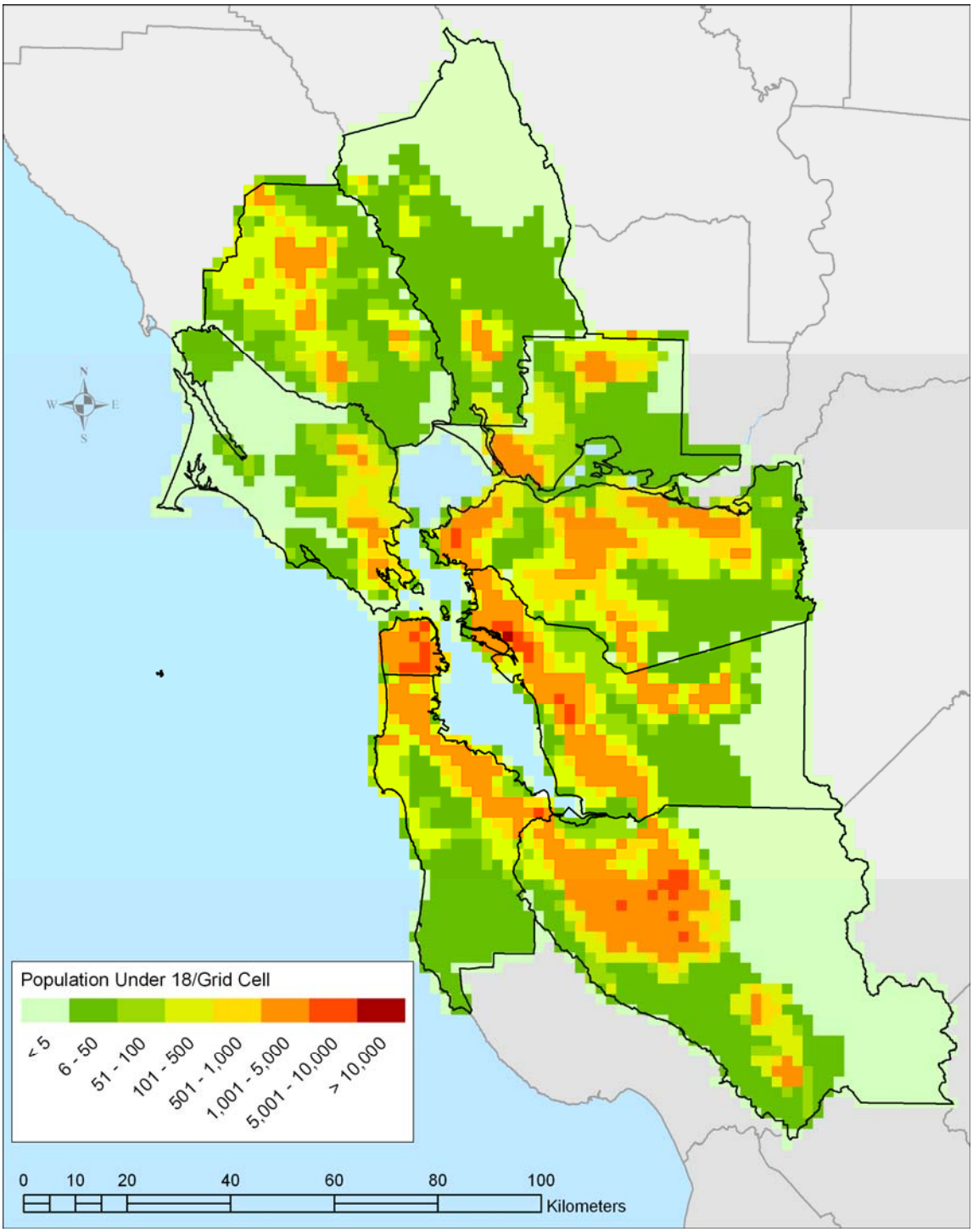

Figure 3a. Distribution of populations under 18 years of age.

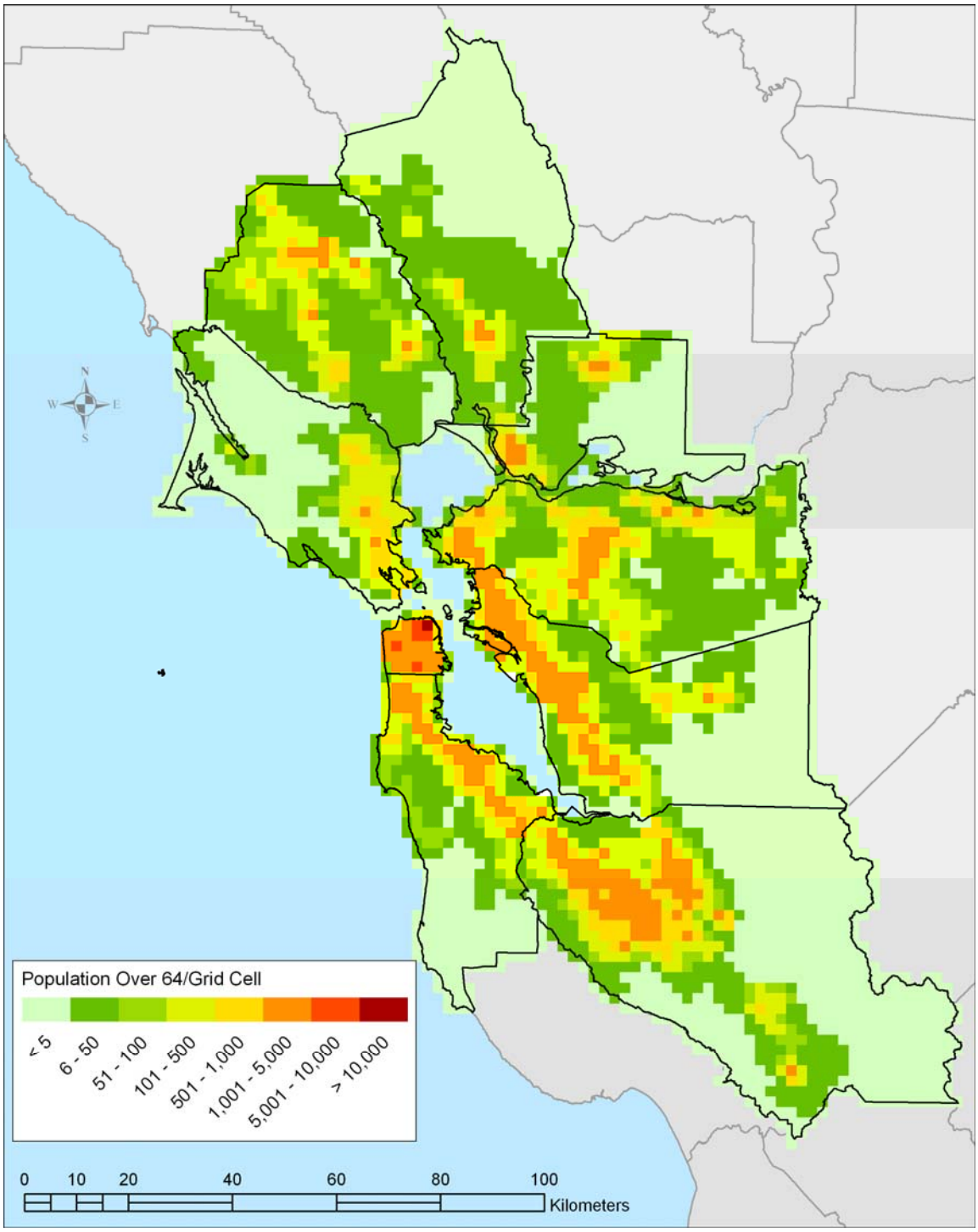

Figure 3b. Distribution of populations over 64 years of age.

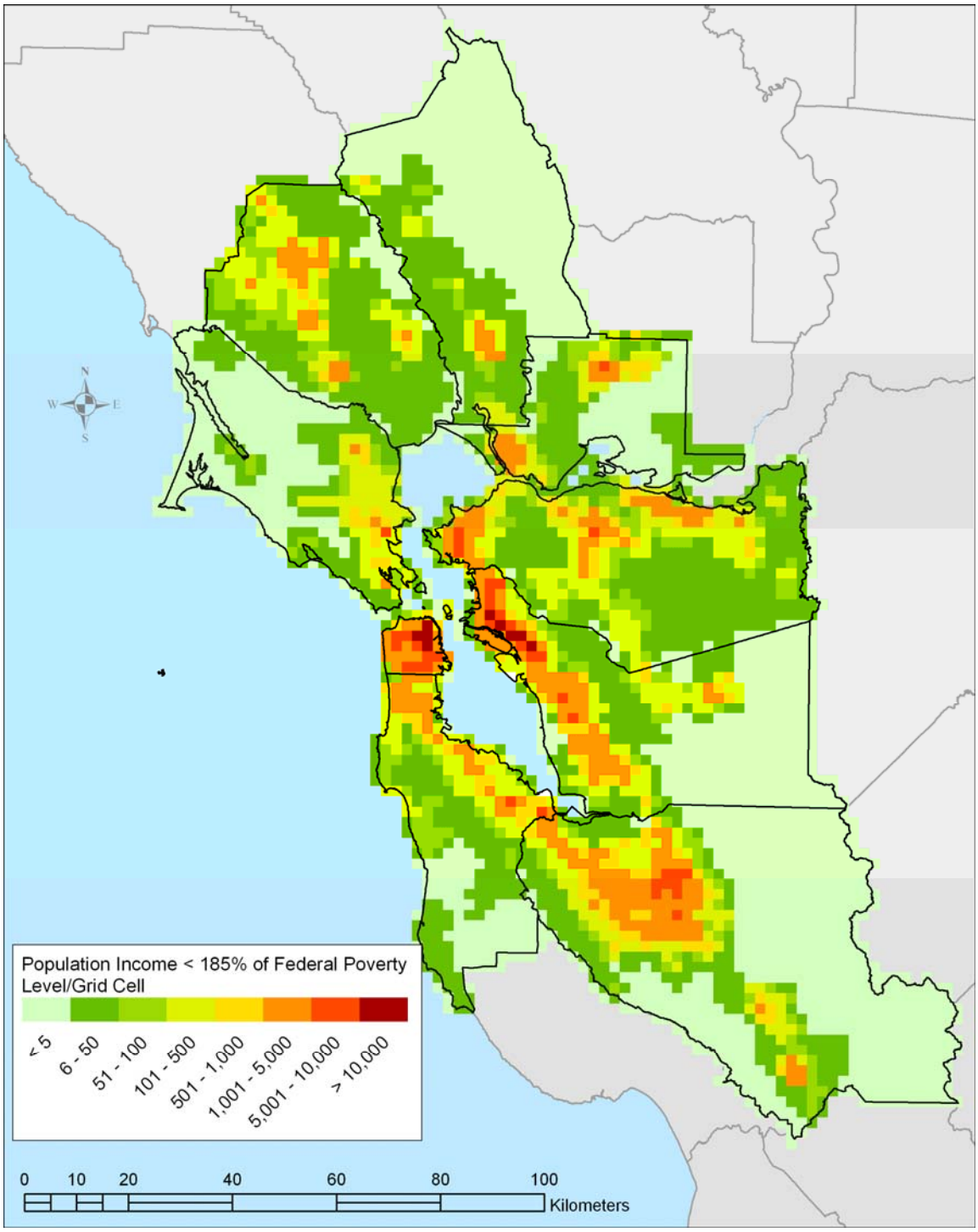

Figure 3c. Distribution of populations living in households earning less than 185% of the federal poverty level.

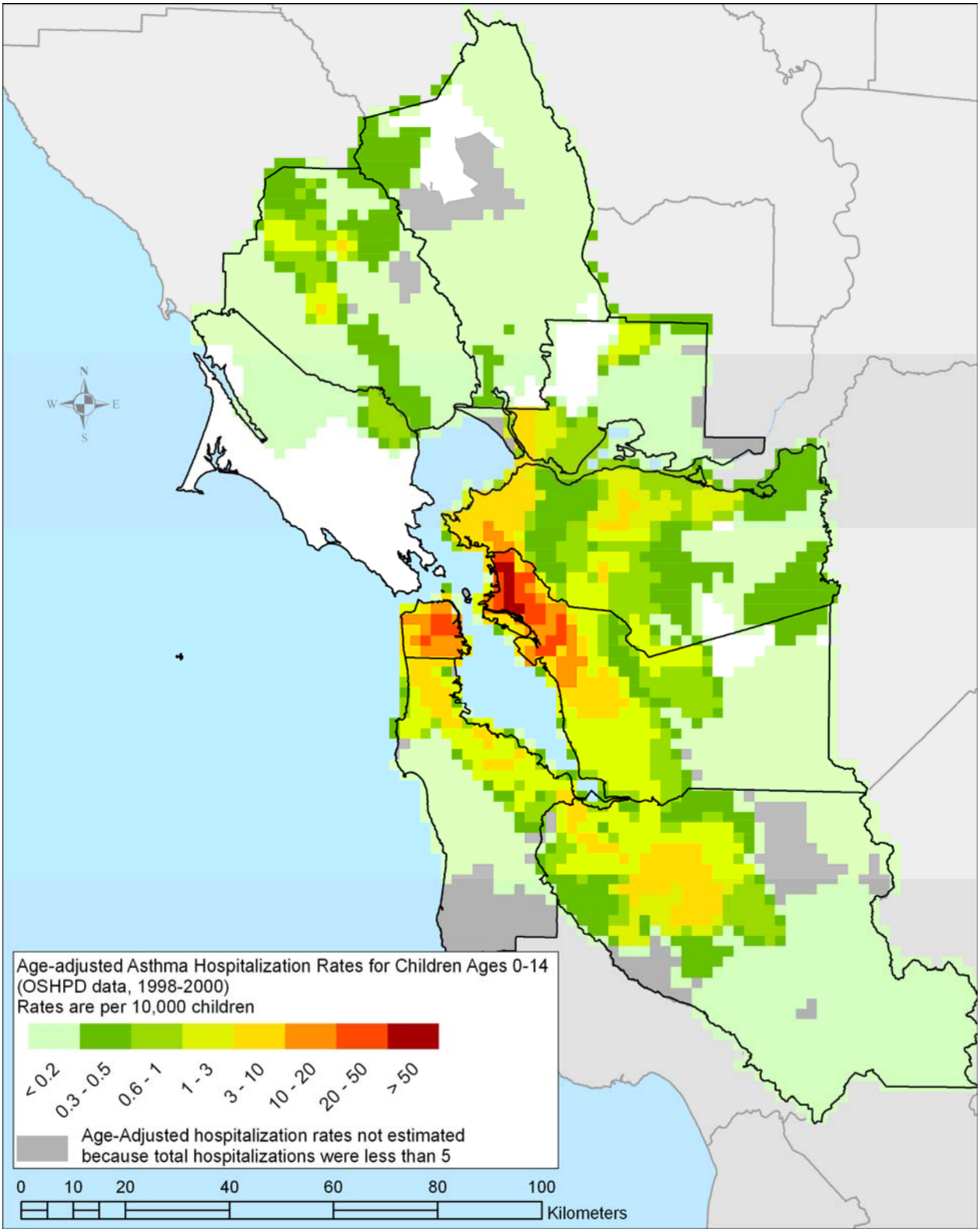

Figure 3d. Age-adjusted rates of hospitalization due to asthma in children 14 years of age and below. Note that white areas represent areas with no available data.

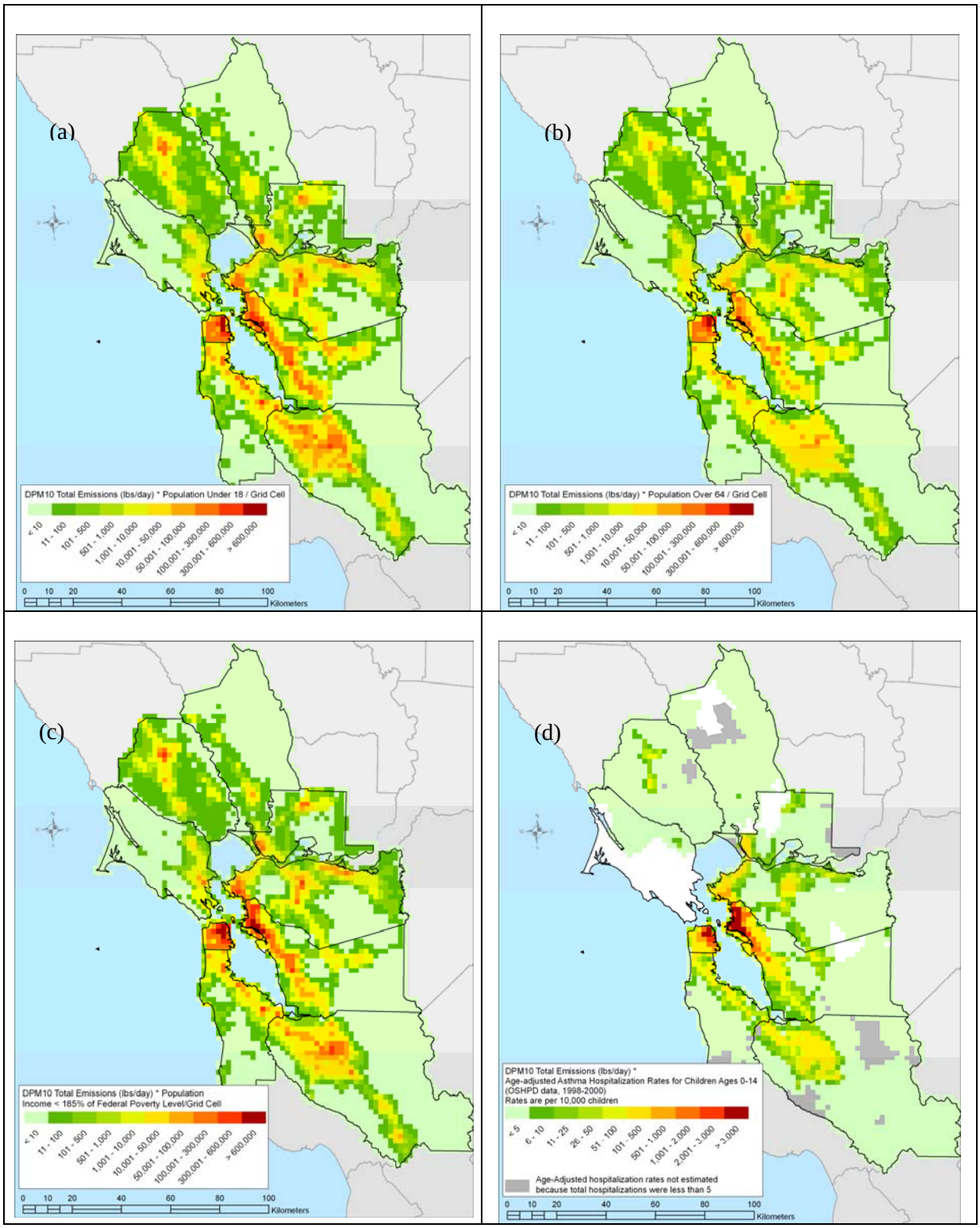

Figure4. (a) Diesel particulate matter (PM) emissions weighted by population under 18; (b) diesel PM emissions weighted by population over 64; (c) diesel PM emissions weighted by population of low-income families (below 185% of the federal poverty level); (d) diesel PM emissions weighted by age-adjusted asthma rates for children 14 and under.

GLOSSARY

Air Quality Management District (AQMD) – Local agency charged with controlling air pollution and attaining air quality standards. The Bay Area Air Quality Management District is the regional AQMD that includes Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo and Santa Clara Counties and the southern halves of Solano and Sonoma Counties.

Area Sources – Sources of air pollutants that individually emit relatively small quantities of air pollutants, but which cumulatively may emit large quantities of emissions. Examples include water heaters, lawn maintenance equipment and consumer products.

California Air Resources Board (ARB) – The State of California agency responsible for air pollution control. Responsibilities include: establishing State ambient air quality standards, setting allowable emission levels for motor vehicles in California and oversight of local air quality management districts.

Cal/EPA – The California Environmental Protection Agency is an umbrella agency for the State's environmental Boards and Departments, including the California Air Resources Board.

Carbon 14 Analysis – A process for determining the age of carbon materials. Old carbon (fossil fuels) contains less carbon 14 than new carbon (wood and vegetation).

Carl Moyer Grant Program – A grant program funded by the State that provides funds to reduce exhaust emissions from heavy-duty diesel engines.

Criteria Air Pollutants – Air pollutants for which the federal or State government has established ambient air quality standards, or criteria, for outdoor concentration in order to protect public health. Criteria pollutants include: ozone, carbon monoxide, sulfur dioxide, particulate matter, nitrogen oxide, and lead.

Chemical Mass Balance Model – A receptor model that uses profiles of different source types, and using best-fit methods, determines likely source contributions to measured ambient concentrations.

Elemental Carbon (EC) – Elemental carbon is mostly soot.

Emissions Inventory – A list of air pollutants emitted into an area's atmosphere, in amounts (commonly tons) per day or year, by type of source.

Health Risk Assessment – An analysis where human exposure to toxic substances is estimated, and considered together with information regarding the toxic potency of the substances, to provide quantitative estimates of health risk.

Indirect Sources – Land-uses and facilities which attract or generate motor vehicle trips and thus result in air pollutant emissions, e.g., distribution centers, shopping centers, and office buildings.

Metropolitan Transportation Commission – The Metropolitan Transportation Commission is the transportation planning agency for the San Francisco Bay Area.

Mobile Source – Any vehicle that produces air pollution, such as cars, trucks and motorcycles (on road mobile sources) or ships, trains and construction equipment (off-road mobile sources).

Organic Carbon (OC) – A complex mixture of organic compounds, including hydrocarbons, that form particles. Sources of (OC) are combustion sources such as gasoline and diesel engines and wood or biomass burning.

Ozone – A pungent, colorless, toxic gas. A product of complex photochemical processes, usually in the presence of sunlight. Ozone in the lower atmosphere is a criteria air pollutant.

Particulate Matter – A particle of solid or liquid matter; soot, dust, aerosols, fumes and mists.

Point Source – A single stationary source, such as a smoke stack.

Port of Oakland – The port commissions owns and operates seaport facilities, Oakland International Airport, and commercial properties including Jack London Square.

Railroad MOU – A memorandum of understanding among the California Air Resources Board and the Union Pacific Rail Road and the BNSF Railway. It requires emissions reductions and health risk assessments for major rail yards.

Stationary Source – A fixed, non-mobile source of air pollution, usually at industrial or commercial facilities.

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Toxic Air Contaminants – Air pollutants which cause illness or death in relatively small quantities. Non-criteria air contaminants that, upon exposure, ingestion, inhalation, or assimilation into organisms either directly from the environment or indirectly by ingestion through food chains, will cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, or physical deformations in such organisms or their offspring.