Air Pollution and Environmental Justice:

Integrating Indicators of Cumulative Impact and Socioeconomic Vulnerability into Regulatory Decision-making

Source: CBE

Source: David Woo

PERE
USC Program for Environmental & Regional Equity

***Presentation:* April 21, 2010**

Manuel Pastor, USC
Rachel Morello-Frosch, UC Berkeley
Jim Sadd, Occidental College

The Primary Research Team

- Manuel Pastor, Ph.D. in Economics, responsible for project coordination, statistical analyses, including multivariate and spatial modeling, and popularization
- James Sadd, Ph.D. in Geology, responsible for developing and maintaining geographic information systems (GIS), including location of site and sophisticated geo-processing
- Rachel Morello-Frosch, Ph.D. in Environmental Health Science, responsible for statistical analysis, health end-points, and estimates of risk.

Project Summary: Integrating Indicators of ***Cumulative Impact*** and ***Socioeconomic*** into Regulatory Decision-making

Address data and analytical needs for implementation of 2004 EJ Working Group Recommendations

- Analyze air pollution data for disparities statewide and regionally (facility location, exposures, estimated health risks)
- Examine air pollution data in relation to health (birth outcomes)
- Conduct local-scale study utilizing community-based participatory research (CBPR) methods to:
  - 'ground-truth' information from emissions inventory data
  - Conduct PM sampling using low cost monitors
- Develop indicators of *cumulative impact* and community *vulnerability/resilience* using existing data sources
  - Relevance for research, policy, and regulation
  - Develop screening methods with indicators to flag locations and populations that may be of regulatory concern for disparate impact
- Consider alternative siting scenarios for CEC

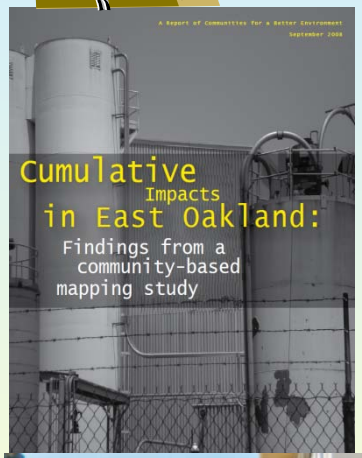
Presentation Today (three of the sub-projects):

- Analyze air pollution data for disparities regionally (facility location, exposures, estimated health risks)

- Examine air pollution data in relation to health (birth outcomes)

- Develop indicators of *cumulative impact* and community *vulnerability/resilience* using existing data sources – an Environmental Justice Screening Method (EJSM)

Bay Area EJ Analysis



- Bay Area has been the site of significant environmental justice organizing in key locations – Bayview, Richmond, West Oakland
- But missing was a framework study establishing whether there was a general pattern
- Study done in community conversation with thirty-five different EJ, environmental and public health groups, partly as a way to build trust for the EJSM
- Another aspect of the trust-building was a ground-truthing study in the Hegenberger Corridor but not presented here

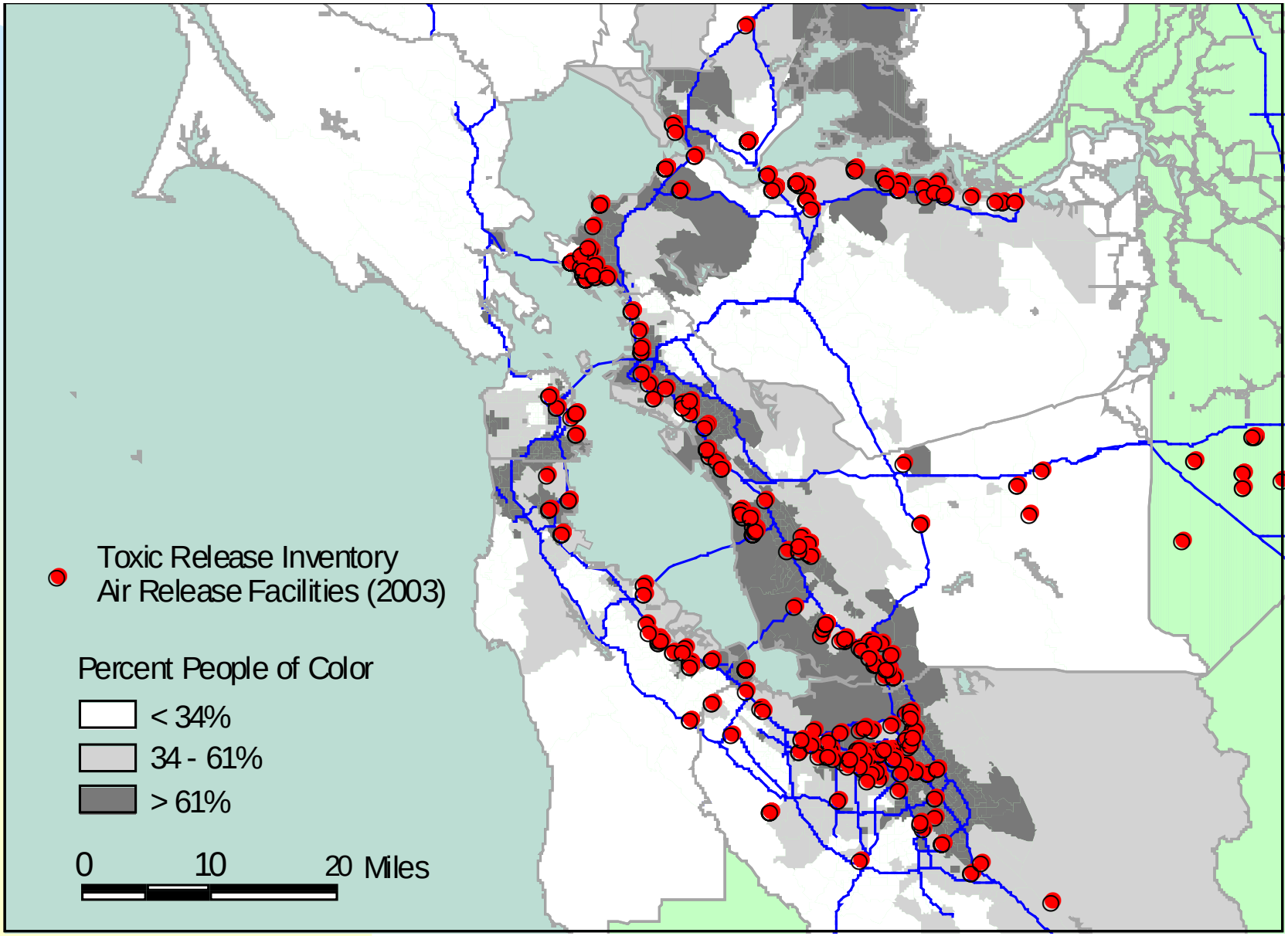
Assembling the Data for Analysis

- Toxic Release Inventory – annual self-reports from point facilities, with analysis attempting to separate out carcinogenic releases, and facilities geocoded as of 2003. The TRI data is standard in national studies although much analysis is flawed due to poor geographic matching.

- NATA – National Air Toxics Assessment (1999). Takes into account national emissions database with modeling of stationary, mobile, and point sources. Publicly available NATA fails to account for cancer risk associated with diesel; we apply risk factors to modeled diesel to complete the California picture.

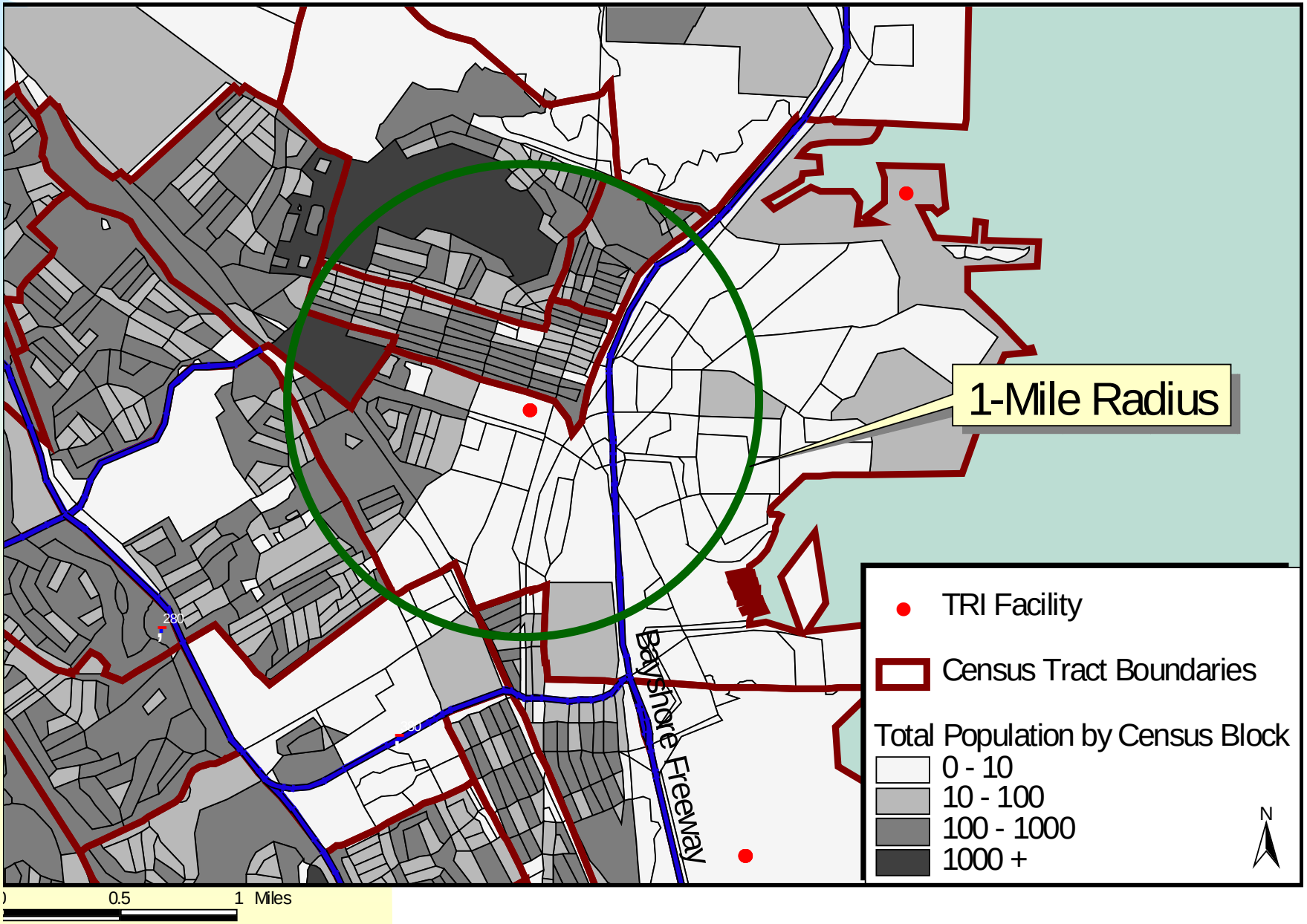
At First Glance . . .

TRI Facilities Relative to Neighborhood Demographics

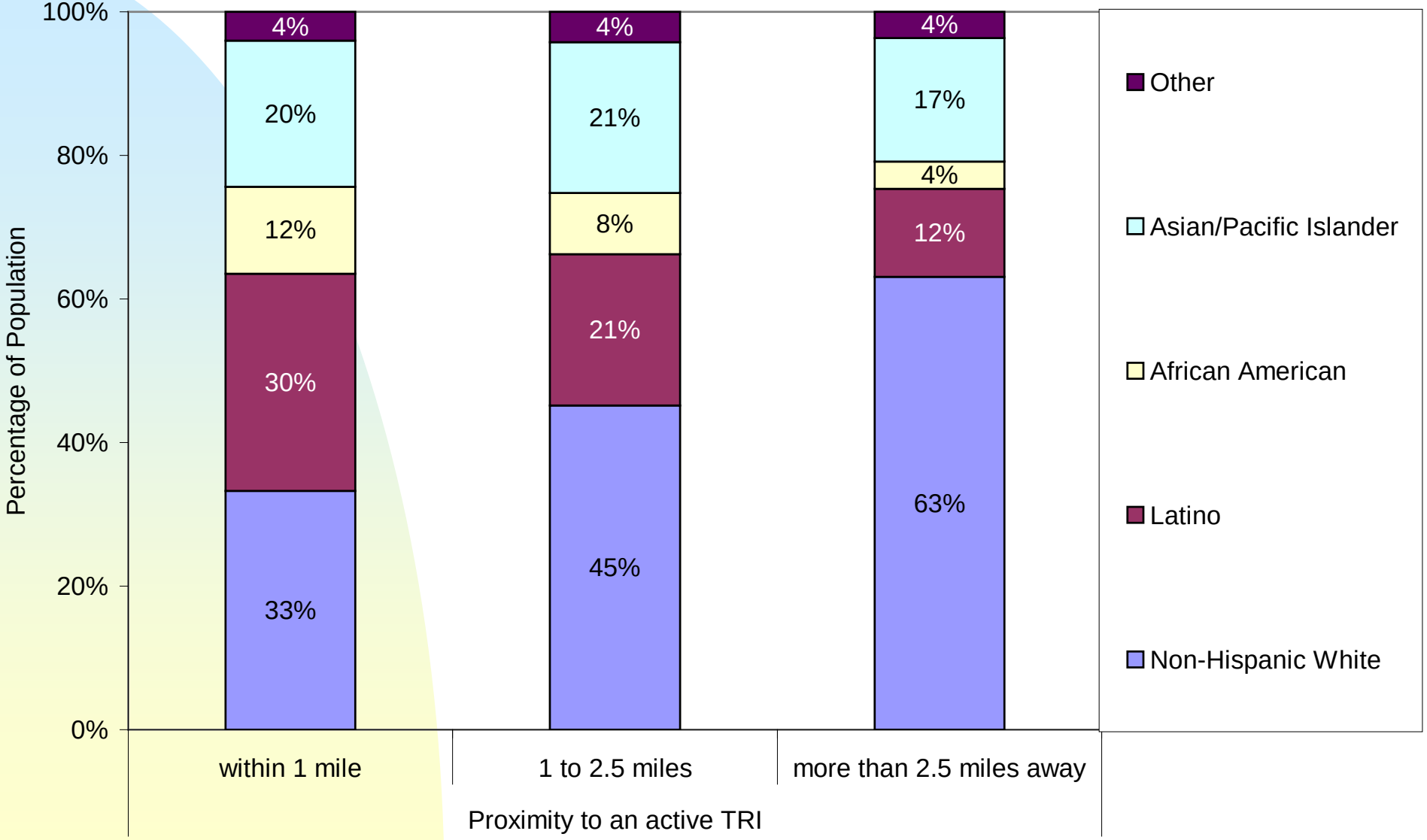


How do we determine TRI proximity?

The one-mile case



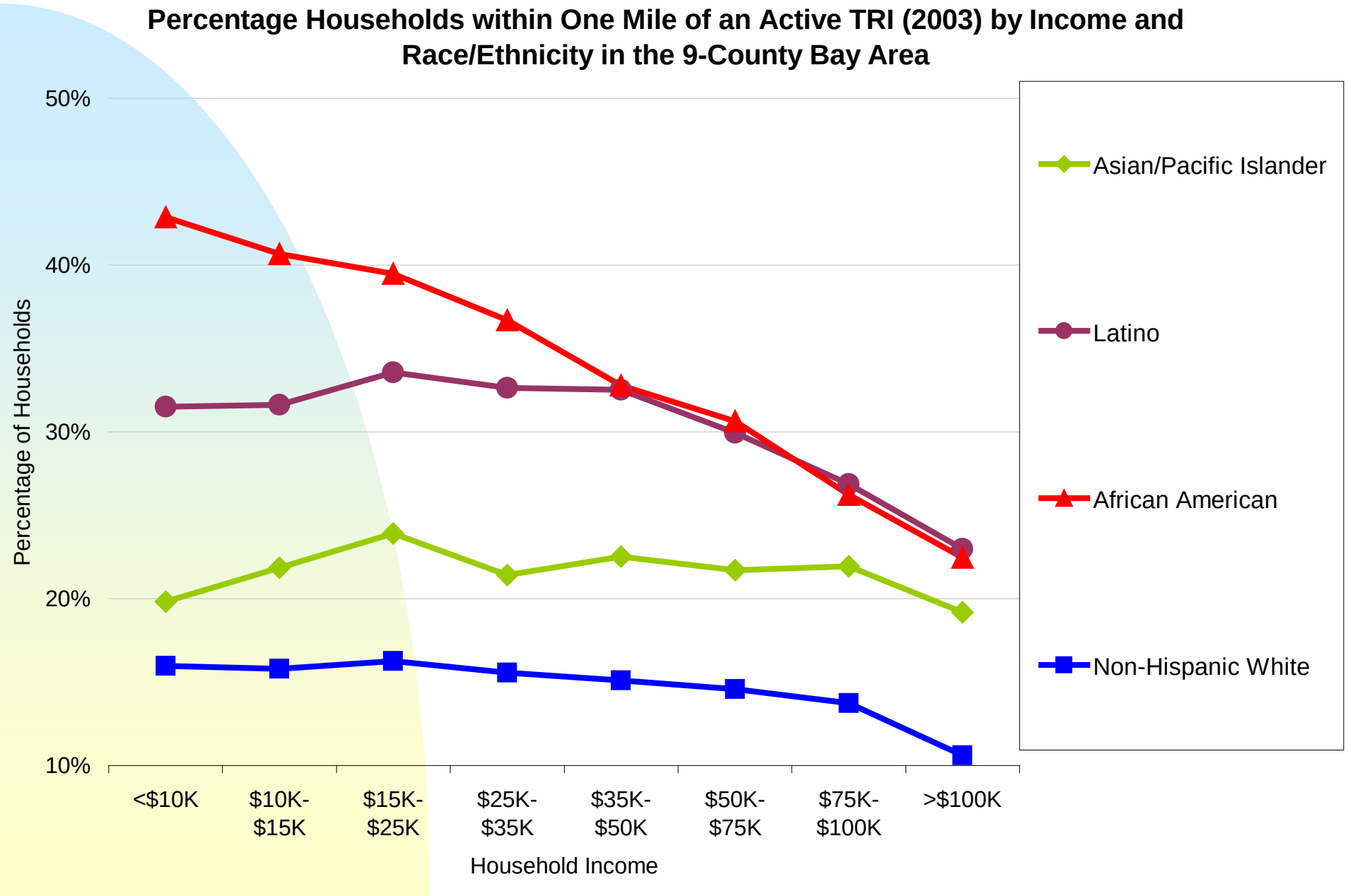
Population by Race/Ethnicity (2000) and Proximity to a TRI Facility with Air Releases (2003) in the 9-County Bay Area



TRI Facilities Relative to Neighborhood Demographics Aside from Race

	TRI Proximity		
Variables	*Less than 1 mile*	*Between 1 mile and 2.5 miles*	*More than 2.5 miles away*
% persons in poverty	12%	9%	6%
Median per capita income	$19,702	$25,140	$34,187
% home owner	52%	57%	61%
% industrial, commercial and transportation land use	17%	9%	5%
Population density (persons per square mile)	9,202	10,107	9,748
% manufacturing employment	19%	16%	12%
% recent immigrants (1980s and later)	26%	21%	15%
% linguistically isolated households	12%	9%	6%

But It Isn't Just Income . . .



TRI Air Releases: Race, Income, and Land Use Together

Multivariate analysis of proximity to a TRI facility:

Model variables	*Coeff. Est.*	*Std. Err.*	*Coeff. Est.*	*Std. Err.*
% owner occupied housing units	-0.8705**	0.3498	-0.5867	0.3823
ln(per capita income)	-0.9722***	0.2933	-0.9035***	0.2965
ln(population density)	-0.1378**	0.0603	-0.1432**	0.0603
% manufacturing employment	6.4811***	0.9542	6.5629***	0.9644
% African American	3.2600***	0.6147	3.3441***	0.6196
% Latino	2.1743***	0.6721	1.5374**	0.7471
% Asian/Pacific Islander	-0.1041	0.6079	-1.0383	0.7841
% linguistically isolated households			2.7777*	1.4229
Log likelihood	-595.58		-593.66	
Percentage predicted correctly	0.8118		0.8190	
N	1403		1403	

****P < 0.01; **P < 0.05; *P < 0.10.*

What About Ambient Air Toxics?

- This category of pollutants come from a diverse array of sources
  - Stationary: large industrial facilities and smaller emitters, such as auto-body paint shops, chrome platers, etc.
  - Mobile: Cars, trucks, rail, aircraft, shipping, construction equipment

- Important because largest proportion of estimated cancer risk (70% in the Bay Area) is related to mobile emissions

U.S. EPA's National Air Toxics Assessment (NATA)

Gaussian dispersion model estimates long-term annual average outdoor concentrations by census tract for base year 1999.

Concentration estimates include:

- 177 air toxics (of 187 listed under the 1990 Clean Air Act)
- Diesel particulates

The model includes ambient concentration estimates from mobile and stationary emissions sources:

Manufacturing (point and area)

e.g., refineries, chrome plating

Non-Manufacturing (point and area)

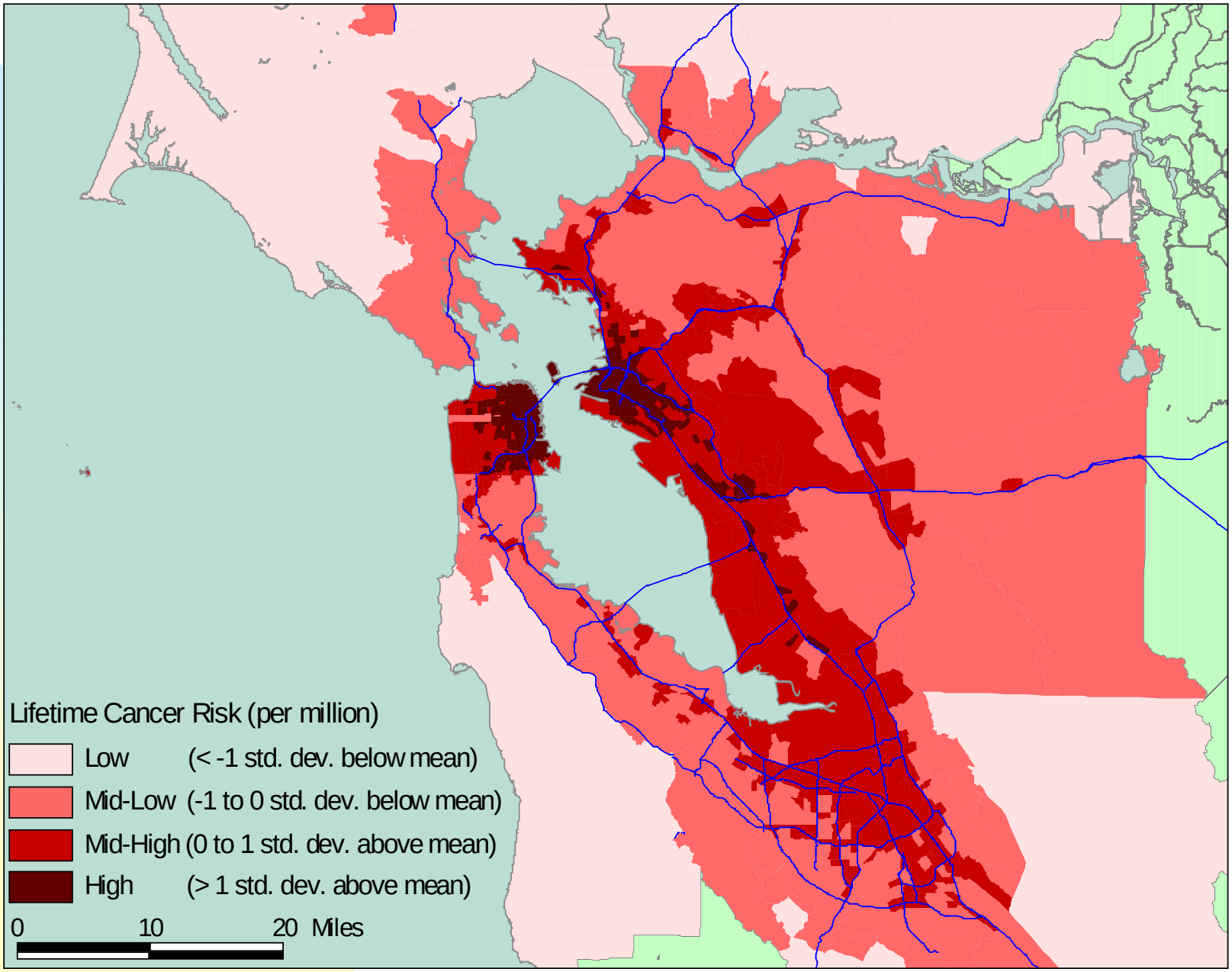
e.g., utilities, hospitals, dry cleaners

Mobile (on road and off road)

e.g., cars, trucks, air craft, agricultural equipment

Modeled air pollutant concentration estimates allocated to tract centroids.

1999 NATA Estimated Cancer Risk (All Sources) by 2000 Census Tracts, 9-County Bay Area



What's the Pattern?

	Cancer Risk			Respiratory Hazard		
Variables	*Least risk*	*Middle range*	*Most risk*	*Lowest hazard ratio*	*Middle range*	*Highest hazard ratio*
% Anglo	68%	48%	39%	66%	49%	33%
% African American	4%	7%	16%	5%	6%	16%
% Latino	17%	20%	17%	18%	19%	24%
% Asian Pacific Islander	7%	21%	24%	7%	22%	23%
% Other	4%	4%	4%	4%	4%	4%
% home owner	70%	61%	28%	71%	59%	34%
Median per capita income	$28,231	$28,187	$22,973	$27,137	$29,329	$20,487
% persons in poverty	7%	8%	15%	7%	8%	15%
Population density (persons per square mile)	2,929	8,175	24,194	2,603	9,346	19,425
% industrial, commercial and transportation land use	3%	8%	17%	4%	8%	20%
% recent immigrants (1980s and later)	10%	21%	24%	10%	21%	26%
% linguistically isolated households	4%	8%	13%	4%	8%	14%

Race, Income, and Land Use Together . . .

Multivariate Correlates of Estimated Cancer and Non-Cancer Risk from Air Toxics, Linear Model

	Cancer Risk				Respiratory Hazard			
Model variables	*Coeff. Est.*	*Std. Err.*	*Coeff. Est.*	*Std. Err.*	*Coeff. Est.*	*Std. Err.*	*Coeff. Est.*	*Std. Err.*
Intercept	3.230***	0.110	3.205***	0.110	-0.115	0.095	-0.115	0.095
% owner occupied housing units	-0.457***	0.045	-0.408***	0.047	-0.230***	0.039	-0.232***	0.041
relative per capita income (tract/region)	0.588***	0.080	0.619***	0.080	0.661***	0.068	0.660***	0.069
relative per capita income squared	-0.001***	0.000	-0.001***	0.000	-0.001***	0.000	-0.001***	0.000
ln(population density)	0.152***	0.008	0.150***	0.008	0.133***	0.006	0.133***	0.006
% industrial/commercial/transportation land use	0.854***	0.079	0.823***	0.079	0.791***	0.068	0.792***	0.068
% African American	1.257***	0.086	1.277***	0.086	1.119***	0.073	1.118***	0.074
% Latino	0.373***	0.086	0.232**	0.096	0.610***	0.074	0.614***	0.083
% Asian/Pacific Islander	0.646***	0.065	0.461***	0.086	0.731***	0.056	0.737***	0.074
% linguistically isolated households			0.643***	0.198			-0.021	0.171
Adj. r-squared	0.5692		0.5721		0.5635		0.5632	
Log likelihood	-465.9250		-460.6600		-251.9300		-251.9250	
N	1403		1403		1403		1403	

****P < 0.01; **P < 0.05; *P < 0.10.*

Controlling for Spatial Autocorrelation

Multivariate Correlates of Estimated Cancer and Non-Cancer Risk from Air Toxics, Spatial Error Model

	Cancer Risk				Respiratory Hazard			
Model variables	*Coeff. Est.*	*Std. Err.*	*Coeff. Est.*	*Std. Err.*	*Coeff. Est.*	*Std. Err.*	*Coeff. Est.*	*Std. Err.*
intercept	3.284***	0.269	3.287***	0.268	-0.166	0.358	-0.172	0.360
% owner occupied housing units	-0.126***	0.034	-0.112***	0.035	-0.060**	0.026	-0.055**	0.027
relative per capita income (tract/region)	0.171***	0.061	0.184***	0.062	0.067	0.047	0.072	0.048
relative per capita income squared	-0.000*	0.000	-0.000*	0.000	-0.000	0.000	-0.000	0.000
ln(population density)	0.087***	0.006	0.087***	0.006	0.068***	0.004	0.068***	0.004
% industrial/commercial/transportation land use	0.696***	0.053	0.686***	0.054	0.561***	0.041	0.557***	0.041
% African American	0.382***	0.072	0.392***	0.072	0.147***	0.055	0.150***	0.055
% Latino	0.297***	0.071	0.235***	0.079	0.239***	0.055	0.218***	0.061
% Asian/Pacific Islander	0.115*	0.060	0.034	0.074	0.018	0.046	-0.009	0.057
% linguistically isolated households			0.254*	0.139			0.085	0.107
lambda	0.978***	0.008	0.978***	0.008	0.987***	0.005	0.988***	0.005
Log likelihood	133.088		134.759		496.588		496.903	
N	1403		1403		1403		1403	

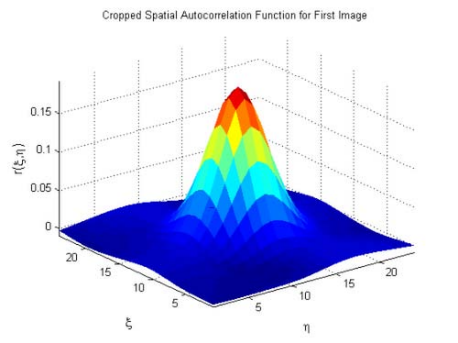
****P < 0.01; **P < 0.05; *P < 0.10.*

What It Is . . . And What It Isn't

Caveats to Results

- Recognize that this is a "snapshot" – albeit multivariate of the region. The results do not imply causality but describe the pattern.
- In particular, this is not time series data and so provide little insight into move-in versus siting dynamics (although still relevant to health disparities).
- Collinearity is a challenge for some variables, particularly linguistic isolation.
- Better land use data would improve accuracy and be useful for policy.
- Note that the results, however, hold across alternative measures (such as CARB's cancer risk estimates, BAAQMD's CARE data, etc.)

Takeaways from This Analysis



- *Analytic:*
  - There is a pattern and it holds even we control for spatial autocorrelation
  - Important findings are linguistic isolation which may have policy implications
- *Process:*
  - Engaging communities in research process strengthens research and policy relevance
  - It also builds trust in what can be complicated processes such as the eventual goal of this project: the EJSM.

Birth Outcomes and Air Pollution

Methods: data sources

- California natality files 1996-2006
  - Information on live births & mothers
- CalAIRS database
  - CO & O_3 daily maximum 8 hour average.
  - NO_2,SO_2, PM_{10}, & $PM_{2.5}$ daily averages.
  - PM_{coarse} estimated by subtracting $PM_{2.5}$ from PM_{10}
- US Census 2000
  - Poverty rate (proportion of residents living in households under FPL)
  - Unemployment rate (workers 16 and older seeking work)
  - Home ownership rate (owner-occupied vs. renter-occupied)
  - Low educational attainment (population over age 25 with less than a high school education)

Methods: eligibility

- For Birth Weight Analysis (LBW = < 2500 grams):
  - Live full-term (37-44 weeks) singleton birth between 1996 and 2006
- For Preterm Birth Analysis (pre-term = 29-34 weeks at delivery):
  - Live singleton birth with a gestational age indicating survival into the third trimester (29-44 weeks gestation).
- Known date of birth, infant sex & birth weight plausible given gestational age
- Known maternal:
  - Age (9-49 years old)
  - Parity
  - Education
  - Race & ethnicity
  - Residence geo-code (census tract and/or ZIP code)
- Residence within 10km of an air monitor active during all months of pregnancy

Covariates

Individual

- Infant sex
- Maternal age
- Race
- Birth place
- Education
- Calendar year/season
- Parity
- Marital status
- Pregnancy risk factors
- Prenatal care

Area

- Poverty Rate
- Unemployment Rate
- Educational Attainment
  - % residents 25 years and older with at least a HS diploma
- Home Ownership Rate

Exposure Assessment

Goal: To produce neighborhood-level estimates of average criterion air pollutant exposures over the course of a woman's pregnancy

gaseous: CO_{itu} NO_{2itu} O_{3itu} SO_{2itu}

particulate: PM_{10itu} $PM_{2.5itu}$ $PM_{coarseitu}$

i indexes the geocode of mother's residence on birth certificate (census tract or ZIP Code tabulation area)

tu indexes the weeks between conception and delivery, i.e. the duration of the pregnancy.

Overview

For each geo-reference, in each week, for each pollutant, calculate:

1) pollutant level from closest monitor*

2) distance to monitor

* We have calculated both nearest neighbor (the approach used in the analyses) and also an IDW averaged value, but since the monitoring network is sparse, these are interchangeable in most cases.

For each pregnancy, average the weekly pollutant levels across the duration of the pregnancy for the mother's residential georeference, only for those measures within a specified distance (2km, 3km, 5km, 10km)

Specifics

Use AQS & CalAIRS.

For each monitor in each week:

Calculate daily summary *average of 18-24 hourly measures, fewer than 18 hourly measures discarded*

Calculate weekly summary

average of daily summaries only one daily summary required to assign a weekly summary

Verify monitor locations.

For each census block, find nearest monitor active during week, assign pollutant level from that monitor.

Aggregate blocks into:

census tracts (2000)

census tracts (1990)

ZCTA's (200)

For each pregnancy:

Calculate monthly summaries

average of at least 3 weekly summary exposure measures, otherwise discarded

Calculate trimester-specific exposures

1st: *average of first 4 monthly summaries*

2nd: average months 5 to 7

3rd: average months 8 to 10 (less if pregnancy shorter)

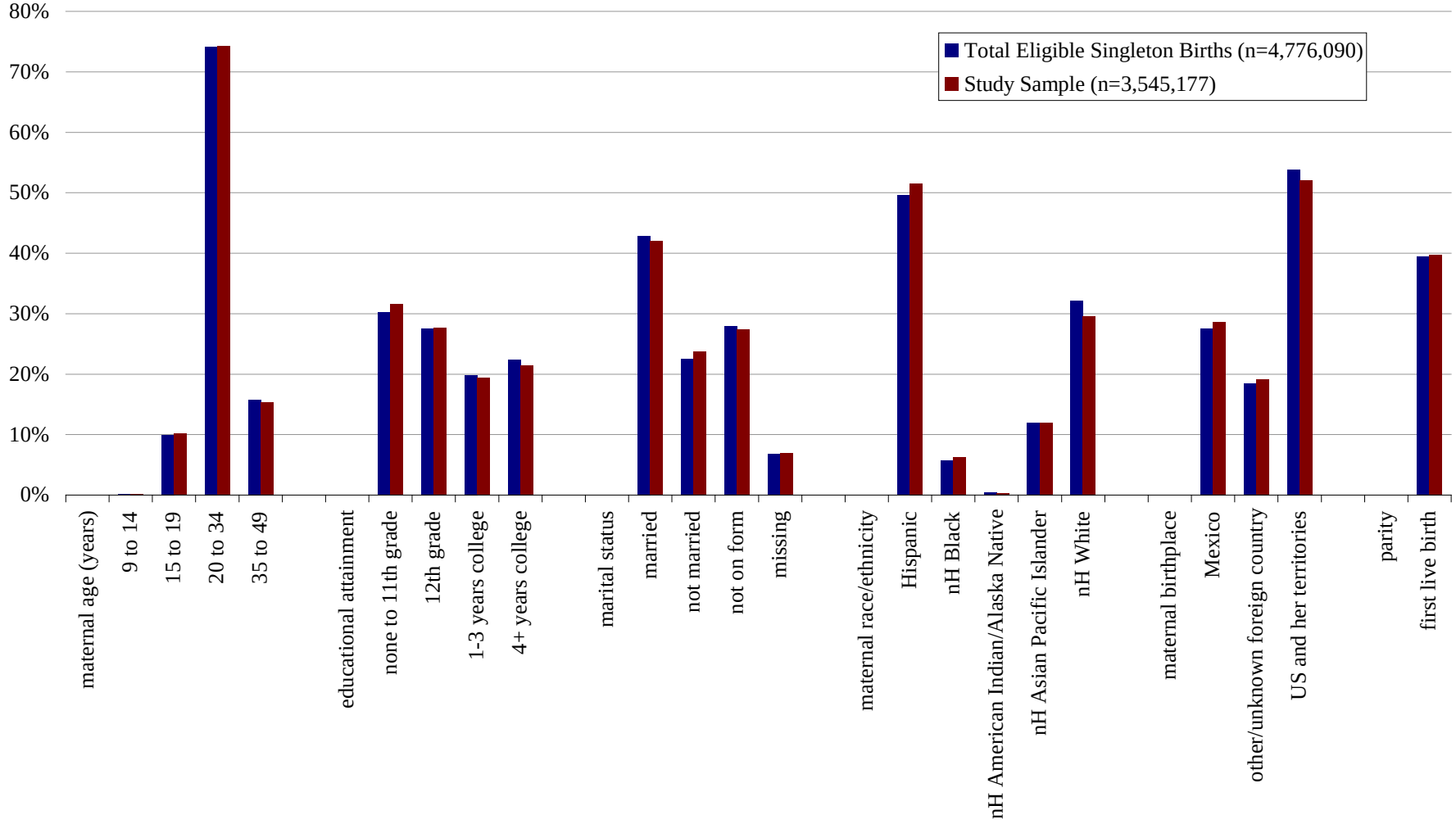
Full pregnancy exposure

average all months of pregnancy (if any one month invalid, then full pregnancy invalid)

Analysis

- Low birth weight
  - Linear multivariable models (SAS 9.2) to estimate impact of air pollutants on birth weight as continuous measure
  - Logistic regression models to estimate air pollution effects on birth weight as dichotomous outcome (<2500 grams versus ≥2500 grams).
- Preterm birth
  - Logistic models to estimate the impact of air pollutants on risk of preterm delivery

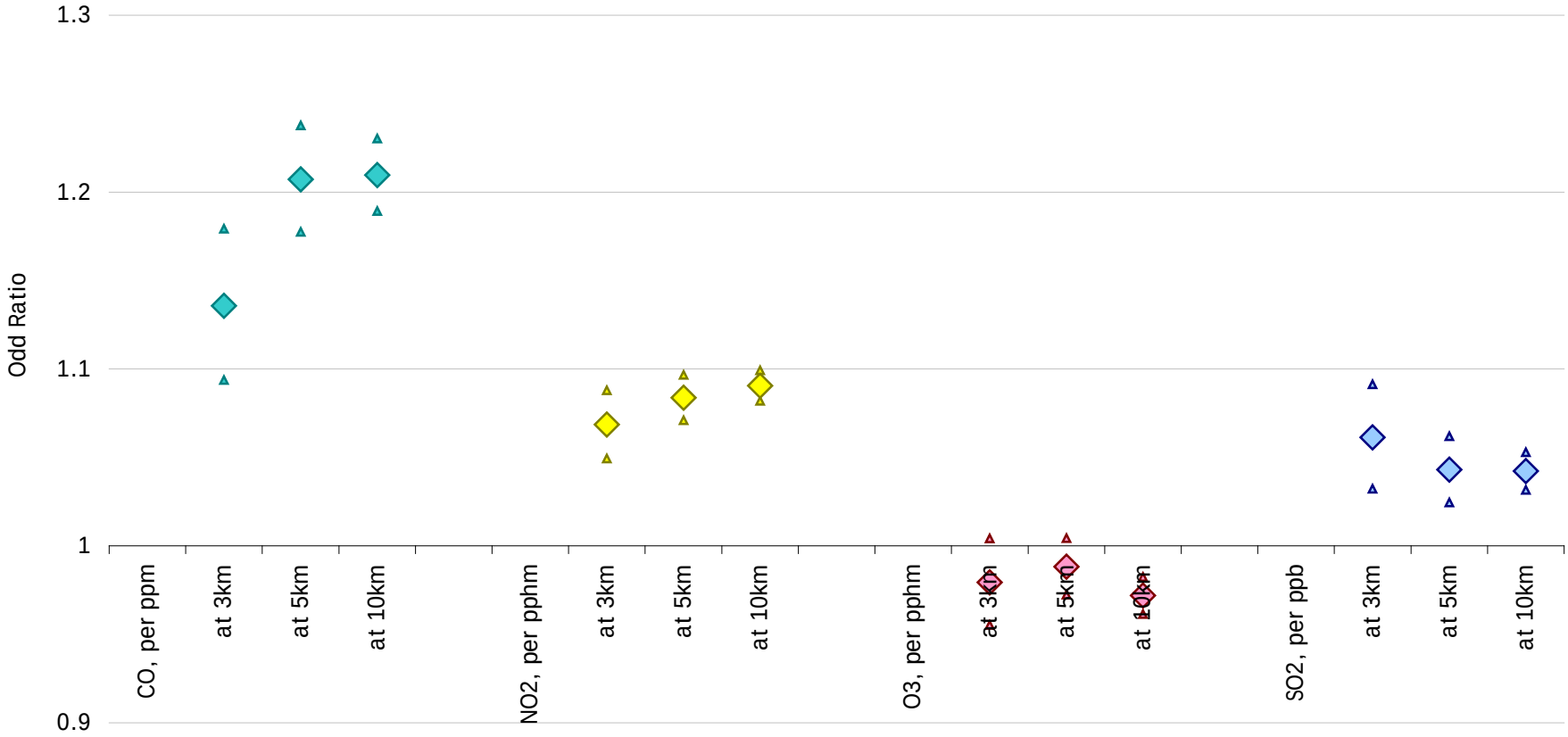
Demographic characteristics of potentially eligible births
and those within 10km of an active monitor for at least one pollutant throughout pregnancy



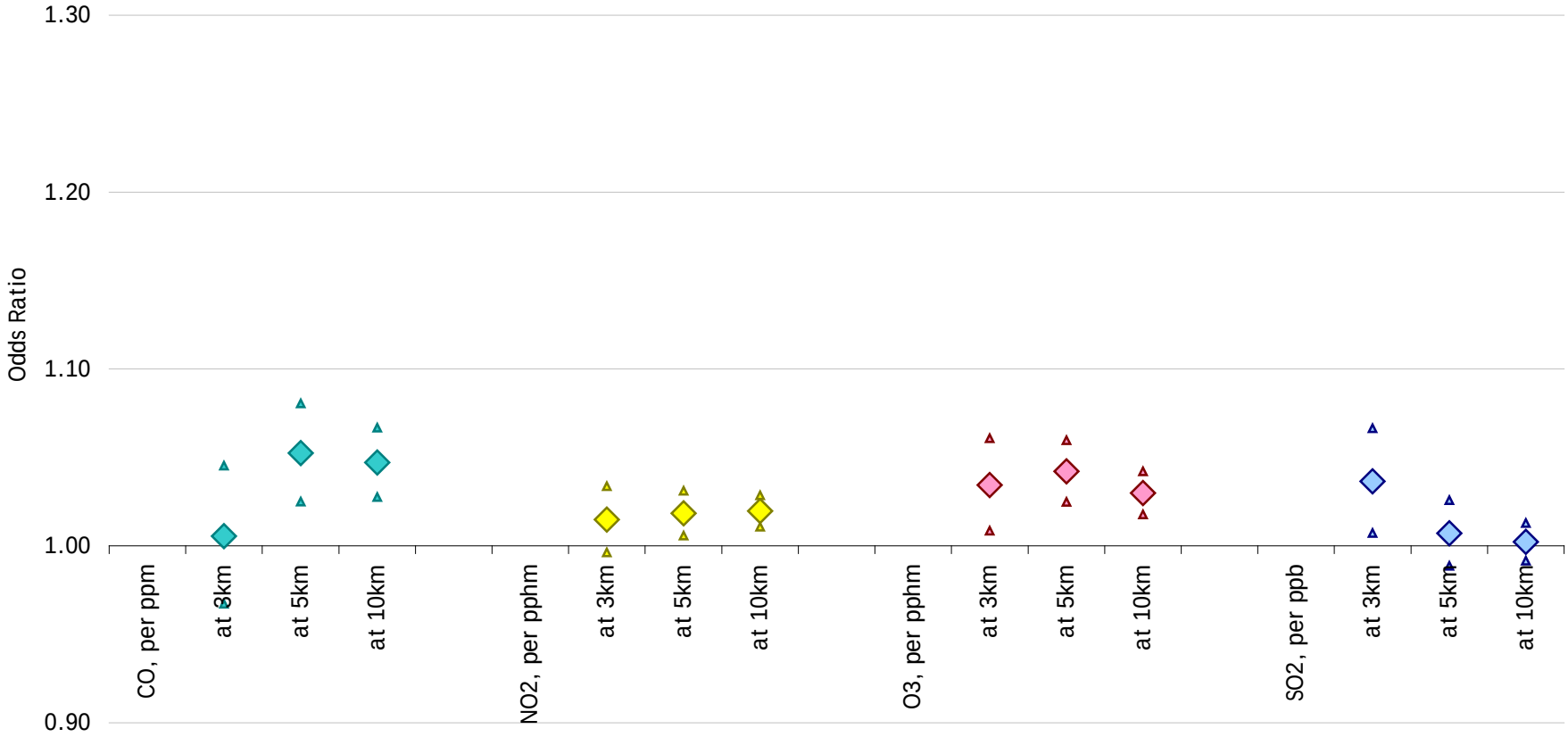
Results

- Pre-term birth (3.1%)

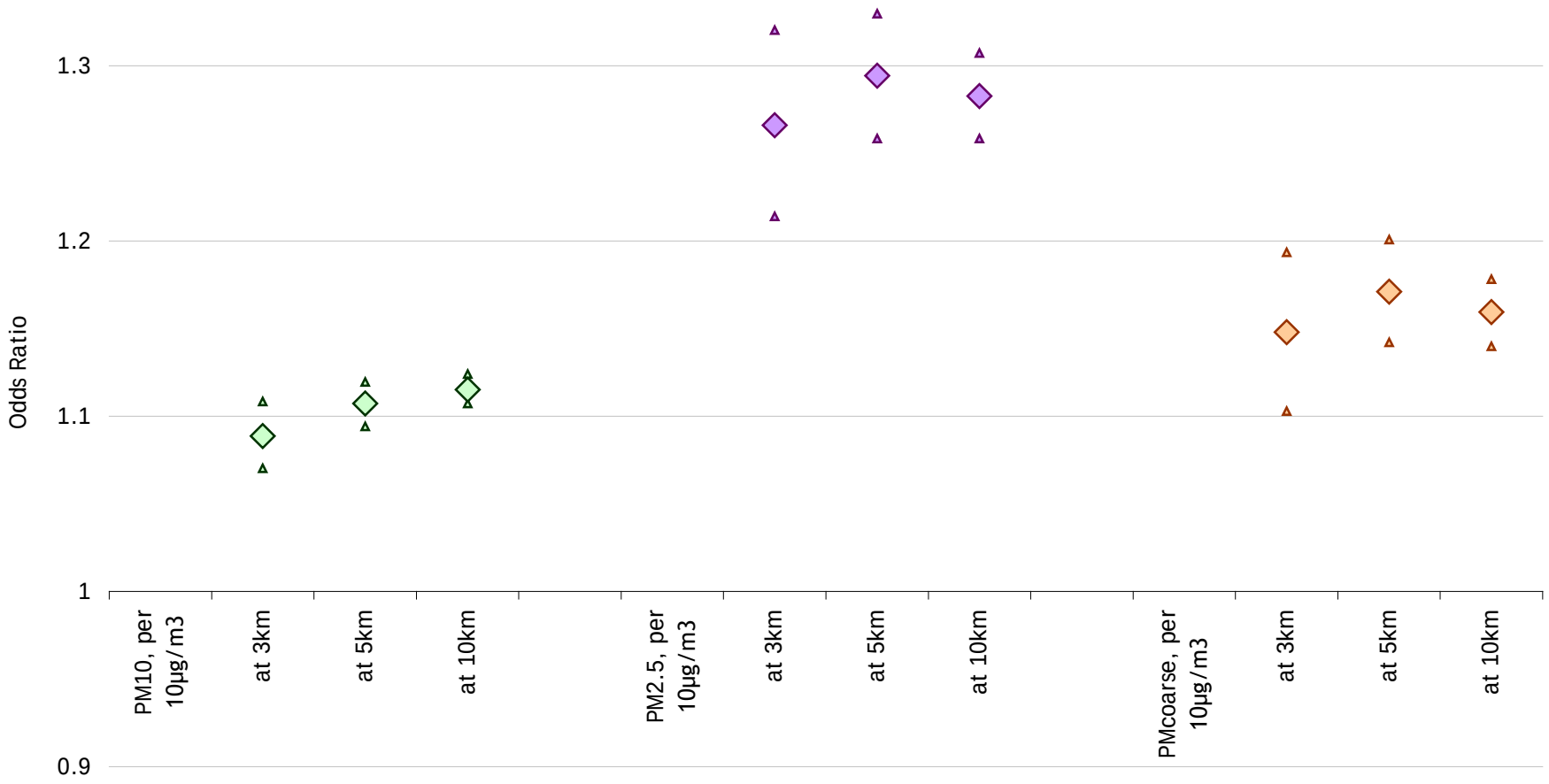
odds ratio of premature delivery (29-34 vs. 39-44 weeks), per change in full-pregnancy gaseous air pollutant average exposure
crude models, 3km, 5km, 10km



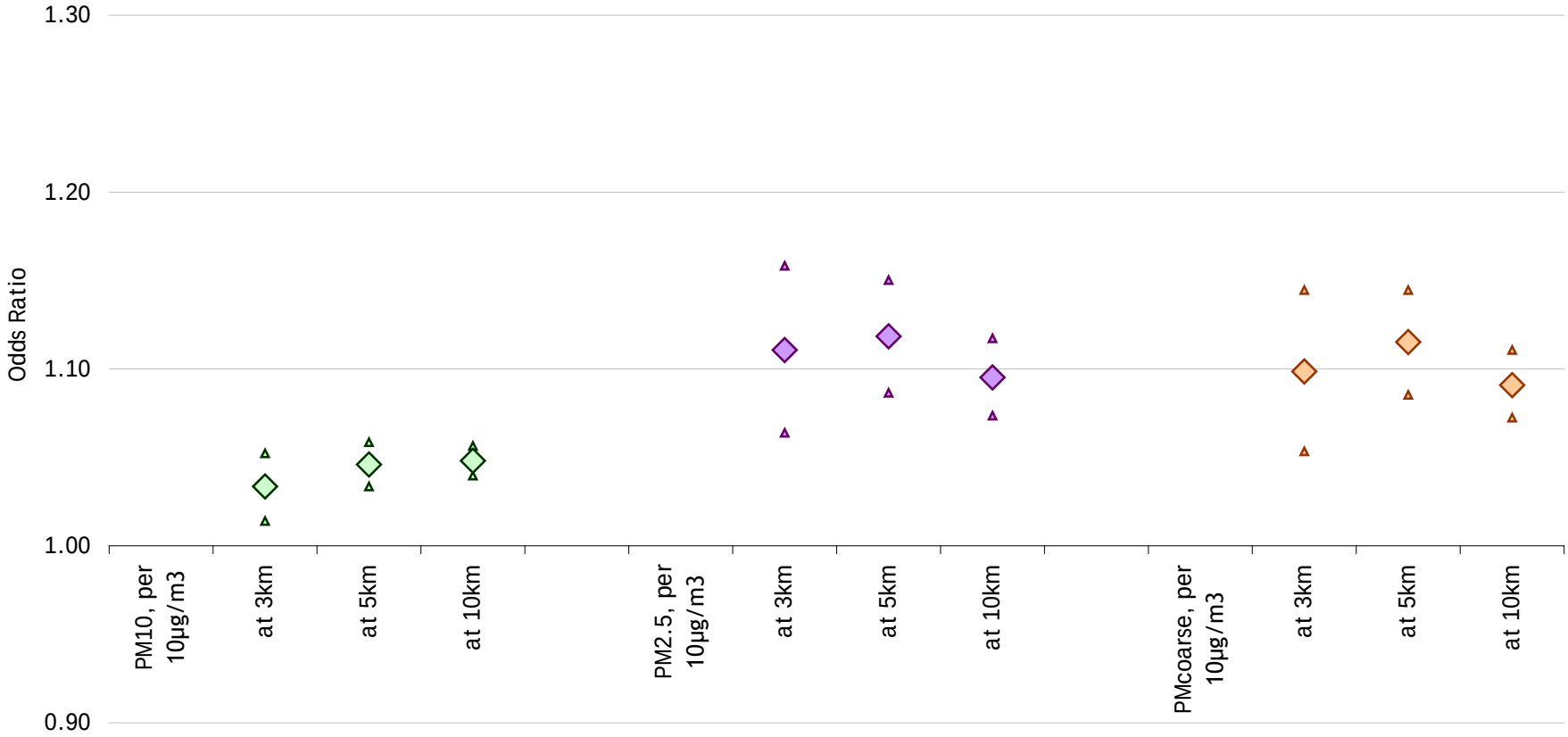
odds ratio of premature delivery (29-34 vs. 39-44 weeks), per change in full-pregnancy gaseous air pollutant average exposure, models controlled for maternal & neighbohood characteristics, 3km, 5km, 10km

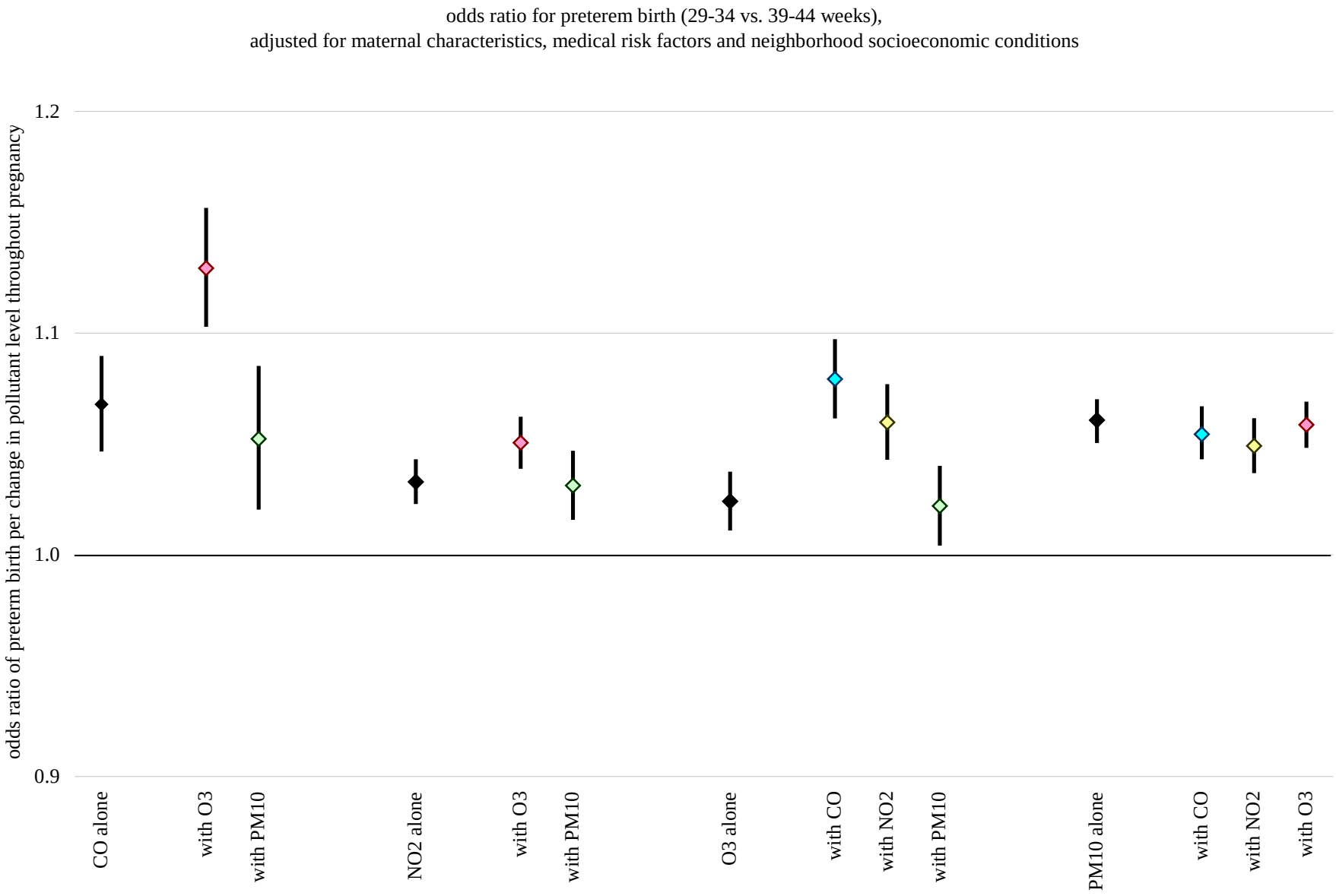


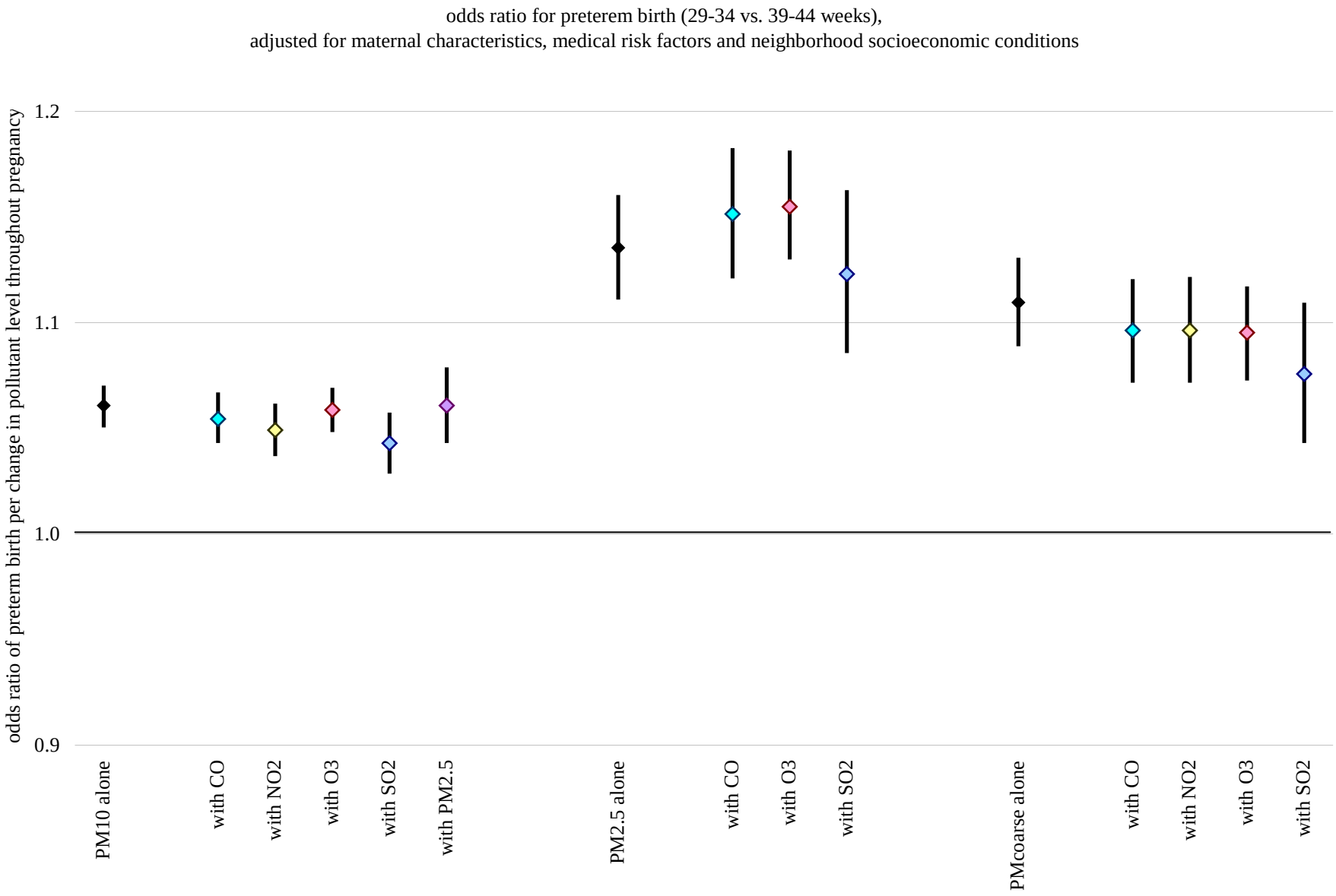
odds ratio of premature delivery (29-34 vs. 39-44 weeks), per change in full-pregnancy particulate matter average exposure, crude models, 3km, 5km, 10km



odds ratio of premature delivery (29-34 vs. 39-44 weeks), per change in full-pregnancy particulate matter average exposure, models controlled for maternal & neighborhood characteristics, 3km, 5km, 10km



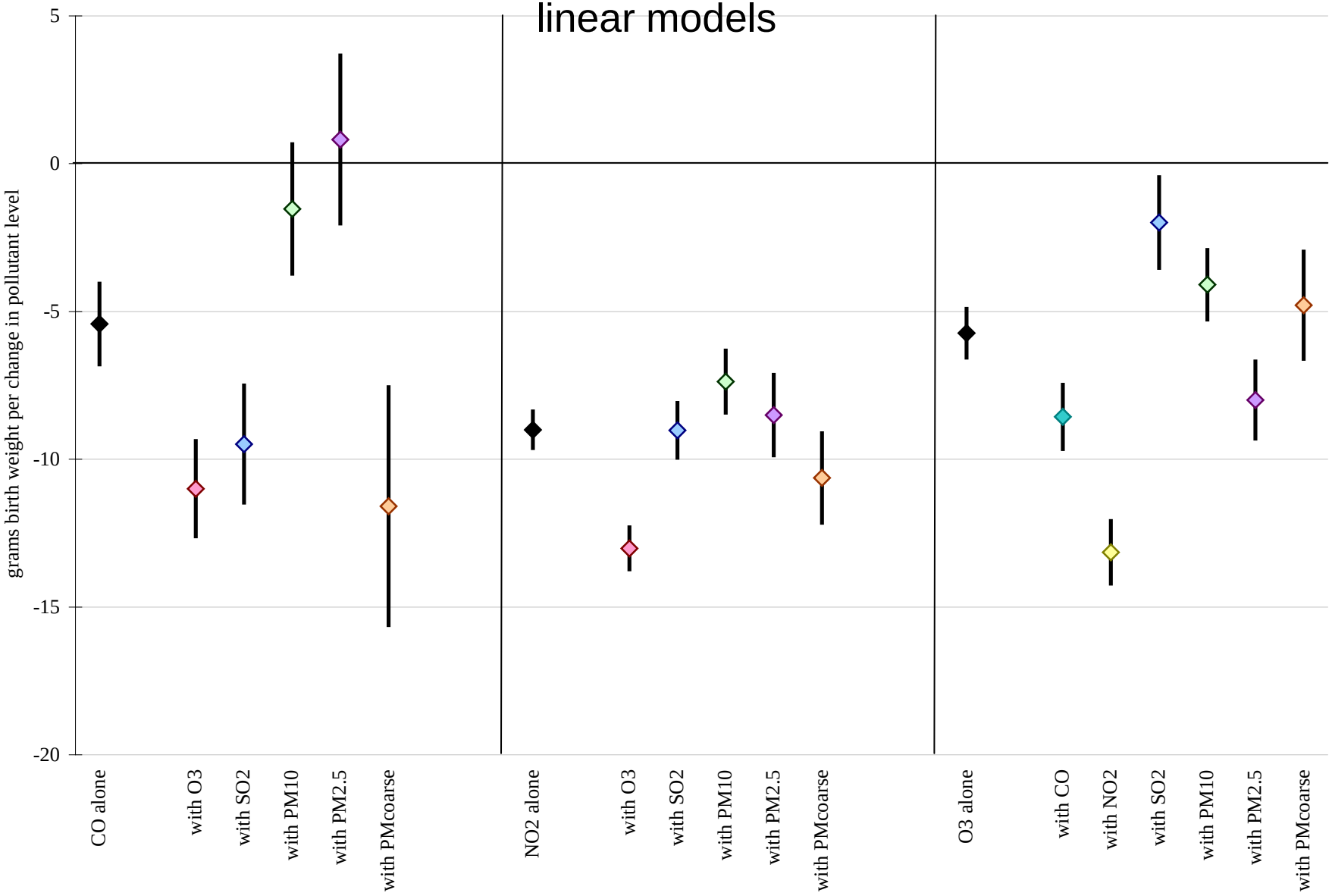

odds ratio for preterem birth (29-34 vs. 39-44 weeks),
adjusted for maternal characteristics, medical risk factors and neighborhood socioeconomic conditions
odds ratio of preterm birth per change in pollutant level throughout pregnancy
1.2
1.1
1.0
0.9
CO alone
with O3
with PM10
NO2 alone
with O3
with PM10
O3 alone
with CO
with NO2
with PM10
PM10 alone
with CO
with NO2
with O3


odds ratio for preterm birth (29-34 vs. 39-44 weeks),
adjusted for maternal characteristics, medical risk factors and neighborhood socioeconomic conditions
odds ratio of preterm birth per change in pollutant level throughout pregnancy
1.2
1.1
1.0
0.9
PM10 alone
with CO
with NO2
with O3
with SO2
with PM2.5
PM2.5 alone
with CO
with O3
with SO2
PMcoarse alone
with CO
with NO2
with O3
with SO2

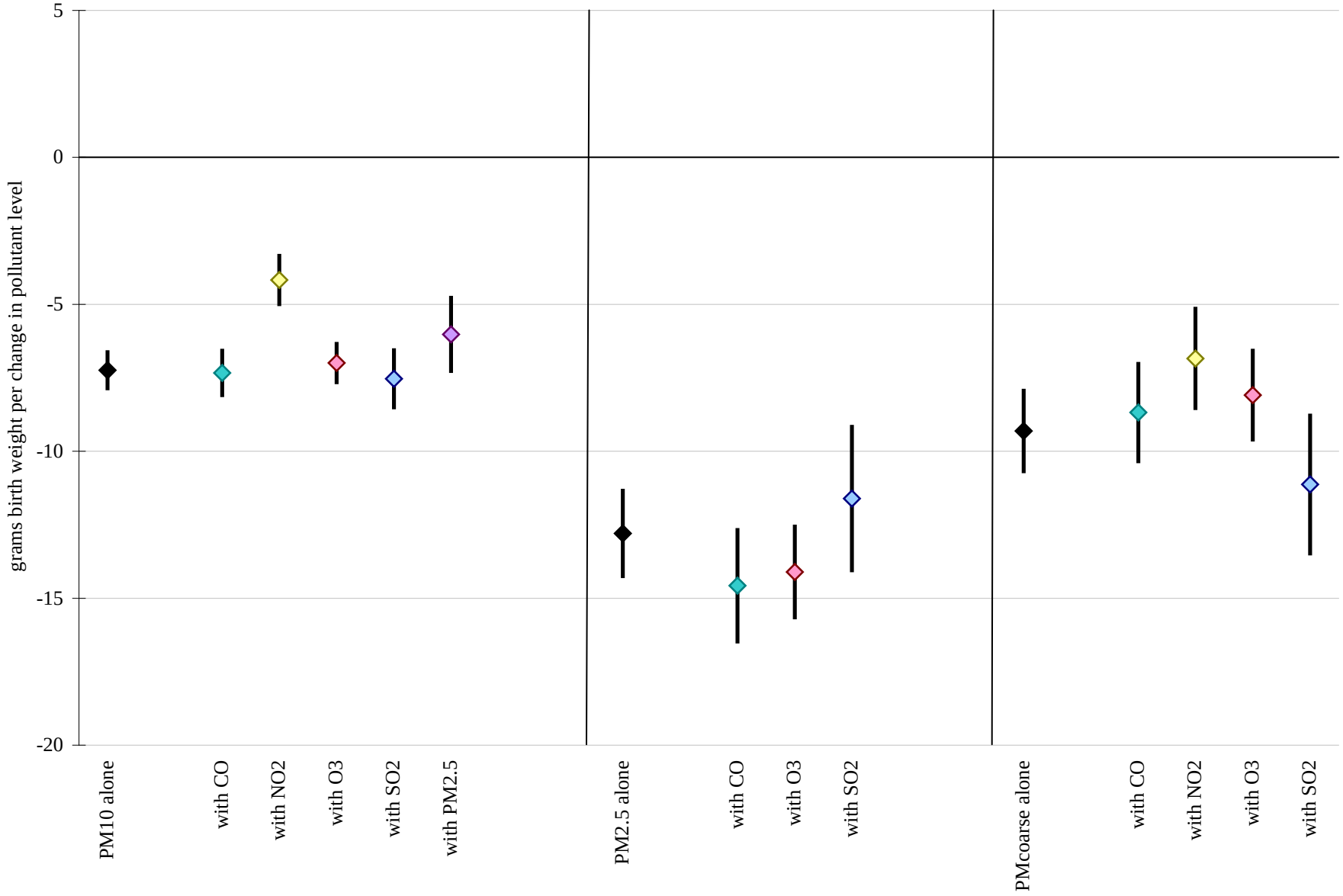
Results

- Low Birth Weight (2.3%)

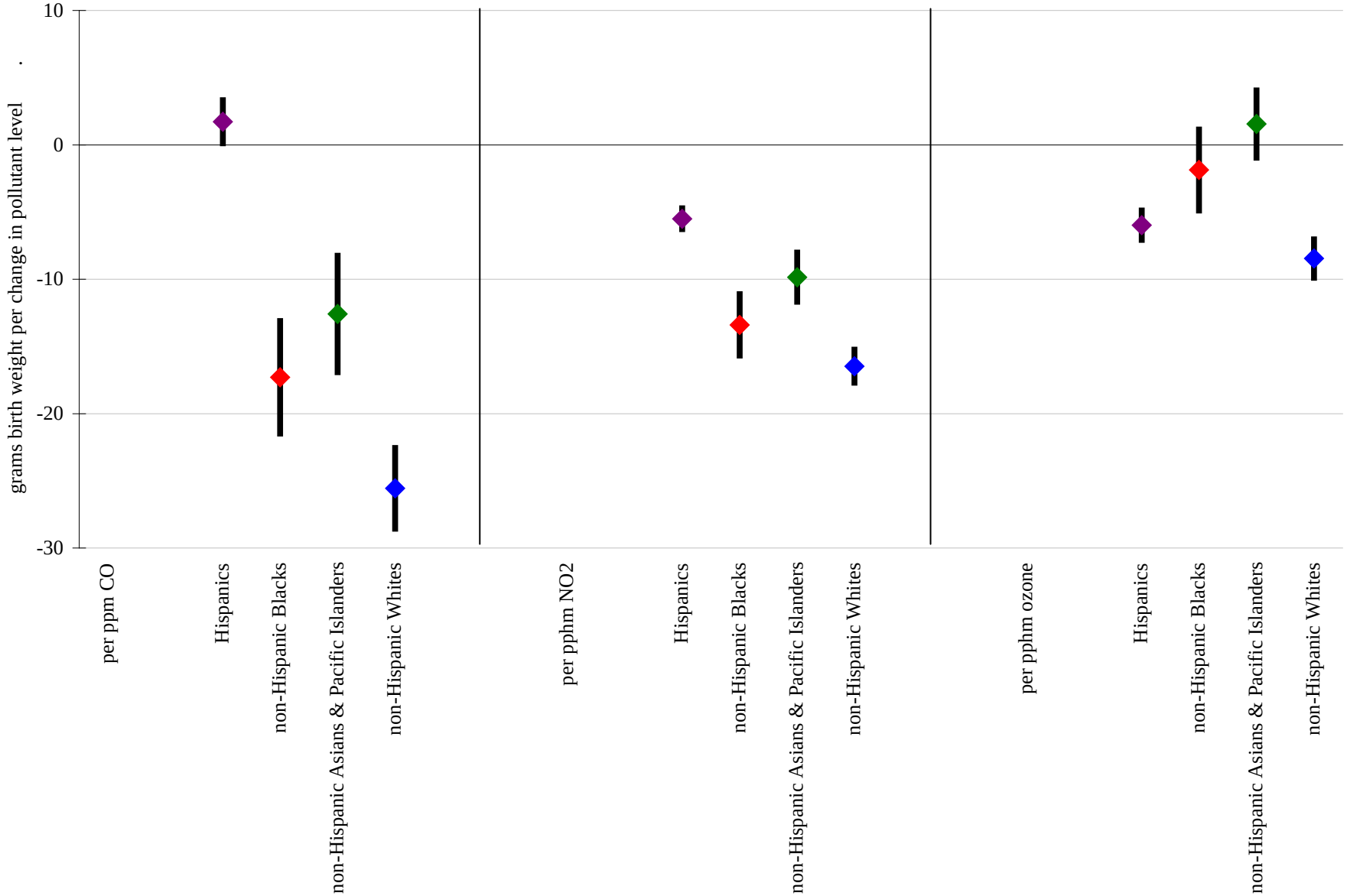
Difference in birth weight associated with full pregnancy gaseous pollutant exposures for births within 10 km monitor distance, single and two-pollutant linear models



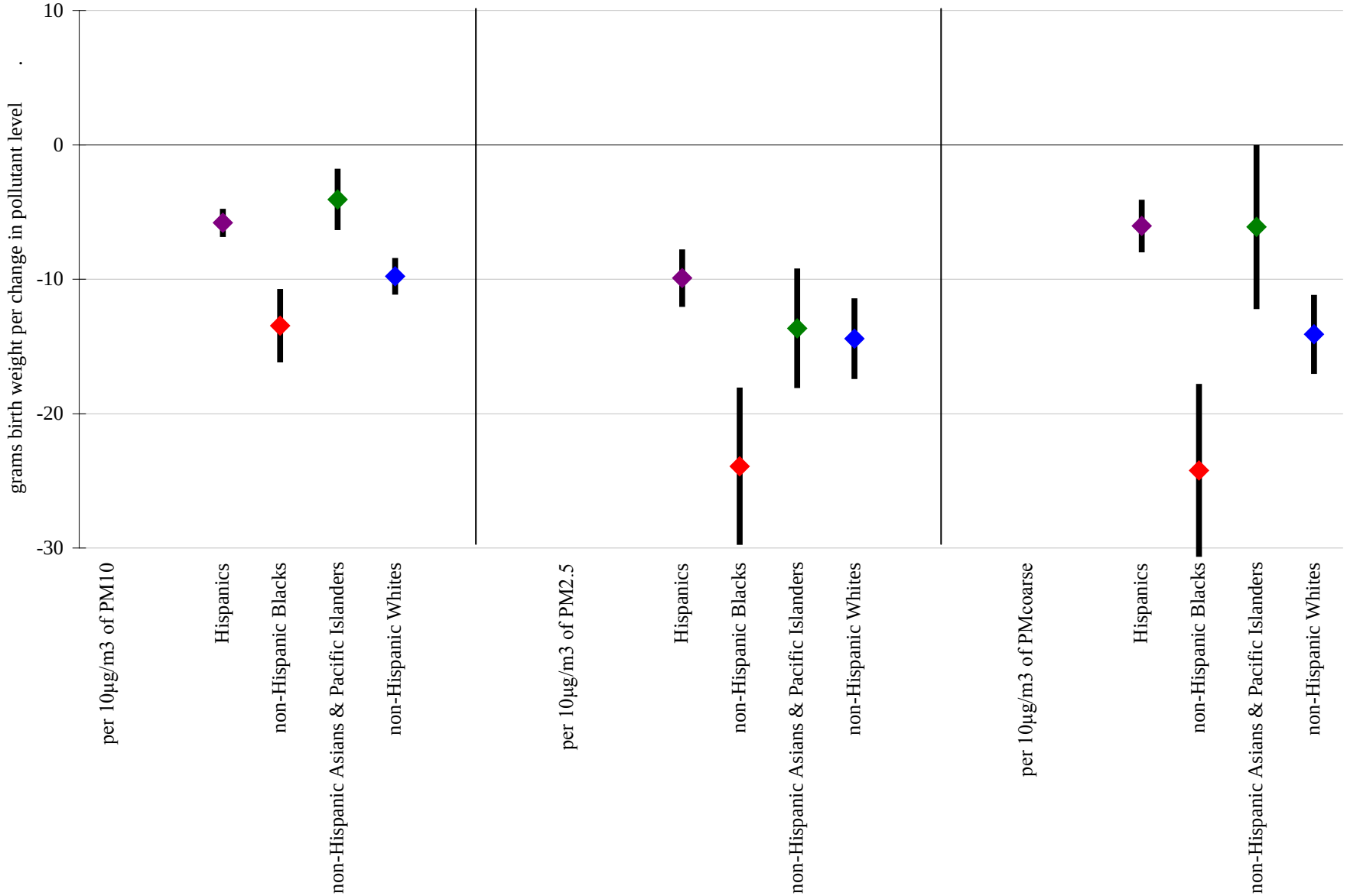
Difference in birth weight associated with full pregnancy particulate pollutant exposures for births within 10 km monitor distance, single and two-pollutant linear models



Difference in birth weight in grams associated with full pregnancy gaseous pollutant exposures for births within 10 km monitor distance, stratified by maternal race and ethnicity



Difference in birth weight in grams associated with full pregnancy particulate pollutant exposures for births, stratified by maternal race and ethnicity



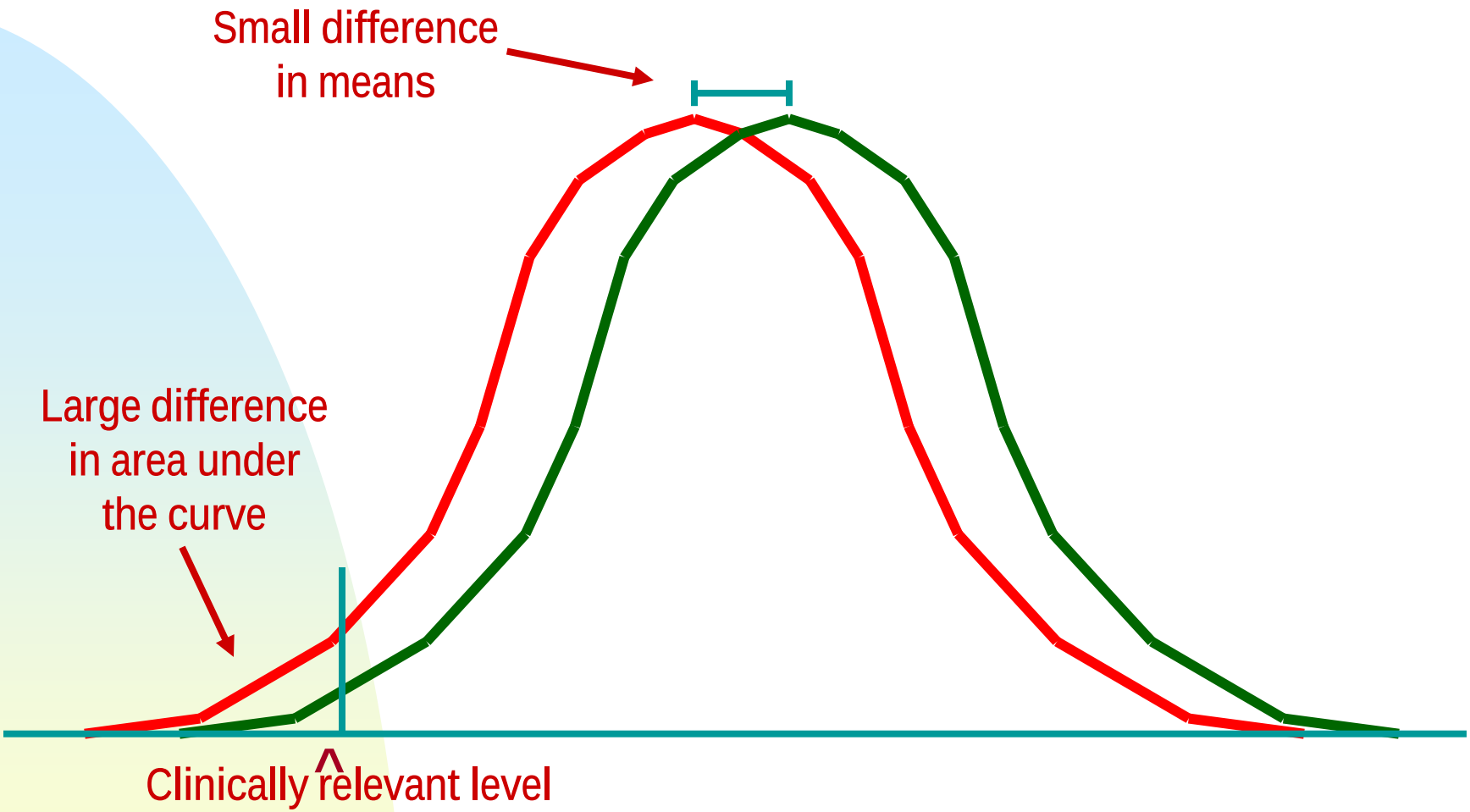
Summary of findings

- Modest relationship between ambient criteria air pollutant exposure (PM2.5, PM10, coarse PM, CO, NO2 and O3) and lower average birth weight among full-term infants as well as higher risk of preterm birth.
- Associations between increasing pollutant exposures and decrements in birth weight and risk of preterm delivery persist during different trimesters
- Strongest effects seen for exposures during the entire gestational period.
- Did not find consistent evidence of effect modification
  - PM2.5 and course PM effect estimates strongest for African Americans

Caveats

- Smoking:
  - Has a large effect on birth weight, but in studies of ambient air pollution not a significant confounder
- Limits of single pollutant analysis:
  - Future work can take source-based approach to assessing health effects rather than isolating the impacts of individual pollutants (e.g traffic density)
- Does not account for transient spikes in air pollutant levels (e.g. fires)

Implications



Small shift in the population distribution of birth weights may have broader health implications that need to be further examined.

Purpose of Environmental Justice Screening Methodology (EJSM)

- Develop indicators of cumulative impact that:
  - Reflect research on air pollution, environmental justice, and health
  - Are transparent and relevant to policy-makers and communities
  - Reviewed by community EJ groups, California Air Resources Board, academic peers and other agencies

- Apply EJ "screening method" to multiple uses:
  - Local land use planning
    - (e.g. Los Angeles, City of Commerce & Richmond – community plans)
  - Regulatory decision-making and enforcement
  - Community outreach

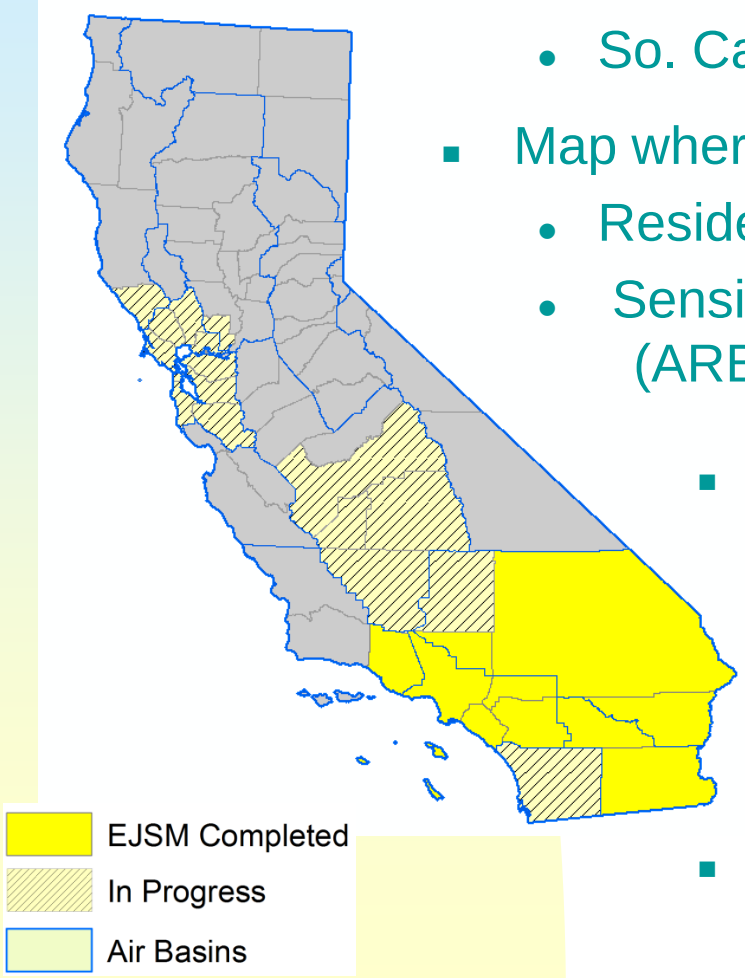
Focus of EJSM

- Developed with specific reference to ambient air quality in neighborhoods
  - Not screening for occupational, indoor, water or pesticides.
- Developed to incorporate land use information into environmental decision-making
  - Performs best with detailed and high spatial resolution land use data.
- Developed using publically available secondary databases, not micro-studies
  - This is screening not assessment

Three Categories of Impact & Vulnerability

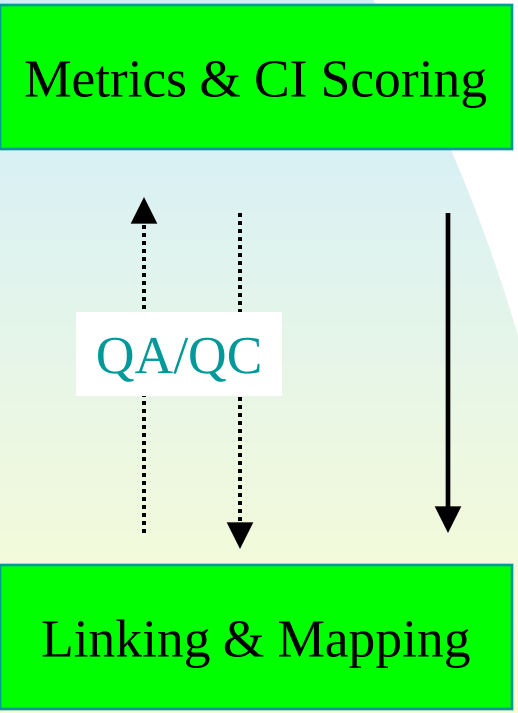
- Proximity to hazards & sensitive land uses
  - Based on EJ literature
  - ARB land use guidelines (sensitive receptors)
  - State data on environmental disamenities
- Health risk & exposure
  - Based on EJ literature
  - Available state and national data
  - Modeling from emissions inventories
- Social & health vulnerability
  - Based on social epidemiological literature on social determinants of health
  - Based on EJ literature on area-level measures of community vulnerability

EJ Screening Method (EJSM)



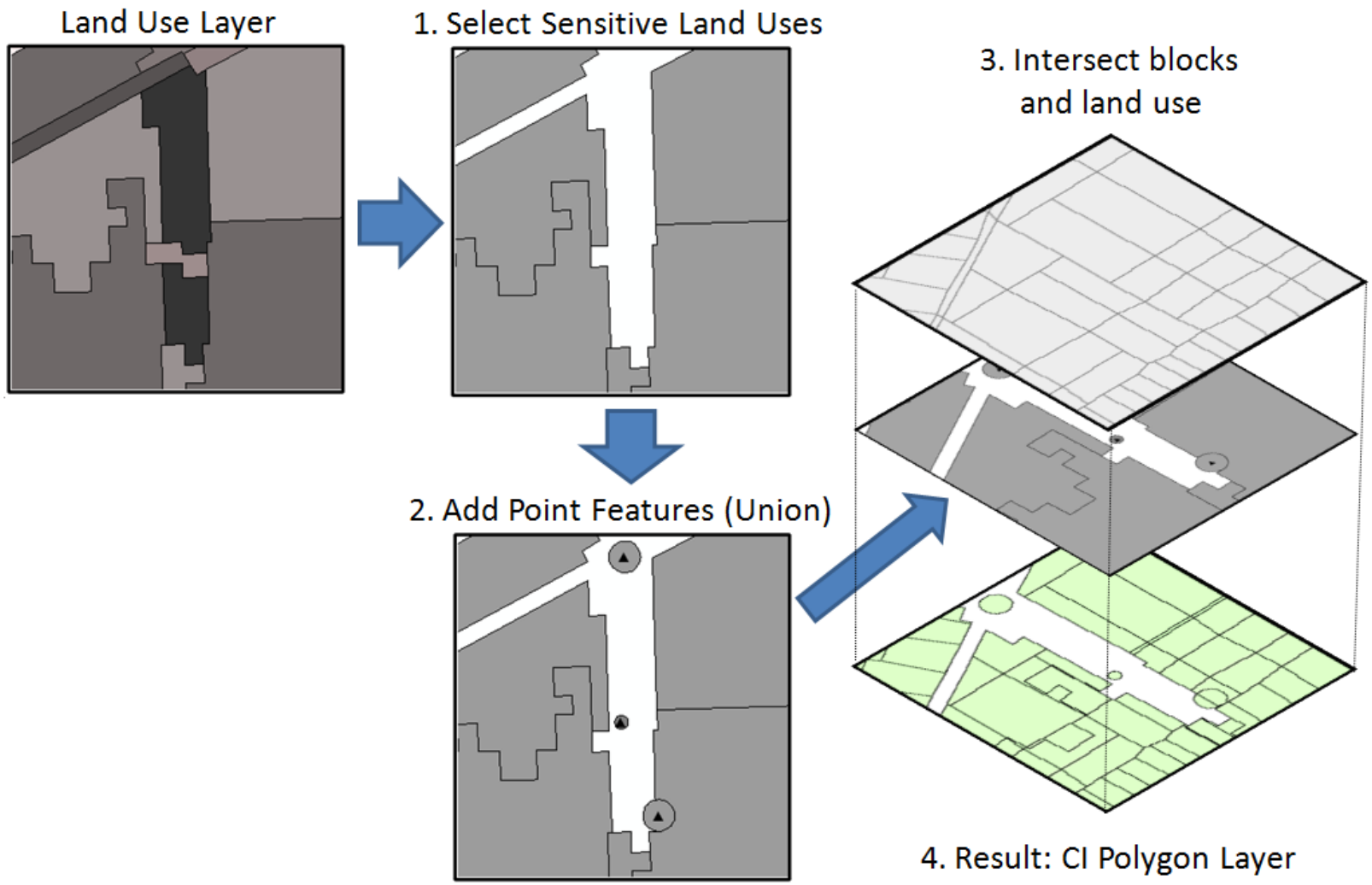
- Two regions; 6 air basins
  - 7 Southern California counties completed
  - 14 counties - in progress
  - So. California – higher quality land use data
- Map where people are exposed
  - Residential land use
  - Sensitive land use categories (ARB land use guidelines, 2005)
- Analytical Unit and Base Map
  - Other efforts map at tract level or as grid
  - Intersect land use polygons with census blocks
  - Developing additional method for areas with low quality land use data
- Scoring System – each polygon receives "points" related to indicators

Screening Method Architecture



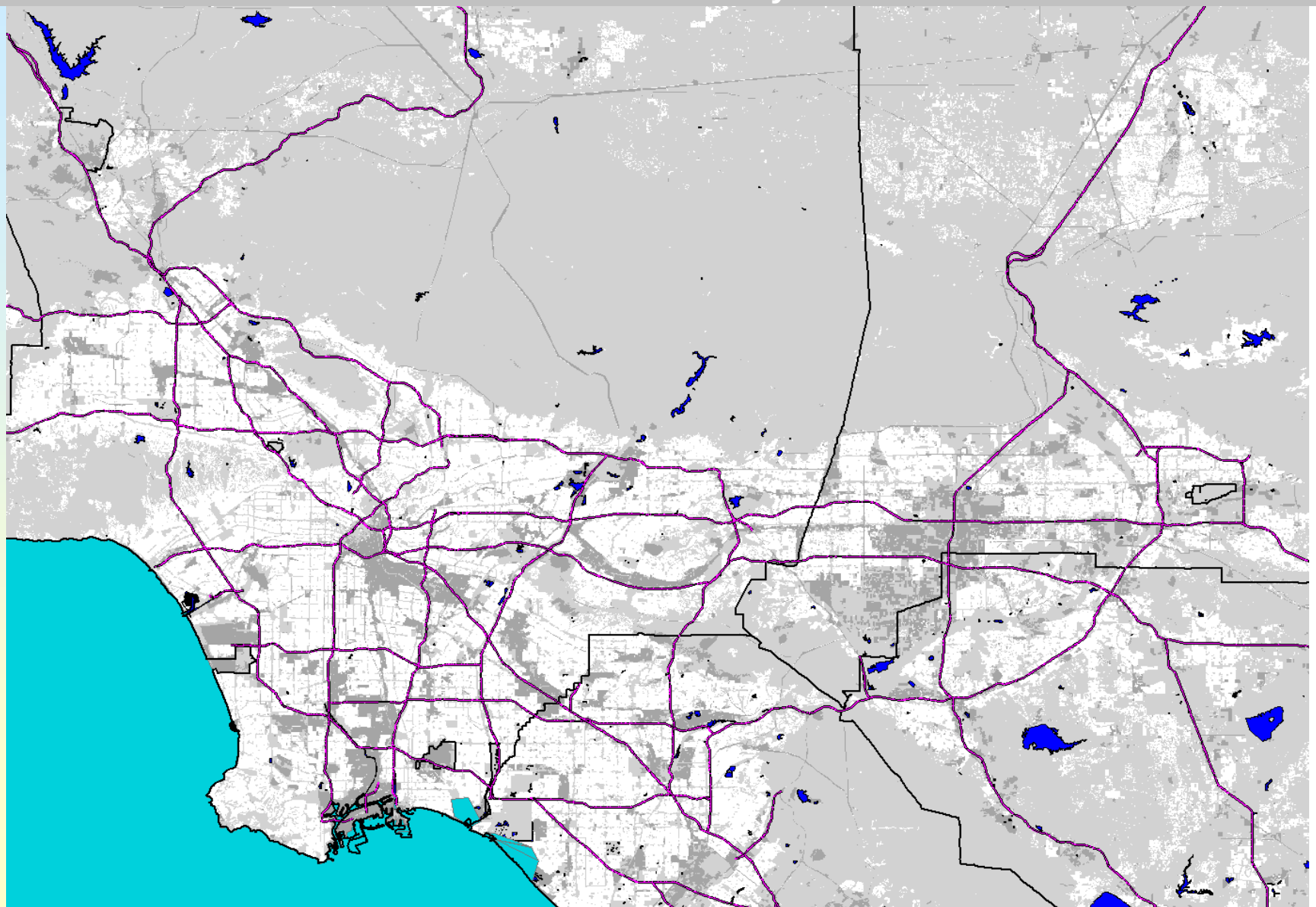
- **Step 1:** GIS Spatial Assessment
  - Derive land use layer – select land use types
  - Create CI polygon mapping layer (intersect land use polygons with census blocks)
  - Calculate land use and hazard proximity metrics for CI polygons
- **Step 2**: Programming (SPSS)
  - Data processing and cleaning
  - Metrics development and ranking
  - Derivation of CI scores
    - By category (Risk, hazard proximity, SES)
    - Total CI score
  - Analytics
    - This work can be done in SAS or R
- **Step 3:** GIS Mapping of Results
- Essential to Steps 1 and 2:
  - Quality control of data layers
  - Document and verify metric derivation and scoring

GIS Spatial Assessment
CI Polygon Mapping Layer

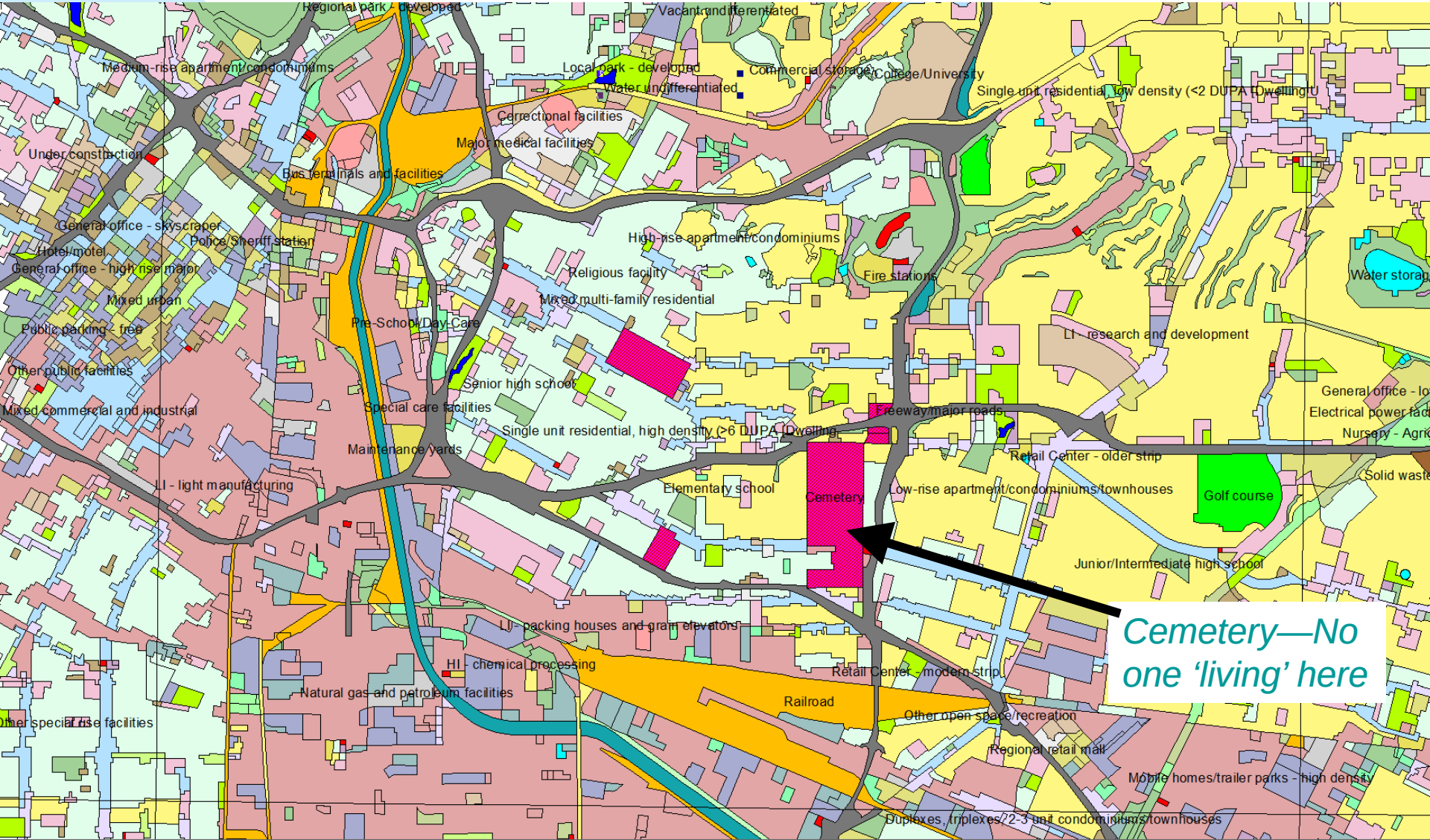


Land Use – Focus screening on where people live

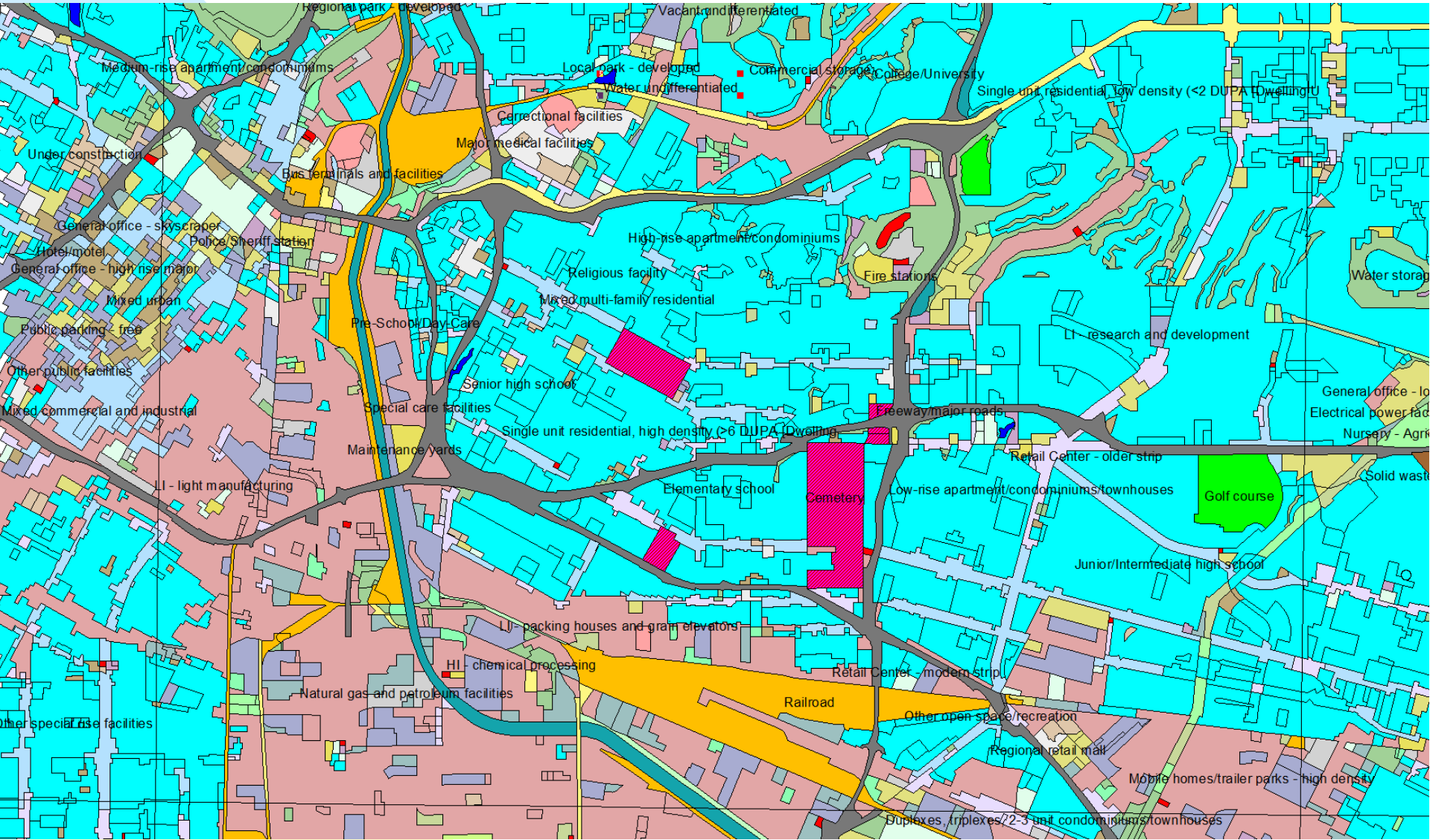
Dark Gray = Industrial, Transportation, etc.;
Light Gray = Open Space, Vacant, etc.
White = Residential and Sensitive Land Uses – only these areas are scored



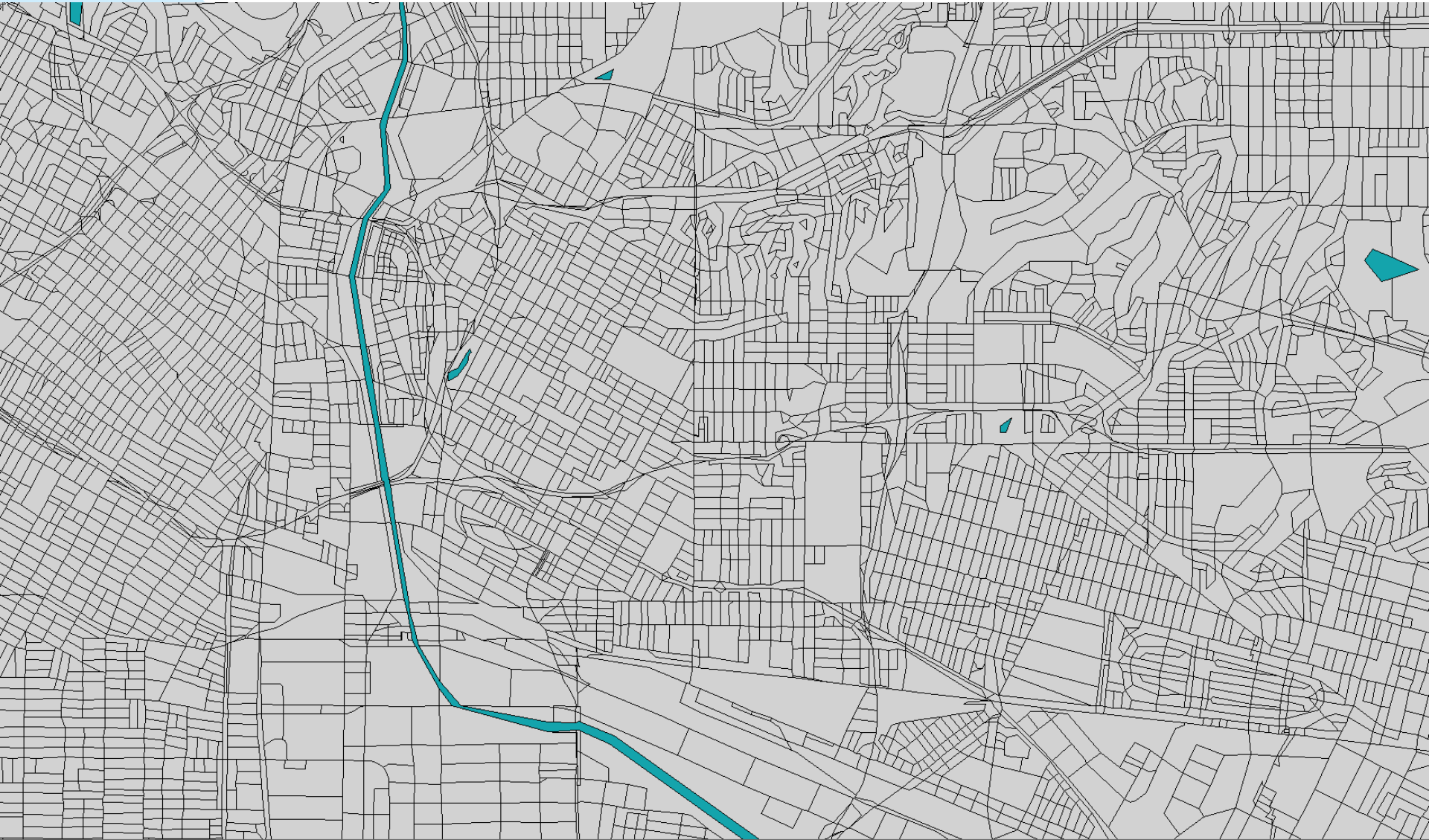
Southern California Assoc. of Governments (SCAG) 2005 Land Use Polygons



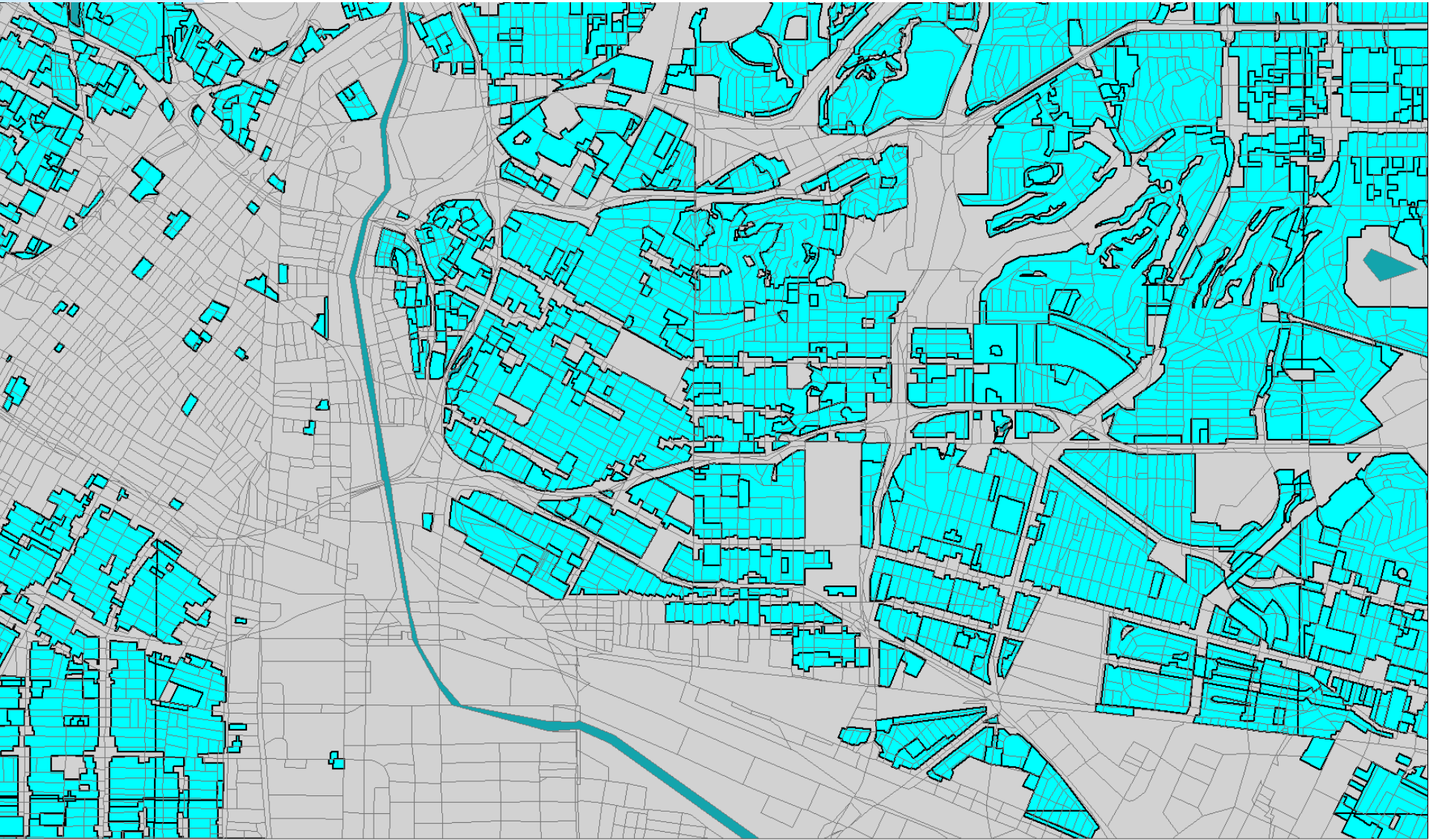
Select Residential & Sensitive Land Uses



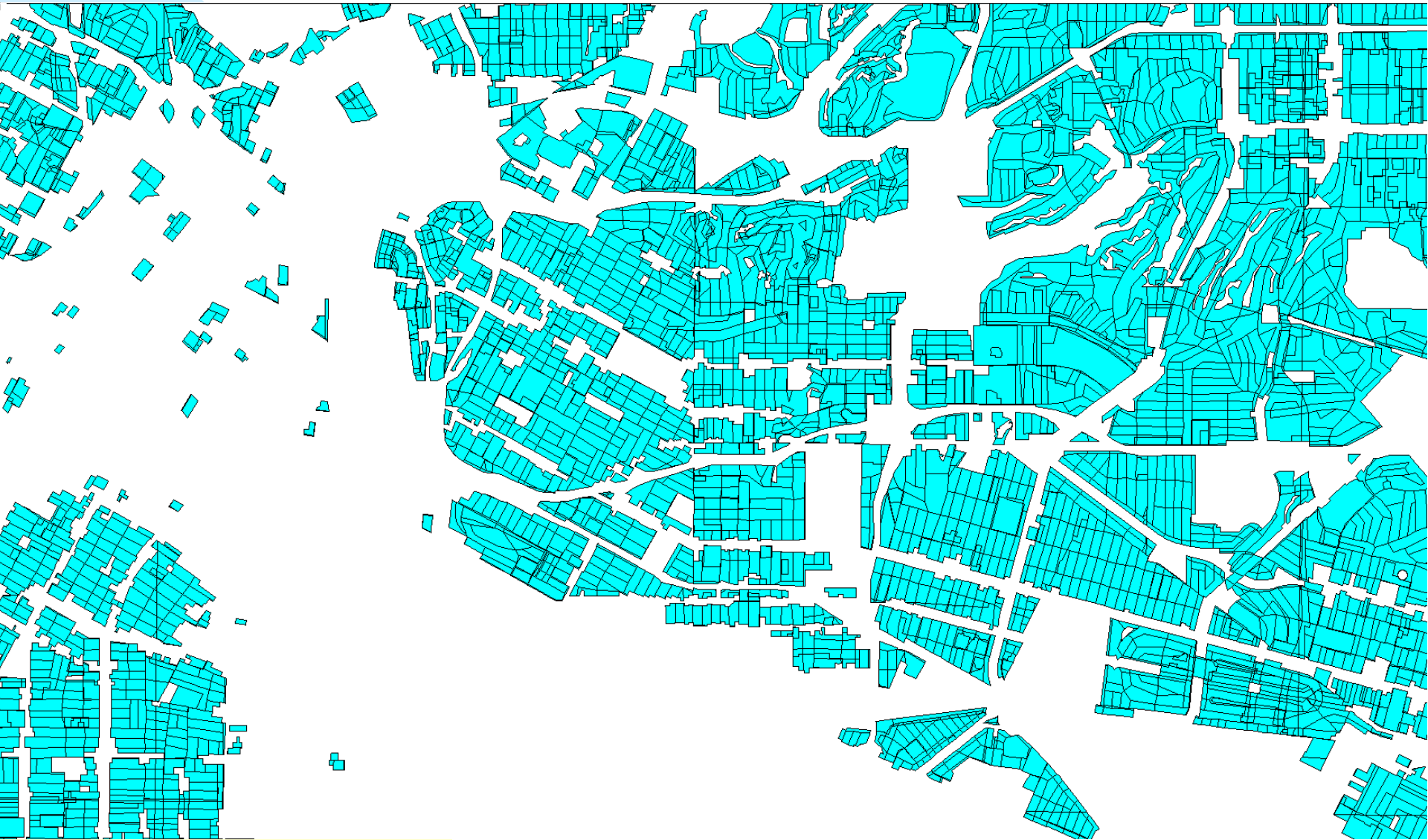
2000 Census Blocks



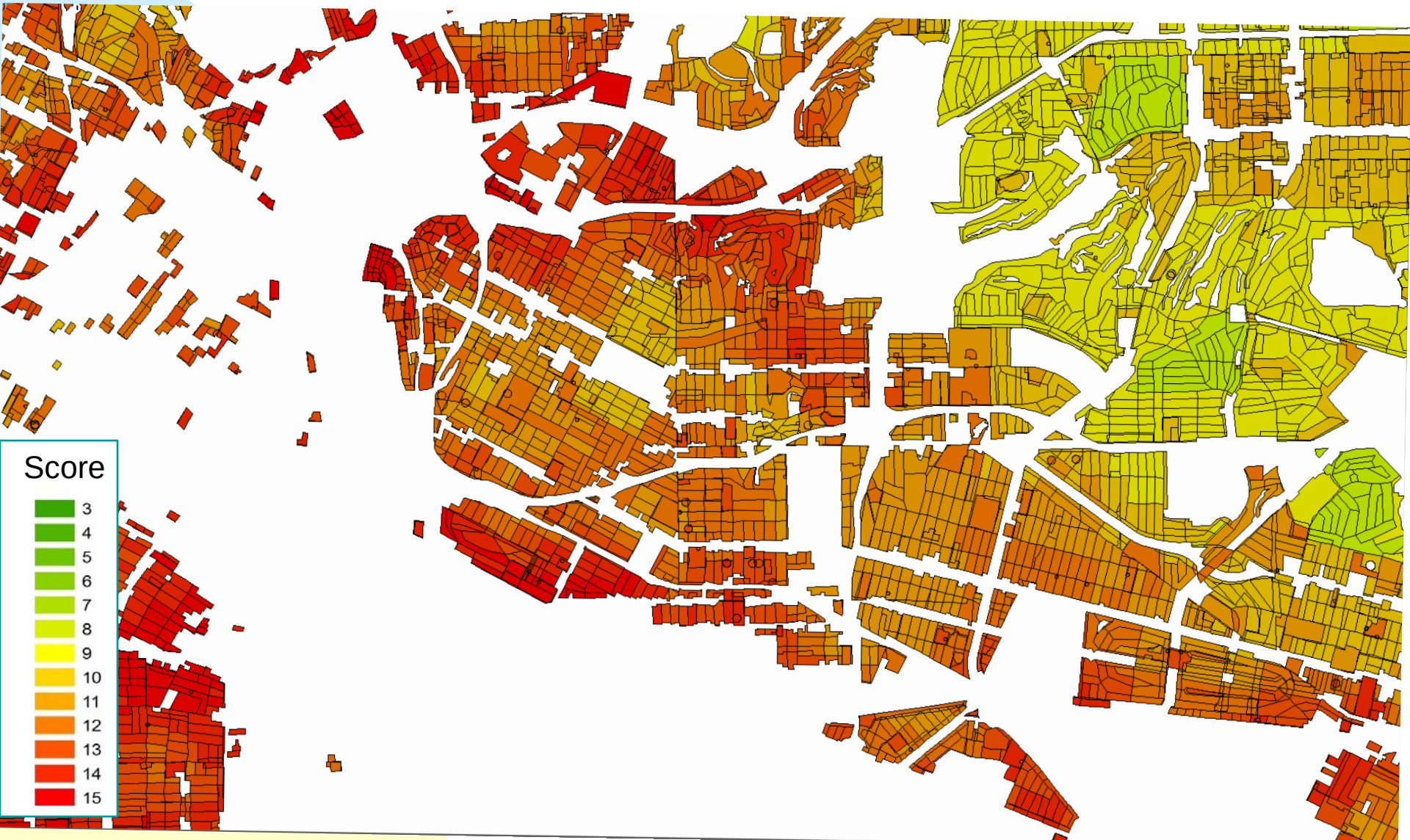
Intersect Land Use Polygons with Blocks



Result: Cumulative Impact (CI) Polygons, each associated with a specific block and land use



Each CI Polygon receives a Cumulative Impacts Score



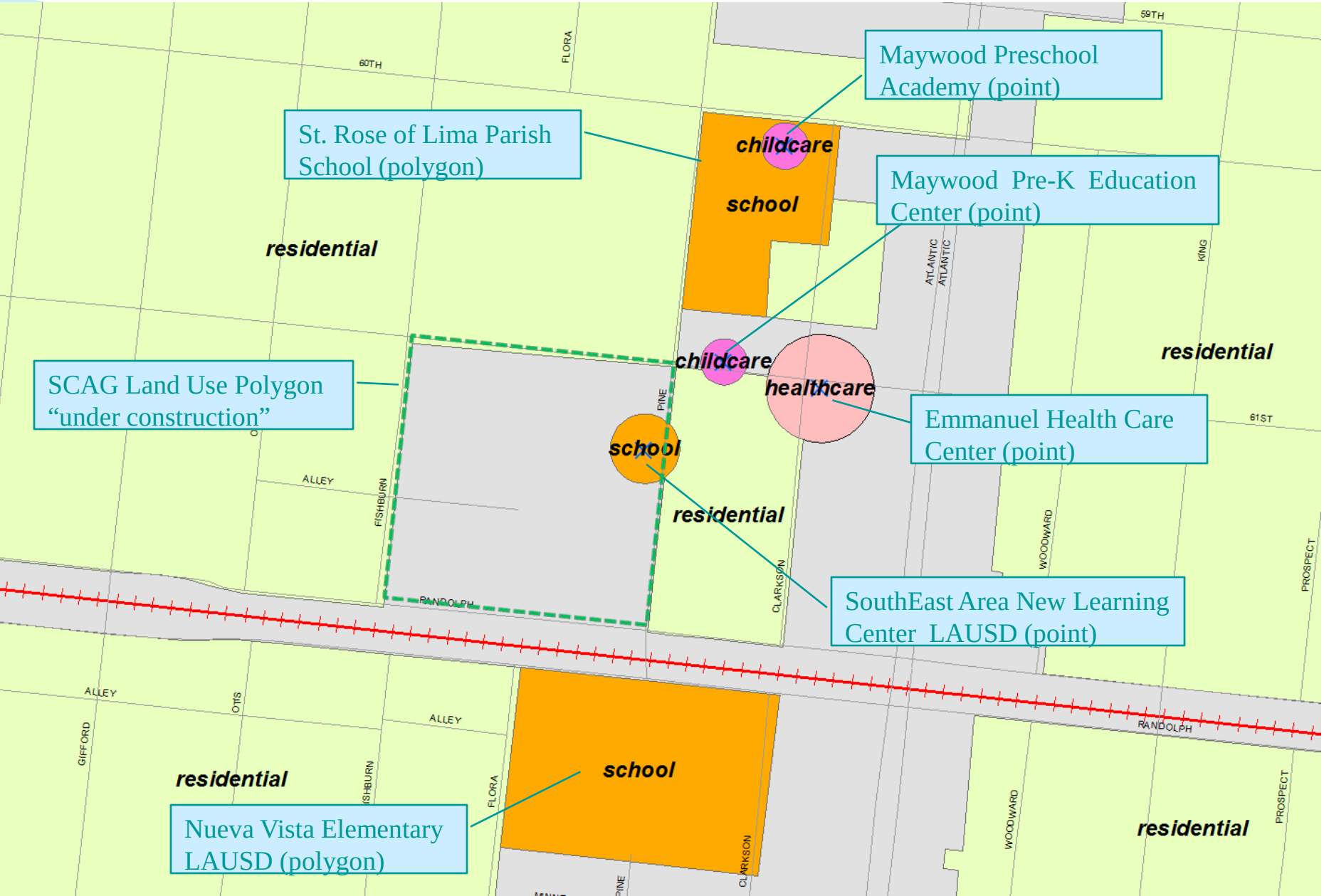
Sensitive Land Uses

- Defined by ARB
  - Air Quality and Land Use Handbook, 2005
- Identified from different data sources
  - SCAG 2005 land use data layer (GIS polygons)
  - Automated from address lists (geocoded points)
- Childcare facilities (SCAG, NAICS address list)
- Healthcare facilities (CaSIL/SCAG)
- Schools (SCAG, CA Dept of Education)
- Urban Playgrounds & Parks (SCAG)

Treatment of Geocoded Sensitive Land Uses Polygons from points

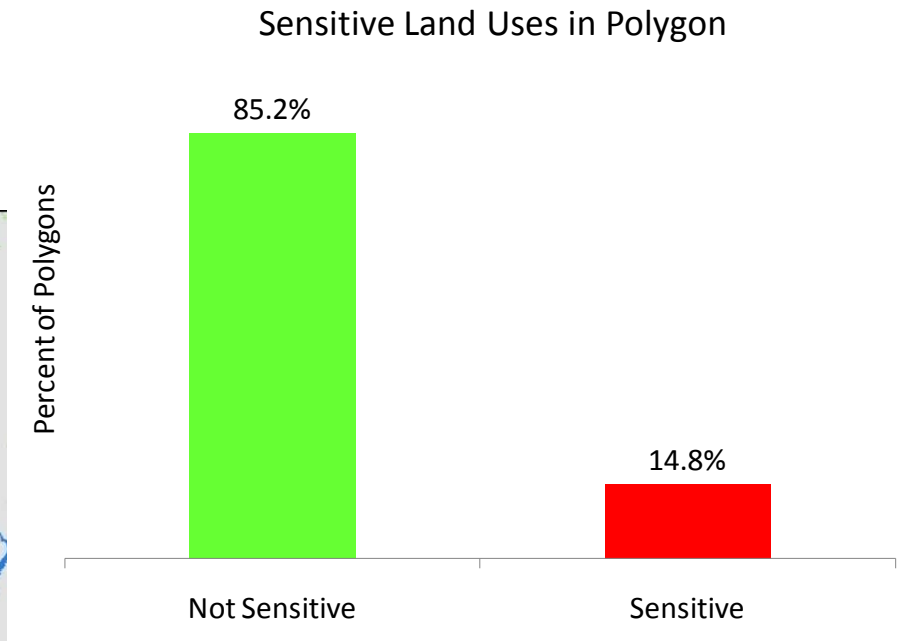
- Some sensitive receptor locations identified as geocoded points must be converted into polygons to create CI polygons, but actual area unknown
- Points buffered to create circle polygons
  - Area equal to that of the smallest equivalent land use in the SCAG data
    - Childcare = 1013 m^2
    - Schools = 2279 m^2
    - Healthcare = 5524 m^2
- These polygons added to CI Polygon base map using GIS Union to avoid area overlap

Geocoded Sensitive Land Uses - Polygons from points
(City of Maywood)



Geocoded Sensitive Receptor Land Uses Polygons from points

Sensitive Land Uses



GIS Spatial Assessment

- Calculate hazard proximity and sensitive land use metrics
  - Initial analysis using CI polygons
  - Transferred to census tracts using a population-weighting procedure

Proximity to Air Pollution Sources & Hazardous Land Uses

- CHAPIS (CARB)
- Chrome Platers (CARB)
- Hazardous Waste TSDs (DTSC)
  - Federal Response (includes Superfund)
  - State response
  - Voluntary cleanup
  - Military evaluation
  - School investigations and cleanup
- Rail
- Ports
- Airports
- Refinery
- Intermodal distribution facilities

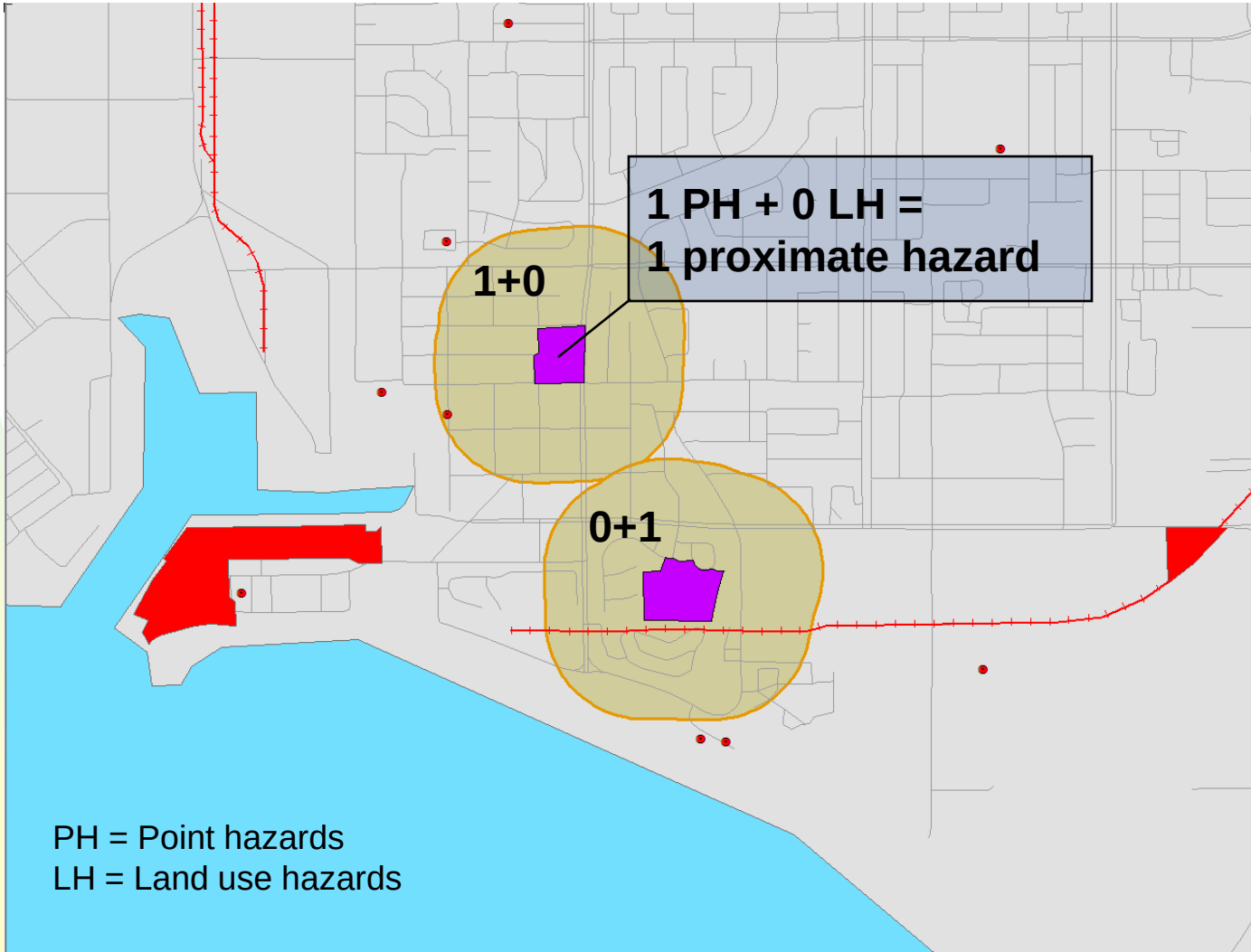
From ARB's "Air Quality and Land Use Handbook" (2005)

- *Number of sites within buffers of polygon edge is derived for each CI polygon*
  - *basic 1,000 ft approach*
  - *distance weighted approach*

Defining Hazard Proximity

1000 Foot Buffer around CI Polygons captures air pollution sources and hazardous land uses

- Buffer CI polygon boundaries
- Hazard proximity based on number of facilities (point-sources) and hazardous land uses inside the buffer

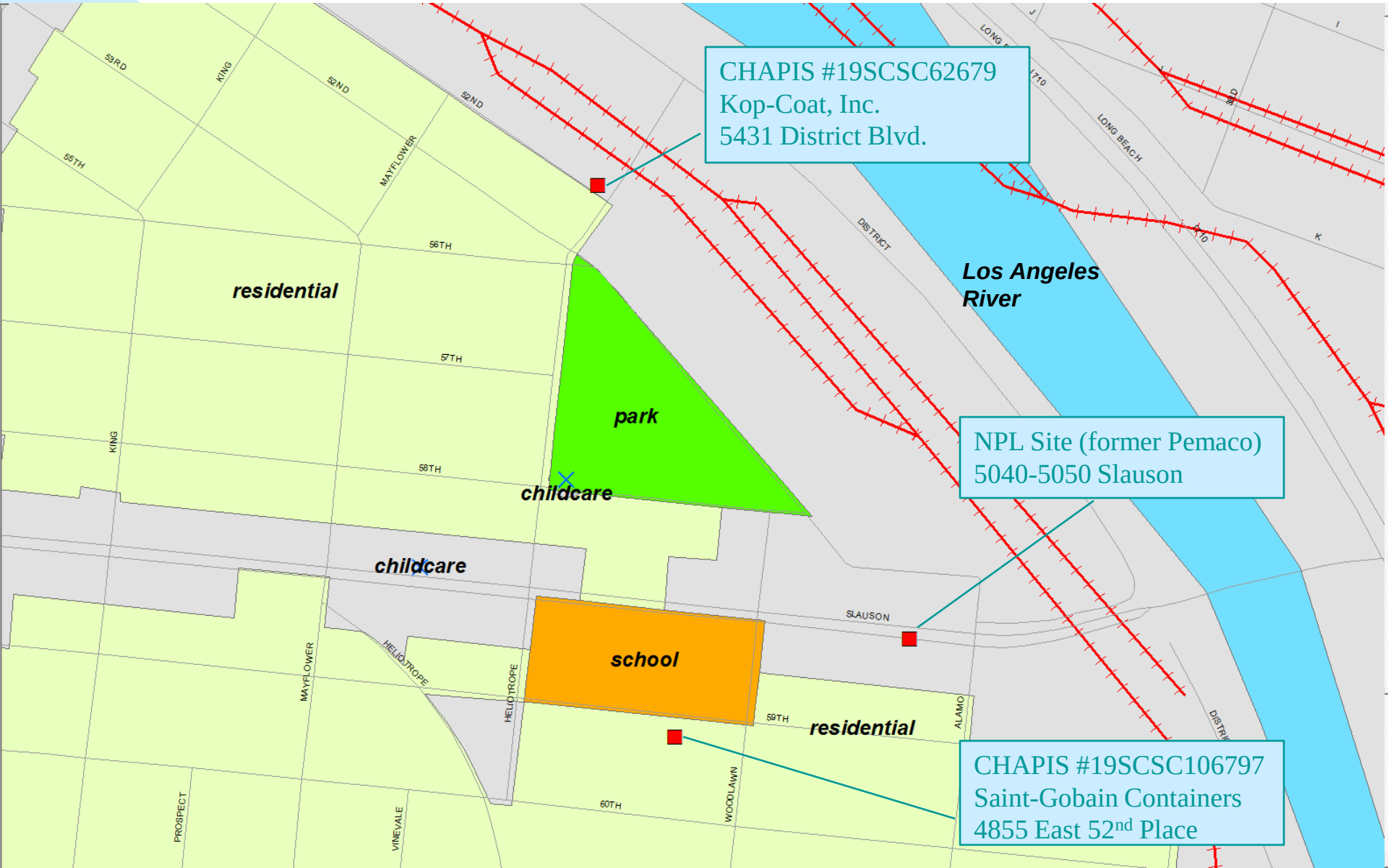


Mapping Accuracy and Accuracy of Facility Location

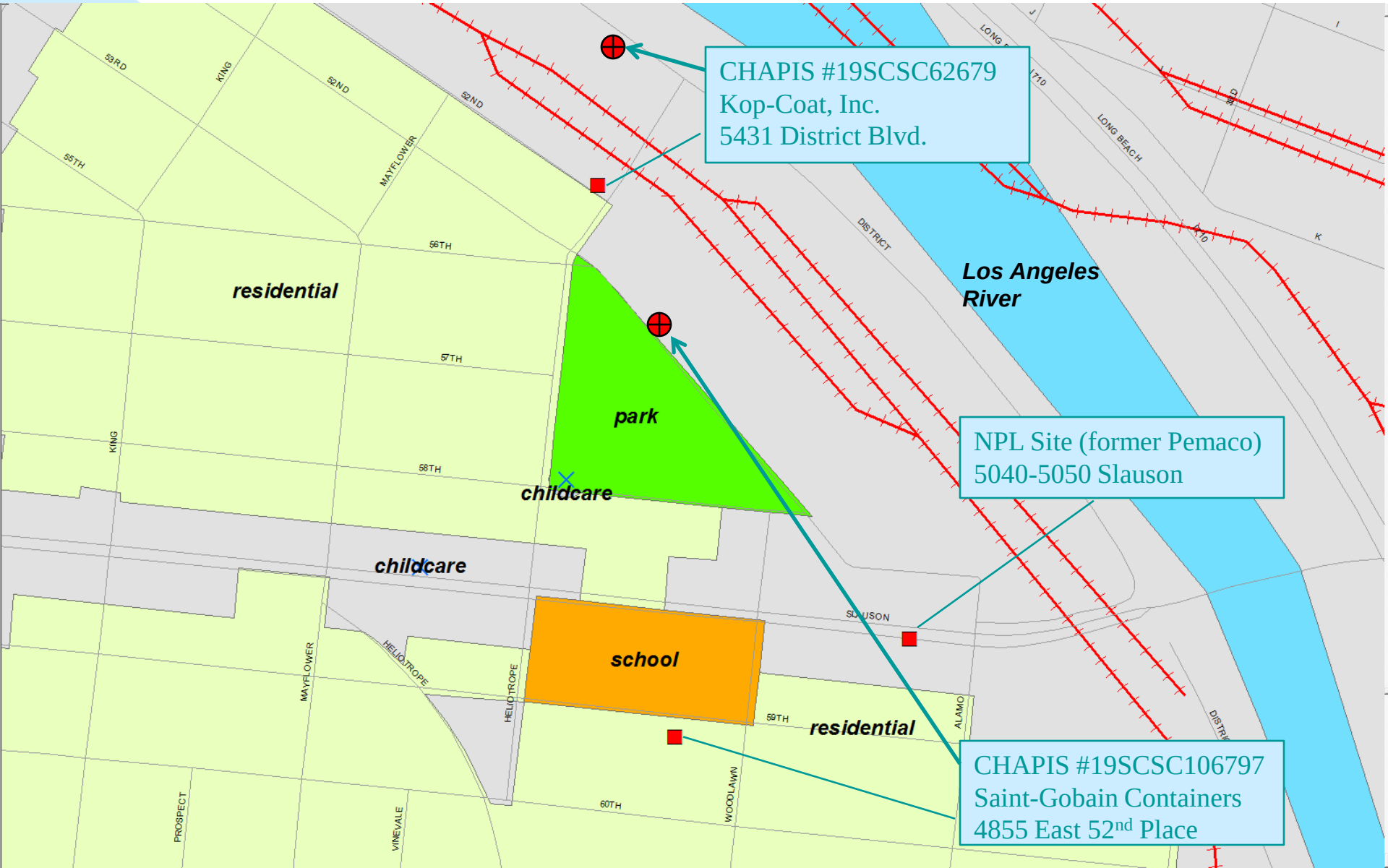
- There is error in reported location of some facilities
- Facilities represented as points in the GIS are actually much larger polygon areas
- Both of these factors introduce error into facility proximity/buffering procedure
- Effect is to “underscore” hazard proximity for some CI polygons

➢ *Distance-weighted hazard scoring is the favored method to address these problems*

Point Location Air Quality Hazards From ARB Data (City of Maywood)



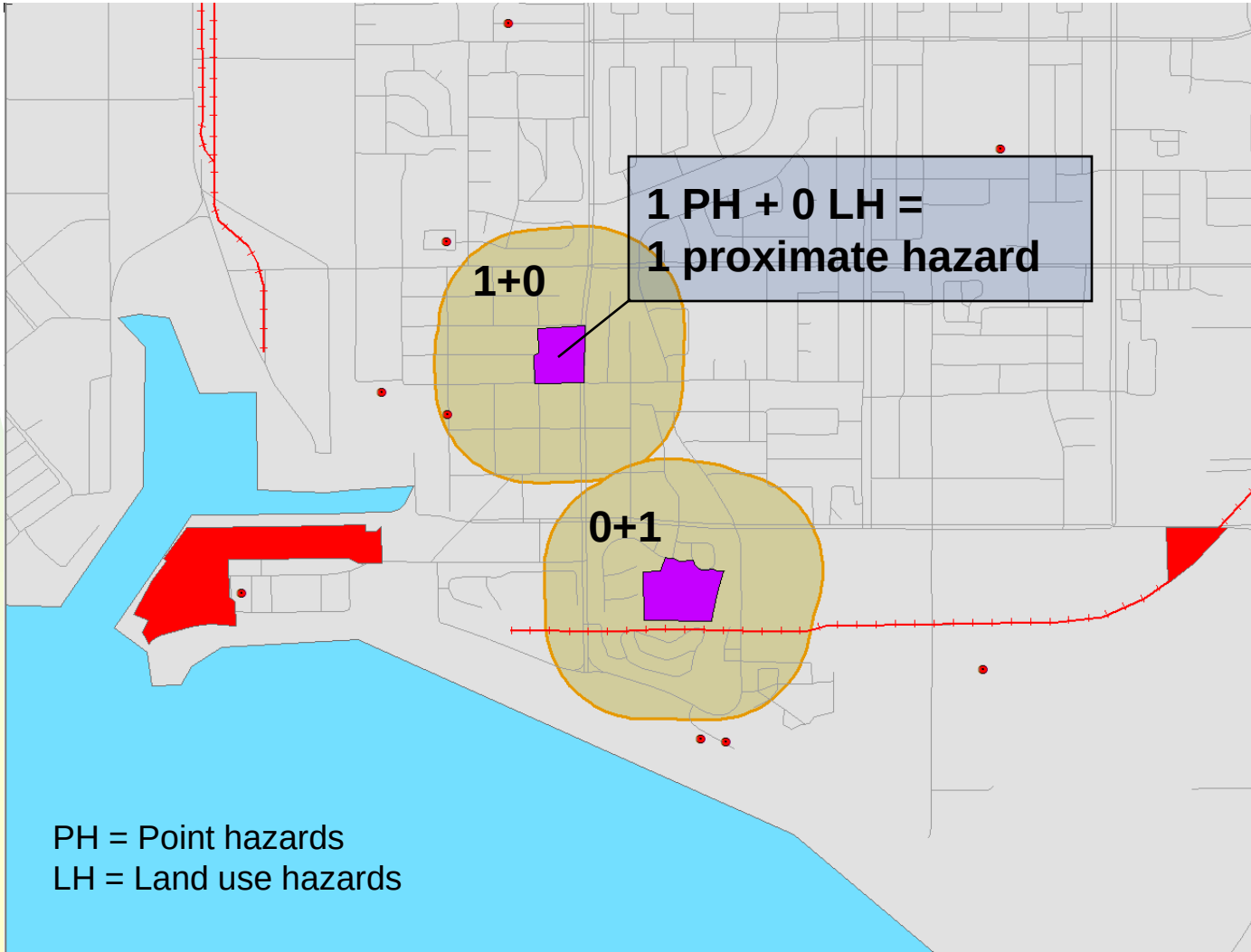
Error in Reported Facility Locations



Facilities Mapped as Points Using Available Data But Actual Facility Area is Much Larger

Defining Hazard Proximity
Distance-weighted Approach

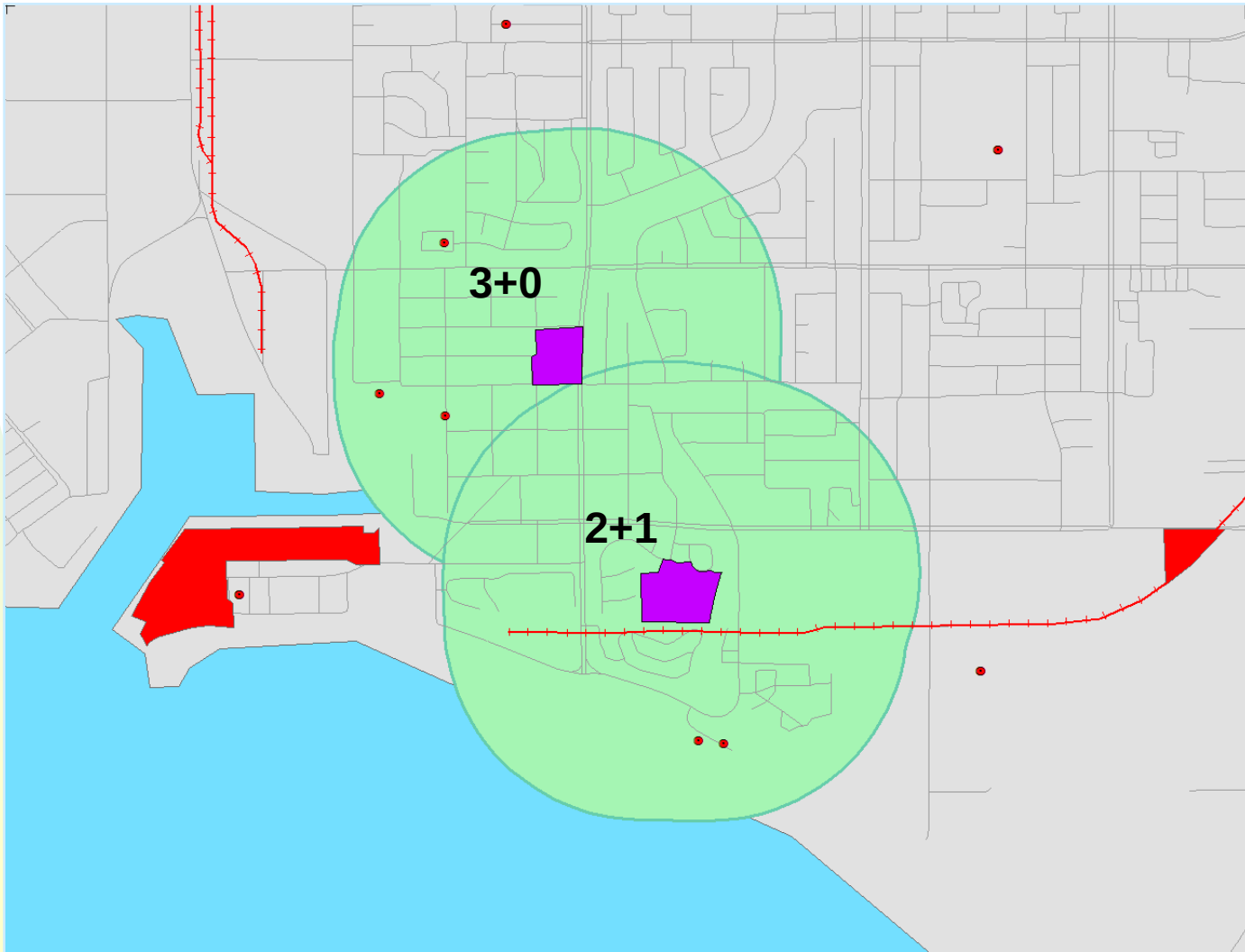
- Buffer CI polygon boundaries <u>at different distances</u>
- Hazard proximity based on number of facilities (point-sources) and hazardous land uses inside the buffer



Defining Proximity – Distance Buffers

2000 Foot Buffer

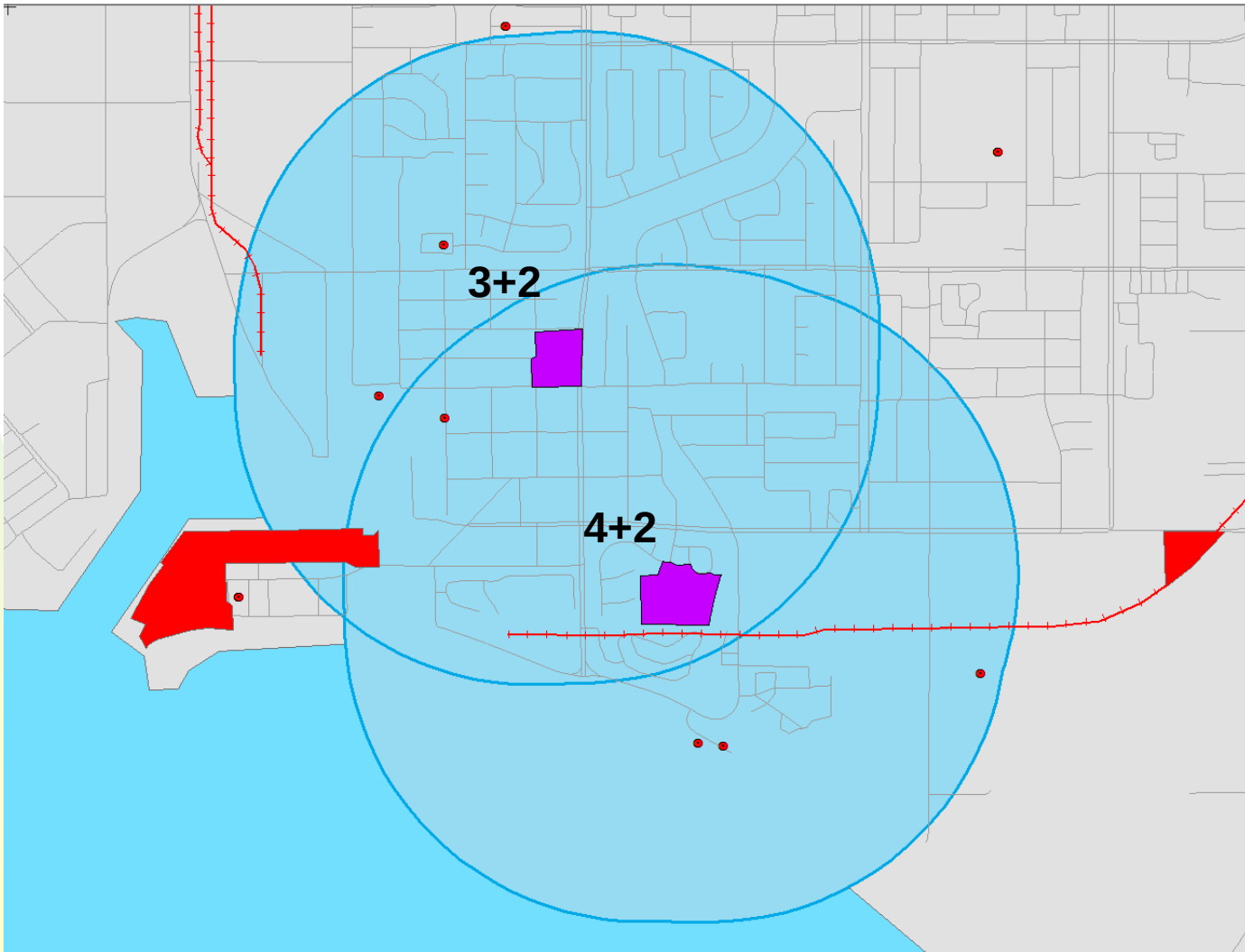
- Buffer CI polygon boundaries <u>at different distances</u>
- Hazard proximity based on number of facilities (point-sources) and hazardous land uses inside the buffer



Defining Proximity – Distance Buffers

3000 Foot Buffer

- Buffers on CI polygon boundaries
- Hazard proximity based on number of facilities (point-sources) and hazardous land uses inside the buffer



Distance Weighting the Hazard Count

Because of the potential for inaccurate hazard locations, a distance weighted approach is used to get the hazard count for each CI polygon:

Distance Weighted Hazard Count =

(1 x #Hazards within 1,000ft) +

(**0.5** x #Hazards 1,000-2,000ft) +

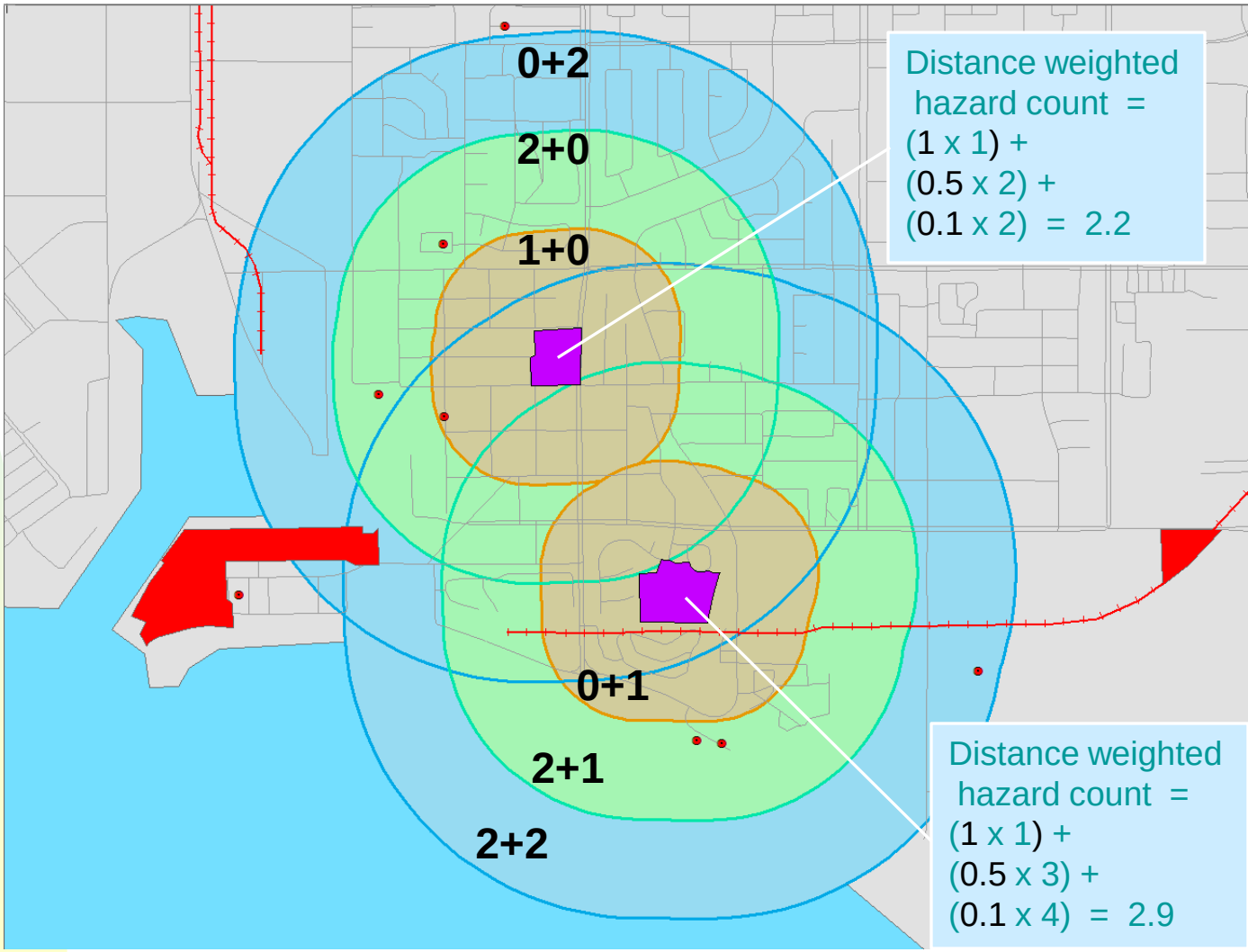
(**0.1** x #Hazards 2,000-3,000ft)

** The above weights can be set to any desired value*

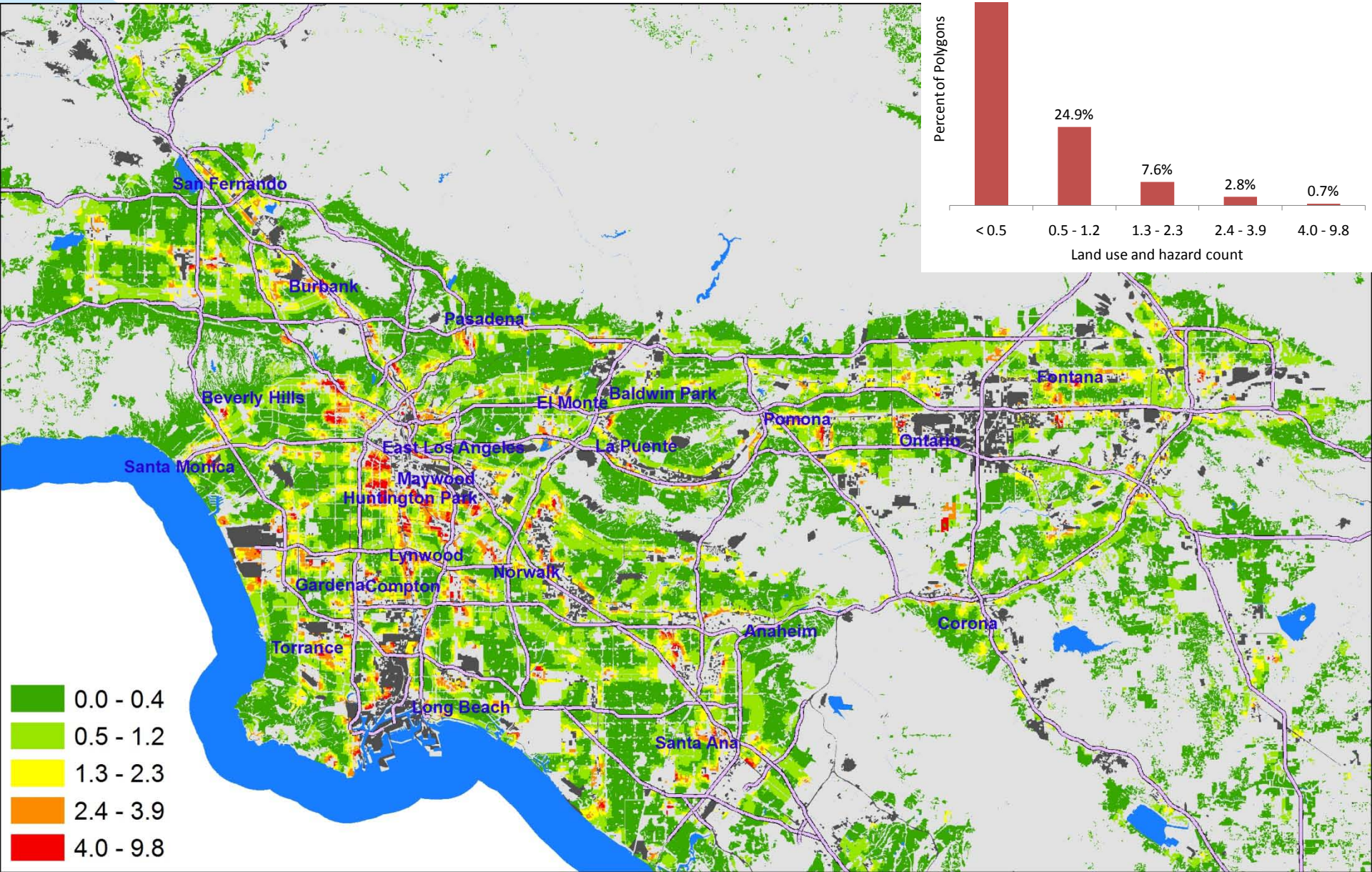
Defining Proximity – Distance Buffers

1000-3000 Foot Buffers, Distance Weighted Hazard Count

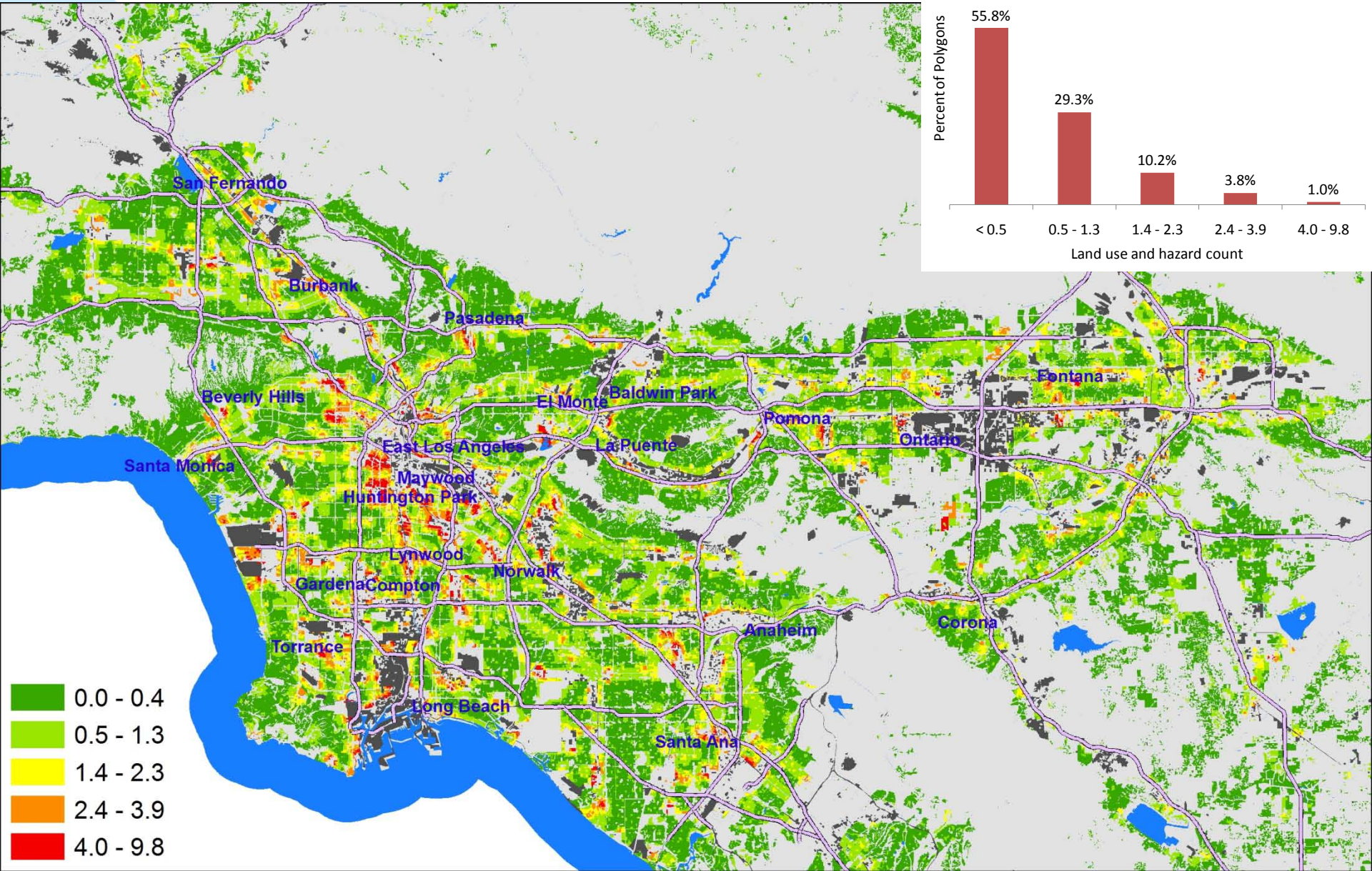
- Buffer CI polygon boundaries <u>at different distances</u>
- Hazard proximity based on number of facilities (point-sources) and hazardous land uses inside the buffer



Distance weighted hazard count around CI Polygons (Jenks natural breaks)



Distance weighted hazard count around CI Polygons **+ 1 if sensitive land use** (Jenks natural breaks)



Calculating Hazard Proximity & Sensitive Land Counts at the Tract Level

Why?

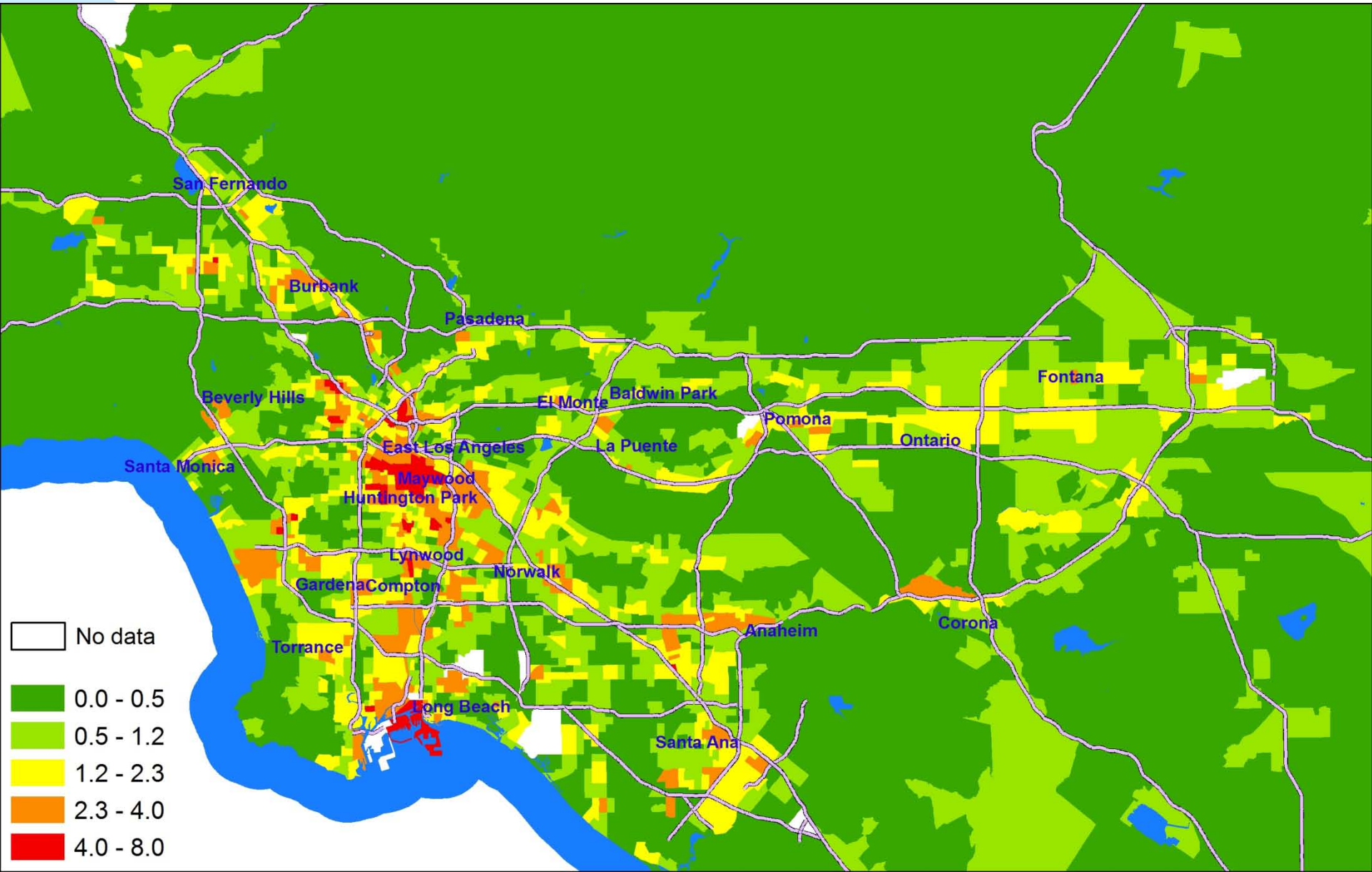
- Tracts are a consistent level of geography for many sources of data; avoid misrepresenting precision
- All of the health risk and social vulnerability measures (discussed later) are available at the tract level

How Calculated:

- Estimate population in each CI polygon (area-weighting of population of its host block)
- Calculate population-weighted average of the hazard and sensitive land use counts across the CI Polygons within each census tract

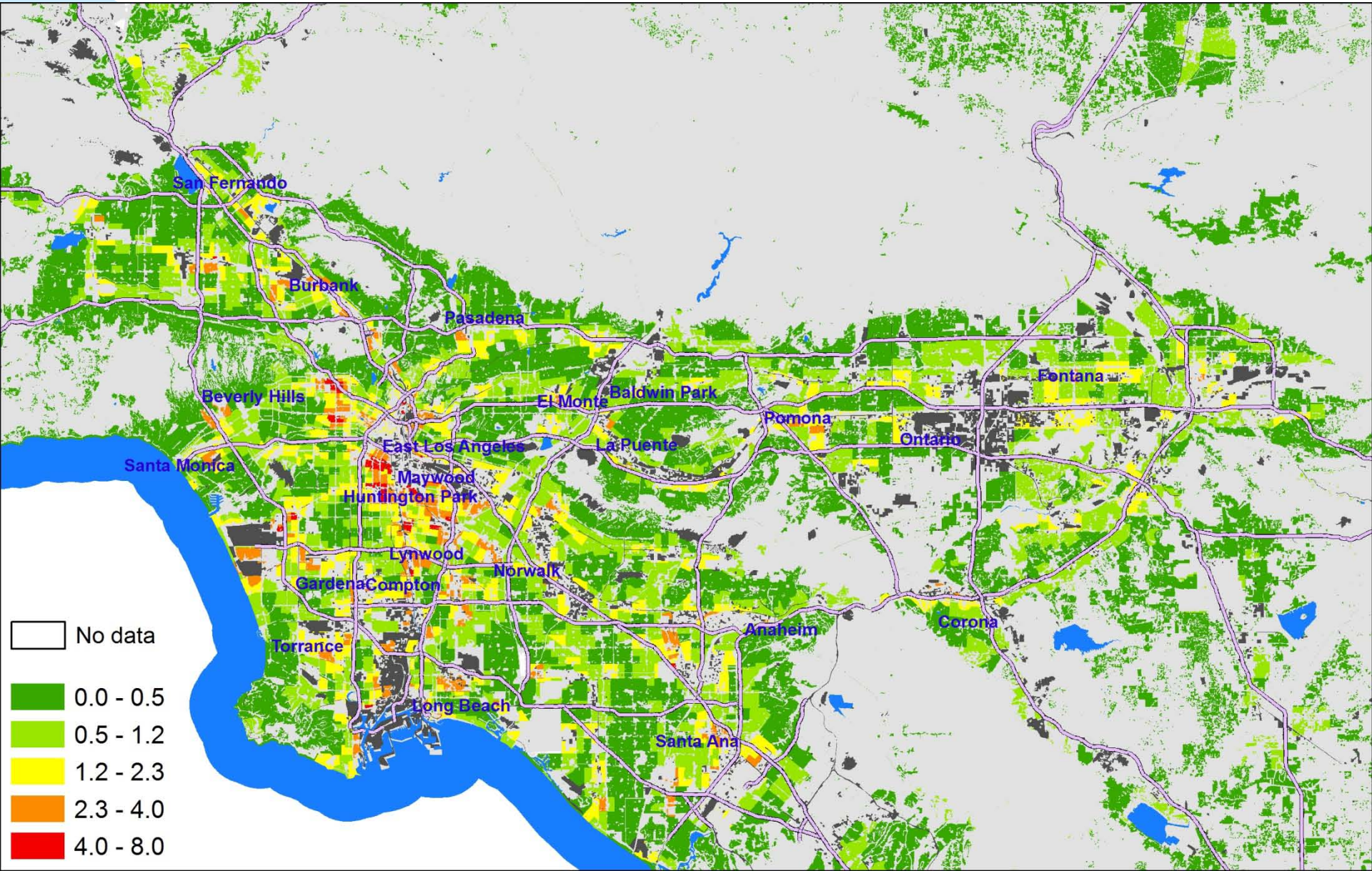
Tract-level Hazard Proximity & Sensitive Land Use Counts

Distance weighted hazard count (+1 if sensitive land use), population weighted to the tract level (Jenks natural breaks)



Tract-level Hazard Proximity & Sensitive Land Use Counts

Distance weighted hazard count (+1 if sensitive land use), population weighted to the tract level, mapped on CI Polygons (Jenks natural breaks)

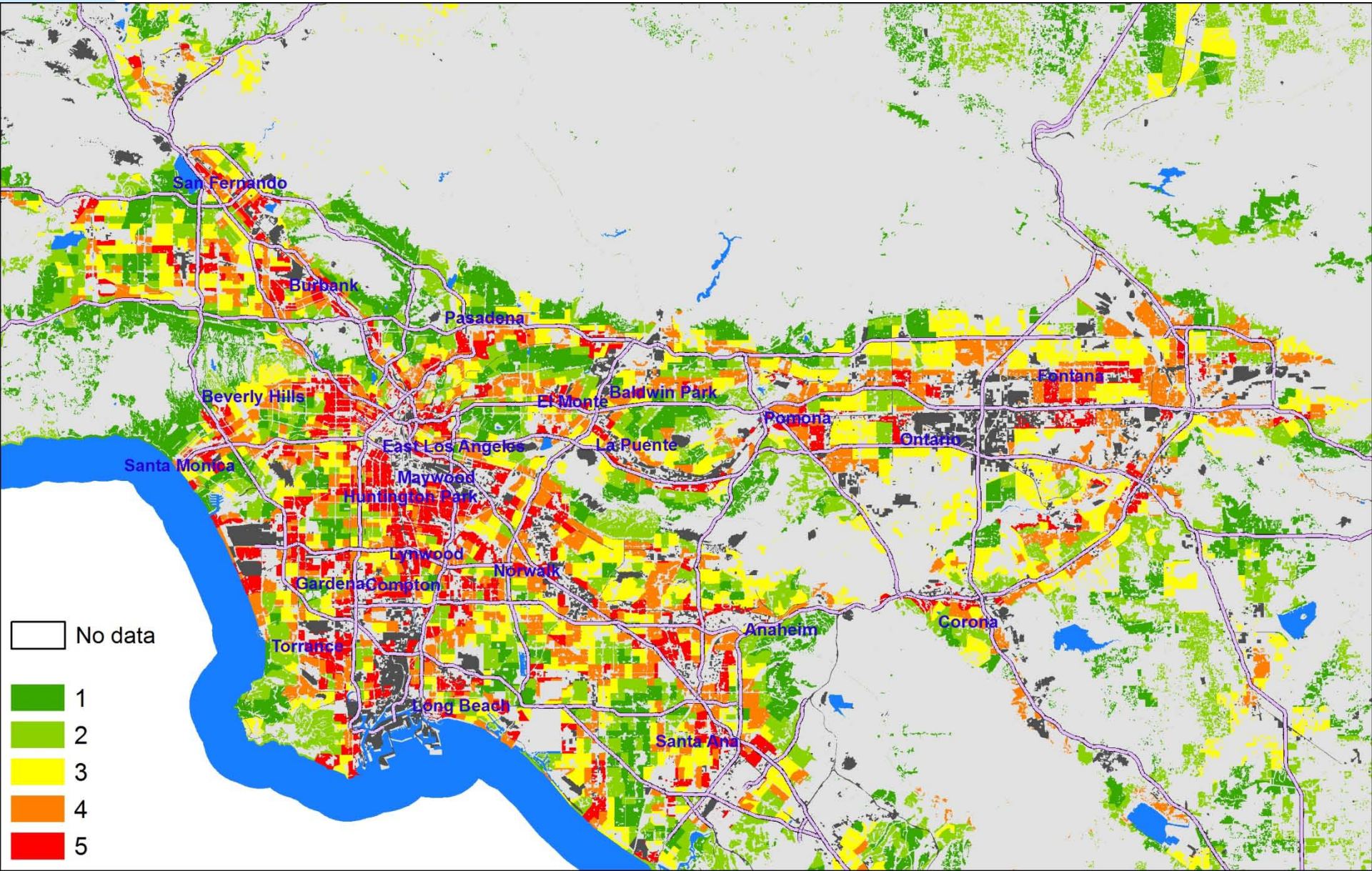


Hazard Proximity & Sensitive Land Use Scores at the Tract Level

- Tract-level hazard and sensitive land use counts are ranked into quintiles across all tracts in the region
- Assigned score of 1-5 based on quintile rank - final hazard proximity and sensitive land use **score** at the tract level
- Quintile distribution is used throughout the EJ Screening Method because it is an accessible and recognizable ranking procedure
  - No “right” distribution to follow (magnitudes of hazards unknown)
  - Other distributions could easily be substituted

Hazard Proximity & Sensitive Land Use Score at the Tract Level

Mapped on CI Polygons (quintile distribution)



Health Risk & Exposure Indicators
(Tract Level)

- RSEI (Risk Screening Environmental Indicators)
  - (2005) toxic conc. hazard scores from TRI facilities
- NATA 1999 (National Air Toxics Assessment)
  - Respiratory hazard from mobile & stationary sources
- CARB Estimated Inhalation Cancer Risk 2001
  - Calculated from modeled air toxics concentrations using emissions from CHAPIS (mobile & stationary)
  - Corrected version of this data

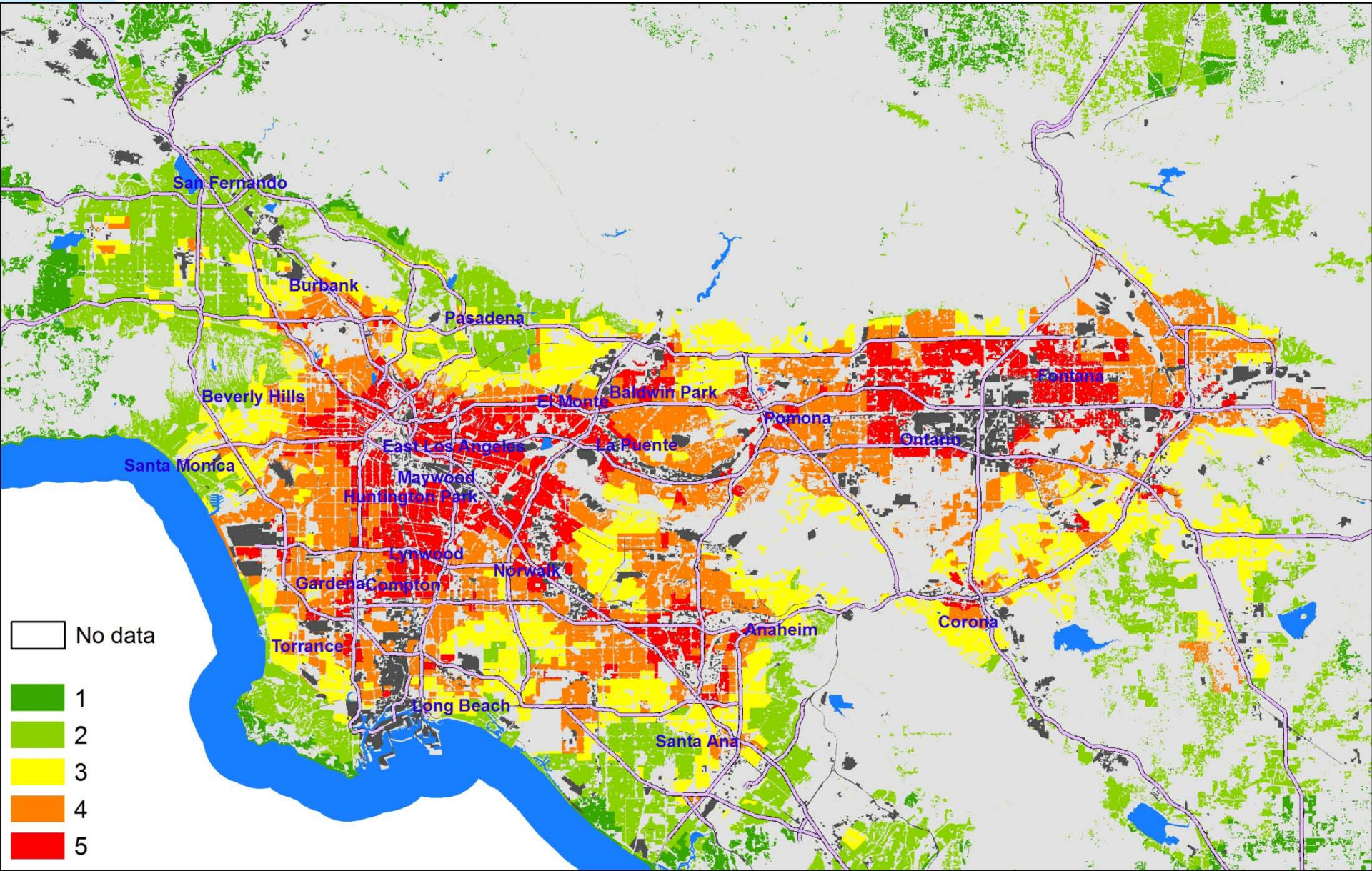
- CARB estimated $PM_{2.5}$ concentration
- CARB estimated Ozone concentration

Health Risk & Exposure Scores
(Tract Level)

- Each health risk indicator is ranked into quintiles (1-5) across all tracts in the region
- Quintile rank values are summed by tract across all indicators
- These tract sums are ranked once again into quintiles and assigned scores 1-5.
- The resulting quintile rank for each tract is it's final health risk score

Health Risk & Exposure Score at the Tract Level

Mapped on CI Polygons (quintile distribution)



Social & Health Vulnerability Indicators

Census Tract Level Metrics (2000)

- % residents of color (non-White)
- % residents below twice national poverty level
- Home ownership - % living in rented households
- Housing value – median housing value
- Educational attainment – % population > age 24 with less than high school education
- Age of residents (% <5)
- Age of residents (% >60)
- Linguistic isolation - % pop. >age 4 in households where no one >age 15 speaks English well
- Voter turnout - % votes cast among all registered voters in 2000 general election
- Birth outcomes – % preterm or SGA infants 1996-03

Social & Health Vulnerability Scores

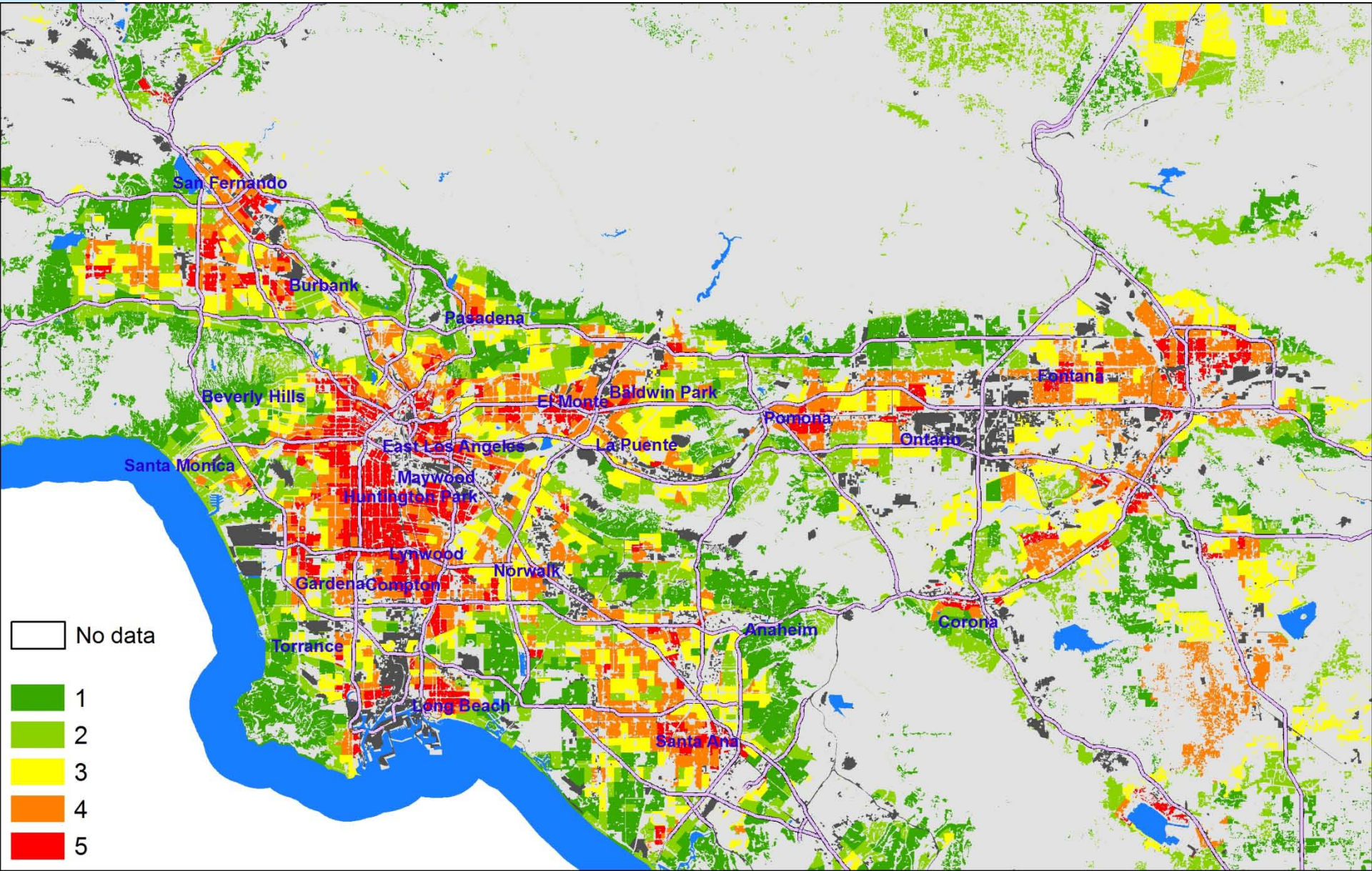
- Each social and health vulnerability metric is ranked into quintiles (1-5) across all tracts in the region

- Final score is derived by taking average ranking (across all metrics) for each tract, and ranking the average once again into quintiles (1-5)

A note on missing values:
To help ensure that the social and health vulnerability scores are reliable, we exclude tracts with less than 50 people, and those with 5 or more missing values among the 10 metrics considered. To account for missing values in tracts with 1 to 4 missing metrics, the average quintile ranking is taken across only the non-missing metrics.

Social Health & Vulnerability Score at the Tract Level

Mapped on CI Polygons (quintile distribution)



Cumulative Impact Scores at the Tract Level

Combine three categories of tract level impact and vulnerability to get Cumulative Impact Score

Cumulative Impact Score =

Hazard Proximity and Sensitive Land Use Score (1-5) +

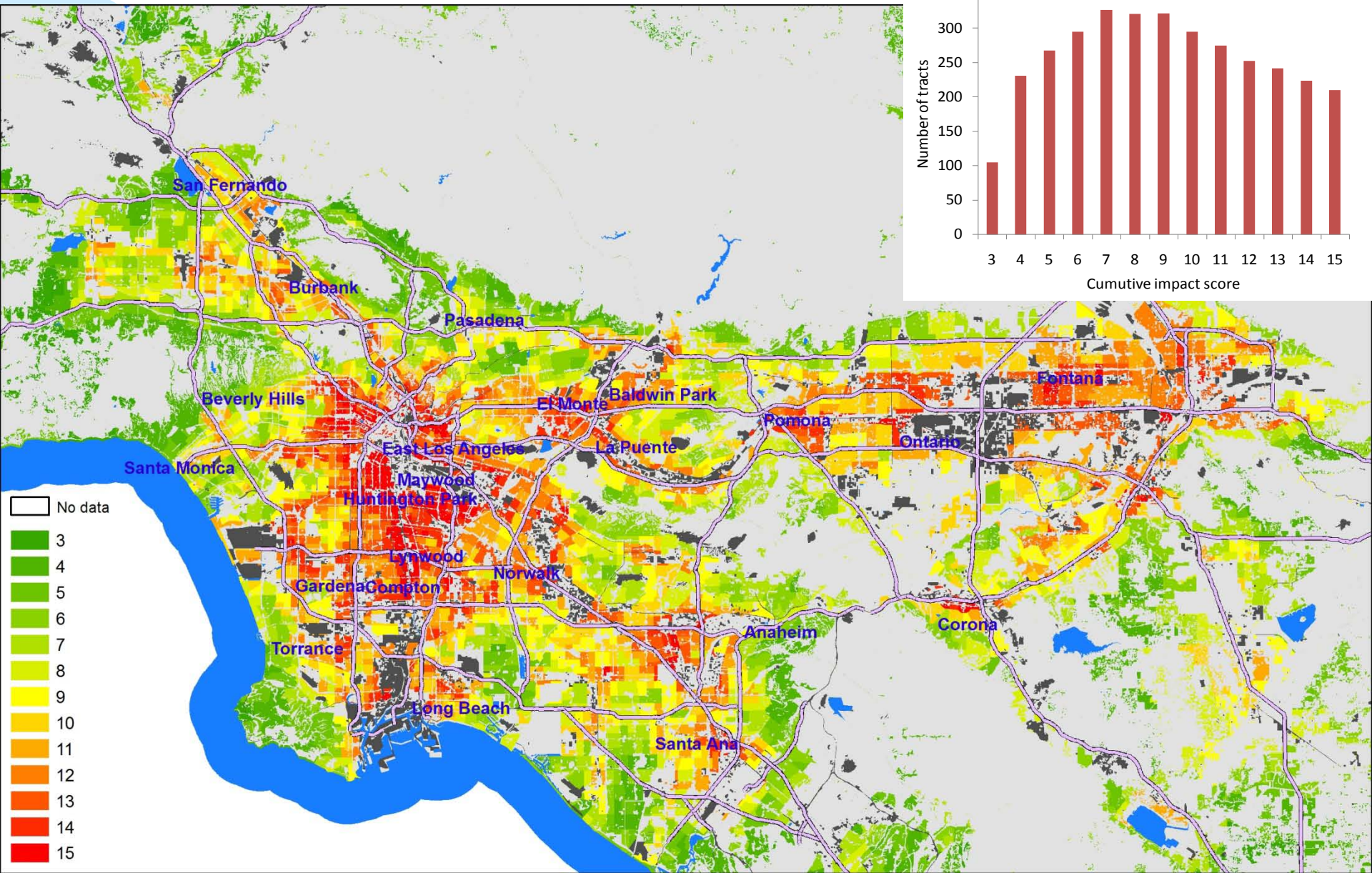
Health Risk and Exposure Score (1-5) +

Social and Health Vulnerability Score (1-5)

- *Final Cumulative Impact Score Ranges from 3-15*

Tract Level Cumulative Impact Score

Distance weighted hazard proximity, mapped on CI Polygons



Alternative Approach: Cumulative Impact Scores at the CI Polygon Level

- Tract level health risk and exposure & social and health vulnerability scores (from above) are applied directly to the CI Polygons in each tract, but...

- Hazard proximity and sensitive land use score is based on ***Jenks Natural Breaks*** with 5 categories rather than quintiles

Cumulative Impact Score =

Hazard Proximity and Sensitive Land Use Score (1-5) +

Health Risk and Exposure Score (1-5) +

Social and Health Vulnerability Score (1-5)

➢ *Final Cumulative Impact Score Ranges from 3-15*

Cumulative Impact Scores at the CI Polygon Level

Why the CI Polygon Level?

Benefit:

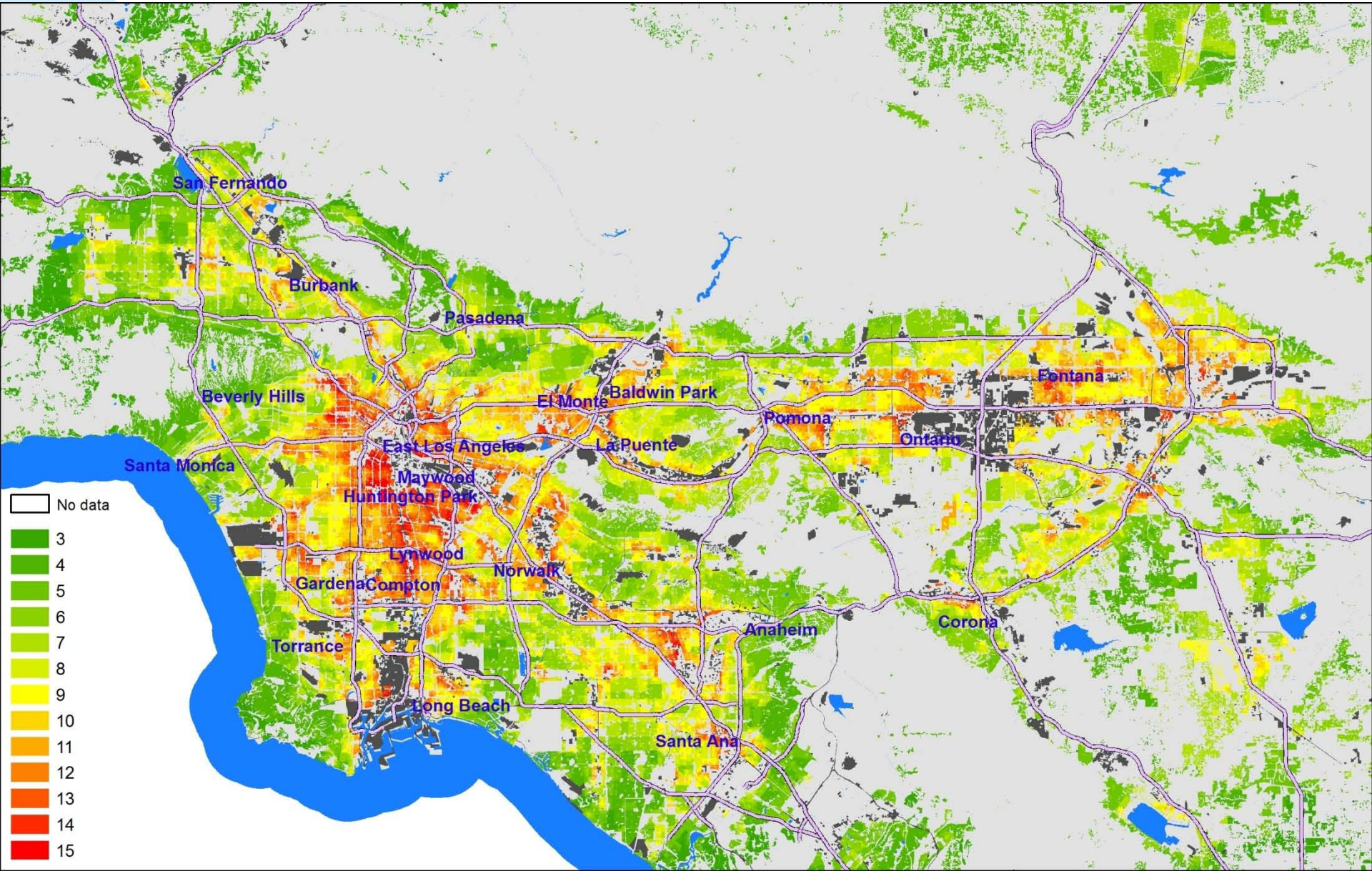
- Finer level of geography that preserves the accuracy of the hazard proximity & sensitive land use information – may be good for land-use decision making

Caution:

- May give a false sense of geographic accuracy in the health risk & exposure and social & health vulnerability measure, which are derived at the tract level
- Generally results in lower Cumulative Impact scores for CI Polygons that are not in upper reaches of the distribution of the hazard proximity & sensitive land use counts

CI Polygon Level Cumulative Impact Score

Distance weighted hazard proximity, mapped on CI Polygons

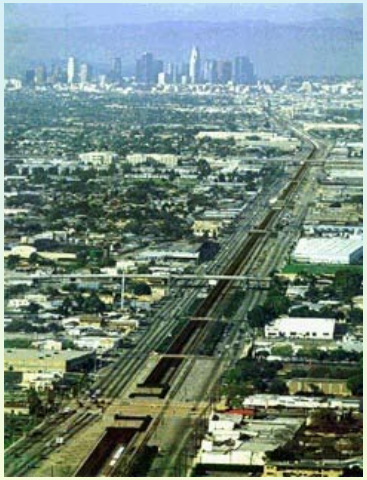


Recommended Approach:

Tract Level Cumulative Impact Score using **Distance Weighted** hazard proximity is best…

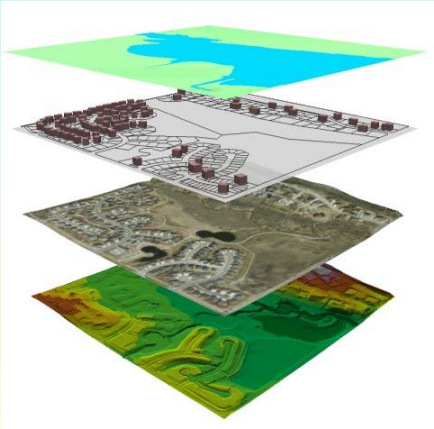
- The tract level is a appropriate geographic unit without overemphasizing precision of underlying data
- Air quality and social demographic measures are available at the tract level
- Using distance weighting on the hazard count:
  - allows for flexibility in changing weights in the face of new standards
  - accounts better for geographic inaccuracies, including the representation of some hazards as points with no geographic dimensions

Potential Contributions



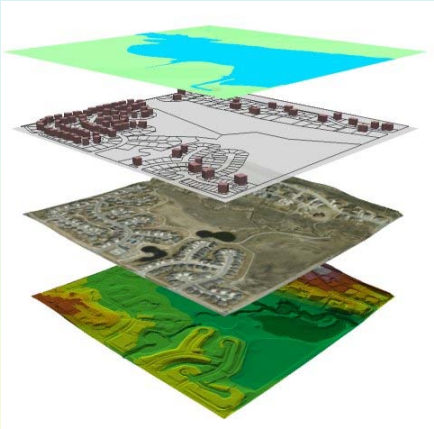
- Screening provides a way of drilling down regionally and highlighting communities of potential regulatory concern
  - Transparent approach and metrics that use publicly available data and is not too difficult to implement & update
    - Open to modification by sophisticated users (change scoring weights, indicators, scoring approaches)

Takeaways from This Analysis



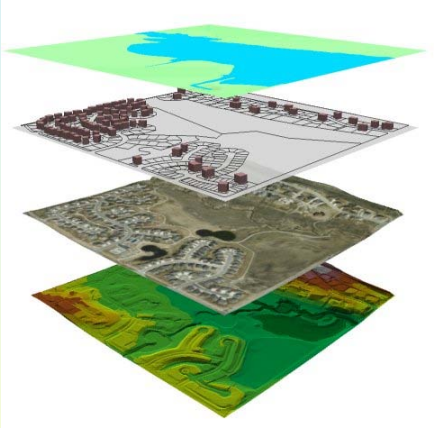
- *Analytic:*
  - An EJSM is technically possible. In our powerplant siting simulation for CEC, it outperforms current method at distinguishing between sites.
  - Could also be useful for identifying communities that are highly exposed and socially vulnerable for increased outreach, policy attention and/or resources
  - Suggests a need to improve land use data to a common standard throughout the state

Takeaways from This Analysis



- *Process:*
  - Engaging communities in the development of the method involves risks – will the information get out too early?
  - Community engagement also means making variable and ranking choices in ways that are intuitive and easier to explain
  - Such a process also builds trust in the potential use of the EJSM for policy and other purposes.

Free at Last . . .



- *Questions?*
- *Comments?*
- *Future Directions?*