Environmental Justice Screening Method:
Integrating Indicators of Cumulative Impact
into Regulatory Decision-making

Rachel Morello-Frosch, UC Berkeley
Manuel Pastor, USC
Jim Sadd, Occidental College
The Primary Research Team

- Manuel Pastor, Ph.D. in Economics, project coordination, statistical analyses, including multivariate and spatial modeling, and popularization
- James Sadd, Ph.D. in Geology, develop and maintain geographic information systems (GIS), including data automation, spatial analysis and geoprocessing
- Rachel Morello-Frosch, Ph.D. in Environmental Health Science statistical analysis, health end-points, and estimates of risk.
Purpose of Screening Methodology

- 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 (CARB), 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 Screening Method

- Specific reference to ambient air quality
  - Not screening for occupational, indoor, water, pesticides.
  - Uses secondary databases (screening, not assessment)
  - Follows guidance of CARB Air Quality and Land Use Handbook (2005)
  - Validated by ARB contract Peer Review Committee
- Developed to incorporate land use information into environmental decision-making
  - Performs best with detailed, high resolution land use data.
  - First applied in So. California
  - Completed for Southern California and the Bay Area (16 counties; 76% of population)
  - In process in 5 southern Central Valley counties.
- Screen and map where people are exposed
  - Residential land use
  - Sensitive land use categories (California ARB land use guidelines, 2005)
Categories of Impact & Vulnerability

- **Proximity to hazards & sensitive land uses**
  - Based on EJ literature
  - CARB land use guidelines (sensitive receptors)
  - State data on air quality hazards

- **Health risk & exposure**
  - Based on EJ and public health literature
  - Available state and national data
  - Modeling from emissions inventories

- **Social & health vulnerability**
  - Based on epidemiological literature on social determinants of health
  - Based on EJ literature on area-level measures of community vulnerability
Screening Method Architecture

- **Step 1:** GIS Spatial Assessment
  - Derivation of land use layer
  - Create CI polygon mapping layer (intersects land use polygons with census blocks)
  - Identify land use and hazard proximity metrics for CI polygons

- **Step 2:** Programming (SPSS)
  - Data processing and cleaning
  - Metrics development
  - 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 - 3:
- Quality control of data layers
- Document and verify metric derivation and scoring
- Scientific and Community peer review
GIS Spatial Assessment –
Derive Land Use Spatial Layer

1. Create land use layer by isolating specific land uses
   - “Sensitive land uses” – daycare, schools, medical facilities, senior housing, urban parks and playgrounds (CARB, 2005)
   - Residential

2. Intersect land use polygons with census blocks

3. Resulting Base Map - CI Polygons
   - Scoring System – each polygon receives “points” related to indicators
   - Final mapping also done using census tracts (discussed later)
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
Scoring – Land Use and Hazard Proximity

- Land use polygons receive a score of 1 if they contain at least one sensitive land use category.
- Calculate hazard proximity metrics:
  - CHAPIS (Priority emitters from California emissions inventories)
  - Chrome Platers
  - Hazardous Waste TSDs
  - Land Uses associated with high levels of air pollution (ARB Handbook)
    - Rail, Ports, Airports, Refineries, Intermodal Distribution Facilities
    - Traffic counts (CARB land use “freeways and high traffic roads”)
- Proximity analysis using CI polygons:
  - Number of sites within distance of CI polygon boundary
  - Distance-weighted approach to address locational inaccuracy
- Transfer values to census tracts using a population-weighting procedure
Defining Hazard Proximity

*Distance-weighted Approach*

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

$1 \text{ PH} + 0 \text{ LH} = 1$ proximate hazard

PH = Point hazards
LH = Land use hazards
Defining Proximity – Distance Buffers

2000 Foot Buffer

- Buffer CI polygon boundaries at different distances
- 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:

\[
\text{Distance Weighted Hazard Count} = (1 \times \#\text{Hazards within 1,000ft}) + (0.5 \times \#\text{Hazards 1,000-2,000ft}) + (0.1 \times \#\text{Hazards 2,000-3,000ft})
\]

* The above weights can be set to any desired value
Buffer CI polygon boundaries at different distances

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

Distance weighted hazard count = $(1 \times 1) + (0.5 \times 2) + (0.1 \times 2) = 2.2$

Distance weighted hazard count = $(1 \times 1) + (0.5 \times 3) + (0.1 \times 4) = 2.9$
Next Step: Calculate Hazard Proximity & Sensitive Land Use Counts at the Tract Level

Why?

- Tracts are a consistent level of geography for many sources of data
- 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 from census blocks)
- Calculate population-weighted average of the hazard and sensitive land use counts using all CI Polygons in each census tract
Scoring: Hazard Proximity & Sensitive Land Use

- Tract-level hazard are ranked into quintiles (1-5) across all tracts in the region to produce the final hazard proximity and sensitive land use **score**

- Quintile distribution is used throughout the EJ Screening Method because it is an easily understood and normal ranking procedure
  
  - No “right” distribution to follow (magnitudes of hazards unknown)
  
  - Other distributions could easily be applied
Hazard Proximity & Sensitive Land Use Score at the Tract Level
Mapped on CI Polygons (quintile distribution)
Scoring for Health Risk & Exposure (Tract Level)

Five indicator metrics, all at tract level
- RSEI - Toxic conc. hazard scores from TRI facilities (2005)
- NATA - Respiratory hazard from mobile/stationary sources (1999)
- CARB Estimated Inhalation Cancer Risk 2001
- CARB estimated PM$_{2.5}$ concentration (2004-06)
- CARB estimated Ozone concentration (2004-06)

Scoring:
- Each indicator is ranked into quintiles (1-5) across all tracts in the region
- Quintile rank values are summed for each tract
- Tract-level sum is ranked into quintiles (1-5) across all tracts in the region
- The resulting quintile rank is the final health risk and exposure score for each tract
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)
- Birth outcomes – % preterm or SGA infants 1996-03

- 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
Social Health & Vulnerability Score at the Tract Level
Mapped on CI Polygons (quintile distribution)
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.
Final Cumulative Impact Scores

Combine three categories of impact and vulnerability to derive final 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
Important Caveats

- Method was developed with specific reference to air quality and does not screen for other concerns (such as water quality or pesticides)
  - Performs best with well-classified, high spatial resolution land use data
    - Currently experimenting with other data types to apply the Screening Method more widely
  - This is screening not assessment, so neighborhood monitoring and ground truth verification is needed.