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Distribution of Seismic Hazard, Regulation, and Vulnerability in greater Los Angeles

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Is there Environmental Justice in the distribution of seismic hazards?

Minorities, poor, and other socially vulnerable populations are often subjected disproportionately to environmental hazards such as pollutants from toxic release facilities which lead to elevated risk for cancer, asthma, lead poisoning, and other diseases. (e.g. Brulle and Pellow, 2006).

-Inequities are a result of direct and institutional discrimination. (distributional injustice is a product of procedural injustice)

-Positive community features can also be unequally distributed: Parks (e.g. Wolch et al., 2005), Representation, Food Stores, etc.

Because earthquake hazards are regulated through procedural practices, such as zoning associated with the Alquist-Priolo Earthquake Fault Zones Act (AP Act), there is the potential for institutional discrimination.

In this study we begin to test the hypothesis that fault zone regulation is spatially related to socially-vulnerable populations in greater Los Angeles using Census Block Group GIS analyses relative to the AP Act and Probabilistic Seismic Hazards Modeling.

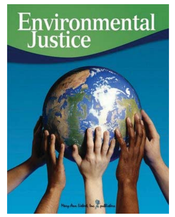

Fig. 1. The EJ movement seeks to identify injustices and work towards equity.

Probabilistic Seismic Hazard Modeling

Given all possible earthquakes, what is the probability of a particular location exceeding a particular ground motion (acceleration, measured relative to gravity)?

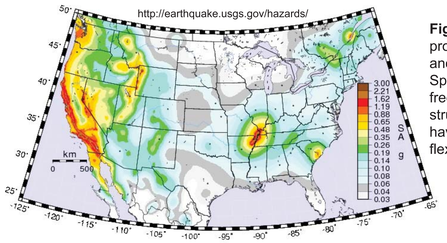

Fig. 2. USGS PSHM for 10% probability of exceedance and Spectral Acceleration 10Hz. Spectral accelerations of high frequency affect stiff low rise structures and low frequencies have a greater impact on flexible high rise structures.

1) Quantification of earthquake sources, magnitudes, and their recurrence (not all sources are defined)
- -earthquake geology
- -historical seismicity
- -tectonic province/regional seismicity

2) Determination the attenuation and amplification relationships for seismic energy (data are incomplete)
- -regional attenuation variations
- -lithologic differences
- -different attenuation relationships and transformations between ground and building shaking.

3) Make a probabilistic calculation
- -dealing with the uncertainties (e.g., parentheses above)
- -sum of all modeled sources affecting a particular location

The California Alquist-Priolo Act

Passed in 1972 following the San Fernando Earthquake.
The premise: Locations of earthquake surface ruptures are predictable and avoidable
Areas within 0.25 miles (~0.4 km) from most active faults are titled AP special study zones (now earthquake fault zones).
-Faults are mapped and homes must be 50 ft (~15 m) from surface traces, AP zoning is disclosed (Hart and Bryant, 1997).

Fig. 3. Chi Chi Earthquake surface rupture

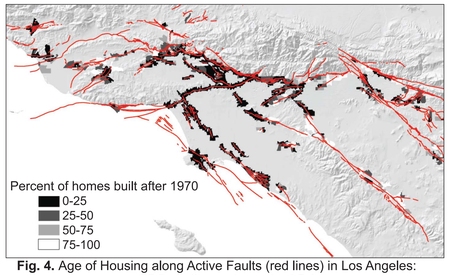

Fig. 4. Age of Housing along Active Faults (red lines) in Los Angeles: most CBGs built up prior to the AP Act

Some AP Issues:
* Disclosure was poorly done prior to home sales (Palm, 1981)
-only in fine print of sale
-real estate agents didn't understand.

* No disclosure to renters.

* Grandfathering and exceptions for non-developers.

* Treats all faults equally.

* By 1972 much of Los Angeles was already built! (Fig. 4)

Spatial Analyses - Methodology

1. **Trimmed 2000 US Census Block Group Shapefiles**:
   A) Counties of Los Angeles, Riverside, Orange, Ventura, San Bernardino.
   B) Areas classified as urban by the 2000 census. (U.S. Census Bureau, 2000).

2. **Appended Vulnerability-Relevant Census Data Using FIPS codes** (Federal Information Processing Standard) e.g., number of families below poverty, age of housing stock, race, gender, renters vs owners, or home value (e.g., Cutter et al., 2003).

3. **Attribute Table Calculations for Census Data (Percentages and Normalizations):** e.g., transformed raw numbers to percentages and in some cases normalized the census block group percentage by the entire urban area's data (e.g. Fig. 9a).

4. **Buffers to Categorize Block Groups (CBGs) Relative to Hazards**:
   A) CBGs overlapping areas with a 2% or greater probability of exceeding accelerations of 100% gravity in the next 50 years (Petersen et al., 2008).
   B) CBGs overlapping AP-Fault Zones. (California Geological Survey, 2002).
   C) CBGs near AP-Fault zone CBG, but not within the AP zone (e.g. Fig. 5).

5. **Visual Comparisons Between Social Vulnerability and Earthquake Hazards (Figs. 5-7 and 9).** e.g., mapping visualizations of fault zone locations and demographics of social vulnerability such as CBG percentage white and locations of active faults.

6. **Statistical (descriptive) Comparisons of CBGs Within Areas of Earthquake Hazard and the Greater Metropolitan Area (Table below):** e.g., Comparing average home value within CBGs that overlap with AP fault zones, those in the larger metro area, those near AP zones, and those within areas of probable zones of intense ground shaking.

Social Vulnerability is Anticorrelated with AP Earthquake Fault Zones

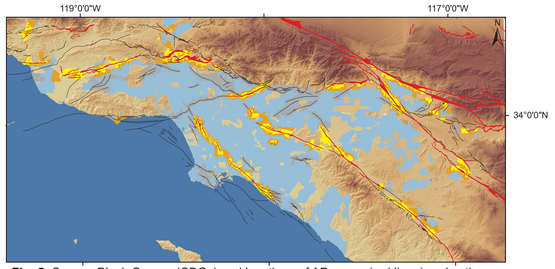

Fig. 5. Census Block Groups (CBGs) and locations of AP zones (red lines) and active faults (black lines). CBGs that cross AP zones are yellow, CBGs that border AP CBGs are orange, CBGs that are near active faults not designated as AP zones are grey, other CBGs are blue.

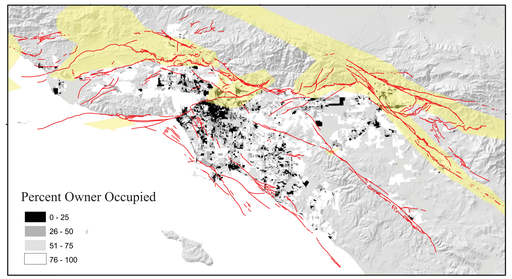

Fig. 6. Census Block Groups and percent owner occupied housing relative to the location of active faults (red) and areas with a 2% or greater probability of experiencing Peak Ground Acceleration at 100% of Gravity in the next 50 years (yellow shading).

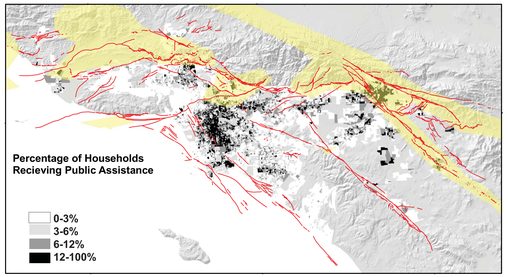

Fig. 7. Census Block Groups and percentage of households receiving public assistance relative to the location of active faults (red) and areas with a 2% or greater probability of experiencing Peak Ground Acceleration at 100% of Gravity in the next 50 years (yellow shading).

Social Vulnerability metrics at the Census Block Group scale relative to earthquake hazards in Los Angeles.

Unit of Analysis	Average	Median	CBG Count	Confidence (95%)
Percent White				
All of LA Metro	55.4%	54.0%	9433	0.472%
AP Zones[1]	57.3%	63.0%	443	2.50%
Near AP Zones[2]	55.7%	60.5%	656	2.02%
PEGM zones[3]	56.6%	55.0%	1415	1.01%
Near Faults, but not AP[4]	68.8%	75.0%	1041	1.17%
Percent of families below poverty				
All of LA Metro	12.4%	8.3%	9433	0.25%
AP Zones[1]	9.1%	6.2%	443	0.85%
Near AP Zones[2]	10.8%	6.1%	656	0.88%
PEGM zones[3]	12.7%	9.2%	1415	0.63%
Near Faults, but not AP[4]	7.5%	4.8%	1041	0.51%
Percent of Households Receiving Public Assistance				
All of LA Metro	5.9%	3.7%	9433	0.13%
AP Zones[1]	4.4%	2.6%	443	0.48%
Near AP Zones[2]	5.6%	3.0%	656	0.51%
PEGM zones[3]	6.3%	4.2%	1415	0.35%
Near Faults, but not AP[4]	3.4%	2.0%	1041	0.32%
Percent Owner Occupied				
All of LA Metro	56.3%	59.0%	9433	0.580%
AP Zones[1]	69.7%	78.0%	443	2.28%
Near AP Zones[2]	62.8%	68.0%	656	2.06%
PEGM zones[3]	58.0%	62.0%	1415	1.47%
Near Faults, but not AP[4]	62.9%	71.0%	1041	1.75%
Owner Occupied Home Values				
AP Zones[1]	$244,656	$194,900	443	$14,932
Near AP Zones[2]	$217,610	$187,150	656	$9,810
PEGM zones[3]	$218,772	$185,800	1415	$7,615
All LA not AP[4]	$222,031	$181,000	9433	$3,355
Near Faults, but not AP[5]	$317,319	$255,000	1041	$12,486

1 – AP Zones are Census Block Groups that overlap with the California Geological Survey's AP earthquake fault zones shapefiles
2 – Near AP Zones are Census Block Groups that lie adjacent to Block Groups that overlap with AP earthquake fault zones.
3 – PEGM zones are the areas determined to have a 2% probability of exceeding 100% the acceleration of Gravity during the next 50 years (Petersen, 2008).
4 – All LA not AP indicates the rest of the Los Angeles area census block groups, not including those overlapping AP Zones.
5– Near Faults, but not AP = CBG within 0.25 miles of a Quaternary active fault, not considered an AP earthquake fault zone. (See figures 5-7)

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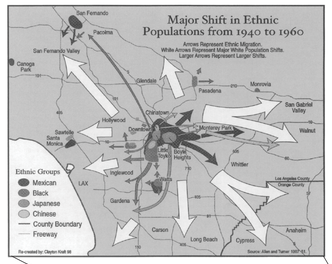
Social Vulnerability in Los Angeles



Ethnic segregation in the 1900s.

Fig. 8 (left). Pulido, 2000 showed a pattern of institutional racism resulting in segregation of minorities in the central city. This segregation continues today and has resulted in non-white, socioeconomically disadvantaged populations to be concentrated near Toxic Release Inventory and Storage and Transfer sites for regulated toxic chemicals (yellow dots in fig. 9a). The approximate location of this map is shown in fig. 9a (black box).

Today minorities and the poor live nearest to toxic waste facilities, but further from AP fault zones.

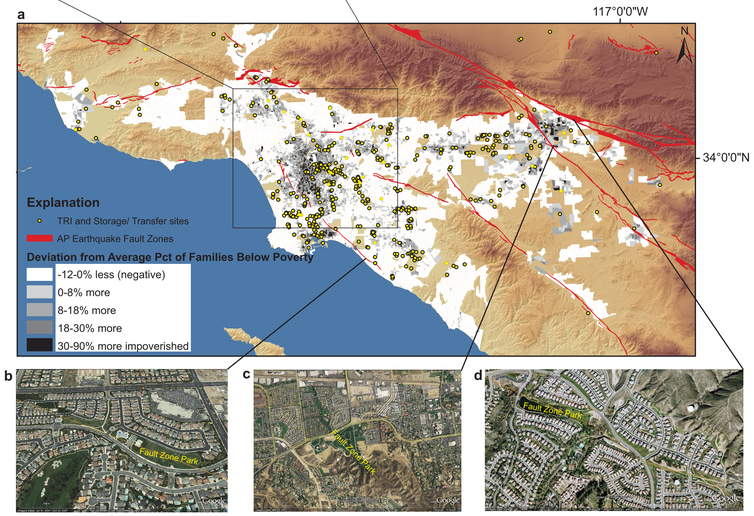


Fig. 9 (above). (a) Deviation from Los Angeles mean percentage of families below the poverty level. Negative numbers (white areas) indicate relatively better off census block groups. Darker areas indicate more economically disadvantaged areas. Locations along AP earthquake fault zones where fault zone parks have been created.

Results and Emerging *Questions*

1) CBGs with high probabilities of experiencing 100% G are not relatively socially vulnerable.
Would this be different if we were to apply spectral accelerations?

2) AP zone CBGs are anticorrelated with social vulnerability.
Are parks and open space the reason for this?
Los Angeles is a relatively parks poor city (e.g. Wolch et al., 2005).

3) CBGs located near active faults not designated as an AP zone are significantly wealthier, whiter, and economically privileged. Why?
Wealthy living along blind thrust faults?
Political pressure to leave these areas out of the zoning regulation?
Significant impact on homeprices where there is an AP zone?