The Color Line Reflected in Green:

The racial/ethnic distribution of heat risk-related land cover in relation to residential segregation

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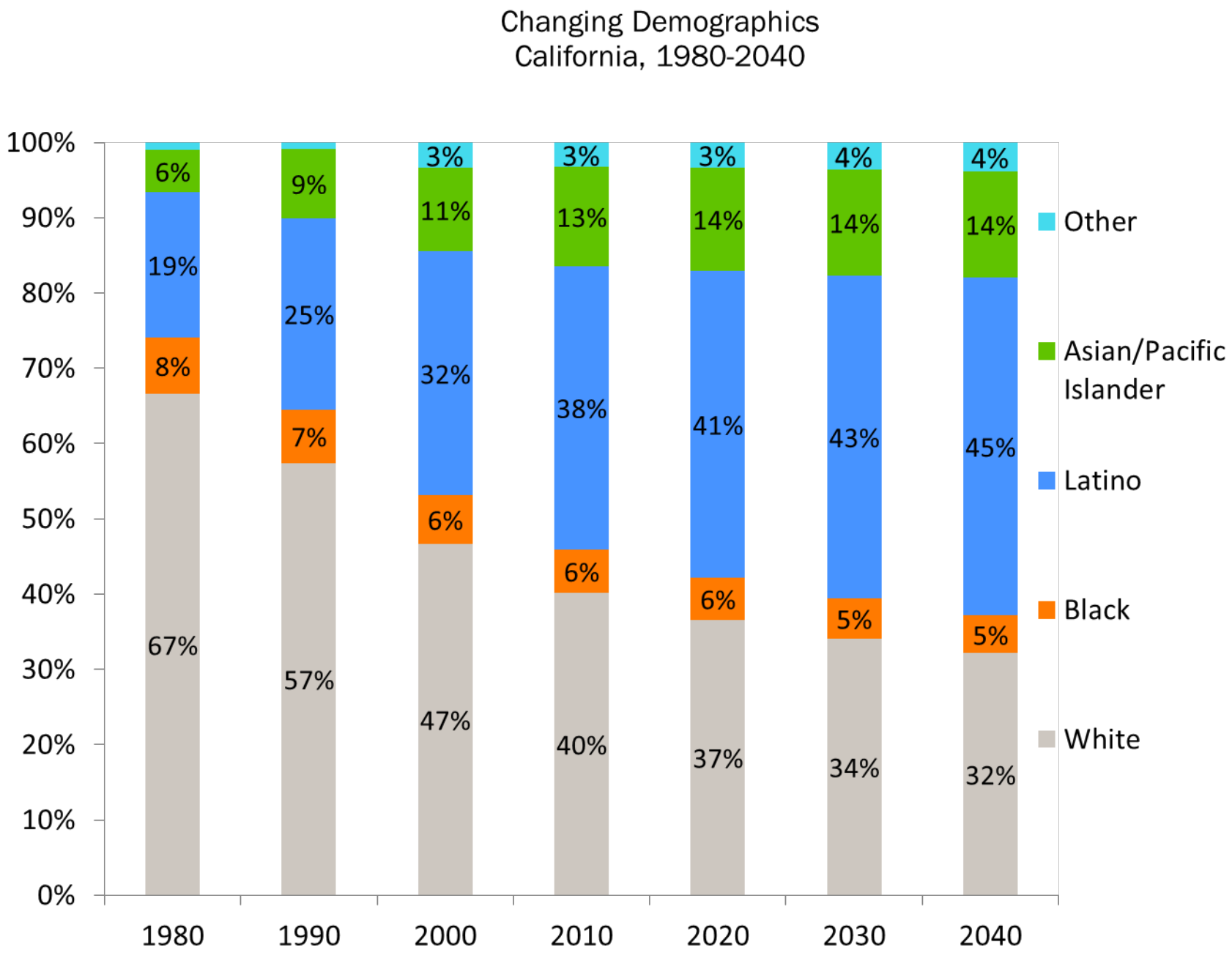
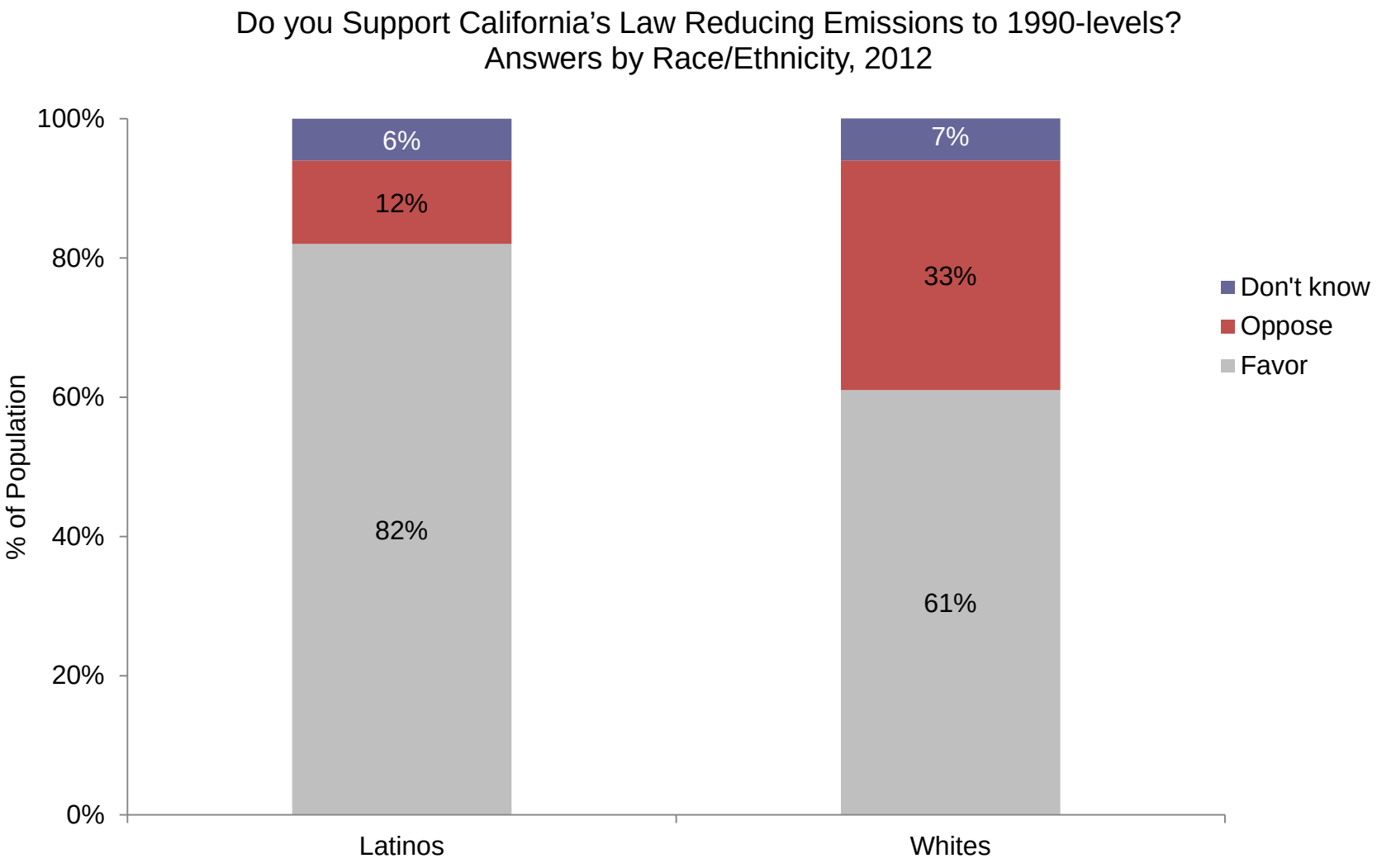

Changing Demographics
California, 1980-2040
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1980
1990
2000
2010
2020
2030
2040
6%
19%
8%
67%
9%
25%
7%
57%
3%
11%
32%
6%
47%
3%
13%
38%
6%
40%
3%
14%
41%
6%
37%
4%
14%
43%
5%
34%
4%
14%
45%
5%
32%
Other
Asian/Pacific Islander
Latino
Black
White

OPINION ON ADDRESSING CLIMATE CHANGE



Source: Public Policy Institute of California, July 2012.

The Color Line Reflected in Green

In the context of a rapidly changing climate, we expect urban heat waves to become more **frequent**, more **intense**, and **longer-lasting**.

Meehl & Tebaldi. *Science* (2004) 305:994-7.

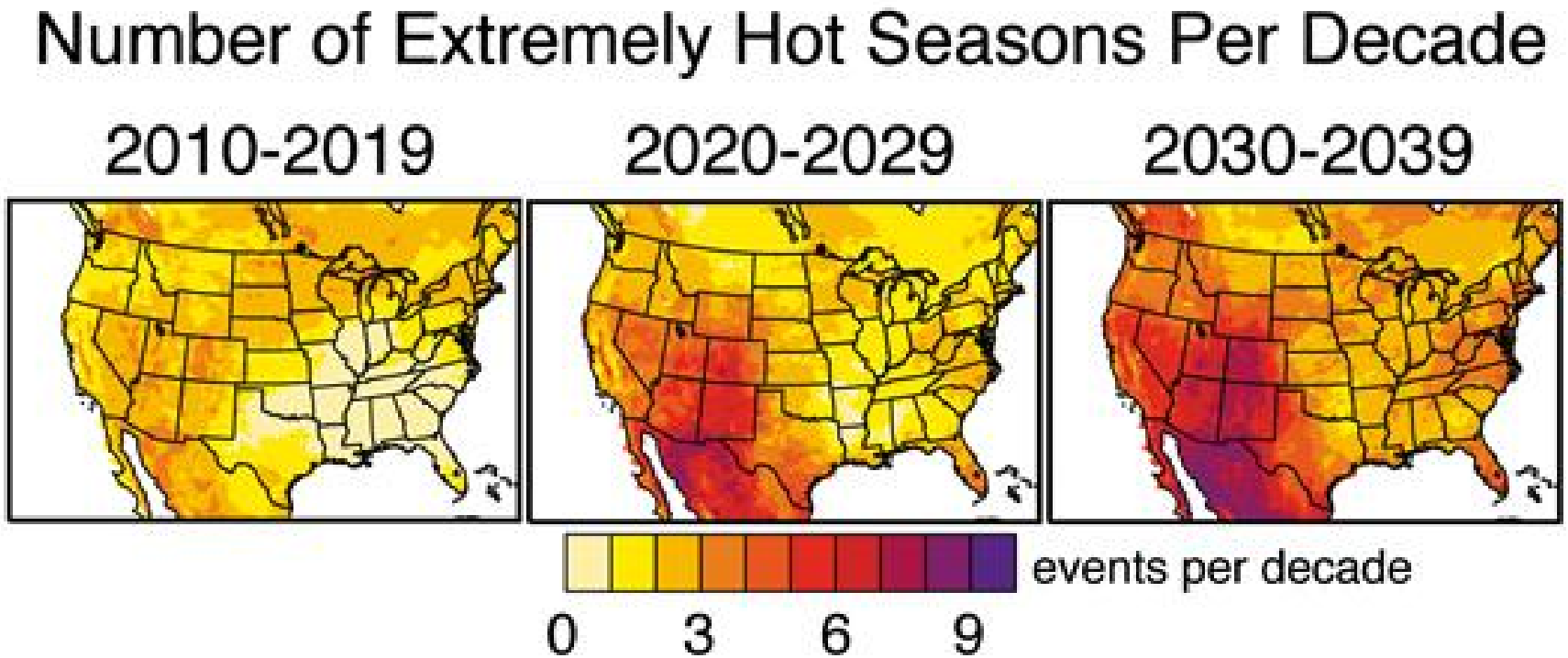


Image credit: Noah Diffenbaugh, Stanford University.

Disparate Impact of Heat-Related Mortality by Race/Ethnicity–California, 1999-2003

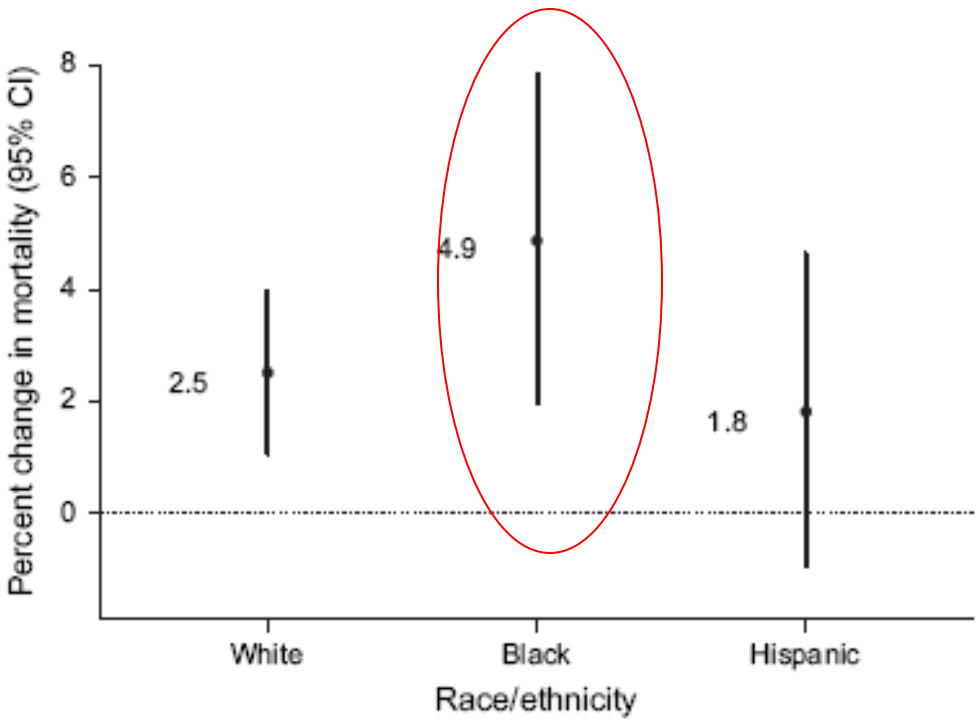


FIGURE 3. Estimated percent change associated with a 10°F (4.7°C) increase in mean daily apparent temperature and nonaccidental mortality by race/ethnic group in nine counties, California, May through September, 1999–2003. CI, confidence interval.

Air Conditioning Prevalence, Mortality and Race – 4 U.S. Cities

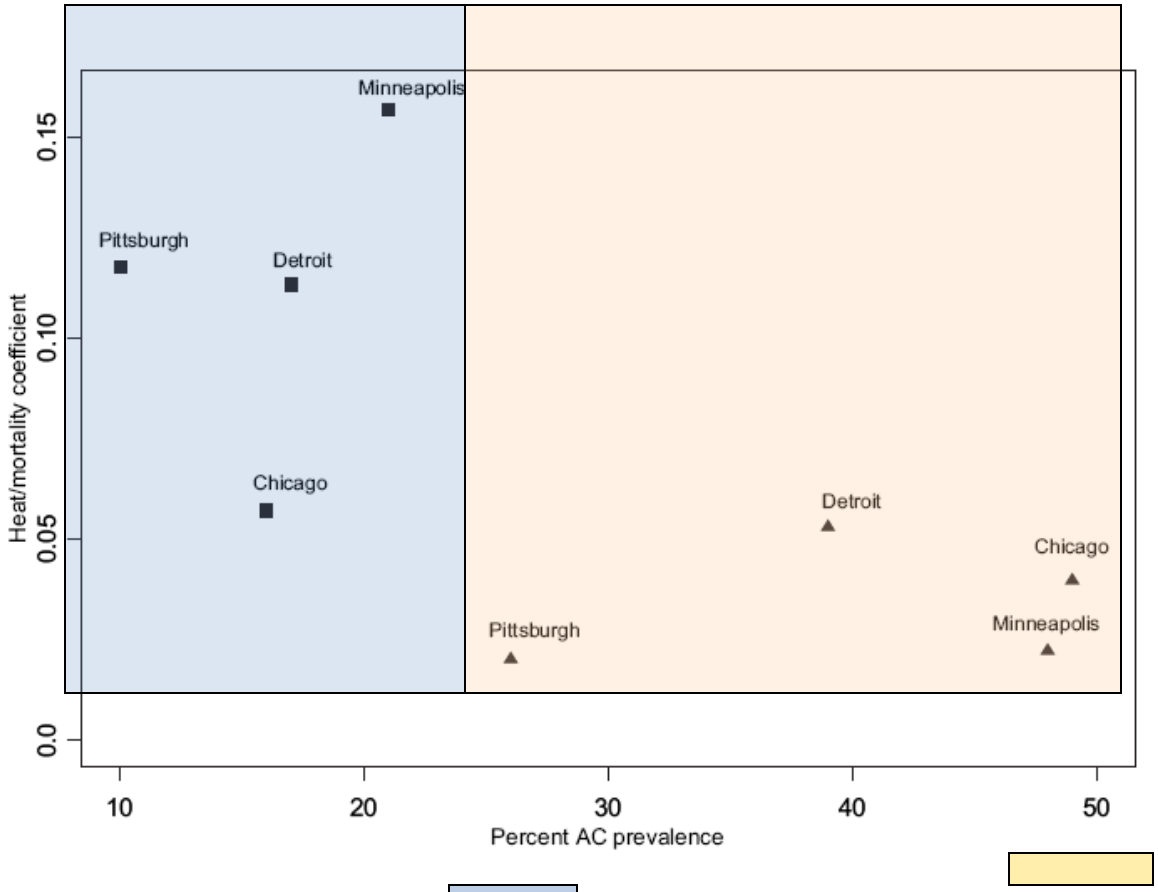
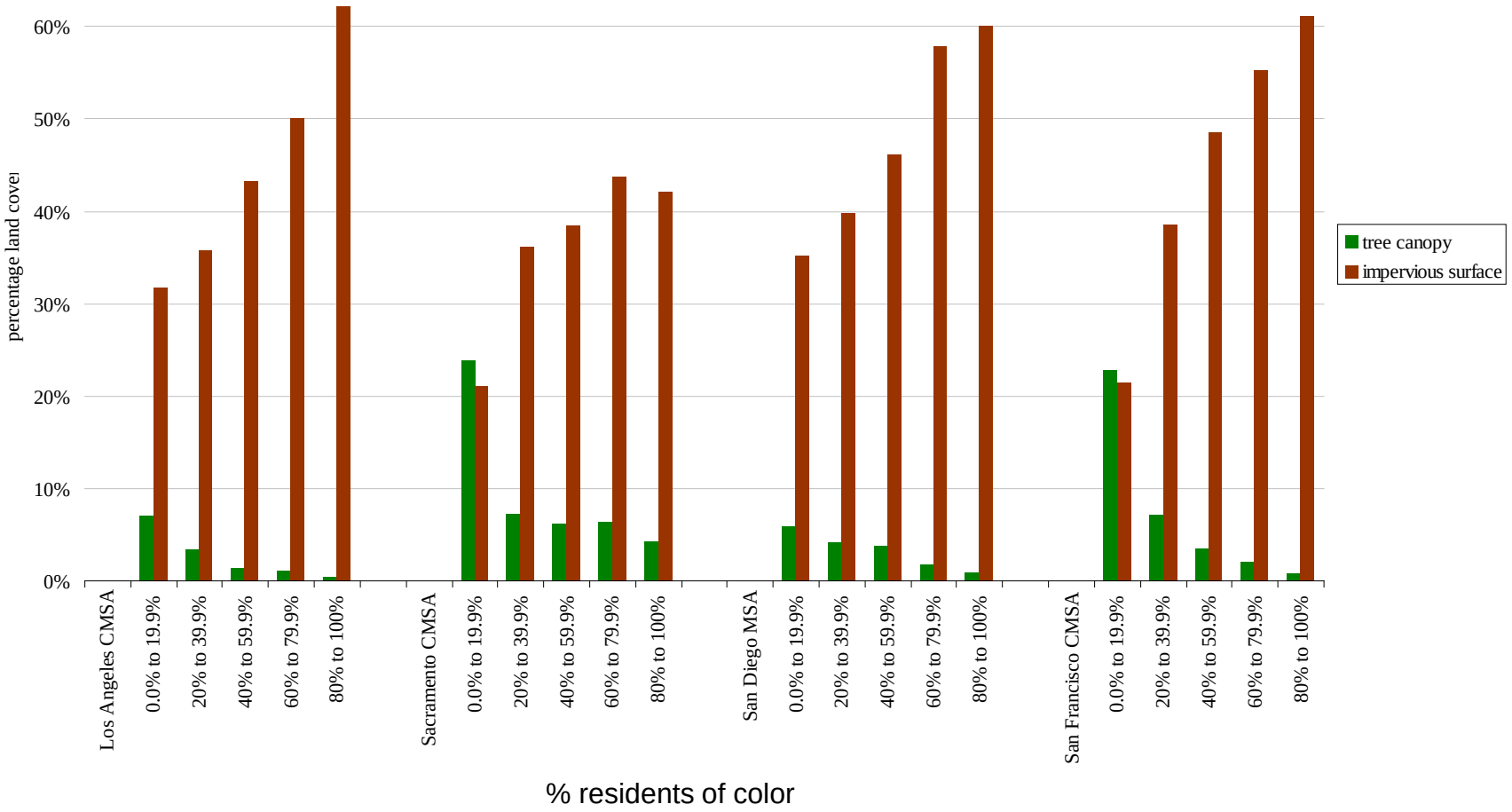


FIGURE. Coefficients for the relative risk of mortality on days at 29 °C apparent temperature compared with days at 15 °C, by prevalence of central air conditioning (AC), race, and city. ▲, Whites (and Whites/Others, for AC prevalence); ■, Blacks. Coefficients are from Poisson regression models with covariates including barometric pressure, PM_{10}, time trend, day of week, and apparent temperature averaged over lags 1, 2, and 3 (heat effect is expressed for apparent temperature lag 0). Data cover the period 1986–1993.

O'Neill et al. 2005

Heat Island Metrics and Racial/Ethnic Composition

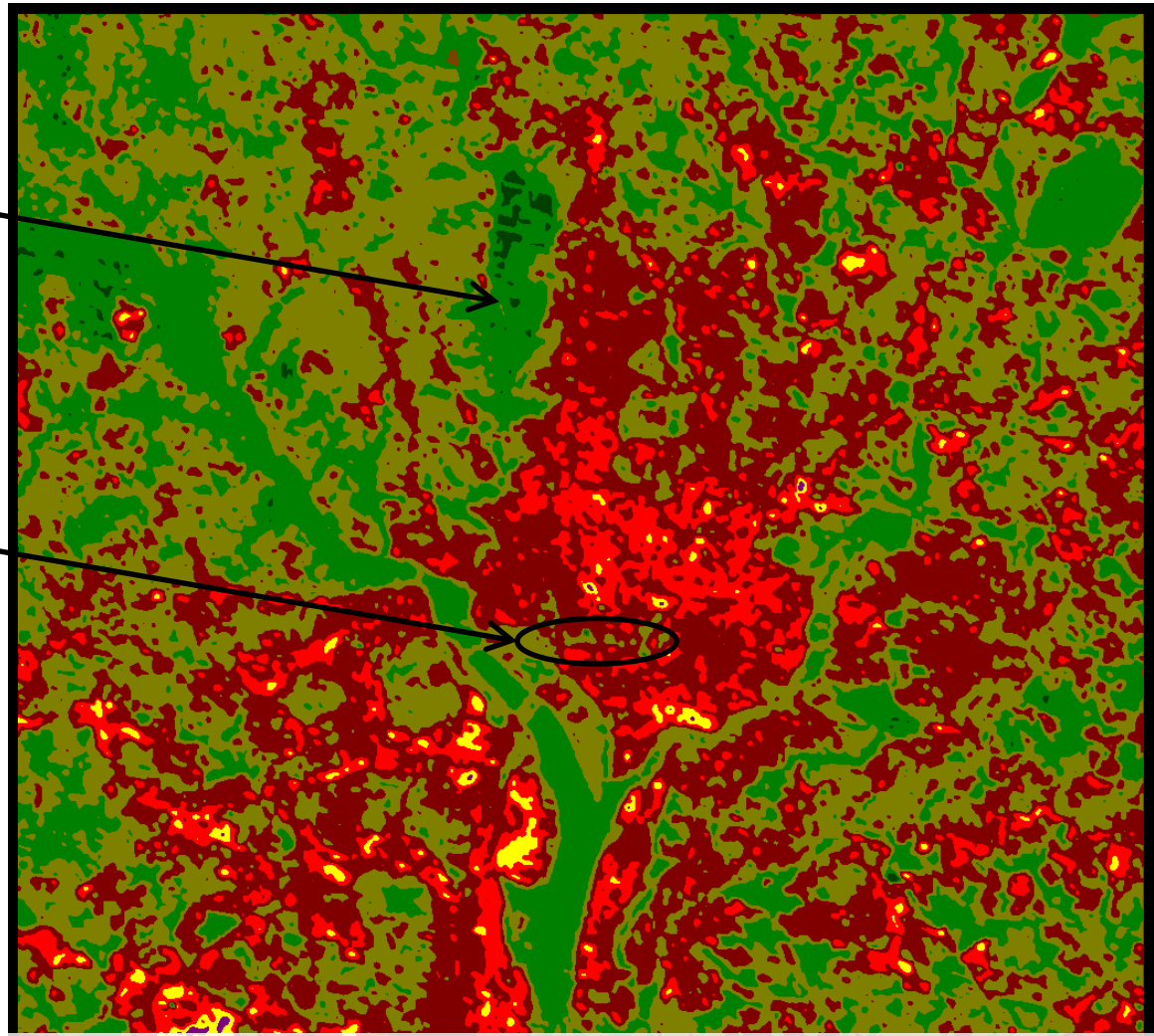
land cover characteristics
across comparable neighborhood racial/ethnic minority groups



Shonkoff, Morello-Frosch et al. Climatic Change 2012.

The Color Line Reflected in Green

We examined possible pathways to explain racial disparities in urban heat risk, such as poverty, home ownership, and segregation.

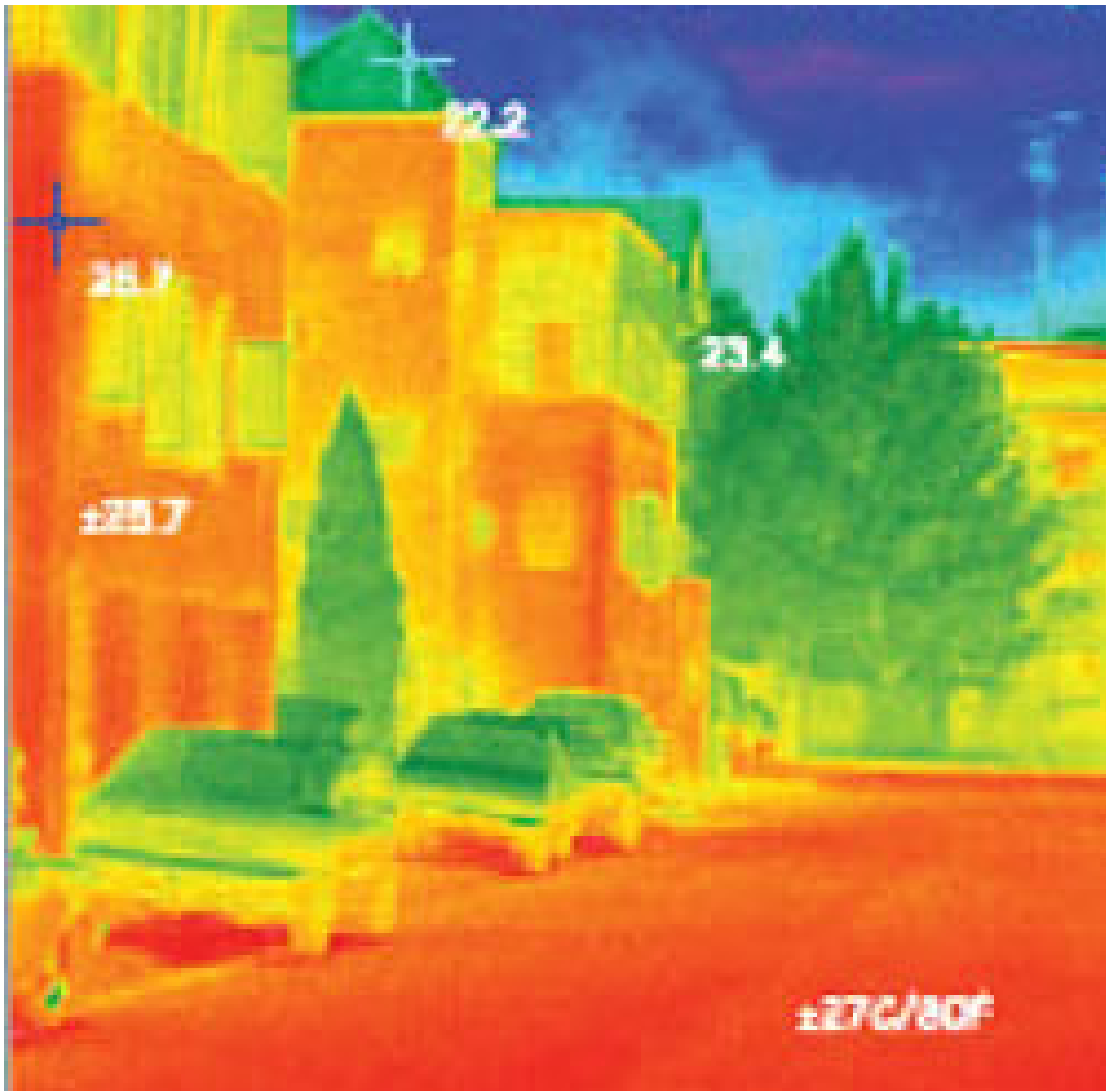


False color image of land surface temperatures, Washington, D.C., Aug 8, 1990. NASA, colorized by Paul R. Baumann, SUNY Oneonta.

Defining “Heat Risk”

We defined an area (block group) to have “heat risk-related land cover” if satellite imagery detected **at least 50% impervious surface**, and ***no* tree canopy**.

National Land Cover Dataset, 2001 vintage



Study population

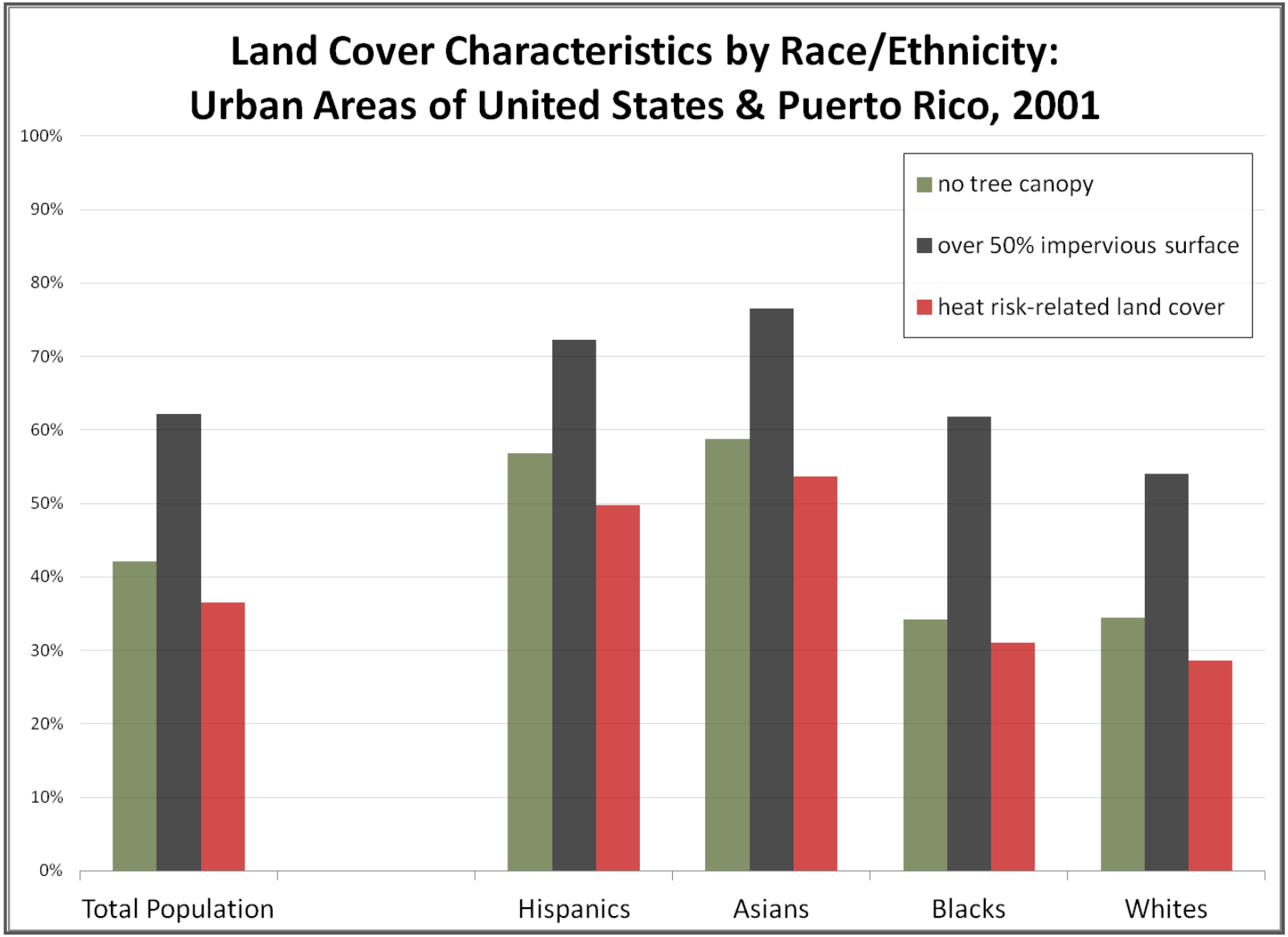
Based on 2000 Census.

Urban: Residents of block groups in the US & Puerto Rico with a population density of 2,000/km2 in the 2000 Census.

- N=81,517,417 People;
- N=63,436 block groups;
- N=304 MSAs

One of four racial/ethnic groups:
Hispanics of any race
Non-Hispanic Asians, Blacks, Whites.

Unadjusted Racial/ethnic disparities



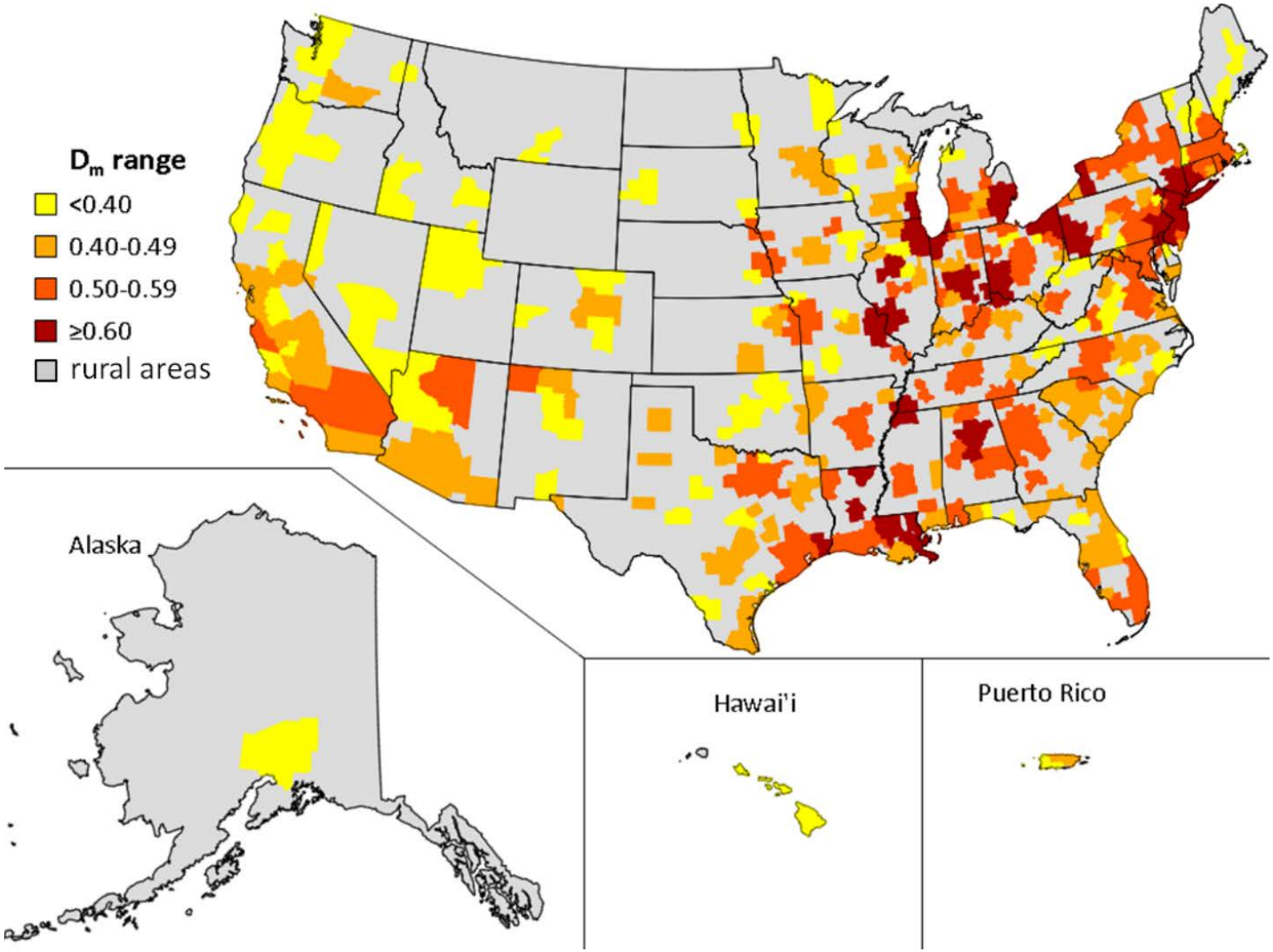
Potential explanations

Racial/ethnic minorities are:

- more likely to live in areas where trees don’t grow as well.
- more likely to be renters than home-owners.
- more likely to be impoverished.
- more likely to be concentrated into densely populated neighborhoods with less advantageous built environment characteristics.
- disadvantaged by historical (and on-going) forces reflected in segregated residential patterns.

Racial Segregation in US Cities:

Multigroup Dissimilarity by Metropolitan Area in the United States



COMMISSION FOR ENVIRONMENTAL COOPERATION

COMISION PARA LA COOPERACION AMBIENTAL

COMMISSION DE COOPÉRATION ENVIRONNEMENTALE

CEC · CCA

Canada

United States of America

Estados Unidos Mexicanos

Three co
Tres países
Trois pays

ECOLOGICAL REGI
REGIONES ECOLÓGIC
RÉGIONS ÉCOLOGIQU

Level I

North American Atlas
Atlas de América del Norte
Atlas nord-américain

Produced in partnership with:

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Elaborado

Ecological regions are areas of general similarity in ecosyst and in the type, quality, and quantity of environme resources. They serve as a spatial framework for the resea assessment, management, and monitoring of ecosystems ecosystem components. They are effective for national regional state of the environment reports, environme resource inventories and assessments, setting regional reso management goals, determining carrying capacity, as wel developing biological criteria and water quality standards. development of a clear understanding of regional and l continental ecosystems is critical for evaluating ecological sustainability, and health.

The maps shown here represent a second attempt to holistic classify and map ecological regions across the North Ameri continent (Commission for Environmental Coopera Working Group, 1997). The mapping from 1997 and 2006 built upon earlier efforts that had begun individually in all t countries (e.g., Wiken 1986, Omernik 1987). These approac recognized the need to consider a full range of physical biotic characteristics to explain ecosystem regions (Ome 2004). Equally, they recognized that the relative importanc each characteristic varies from one ecological region to ano regardless of the hierarchical level. In descrit ecoregionalization in Canada, Wiken (1986) stated:

> *Ecological land classification is a process of delineating and classifying ecologically distinctive areas of the Earth's surface. Each area can be viewed as a discrete system which has resulted from the mesh and interplay of the geologic, landform, soil, vegetative, climatic, wildlife, water and human factors which may be present. The dominance of any one or a number of these factors varies with the given ecological land unit. This holistic approach to land classification can be applied incrementally on a scale related basis from very site-specific ecosystems to very broad ecosystems.*

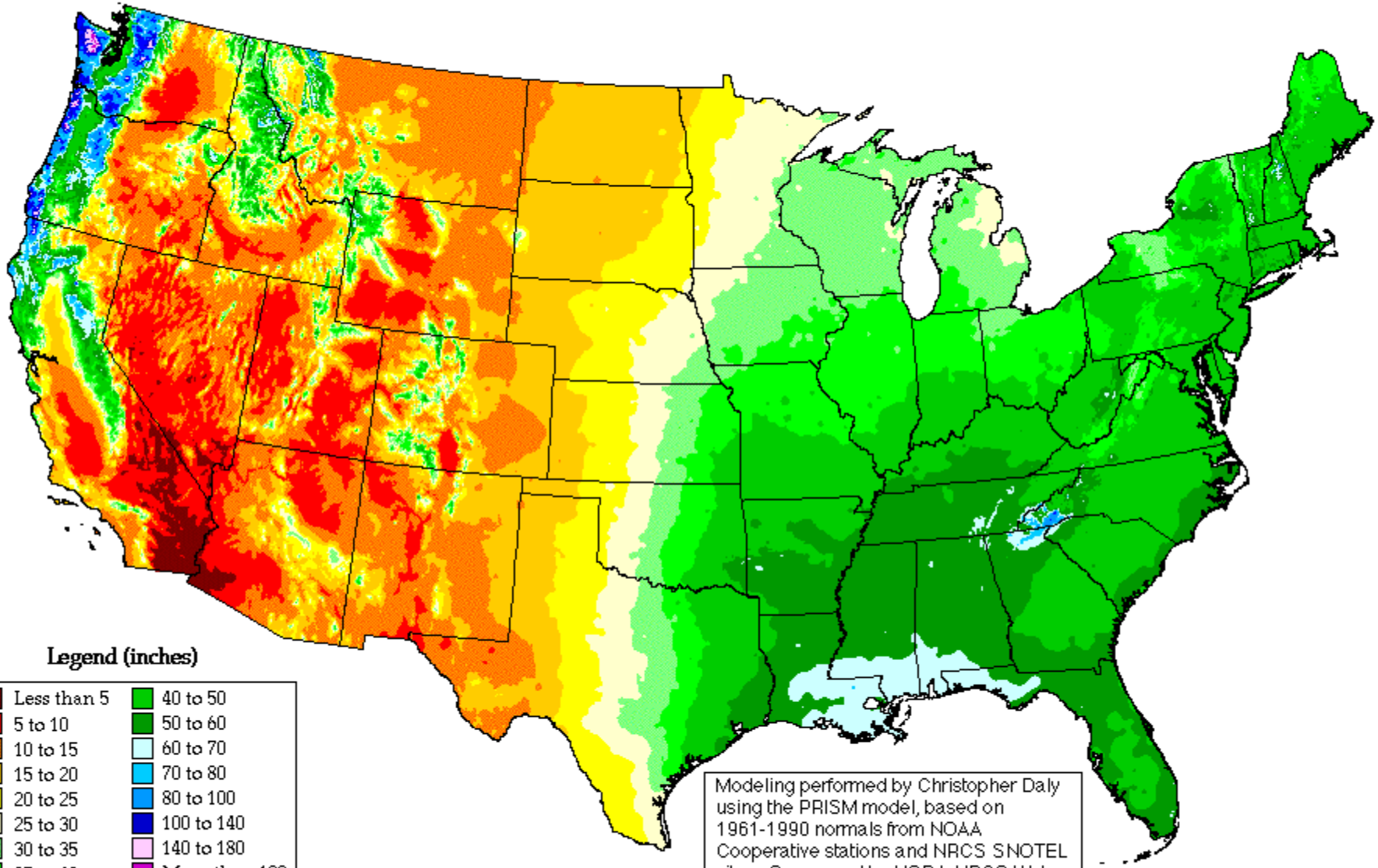
Determining ecological regions at a continental level i challenging task. It is difficult, in part, because North Ame is ecologically diverse and because a nation's territo boundaries can be a hindrance to seeing and appreciating perspectives across the land-mass of three count Developing and refining a framework of North Ameri ecological regions has been the product of research consultation between federal, state, provincial and territo agencies. These agencies were often government departm but the initiative also involved nongovernmental gro universities and institutes. The Commission for Environme Cooperation (CEC) was instrumental in bringing these gro together. The CEC was established in 1994 by Canada, Mex and the United States to address environmental conc common to the three countries. The CEC derives its for mandate from the North American Agreement Environmental Cooperation (NAAEC), the environmental accord to the North American Free Trade Agreement (NAFT

These maps represent the working group's best consensu the distribution and characteristics of major ecosystems o three levels throughout the three North American countries. methodology incorporated these points in mapping ecolog regions:

- Ecological classification incorporates all major component ecosystems: air, water, land, and biota, including humans.
- It is holistic ("the whole is greater than the sum of its parts"
- The number and relative importance of factors that are hel in the delineation process vary from one area to ano regardless of the level of generalization.

Annual Average Precipitation

United States of America



Legend (inches)

Less than 5	40 to 50
5 to 10	50 to 60
10 to 15	60 to 70
15 to 20	70 to 80
20 to 25	80 to 100
25 to 30	100 to 140
30 to 35	140 to 180
35 to 40	More than 180

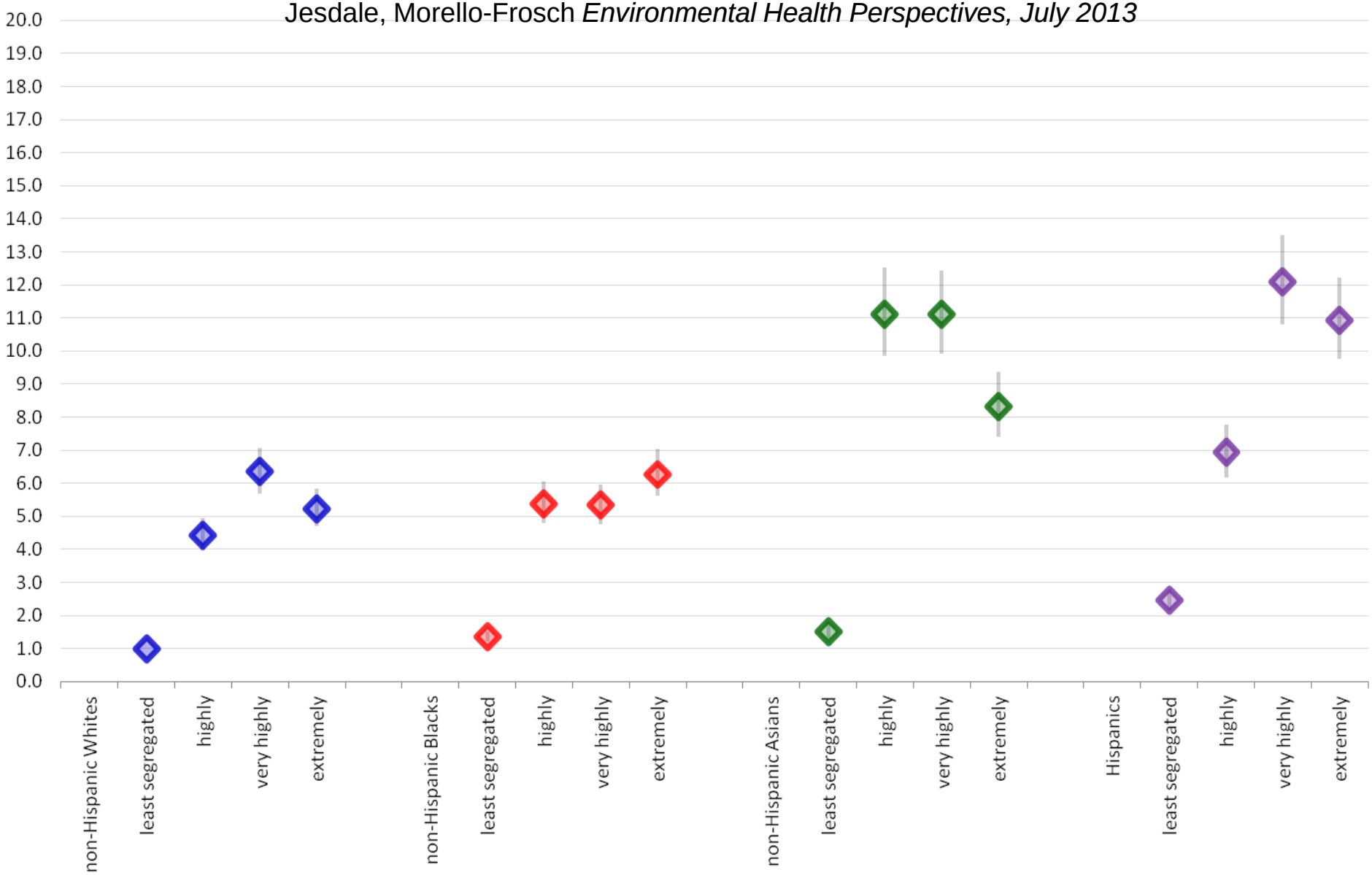
Period: 1961-1990

Modeling performed by Christopher Daly using the PRISM model, based on 1961-1990 normals from NOAA Cooperative stations and NRCS SNOTEL sites. Sponsored by USDA-NRCS Water and Climate Center, Portland, Oregon.

Oregon Climate Service
George Taylor, State Climatologist
(541) 737-5705

Odds Ratio for Living in a Heat Risk-Related Land Cover Area Relative to Whites in the Least Segregated Metropolitan Areas Un-adjusted

Jesdale, Morello-Frosch *Environmental Health Perspectives, July 2013*

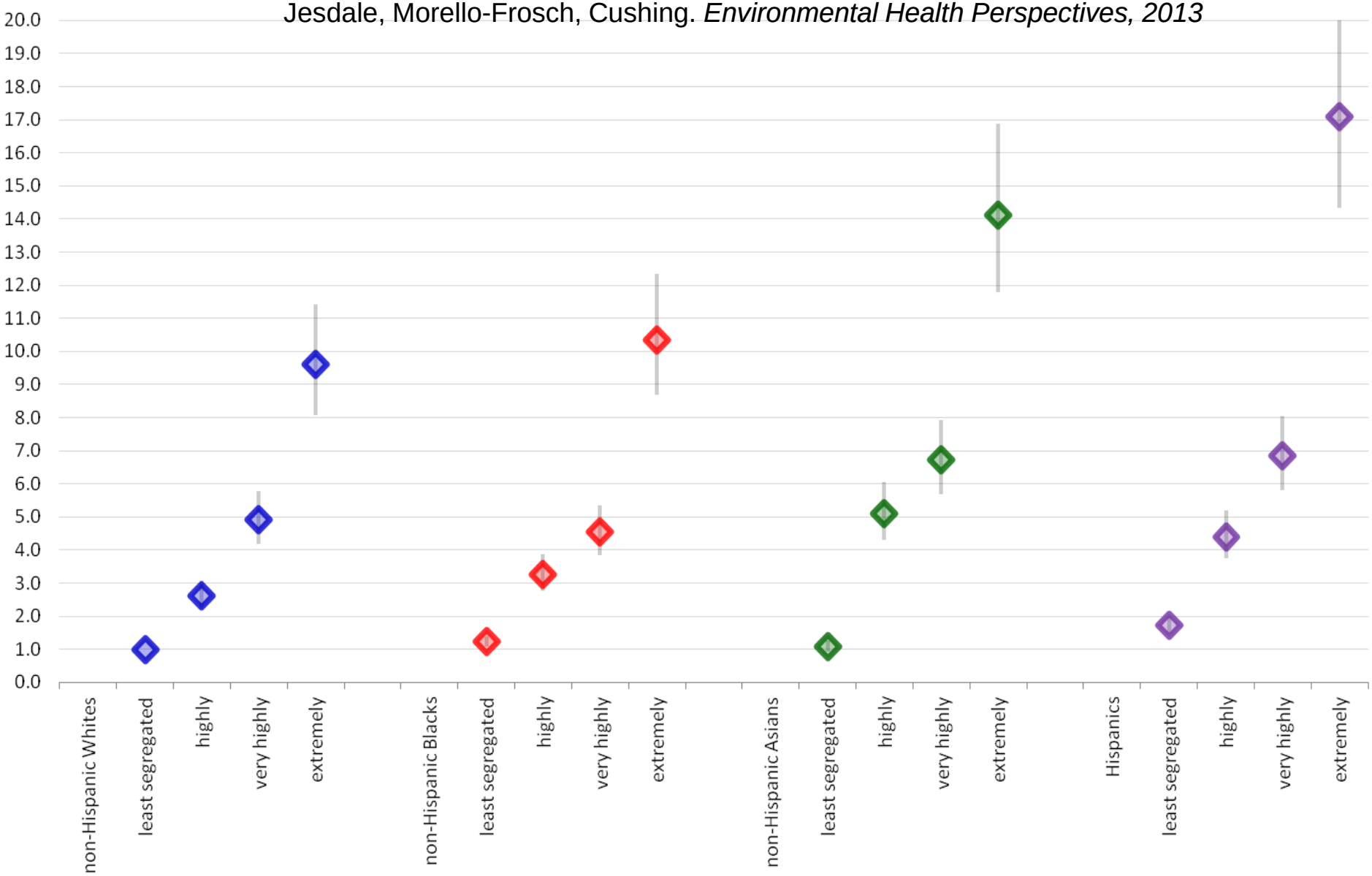


Odds Ratio for Living in a Heat Risk-Related Land Cover Area Relative to Whites in the Least Segregated Metropolitan Areas Adjusted for Ecoregion and Rainfall Patterns

Jesdale, Morello-Frosch, Cushing. *Environmental Health Perspectives, 2013*

Odds Ratio for Living in a Heat Risk-Related Land Cover Area Relative to Whites in the Least Segregated Metropolitan Areas Adjusted for Ecoregion, Rainfall, Poverty & Home Ownership

Jesdale, Morello-Frosch, Cushing. *Environmental Health Perspectives, 2013*



Conclusions

Black, and especially Hispanic and Asian populations are more likely than Whites to live in heat-prone neighborhoods in US urban areas, after controlling for ecologic factors that affect tree growth.

Residential segregation increases the likelihood that all racial/ethnic groups will live in heat-prone neighborhoods.

Poverty and home ownership do not explain these disparities.

Segregation may operate through concentrating minority populations into neighborhoods with undesirable built environment characteristics.

Future work for climate vulnerability indicators

Advance science of climate vulnerability assessment and screening to address equity concerns

Integrate other indicators of non-environmental stressors and sources of community resilience

- Social inequality– e.g. Gini coefficient, segregation,
- Food security, built environment, health care access

Apply indicator screening approaches to other climate change / sustainability decision-making scenarios.

Implications

Climate change adaptation efforts should explicitly incorporate an **environmental justice** perspective to better protect vulnerable urban populations.

Land cover heat risk is amenable to change through

1) Urban forestry

2) Built environment interventions

3) Land use planning

Example: urban forestry efforts should incorporate both a current tree canopy assessment *and* populations at risk for heat-related adverse health outcomes.

Cal-Enviro Screen
http://oehha.ca.gov/ej

A interactive map from OEHHA.

CalEnviroScreen 2.0

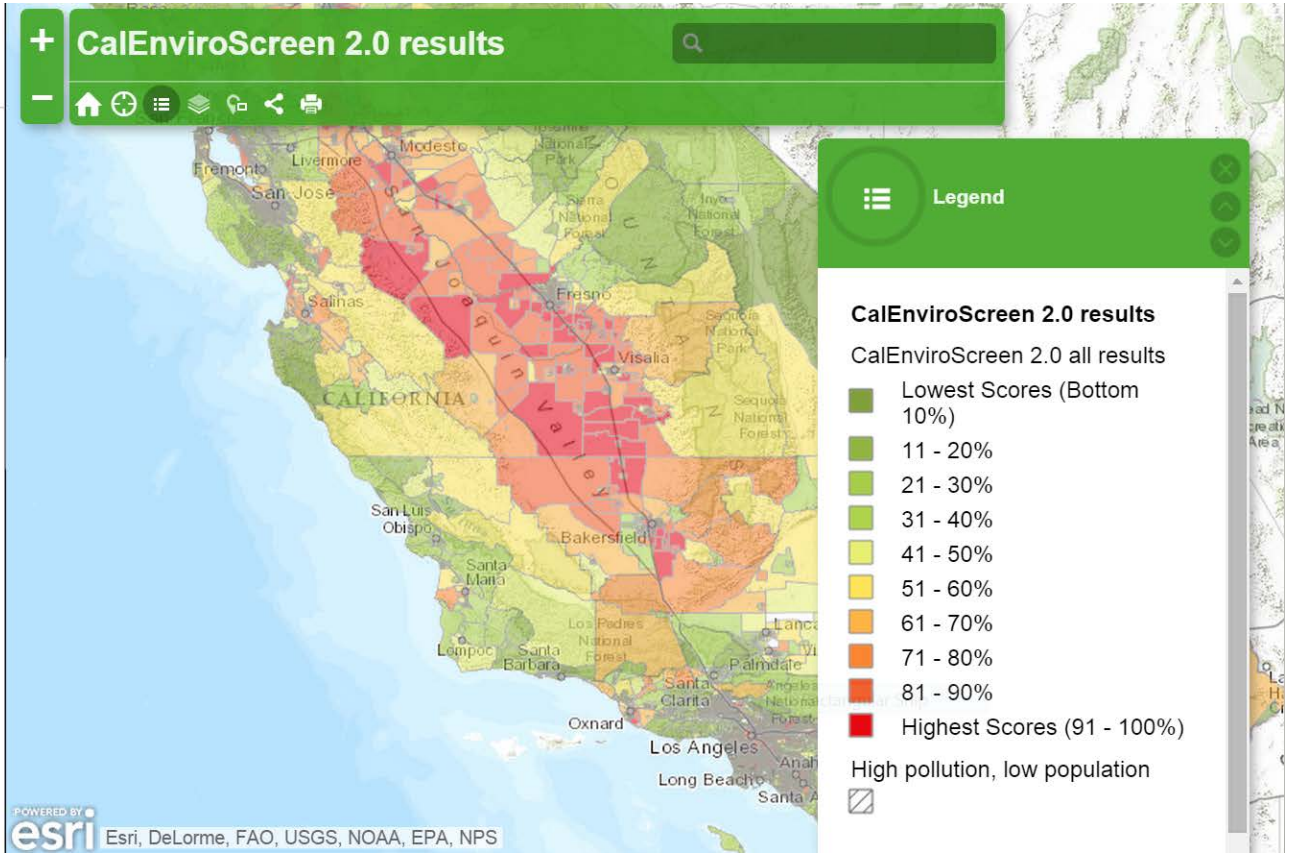
CalEnviroScreen 2.0 scores

This map shows the CalEnviroScreen 2.0 score for each census tract in California. The scores are calculated by combining the scores for 19 individual indicators that make up CalEnviroScreen. These indicators relate to pollution exposures, environmental conditions, and population characteristics.

The indicators and methodology for combining the scores are described in detail in the CalEnviroScreen report. Results are also available as an Excel spreadsheet, Google Earth file, and ArcGIS geodatabase.

To explore the map, zoom to or type a location into the search bar. Clicking on a census tract shows a popup window with the individual results for each of the 19 indicators that make up its CalEnviroScreen score.

Map tools available here include finding your current location, viewing the legend, changing base maps, viewing a regional overview map,



Thank you

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