California Building Resilience Against Climate Effects (CalBRACE) Project

Short Title: Impervious Surfaces
Full Title: Percent of the land area covered by impervious surfaces

CalBRACE Domain: Adaptive Capacity

Why is this important to health?

Impervious surfaces are areas covered by material that impedes the infiltration of water into the soil. Examples of impervious surfaces are buildings, pavements, concrete, and severely compacted soils. Impervious surfaces retain heat and limit absorption of water into the ground, which can lead to the urban heat island effect, a phenomenon in which urban areas are warmer than the surrounding non-urban areas. Measures of impervious surfaces are important for assessing impacts from infrastructure development and built environment on urban temperatures, precipitation runoff, and water quality. Communities of color are disproportionately represented in densely populated areas with more impervious surfaces, which increases their risk of exposure to heat stress.[1]

Summary of Evidence for Climate and Health
Increased heat exposure due to increasing temperatures over time and heat waves can lead to adverse health effects. Studies in cities, including Montreal, Barcelona, Hong Kong, and Taiwan, and in the United States found associations between heat-related health effects and impervious surfaces.[2] A New York City study found that extensive urban development has the potential to increase afternoon temperatures.[3] Another study in New York City found a significant positive association between impervious land cover and heat-related deaths among elderly persons.[4]

Key References:

1. Jesdale BM, Morello-Frosch R, Cushing L. The Racial/Ethnic Distrbution of Heat Risk-Related Land Cover in Relation to Residential Segregation. *Environmental Health Perspectives.* 2013; 121(7): 811-817.
2. Gronlund CJ. Racial and Socioeconomic Disparities in Heat-Related Health Effects and Their Mechanisms: A Review. *Current Epidemiology Reports.* 2014; 1: 165-173.
3. Civerolo K, Hogrefe C, Lynn B, et al. Estimating the effects of increased urbanization on surface meteorology and ozone concentrations in the New York City metropolitan region. *Atmospheric Environment.* 2007; 41: 1803-1818.
4. Rosenthal JK, Kinney PL, Metzger KB. Intra-urban vulnerability to heat-related mortality in New York City, 1997-2006. *Health & Place.* 2014; 30: 45-60.

What is the Indicator?

Detailed Definition

- Indicator (percent)=% Area with impervious surface × (population or area weight)
- Stratification: 8 race/ethnicity strata (African American, American Indian/Native Alaskan, Asian, Latino, Multiple, Native Hawaiian and Other Pacific Islander, White, total) and 2 weight strata (area-weighted and population-weighted)

- Interpretation: Climate resilient communities will have lower values of impervious surfaces

Data Source and Methodology

- Impervious surfaces data from Multi-Resolution Land Characteristics Consortium, National Land Cover Database (NLCD) 2011 (http://www.mrlc.gov/nlcd11_data.php).
  - Years available: 2011
  - Geographies available: United States
- Population of 2010 U.S. Census blocks, U.S. Census Bureau Redistricting File for California (http://www2.census.gov/census_2010/01-Redistricting_File--PL_94-171/California/).
  - Years available: 2010
  - Geographies available: Census block, census tract, city, county, county division, region (derived), state

Percent developed impervious surfaces data was obtained for 30 x 30 meter grids for the State of California from the U.S. Forest Service. Land cover classifications for imperviousness measures were reclassified to a dichotomous variable to represent presence or absence of impervious surfaces. The grids, represented as raster layers for geospatial software, were imported into ArcMap and the zonal statistics tool was used to calculate average imperviousness by Census block, excluding water areas. Population weighted averages (by race/ethnicity) and area weighted averages were obtained for Census tracts, places, counties, county divisions, and regions. The confidence interval, deciles, and relative risk were calculated. Regions in the Healthy Communities Indicators Project were based on counties of metropolitan transportation organizations as reported in the *2010 California Regional Progress Report* and regions in the BRACE project are based on county aggregations in the *Adaptation Planning Guide Understanding Regional Characteristics*.

Limitations

Standard error estimates for impervious surfaces data are not available. The NLCD can slightly underestimate (1.4% on average) impervious surfaces at the local level. A small percentage of census blocks have areas smaller than raster grid areas which decreases the accuracy of the tree coverage area estimates. Water features were excluded from the analysis due to the assumption that water features should not have impervious surfaces or populations. Reclassification of NLCD land cover data from ordinal categorical to dichotomous variable may overestimate the effect of imperviousness since any amount of impervious surfaces 1-100% was reclassified to indicate presence of impervious surfaces in the 30 x 30 meter raster grid.

Acknowledgement and Disclaimer

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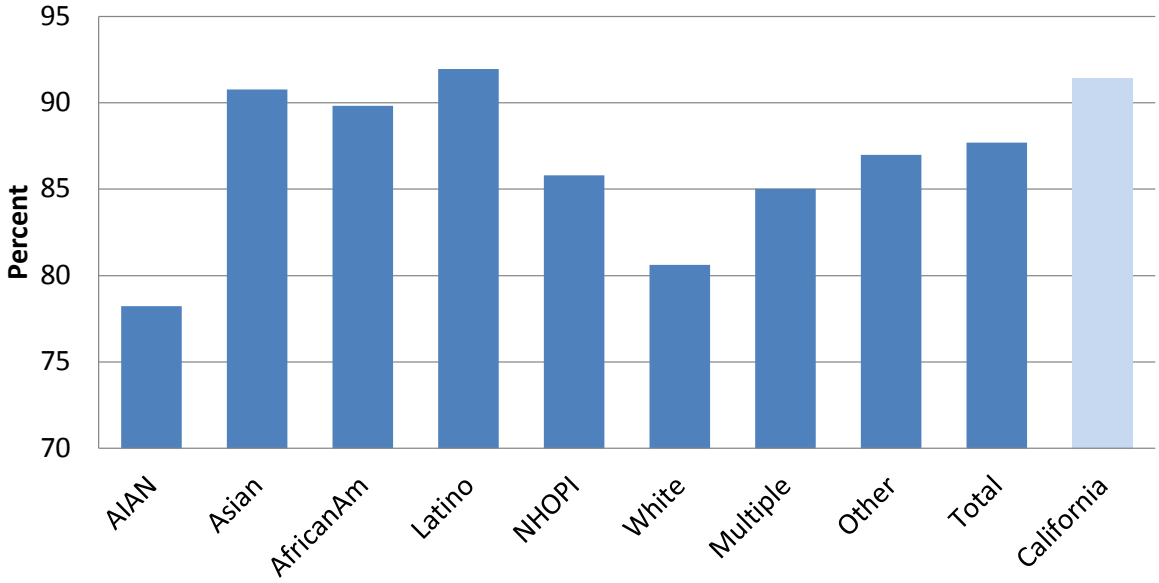
Examples of Maps, Figures, and Tables:

Figure 1. Population-Weighted Percent Impervious Surfaces by Race/Ethnicity, San Bernardino , CA, 2011



Race/ethnicity abbreviations are AIAN=American Indian/Alaska Native, AfricanAm=African American, NHOPI=Native Hawaiian/Other Pacific Islander.

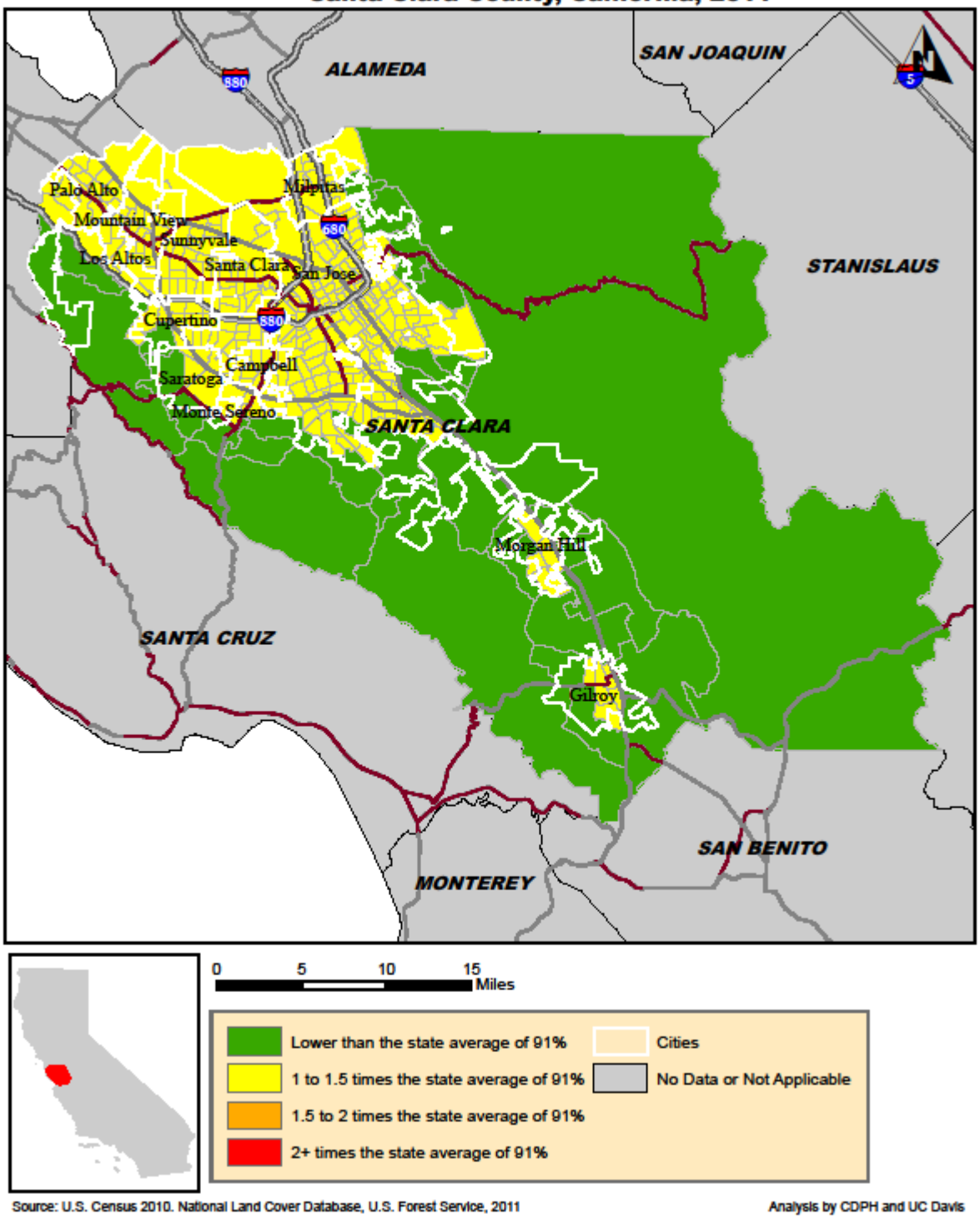
Source: National Land Cover Database, U.S. Forest Service, 2011

Table 1. Population-weighted Percent Impervious Surfaces by Cities/Towns (Population > 3,000), Santa Cruz County, California, 2011

Name	Percent Impervious Surfaces (%)	Population
Amesti CDP	69.6%	3,478
Aptos CDP	70.5%	6,220
Ben Lomond CDP	58.9%	6,234
Bonny Doon CDP	18.3%	2,678
Boulder Creek CDP	41.4%	4,923
Capitola city	98.5%	9,918
Day Valley CDP	50.8%	3,409
Felton CDP	56.0%	4,057
Freedom CDP	89.8%	3,070
Interlaken CDP	71.6%	7,321
Live Oak CDP	96.4%	17,158
Pleasure Point CDP	96.7%	5,846
Rio del Mar CDP	91.5%	9,216
Santa Cruz city	93.2%	59,946
Scotts Valley city	82.8%	11,580
Seacliff CDP	98.7%	3,267
Soquel CDP	85.6%	9,644
Twin Lakes CDP	96.2%	4,917
Watsonville city	98.3%	51,199
Santa Cruz County	**80.8%**	**262,382**
California	**91.4%**	**37,253,956**

Source: U.S. Census 2010. National Land Cover Database, U.S. Forest Service, 2011

Map 1: Population-Weighted Percent Impervious Surfaces by Census Tracts
Santa Clara County, California, 2011



Source: U.S. Census 2010. National Land Cover Database, U.S. Forest Service, 2011

Analysis by CDPH and UC Davis