Rx for Hot Cities:

Climate Resilience Through More Trees and Solar Reflectance

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Disparities in tree cover and heat vulnerability

Watts: 10% Tree Cover

Bel-Air: 35% Tree Cover

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TreePeople

Climate Resolve

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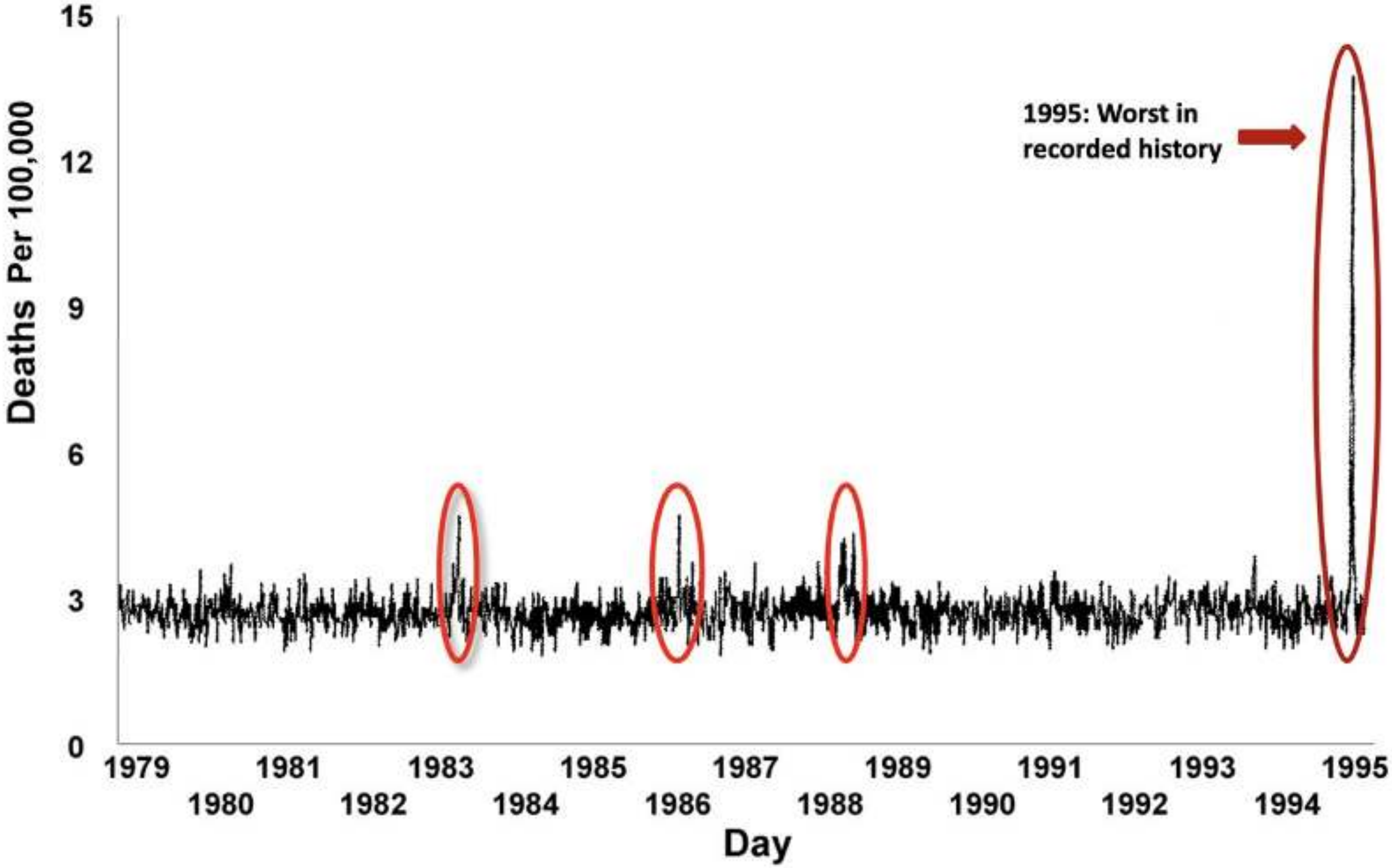
Quick facts about heat and health

- Heat is the leading weather-related cause of death in the U.S.
- Urban area residents are particularly sensitive to heat, especially in non-tropical areas.
- The Urban Heat Island (UHI) contributes to this sensitivity.
- The vulnerability of people varies among cities and neighborhoods.
- Summer climate variability is more important than the actual temperature (more people die of heat in Toronto than Singapore!).
- Extended heat events and excessive nighttime temperatures are most important contributors.
- We can improve the city's environment to lessen the negative health impact of heat.

Summer daily mortality
Chicago, June-August, 1979-1995



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An air mass approach to evaluate heat-health relationships

- We evaluate "weather situations" rather than individual weather elements, using the spatial synoptic classification (SSC)
- Puts each day into a particular air mass type
- Two types particularly oppressive: DT and MT+

Oppressive Hot Air Masses	
Dry Tropical (DT)	Represents the hottest and driest conditions found at any location. There are two primary sources of DT: either it is transported from the desert regions, or it is produced by rapidly descending air.
Moist Tropical+ (MT+)	Hotter and more humid subset of common MT, and thus captures the most "oppressive" subset of MT days. Air mass originates over warm water bodies. Warmest nights of any air mass.

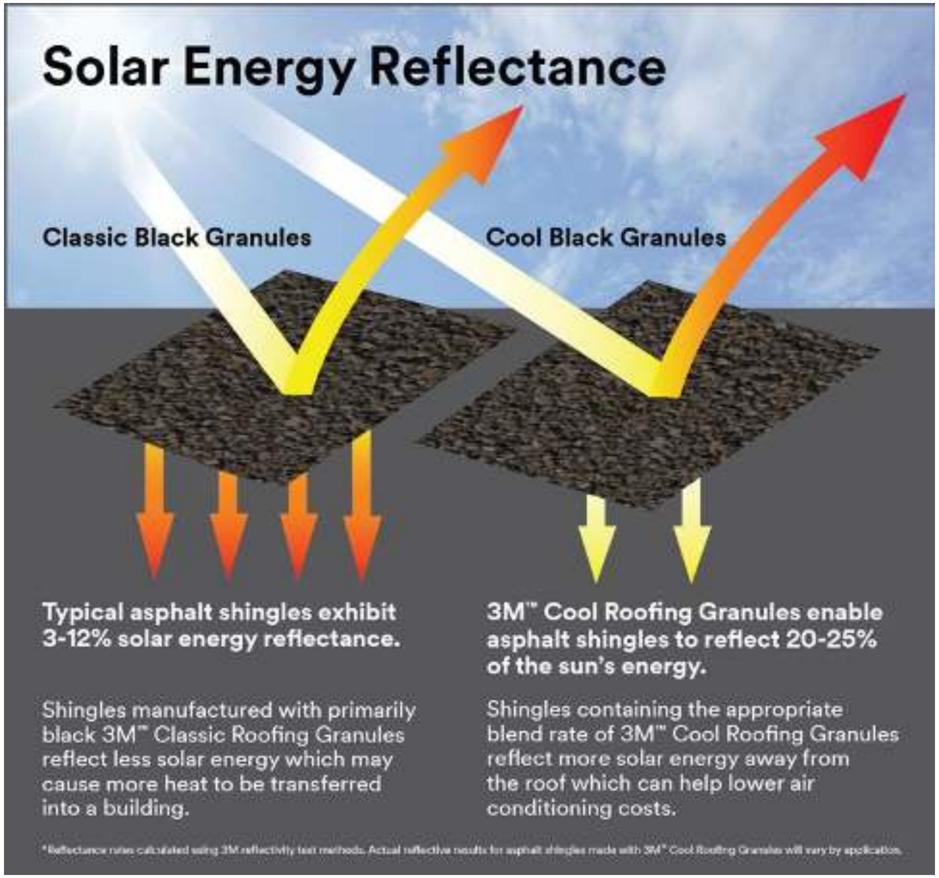
Mean mortality increases within offensive air mass types

LOCATION (FREQ)	Dry Tropical (DT)	Moist Tropical + (MT+)
New York (11%)	+16.6 (7%)	+16.9 (7%)
Los Angeles (4%)	+8.4 (5%)	+8.4 (5%)
Phoenix (1%)	+2.7* (7%)	None
Rome (11%)	+6.2 (14%)	+5.0 (12%)
Toronto (7%)	+4.2 (11%)	+4.0 (10%)

*DT+ air mass for Phoenix

Reflective roofing: energy efficiency and comfort

- Reduces electricity use and cooling costs in year-round cooling environments
- Improves air quality by reducing the formation of ozone
- Provides a more pleasant home environment



We tested "prescriptions" of

tree canopy

+

solar reflectance (albedo) of roofs & pavements

Low • Moderate • High

LA County-wide analysis → District-scale analysis → Climate change projections → National implications

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Two levels of spatial analysis using observed health and weather data

Countywide: Evaluate the entire county and assume similar "prescriptions" are employed throughout

- Advantage: large sample size for mortality
- Disadvantage: cannot break down results locally

District level: Evaluate a number of socially-homogeneous districts within LA County separately

- Advantage: can determine impact of socio-economic factors
- Disadvantage: sometimes population sizes are too small to do an adequate mortality evaluation

Prescription scenarios

	Tree Cover	Solar Reflectance (Albedo)
Rx 1	Low	High
Rx 2	High	Low
Rx 3	Medium	Medium
Rx 4	High	High

Tree Cover Prescriptions Defined

Low = 25% relative increase (baseline x 1.25)

Medium = 100% relative increase (baseline x 2)

High = 40% tree cover (regardless of baseline)

For example, the tree cover for L.A. County is approximately 16%. A low scenario would be an increase to 20%; medium to 32%; high to 40%.

Solar Reflectance Prescriptions Defined

Baseline = All roofs combined reflect 17% of the solar energy that falls on them. Pavements, on average reflect 10%.

Low = Roofs reflect 27% of solar energy. Pavements reflect 20%.

Medium = Roofs reflect 37% of solar energy. Pavements reflect 25%.

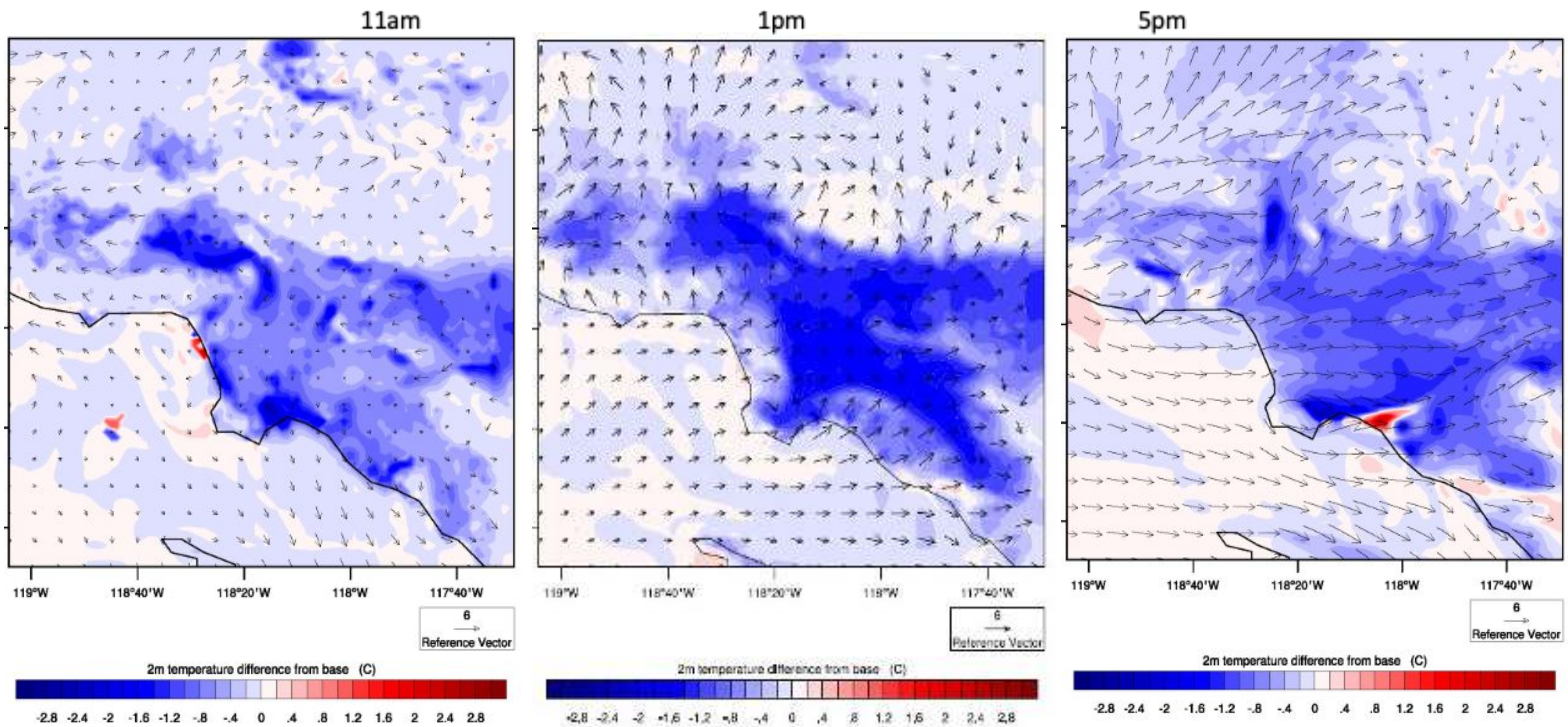
High = Roofs reflect 45%. Pavements reflect 35%.

We evaluated 4 excessive heat events for all of L.A. County and for individual "districts"

- July 22-26, 2006: hot and humid, all MT+ days
- June 19-22, 2008: drier, mix of MT and DT days
- August 26-30, 2009: less extreme, wanted to evaluate more common heat event
- September 24-29, 2010: very hot, dry Santa Ana event dominated by DT days

Model results:
County-level air temperature differences

County-level mitigation Rx 1; Low tree cover, high reflectance
2m Air T differences: Control - Rx1
Heat Wave: August 26, 2009



Countywide model: Santa Ana heat event, Sept. 2010 (DT)

Date		Rx 0 (baseline)	Rx 1	Rx 2	Rx 3	Rx 4
	SSC Type	DT	DT	DM	DM	DM
	5am AT	20.9	20	20.3	20.1	19.9
	Mean AT	22.5	21.6	21.6	21.4	21.1
9/26/10	Mortality increase (%)	5.0	4.9	0	0	0
	SSC Type	DT	DT	DT	DT	DT
	5am AT	24.6	23.7	23.9	23.9	23.6
	Mean AT	27.7	26.7	27	26.9	26.5
9/27/10	Mortality increase (%)	11.7	9.5	9.9	9.7	8.8
	SSC Type	DT	DT	DT	DT	DT
	5am AT	23.8	23.1	22.9	23	22.7
	Mean AT	26.4	25.8	26	26	25.6
9/28/10	Mortality increase (%)	18.2	15.4	15.9	15.6	14.3
	SSC Type	MT	MT	MT	MT	MT
	5am AT	21.5	20.6	20.8	20.8	22.3
	Mean AT	22.9	22.4	22.6	22.5	22.8
9/29/10	Mortality increase (%)	14.5	12	12.8	12.5	12.1
Mean 4-day (9/26-29) increase in mortality (%)		**12.4**	**10.5**	**9.7**	**9.5**	**8.8**
Net decrease in heat-related mortality increases		n/a	-16%	-22%	-24%	-29%

Approximately 150 people die daily in Los Angeles County during summer.

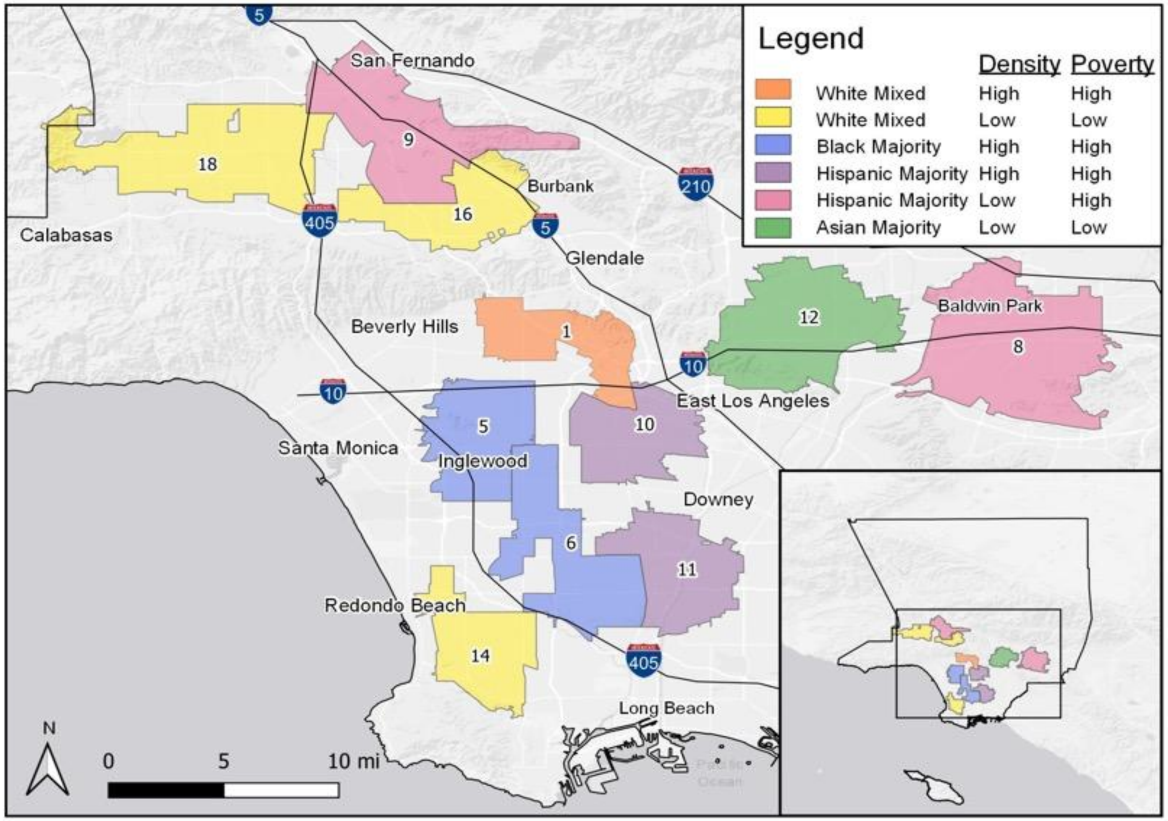
- One day shifted from an oppressive DT air mass to a benign dry moderate (DM) air mass
- This reduced mortality for that day from a 5% increase for the baseline (approx. 8 deaths) to 0
- For the entire heat event, the increase in mortality went from 12.4% (12.4% of 600 total deaths = 74 extra deaths) to 8.8% (52 deaths)
- Thus, under the Rx 4 scenario (high canopy/high albedo), we estimate 22 saved lives during this heat event

District-level analysis

County divided into **18 unique and rather homogeneous districts**. Must be inclusive of entire zip code areas.

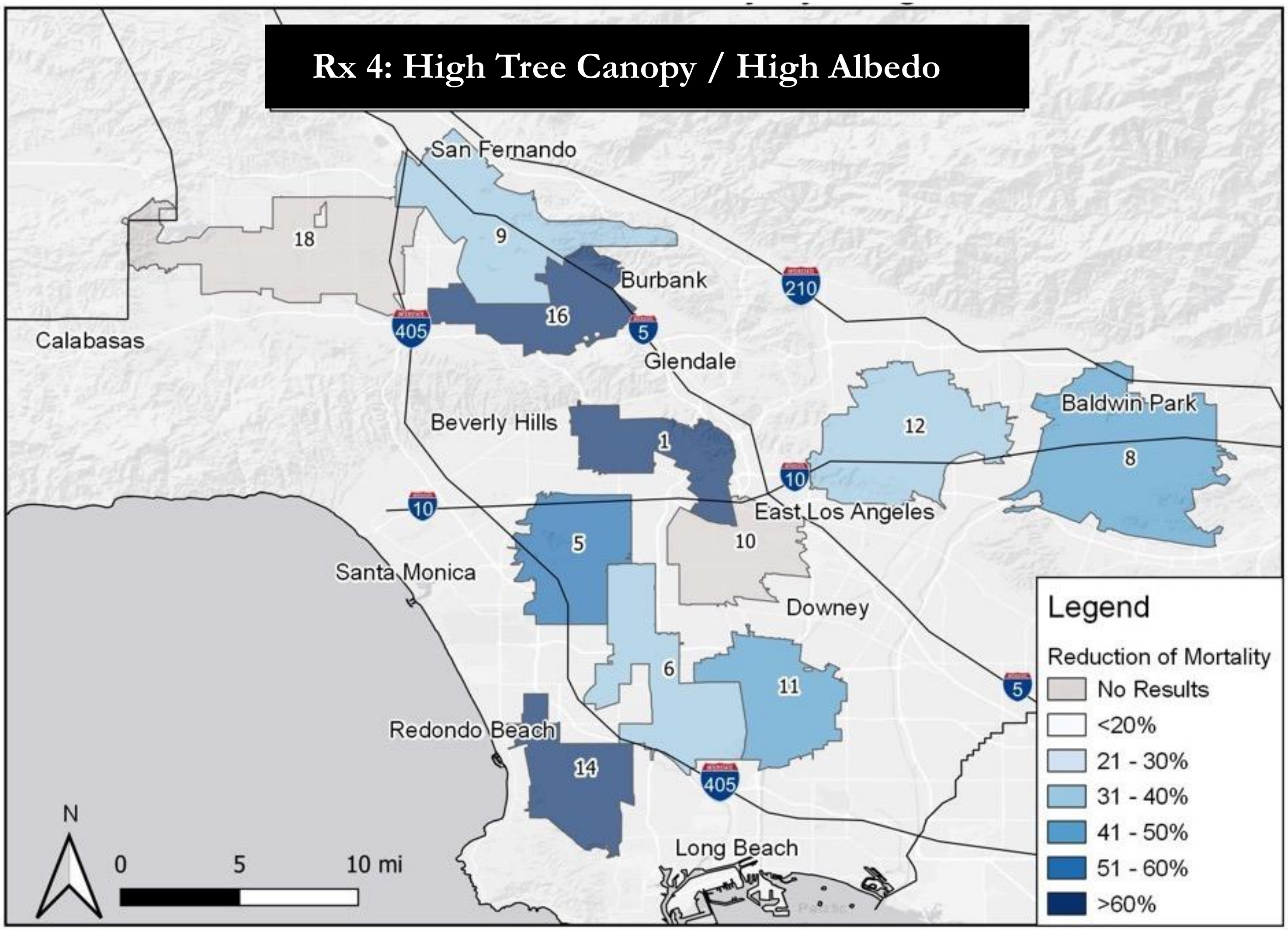
Some districts proved problematic; e.g., missing data, low population densities.

We reduced the number of districts to be evaluated to 11. Virtually all low-income districts were included within the 11 districts.



Map credit: Cassie Roberts

Mortality reductions by district
Sept. 24-29, 2010 (very hot, dry Santa Ana, DT)



Map credit: Cassie Roberts

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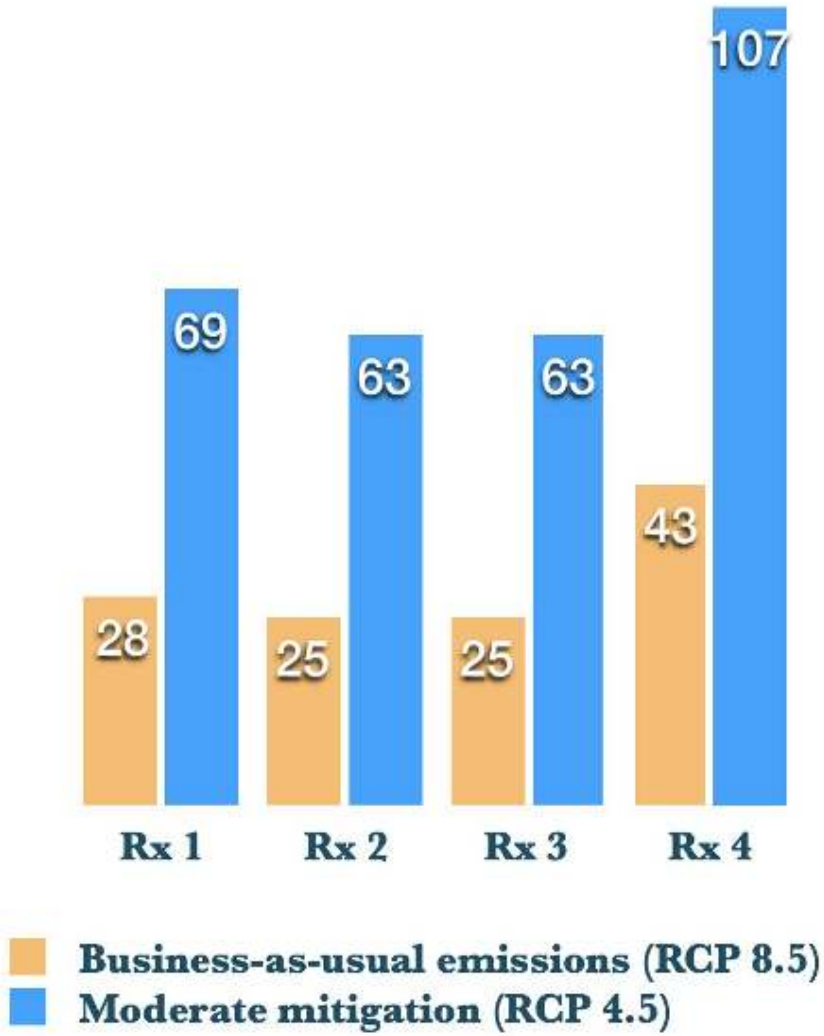
Climate projections:
How many years can we delay climate change-induced warming?



Mean max temperature reduction:

Rx 1: -1.1°C

Rx 2: -1.0°C

Rx 3: -1.0°C

Rx 4: -1.7°C

Summary of results

Temperature reductions often exceeded 1.0°C (1.8°F), and went up to 2.0°C (3.6°F) --- a life or death difference

25%+ reductions in heat-related deaths are possible, saving dozens of lives during the worst heat waves

Oppressive air masses could be shifted to more benign ones

Heat impacts of climate change could be delayed ~25-60+ years

Results continued

- Lower income, more densely populated districts generally demonstrated the greatest increases in heat-related mortality (eg. Districts 1, 5, 11).

- These districts also showed the greatest benefits from use of "cool solutions", based upon mortality reductions.

- There were some unexplained exceptions: eg. Low-income District 10 showed little impact, wealthier but hot district 16 showed greater impact.

- Use of "cool solutions" can delay climate change by at least several decades in Los Angeles.

Concluding remarks

- The importance of heat upon human health cannot be overstated.
- We must gain understanding about the regionality of the problem, the impact of the urban heat island, and the potential impact of climate change.
- For those who are skeptical of climate change disaster, we must emphasize that heat is **already** the largest weather-related killer!
- We are now working on a heat wave categorization system through the Arsht-Rockefeller Foundation to help with proper interventions.
- Academics, the private sector, the government, and nonprofits must unite (like LAUCC) to tackle this problem and to come up with adaptation and/or mitigation policy options.