A socio-spatial model of hospitalizations from exposure and sensitivity to high temperatures

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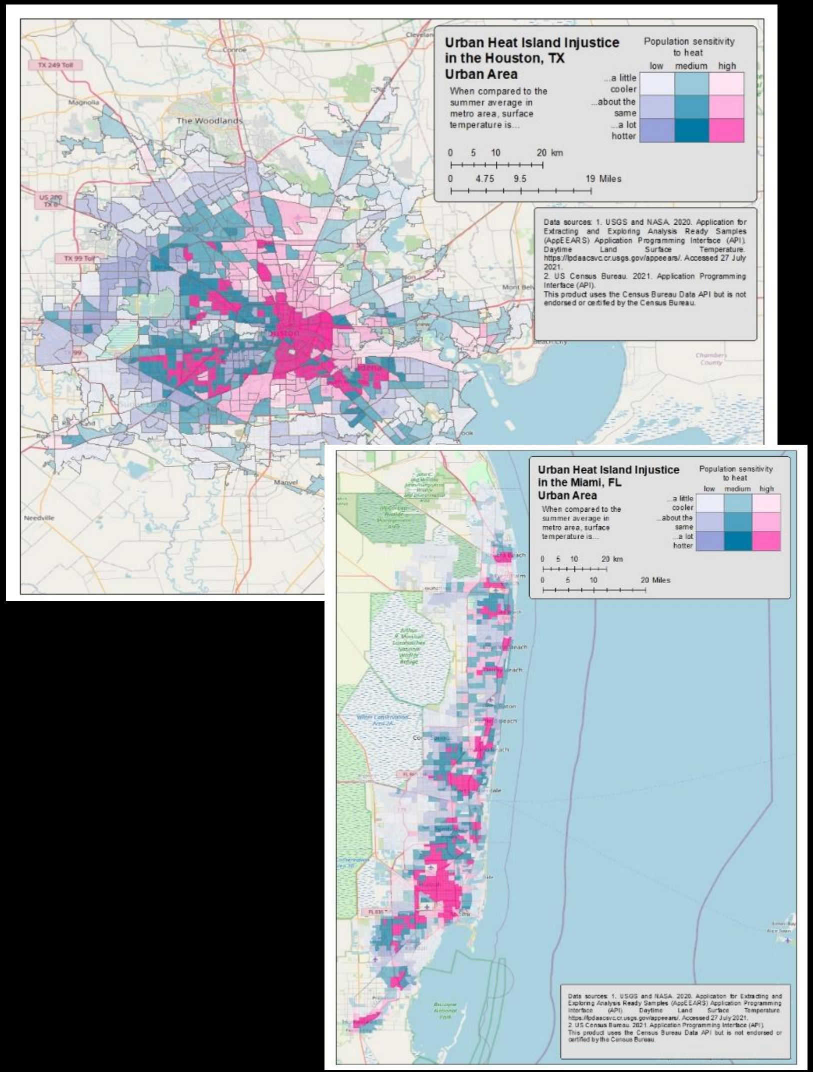
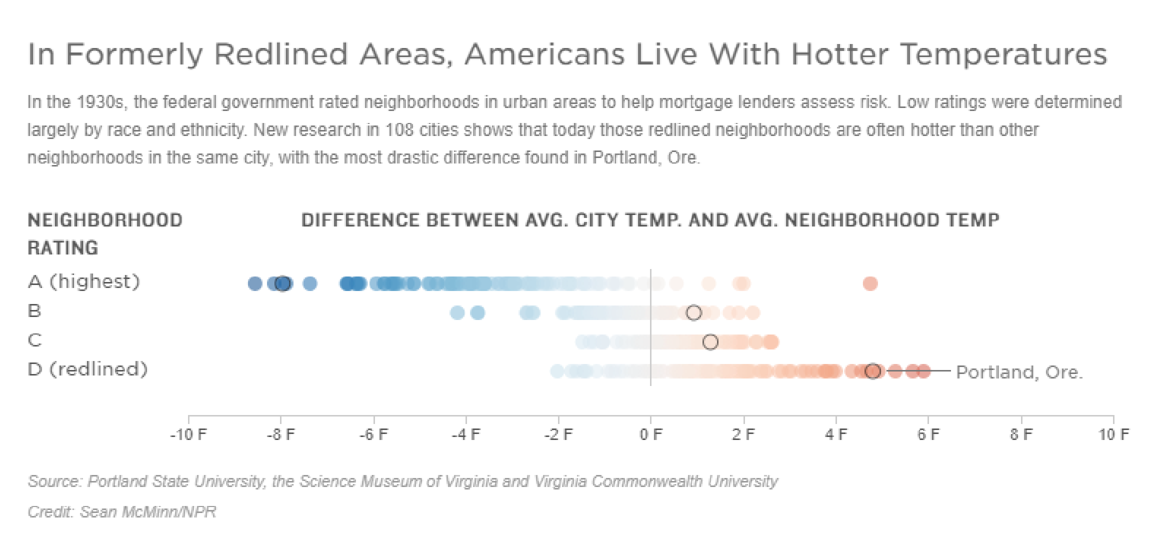
Introduction

- Temperatures already elevated due to global climate change increasing heat-health risks in cities
- Cities warming more than surrounding areas due to urban heat island (UHI)
- Spatial variability in warming within cities due to land use/land cover change into impervious surfaces (micro-UHIs)
- Spatial variability in population vulnerability to heat due to racist urban development policies (e.g., redlining and public disinvestment)

https://blog.ucsusa.org/author/juan-declet-barreto





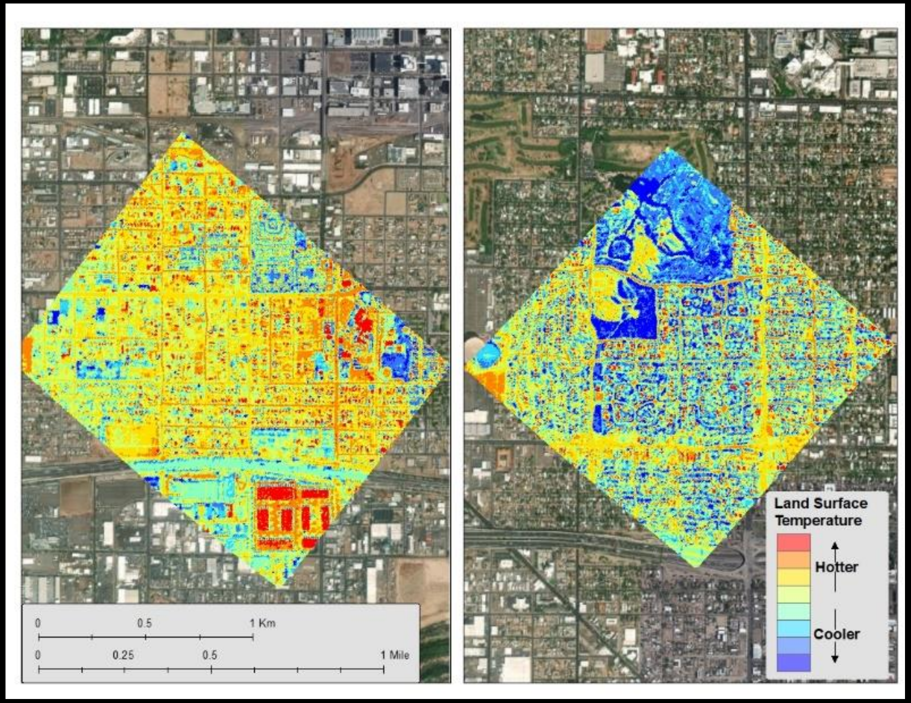
Source: NPR reporting of Hoffman et al. (2020)
https://www.npr.org/2020/01/14/795961381/racist-housing-practices-from-the-1930s-linked-to-hotter-neighborhoods-today

Research Questions

- How does population sensitivity to extreme heat vary spatially according to socio-economic and built environment conditions in residential neighborhoods within an urbanized area?
- What are the effects of exposure and sensitivity to high summertime temperatures on heat-related hospitalizations in neighborhoods with different socio-economic and built environment conditions?

Study Area

Month	Min	Max	Mean	SD
May	12.8	46.1	34.4	4.6
June	25.0	48.9	39.0	3.8
July	26.1	50.0	40.8	3.3
August	26.7	47.2	39.3	3.1
September	23.3	47.8	36.8	3.2
October	11.1	41.1	30.5	4.2



Data source: Stefanov et al. (2015)

https://www.travelinusa.us/

Methods & Data

- Construction of Cumulative Heat Sensitivity Index (CHSI) for Census Block Groups
- Modeling of observed rates of heat-related hospitalizations
- Estimation of heat-related hospitalization risks

Cumulative Heat Sensitivity Index (CHSI)

	Not White	No AC	No H.S. Diploma	Below Poverty	Age 65 or Older	Living Alone	Age 65 x Alone	Unv. Surface (Mean)	Unv. Surface (SD)
Mean	39.9	10.3	15.3	14.0	14.1	25.2	8.0	21.9	9.4
SD	26.4	19.0	16.3	14.7	17.3	13.8	9.2	9.2	4.0
Not White									
No AC	0.62***								
No H.S. Diploma	0.78***	0.65***							
Below Poverty	0.64***	0.57***	0.63***						
Age 65 or Older	-0.51***	-0.19***	-0.21***	-0.22***					
Living Alone	-0.21***	0.02	-0.12***	0.10***	0.40***				
Age 65 x Alone	-0.38***	0.08***	-0.10	-0.09***	0.87***	0.62***			
Unv. Surface (Mean)	0.29***	0.22***	0.31***	0.29***	-0.08***	0.06***	-0.01		
Unv. Surface (SD)	0.14***	0.16***	0.17***	0.14***	-0.21***	-0.07***	-0.14***	0.69***	

*p ≤ 0.05. **p ≤ 0.01. ***p ≤ 0.001.

Table 3. Means, SDs, and Pearson's correlations for heat sensitivity variables in Maricopa County census block groups (n = 2,387).

Cumulative Heat Sensitivity Index (CHSI)

	Factor 1: Socio-economic Sensitivity	Factor 2: Elderly Isolation Sensitivity	Factor 3: Built Environment Sensitivity
Not White	**0.85**	-0.36	0.09
No AC	**0.82**	0.00	0.08
No H.S. Diploma	**0.88**	-0.07	0.12
Below Poverty	**0.83**	0.02	0.12
Age 65 or Older	-0.24	**0.86**	-0.10
Living Alone	0.05	**0.77**	0.03
Age 65 x Alone	-0.08	**0.95**	-0.03
Unv. Surface (Mean)	0.24	0.06	**0.89**
Unv. Surface (SD)	0.04	-0.13	**0.92**

→

$$CHSI_x = T_x^{\alpha} + T_x^{\beta} + T_x^{\gamma}$$

Modeling of observed rates of heat-related hospitalizations

Indicator	Source	Time period	Geographic scale
Exposure and Health Outcomes			
Heat-related Inpatient Admissions	ADHS[1]	2005-2009	Point
Daily Maximum Air Temperature	AZMET, MFCDC, NOAA[2]	2005-2009	Point

Basic model of hospitalization risk:

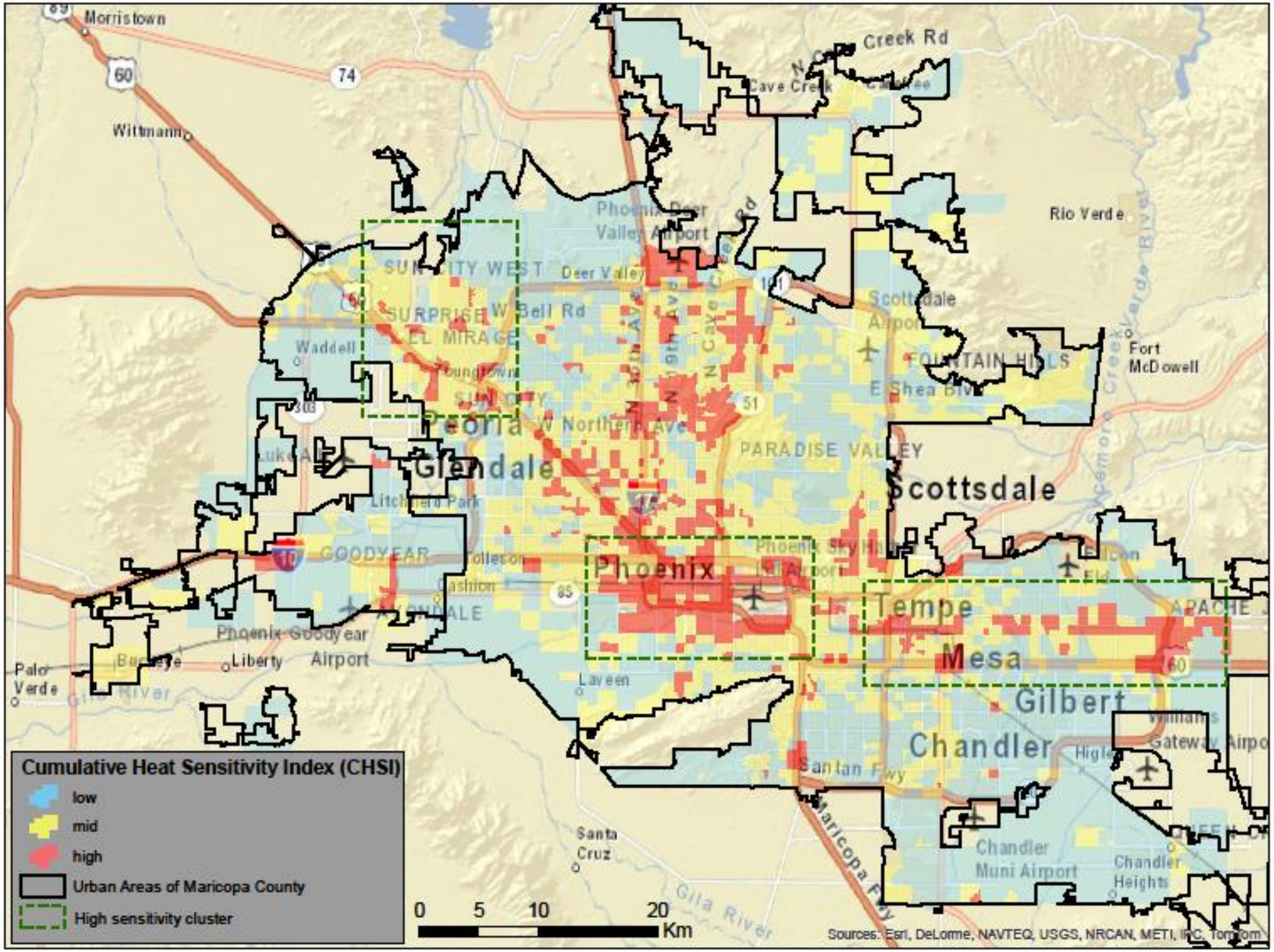
$$E\left(\frac{H}{PD} \mid t\right) \equiv \mu(t, \boldsymbol{\beta}) = \exp(\beta_0 + \beta_1 t + \beta_2 t^2)$$

CHSI group heat-related hospitalization risk:

$$\begin{aligned} E\left(\frac{H}{PD} \mid t, l, m\right) &= \mu(t, l, m, \boldsymbol{\beta}) \\ &= \exp(\beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 l + \beta_4 m + \\ &\quad \beta_5 tl + \beta_6 tm + \beta_7 t^2 l + \beta_8 t^2 m), \end{aligned}$$

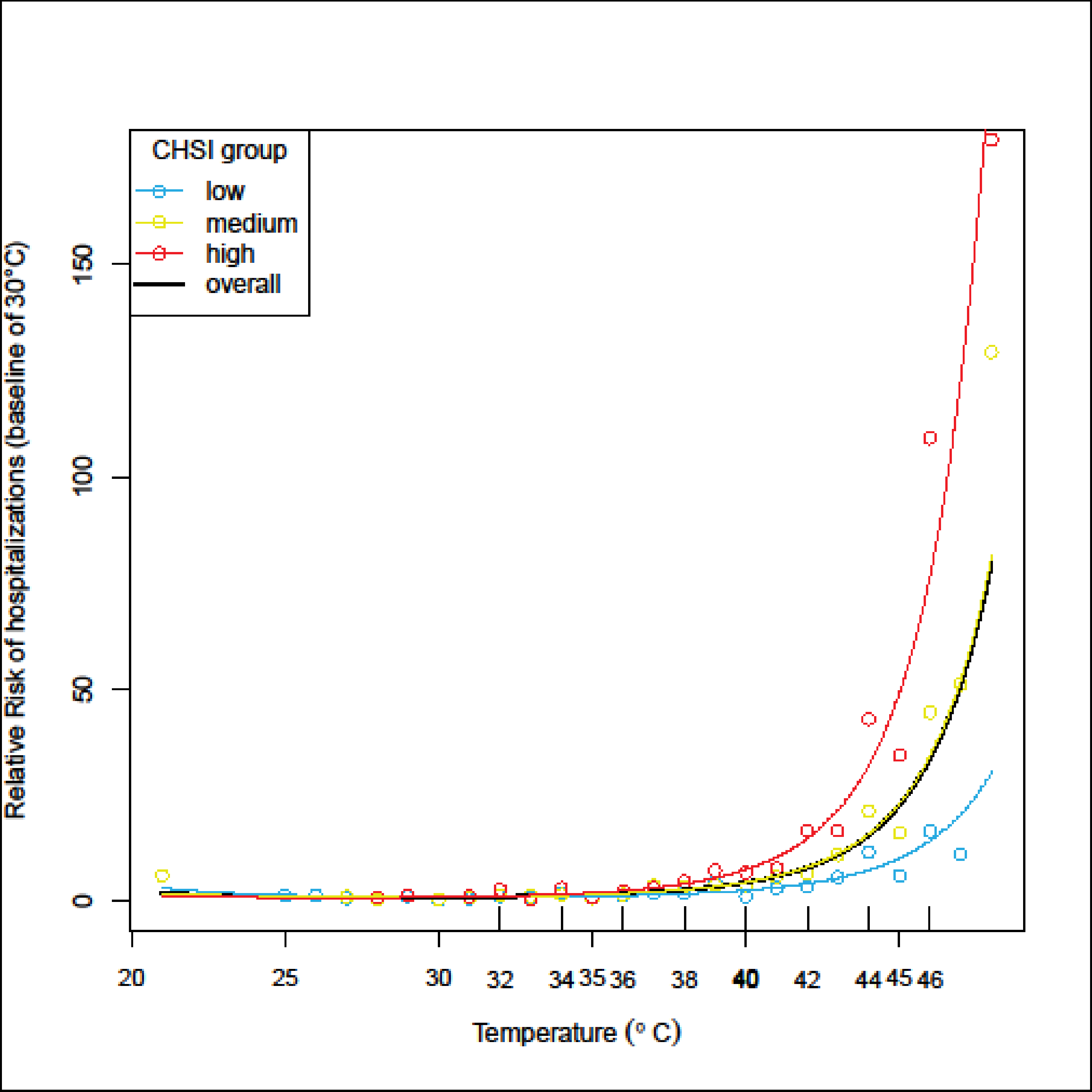
Results

- Three dimensions of heat sensitivity
  - socio-economic
  - age and social isolation
  - built environment
- Sensitivity to heat-related hospitalizations is unevenly distributed



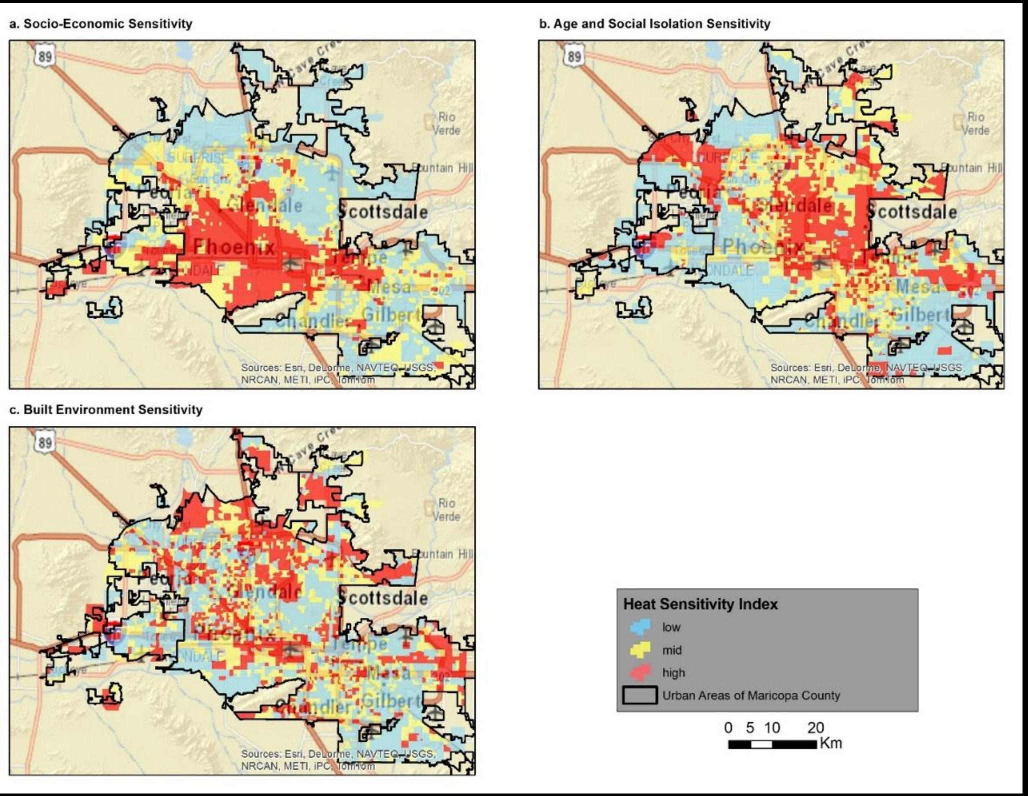
Results

- Baseline risks: Hospitalization risks increase rapidly beyond maximum daily air temperature t=30°C.
- CHSI-specific curves behave as expected
- Temperature risks: Risk of heat-related hospitalizations increases rapidly with each 1°C increase in temperature
- With respect to risk at baseline:
  - low CHSI ~1-44 percent higher
  - medium CHSI 5-52 percent higher
  - High CHSI 10-60 percent higher

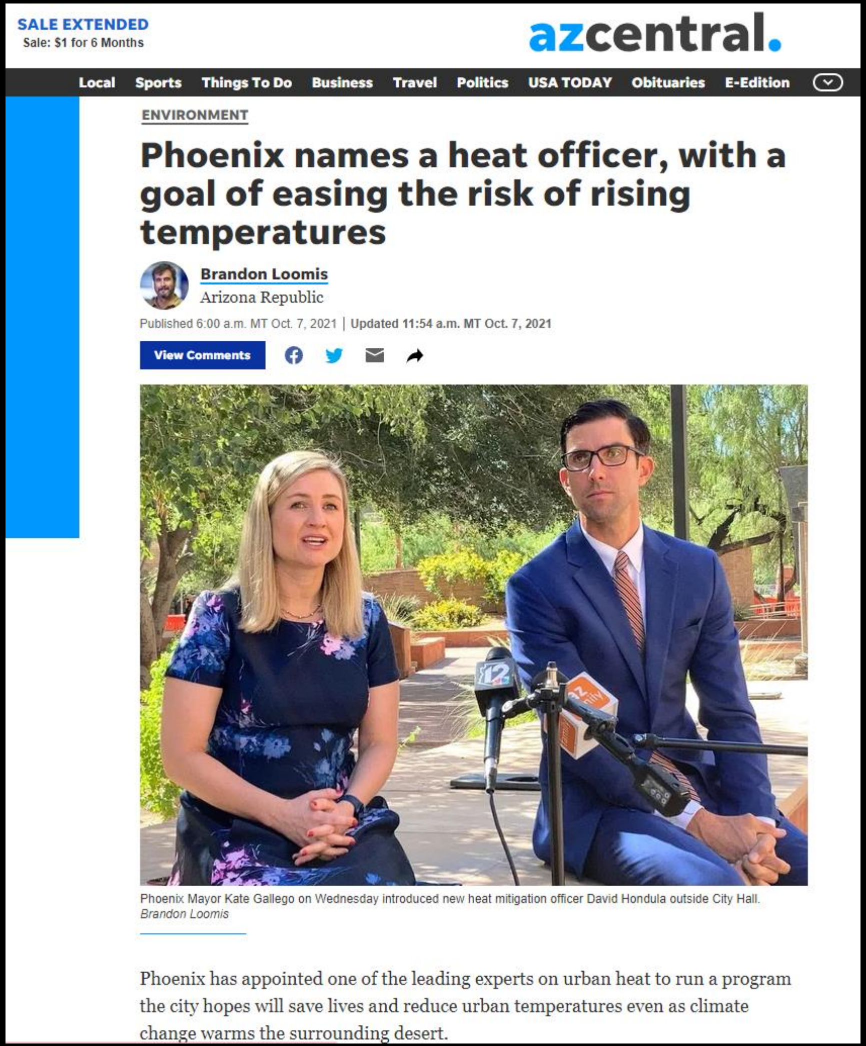


Discussion & Conclusions

- Our findings are in line with previous research on SES-based differences in heat mortality/morbidity
- CHSI factors show heat sensitivity is highest in the Phoenix city urban core, lower in the expanding suburbs, and lowest near the suburban fringes…
- …but a dual pattern of vulnerability is evident in individual factor maps
- Need to "shift the gaze to the historical and multi-causal production of harms" (Ranganathan & Bratman, 2021, 112)
- Practices and policies that created inequitable burdens are the socio-spatial expression of uneven development (Heynen 2003)



Discussion & Conclusions



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ENVIRONMENT

Phoenix names a heat officer, with a goal of easing the risk of rising temperatures

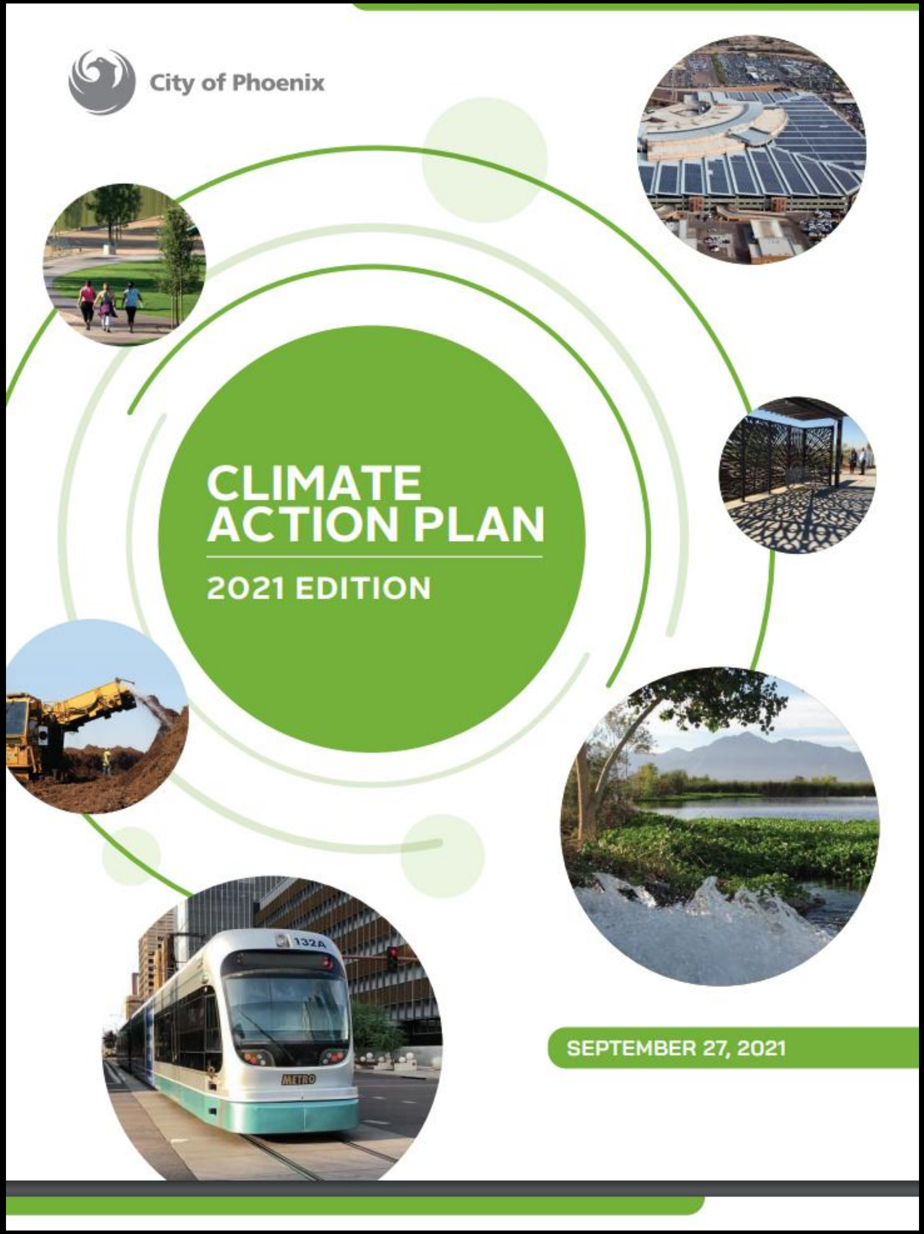
Brandon Loomis
Arizona Republic

Published 6:00 a.m. MT Oct. 7, 2021 | Updated 11:54 a.m. MT Oct. 7, 2021

View Comments

Phoenix Mayor Kate Gallego on Wednesday introduced new heat mitigation officer David Hondula outside City Hall.
Brandon Loomis

Phoenix has appointed one of the leading experts on urban heat to run a program the city hopes will save lives and reduce urban temperatures even as climate change warms the surrounding desert.



{ Thank You

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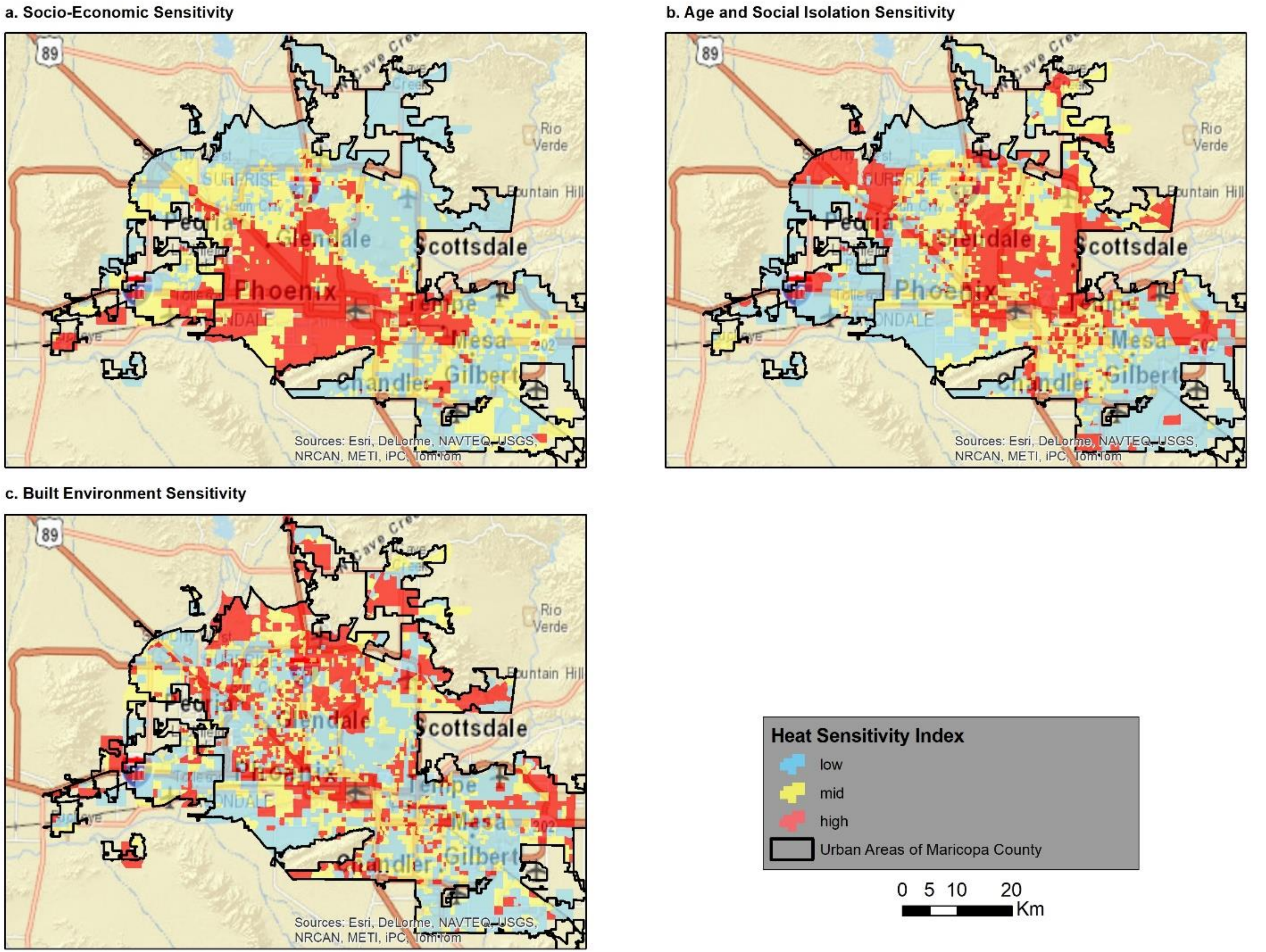
Union of Concerned Scientists


a. Socio-Economic Sensitivity
b. Age and Social Isolation Sensitivity
c. Built Environment Sensitivity
89
Rio Verde
Scottsdale
Phoenix
Glendale
Tempe
Mesa
Gilbert
Chandler
Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom
Heat Sensitivity Index
low
mid
high
Urban Areas of Maricopa County
0 5 10 20
Km