Climate Adaptation through Design: Heat Mitigation and Mortality

2014 Urban Climate Institute
Urban Warming and Public Health

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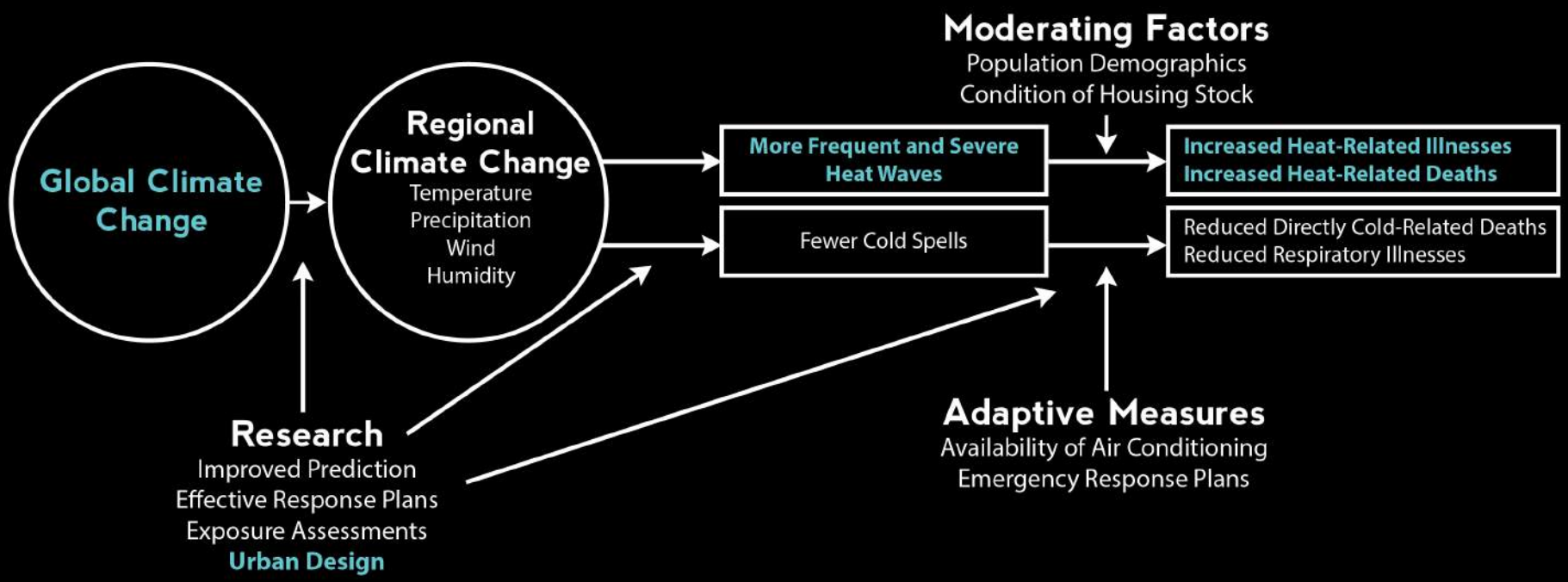

McGeehin, Michael A., and Maria Mirabelli. "The potential impacts of climate variability and change on temperature-related morbidity and mortality in the United States." *Environmental Health Perspectives* 109, no. Suppl 2 (2001): 185.

CULE

Climate, Urban Land-use, and Excess mortality

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Avoided Heat-Related Mortality through Climate Adaptation Strategies in Three US Cities

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Abstract

Heat-related mortality in US cities is expected to more than double by the mid-to-late 21st century. Rising heat exposure in cities is projected to result from: 1) climate forcings from changing global atmospheric composition; and 2) local land surface characteristics responsible for the urban heat island effect. The extent to which heat management strategies designed to lessen the urban heat island effect could offset future heat-related mortality remains unexplored in the literature. Using coupled global and regional climate models with a human health effects model, we estimate changes in the number of heat-related deaths in 2050 resulting from modifications to vegetative cover and surface albedo across three climatically and demographically diverse US metropolitan areas: Atlanta, Georgia, Philadelphia, Pennsylvania, and Phoenix, Arizona. Employing separate health impact functions for average warm season and heat wave conditions in 2050, we find combinations of vegetation and albedo enhancement to offset projected increases in heat-related mortality by 40 to 99% across the three metropolitan regions. These results demonstrate the potential for extensive land surface changes in cities to provide adaptive benefits to urban populations at risk for rising heat exposure with climate change.

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Introduction

Human health effects associated with rising temperatures are expected to increase significantly by mid-to-late century. A large body of work now estimates an increase in mean global temperature from pre-industrial averages of more than 2°C by late century under mid-range emissions scenarios [1]. A smaller but growing body of work has sought to estimate the effects of projected warming on heat-related mortality. Employing health impact functions derived from epidemiological studies of historical warm season mortality rates, recent work projects an increase in annual heat-related mortality of between 3,500 and 27,000 deaths in the United States by mid-century [2]. Studies focused on individual cities estimate an increase in annual heat-related mortality by a factor of 2 to 7 by the mid-to-late 21st century [3–5].

The urban heat island effect compounds the potential effects of urban heat island effect may further increase heat-related mortality is not well established.

Here we examine the potential for urban heat island mitigation as a climate adaptation strategy to reduce projected heat-related mortality in three large US cities by mid-century. Future year climate and seasonal mortality are modeled across the metropolitan statistical areas (MSAs) of Atlanta, Georgia, Philadelphia, Pennsylvania, and Phoenix, Arizona to capture a wide continuum of climatic, geographic, and demographic characteristics known to underlie population vulnerability to extreme heat. Using coupled global and regional scale climate models together with an environmental health effects model, we project the number of heat-related deaths expected for these regions in 2050 in response to a "business as usual" (BAU) and an array of urban heat management scenarios characterized by variable land cover modifications. Employing separate health impact functions

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urbanization → **climate** → **health**

urbanization	climate	health
buildings transportation land cover	temperature precipitation storms	heat-illness famine vector-borne ozone allergies

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		ozone
		allergies

urbanization

buildings
transportation
land cover

→

climate

temperature
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storms

→

health

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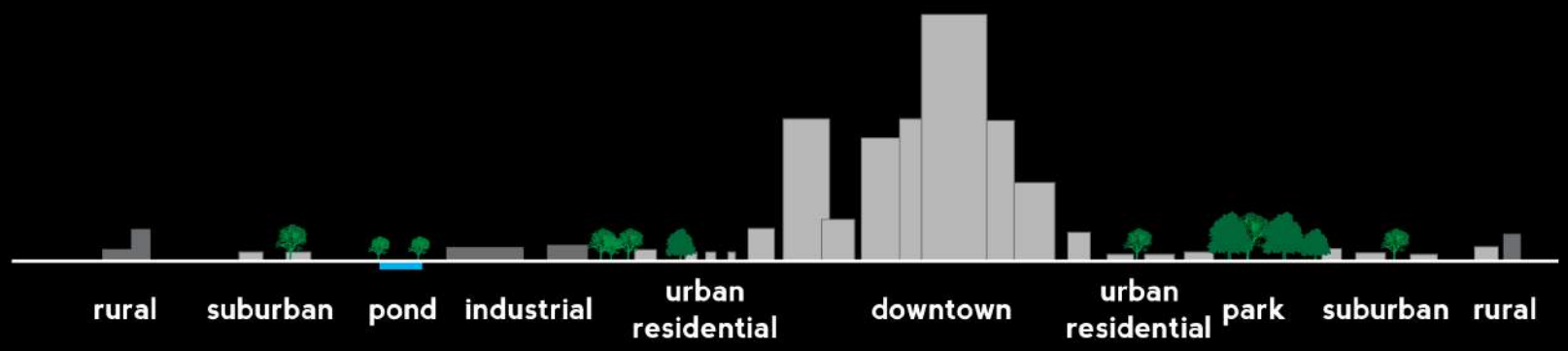
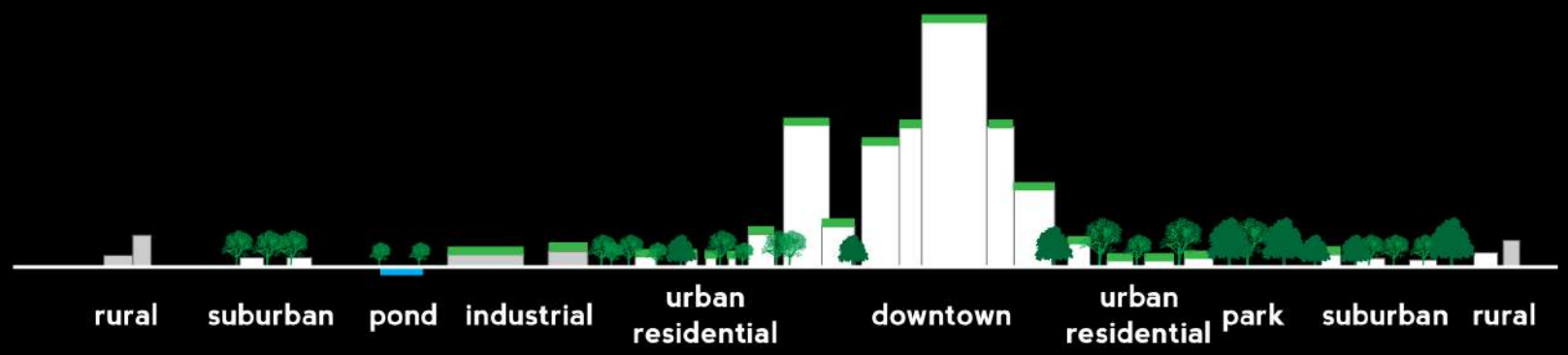
Business as Usual



Scenarios



Scenarios

VEGETATION

PRG	Private Greening	Homes and Commercial Buildings
PUG	Public Greening	Streets and Public Lands
GREEN	Combined Greening	Greening on Public and Private Lands

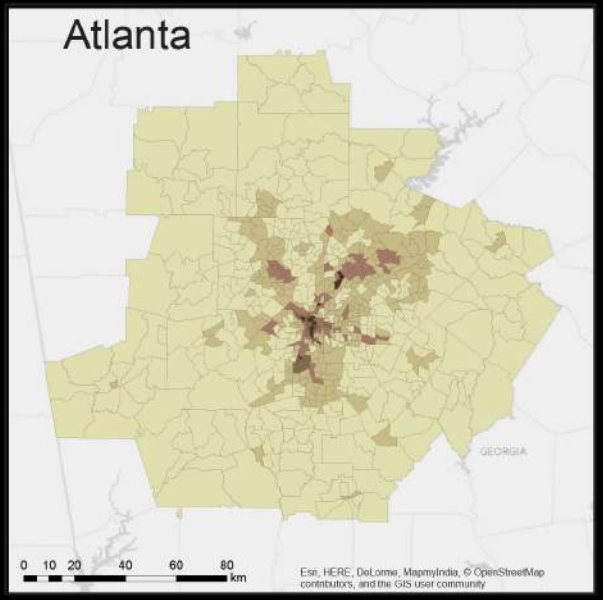
REFLECTIVITY

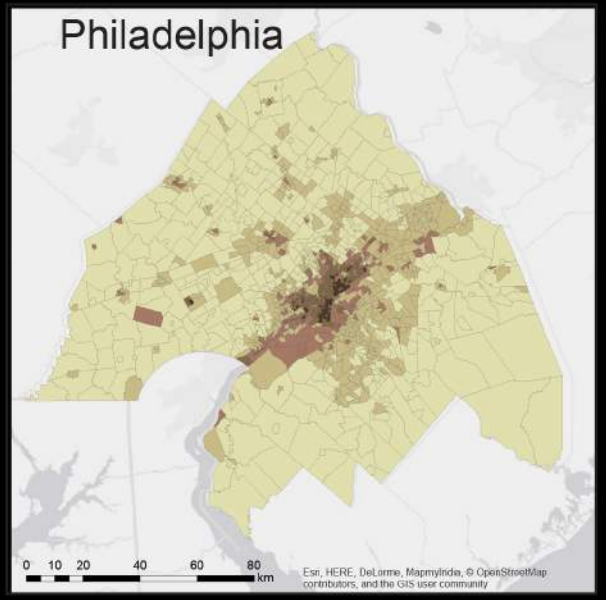
BAE	Building Albedo	Homes and Commercial Buildings
RAE	Road Albedo	Streets and Parking Lots
ALBEDO	Combined Albedo	Combination of Buildings and Streets

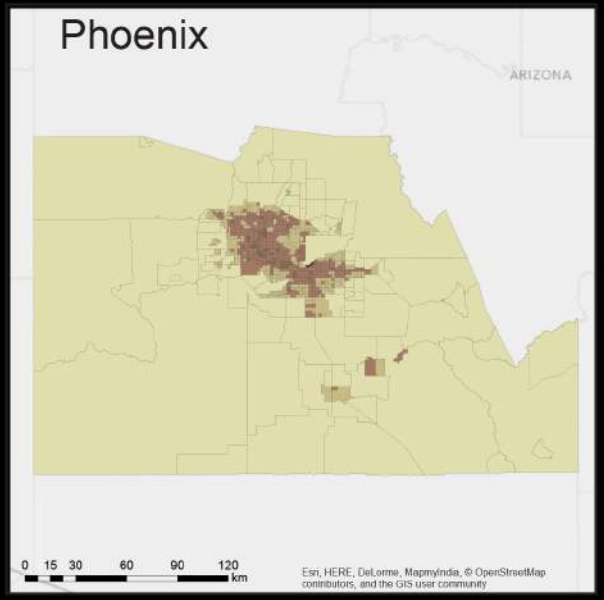
COMBINED

ALL	Combined Greening & Albedo	Combined Greening followed by Combined Albedo

Potential Land Cover Change







Land Cover Change (% of tract area)

- 0 to 20%
- 20 to 40%
- 40 to 60%
- 60 to 80%
- 80 to 100%

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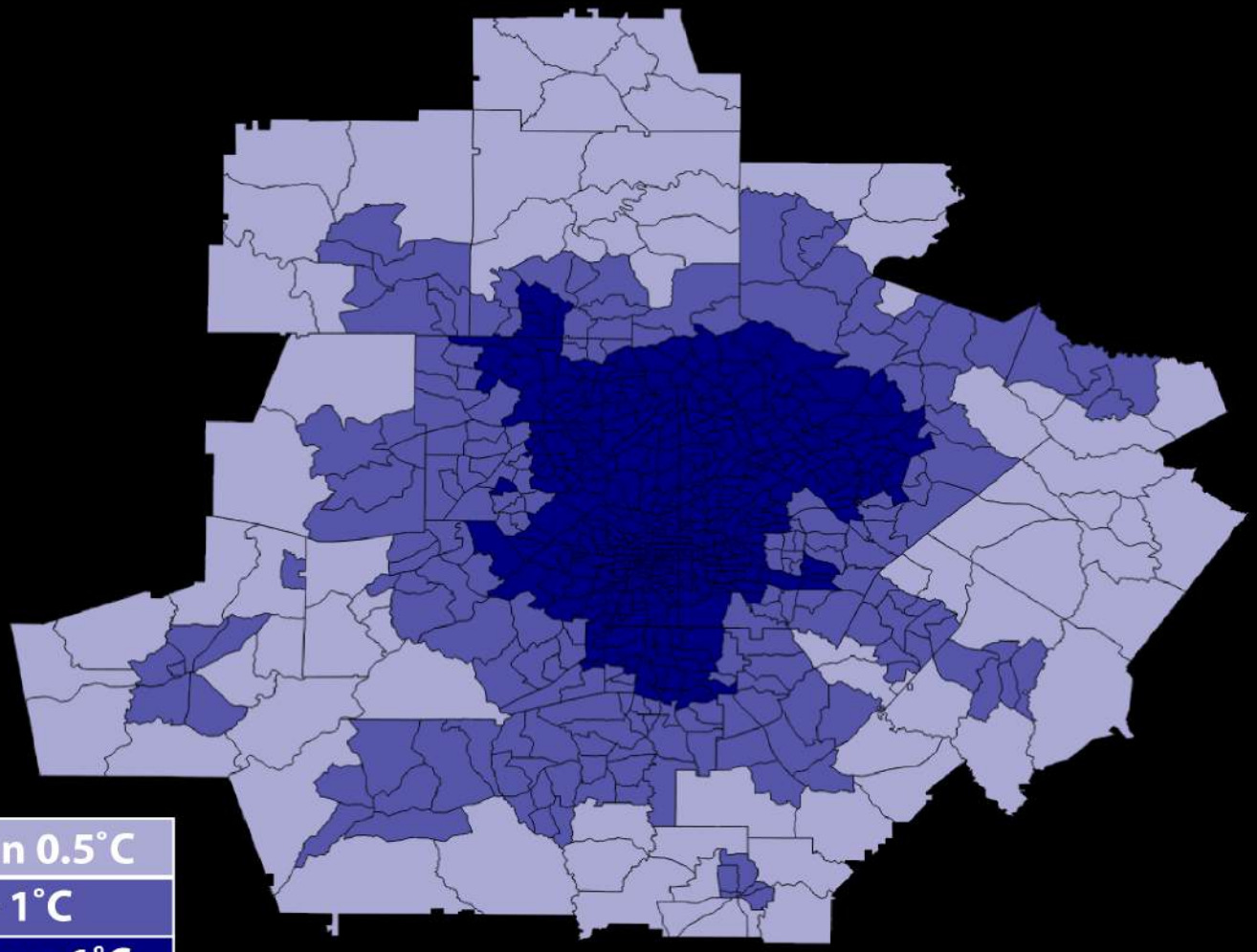
urbanization → **climate** → **health**

buildings
transportation
land cover

temperature
precipitation
storms

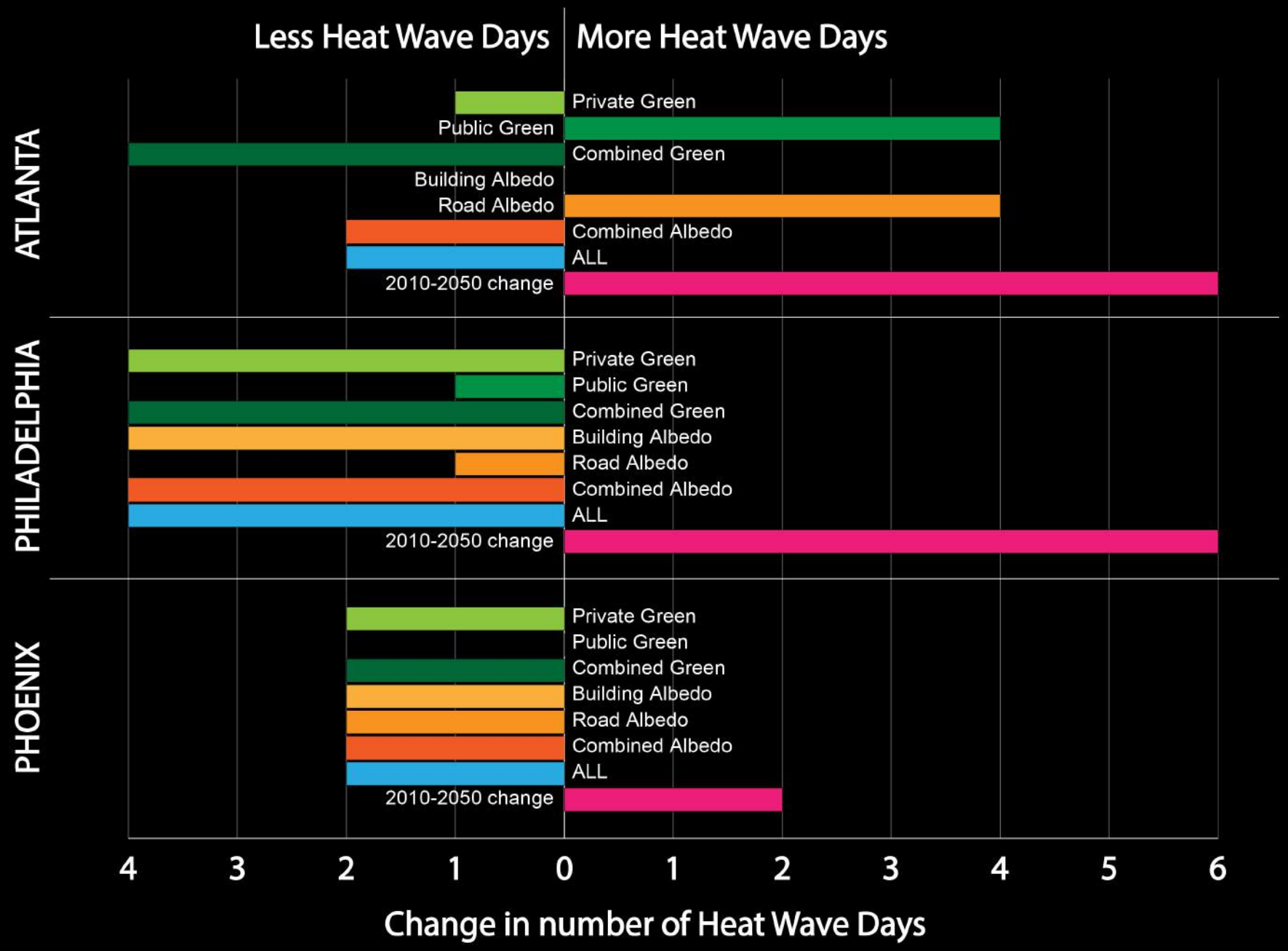
heat-illness
famine
vector-borne
ozone
allergies

Potential Summer Temperatures



less than 0.5˚C
0.5 - 1˚C
more than 1˚C

Expected summer cooling
(relative to 2050 'Business as Usual')


Less Heat Wave Days
More Heat Wave Days
ATLANTA
Private Green
Public Green
Combined Green
Building Albedo
Road Albedo
Combined Albedo
ALL
2010-2050 change
PHILADELPHIA
Private Green
Public Green
Combined Green
Building Albedo
Road Albedo
Combined Albedo
ALL
2010-2050 change
PHOENIX
Private Green
Public Green
Combined Green
Building Albedo
Road Albedo
Combined Albedo
ALL
2010-2050 change
4
3
2
1
0
1
2
3
4
5
6
Change in number of Heat Wave Days

urbanization → **climate** → **health**

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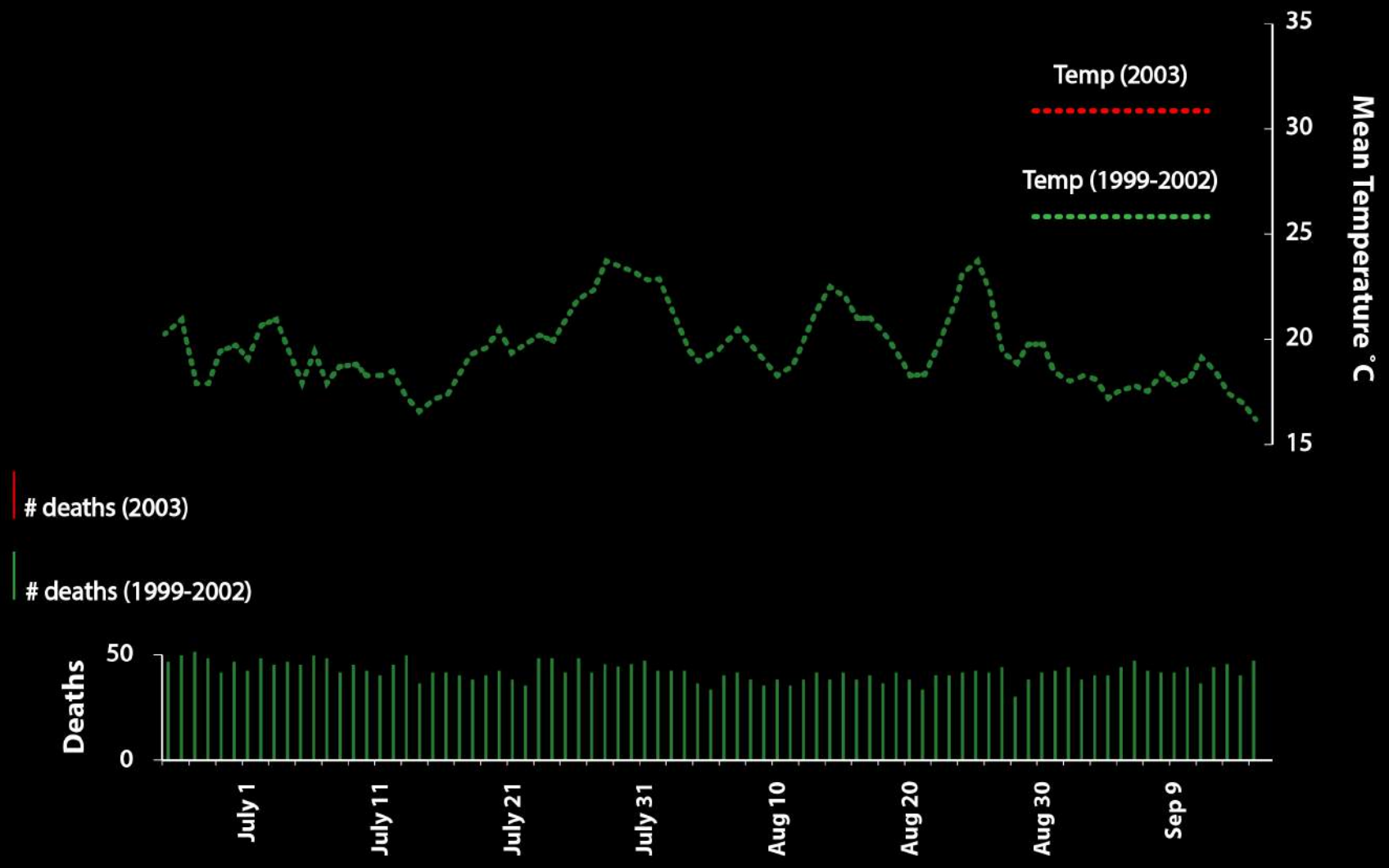
Health Impacts

Study	Temperature metric	Relative risk	Mortality type	Study population
Zanobetti and Schwartz, 2008	mean daily apparent temperature (May-Sept)	1.018 (1.0109, 1.025) per 5.55°C (O_3 and $PM_{2.5}$ adjusted)	non-accidental	all ages in 9 US cities (1999–2002)
Medina-Ramon and Schwartz, 2007	minimum daily T (May-Sept) above 17°C; measured as 2-day cumulative T	1.0043 (1.0024, 1.0061) per 1°C (O_3 adjusted)	all cause	all ages in 42 US cities (1989–2000)

Extreme Heat and Excess Mortality



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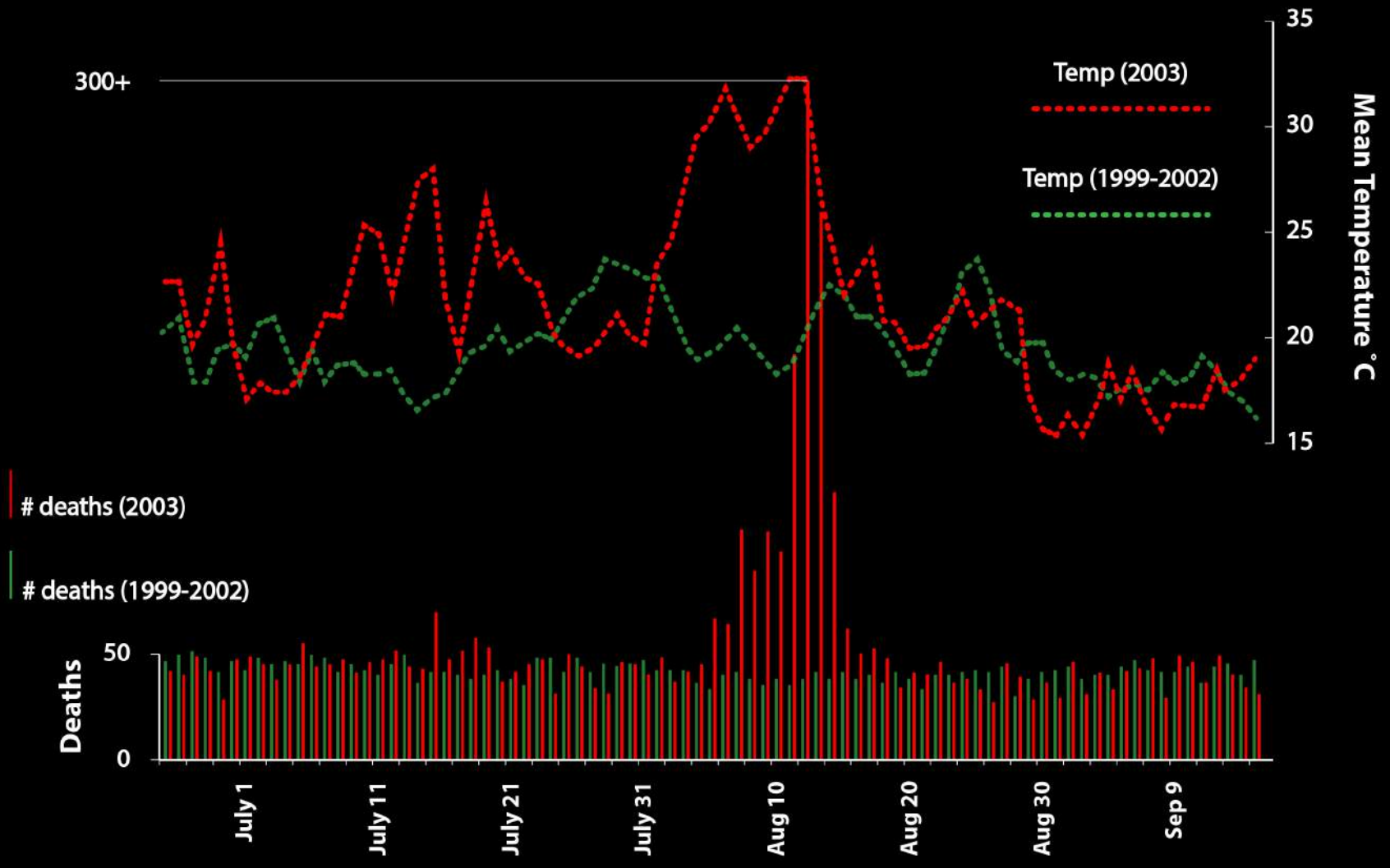

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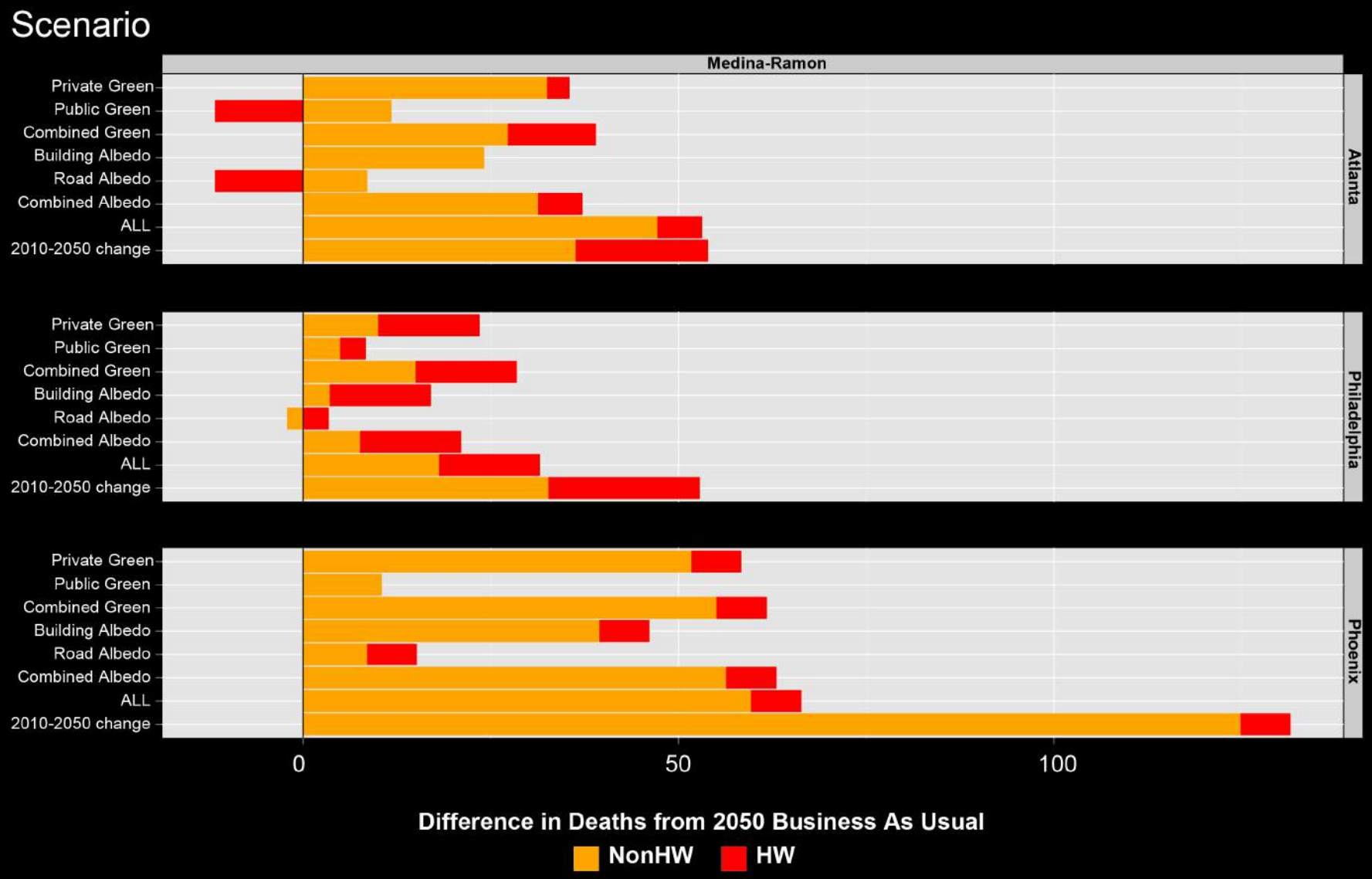
Anderson and Bell, 2011	heat wave periods classified as 2 or more days with mean daily T above 95th percentile of 1987–2005 average for May-Sept	1.0367 (1.0295, 1.0439) per heat wave day	non-accidental	all ages in 43 US cities (1987–2005)

Health Impacts



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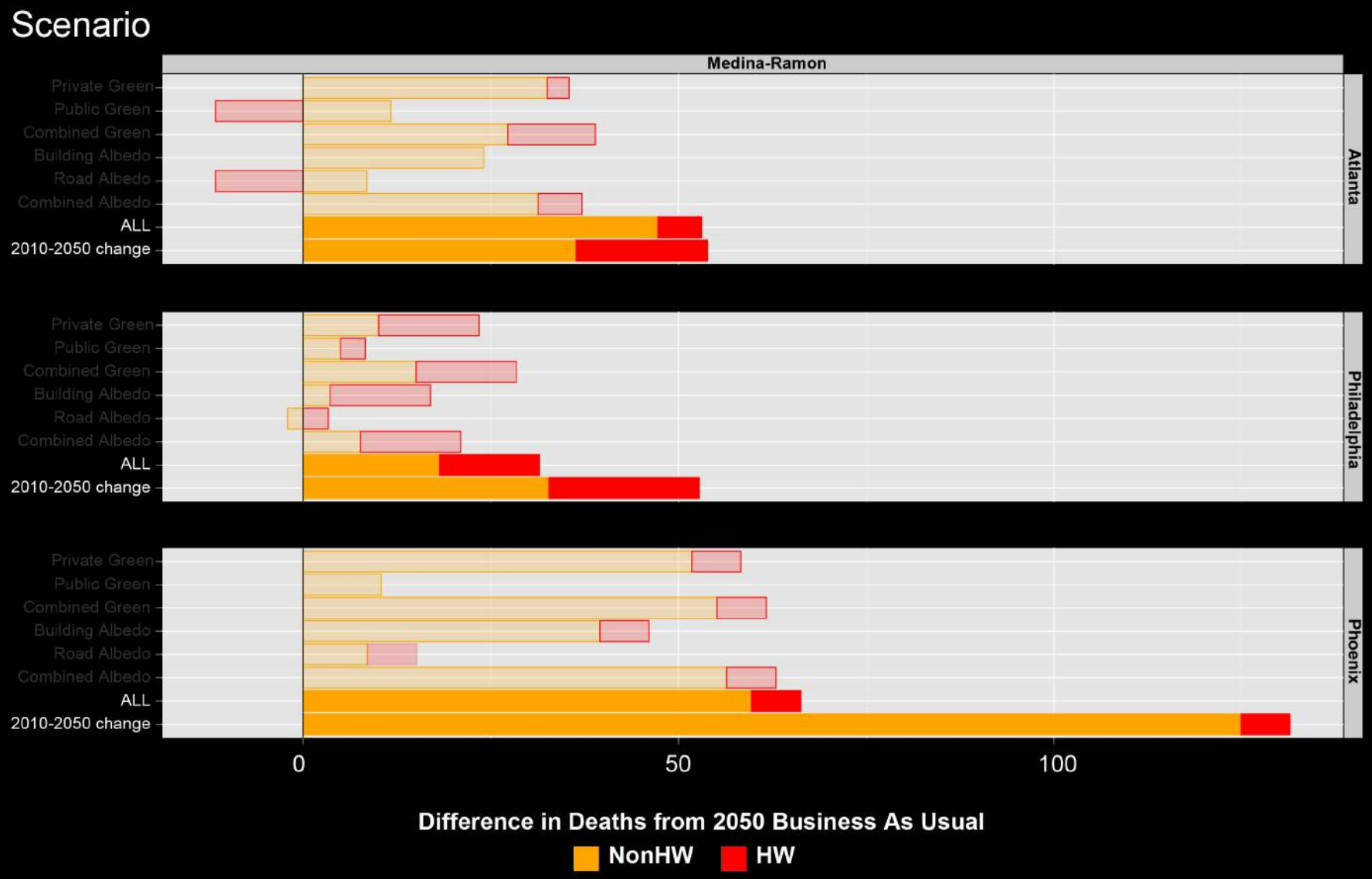

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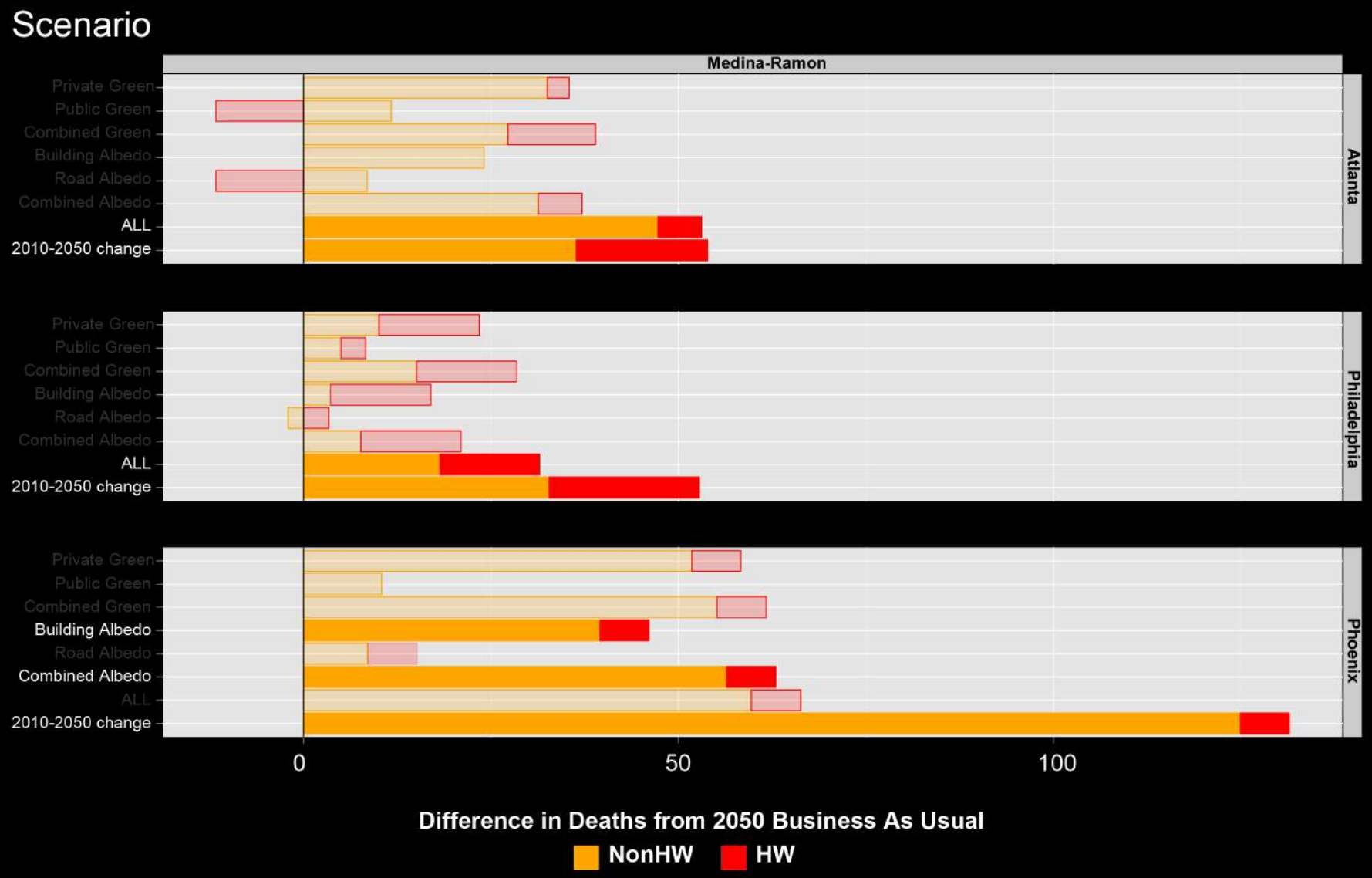

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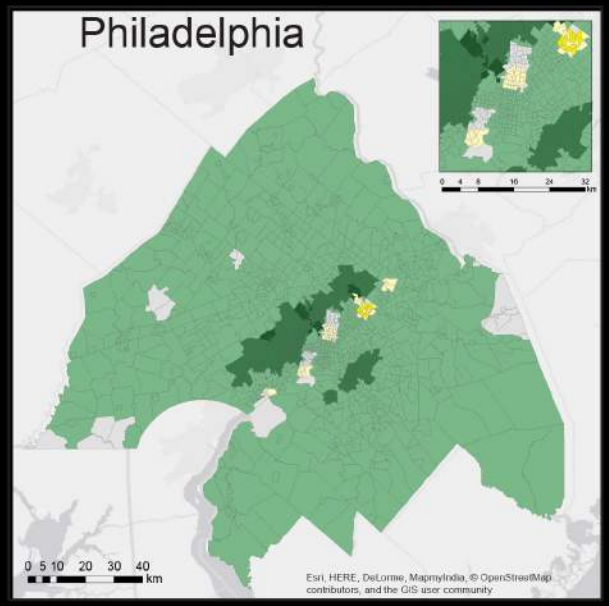
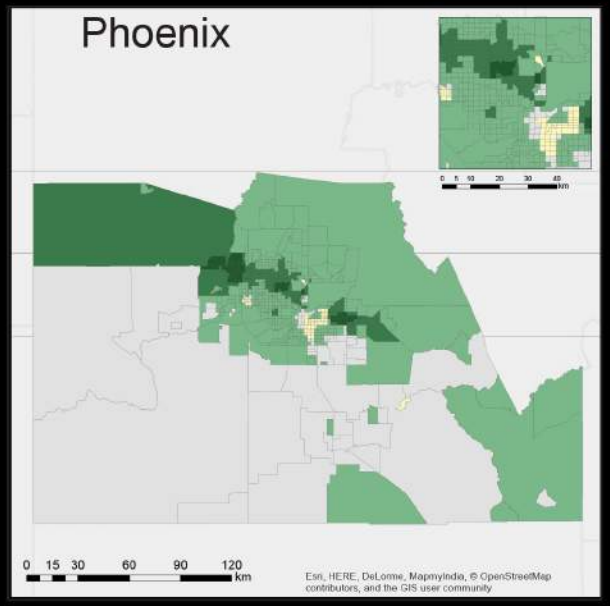
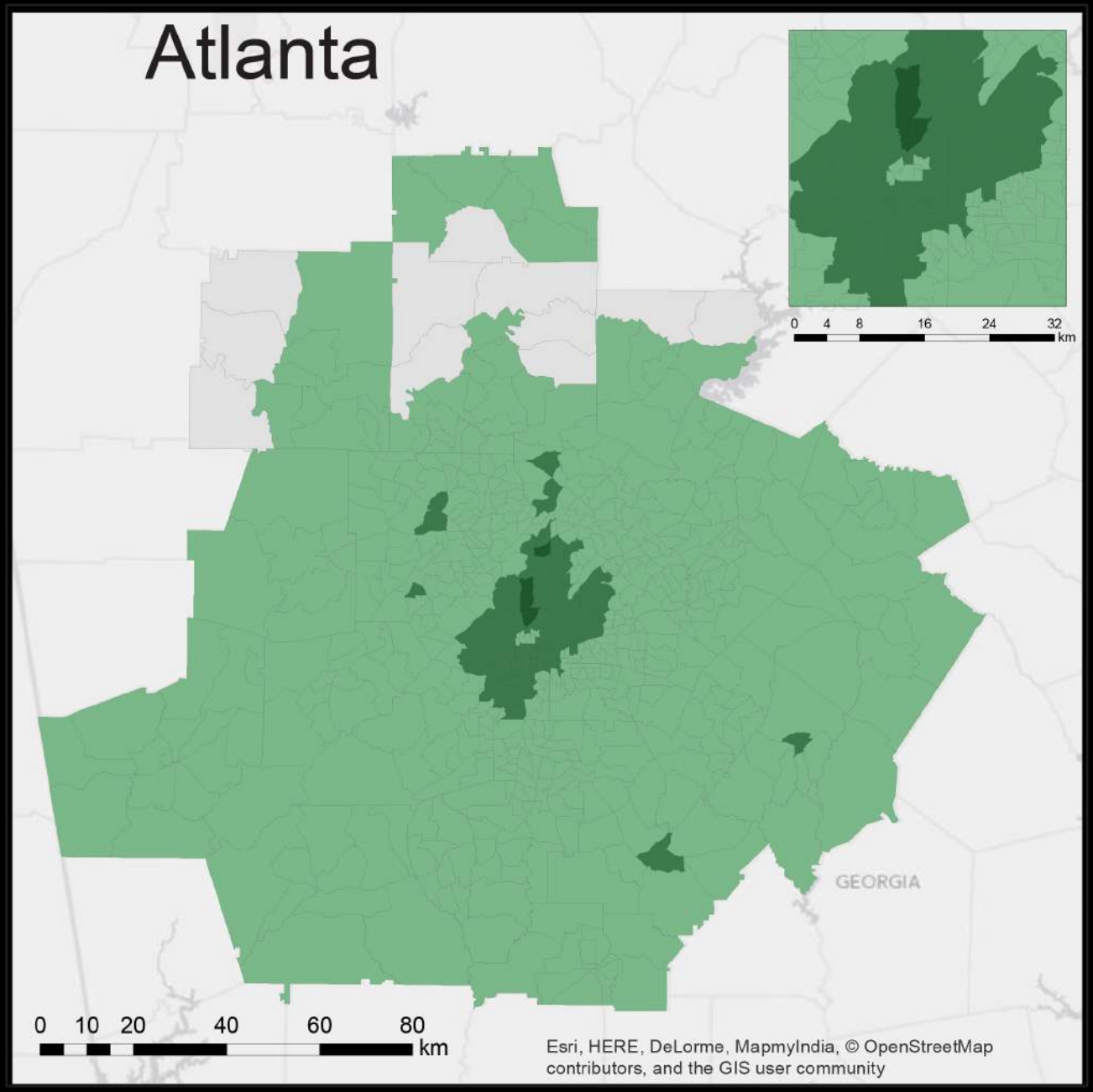




change in mortality/100,000

- more than 2 increase
- 1 to 2 increase
- less than 1 increase
- minimal change
- less than 1 decrease
- 1 to 2 decrease
- more than 2 decrease



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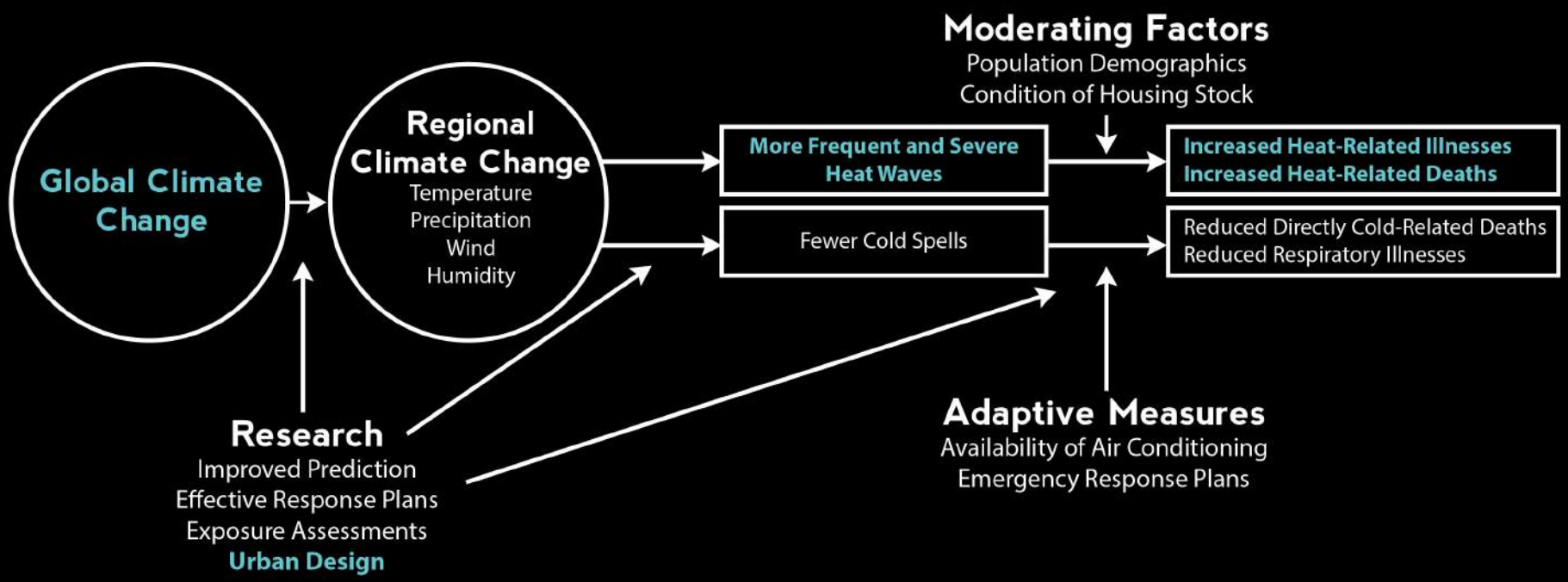

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