CLIMATE ADAPTATION
RESEARCH SYMPOSIUM

MEASURING & REDUCING SOCIETAL IMPACTS

Equitable Adaptation to Climate-Related Flood Risks: Part 2

Thanks for joining us!
The session will begin shortly.

UCLA Luskin Center for Innovation

Thank you to our event collaborators

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Widgets are resizable and movable

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Have a question for presenters? Click the ? icon.

Alique Berberian
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Ph.D. Student, UCLA, Environmental Health Sciences

Excess Contaminant Releases During Hurricane Harvey: Implications of Natech Disasters for Climate Justice

Excess Contaminant Releases During Hurricane Harvey: Implications of Natech Disasters for Climate Justice

Alique Berberian, MPH, MIA
UCLA Climate Adaptation Research Symposium

Natural technological disasters

Natech

Cascading events in which natural hazards trigger technological disasters or accidents that release hazardous substances.

Motiva Enterprises LLC in Port Arthur, TX | Reuters/Andres Latif

Climate justice concerns

Texas Gulf Coast is a major petrochemical hub.

Houston Ship Channel industrial corridor has:

- 866 industrial facility parcels
- 5 refineries
- 3400 above ground storage tanks

Health risks to residents living near industrial sites who are disproportionately low-income people of color.

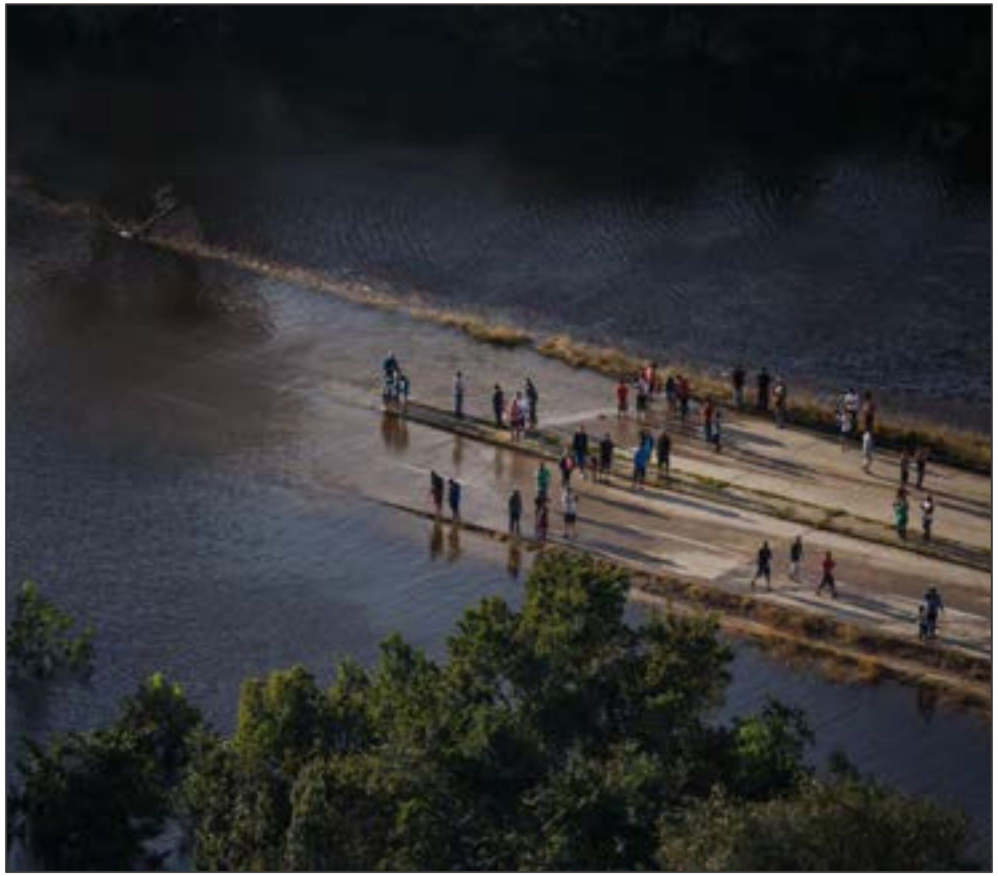
Flooded residential neighborhood near Interstate 10 in Houston, TX | Marcus Yam / Los Angeles Times

Prior research

Releases of hazardous substances in the US Gulf Coast due to Hurricanes Katrina and Rita (Ruckart et al. 2008).

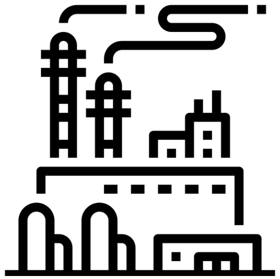
People of color and low SES households experienced inequitable distribution of flooding during Harvey (Chakraborty et al. 2019; Collins et al. 2019).

Neighborhoods with higher % Hispanic and poor residents had greater densities of petrochemical facilities reporting Harvey-related chemical releases (Flores et al. 2021)



Houston, TX | Marcus Yam / Los Angeles Times

Project aims



Evaluate the extent, type and location of **excess contaminant releases from hazardous sites due to Hurricane Harvey** in 41 Texas counties designated for relief assistance by the Federal Emergency Management Agency (FEMA).

Analyze excess toxic releases by **region, event type and neighborhood demographics** to characterize types of industries most likely to have excess contaminant releases and potential exposures to vulnerable populations.

Hurricane Harvey (2017)

Made landfall on August 25, 2017 near Port Aransas and Port O'Connor on the Texas Gulf Coast.

Flooding displaced more than 30,000 people. Damaged or destroyed over 200,000 homes and businesses.

Rainfall, flooding and winds caused toxic material releases from industrial sites into local air, water and soil.

Tropical Storm Harvey in the western Caribbean Sea | NOAA's GOES-East satellite

Methods

Study period

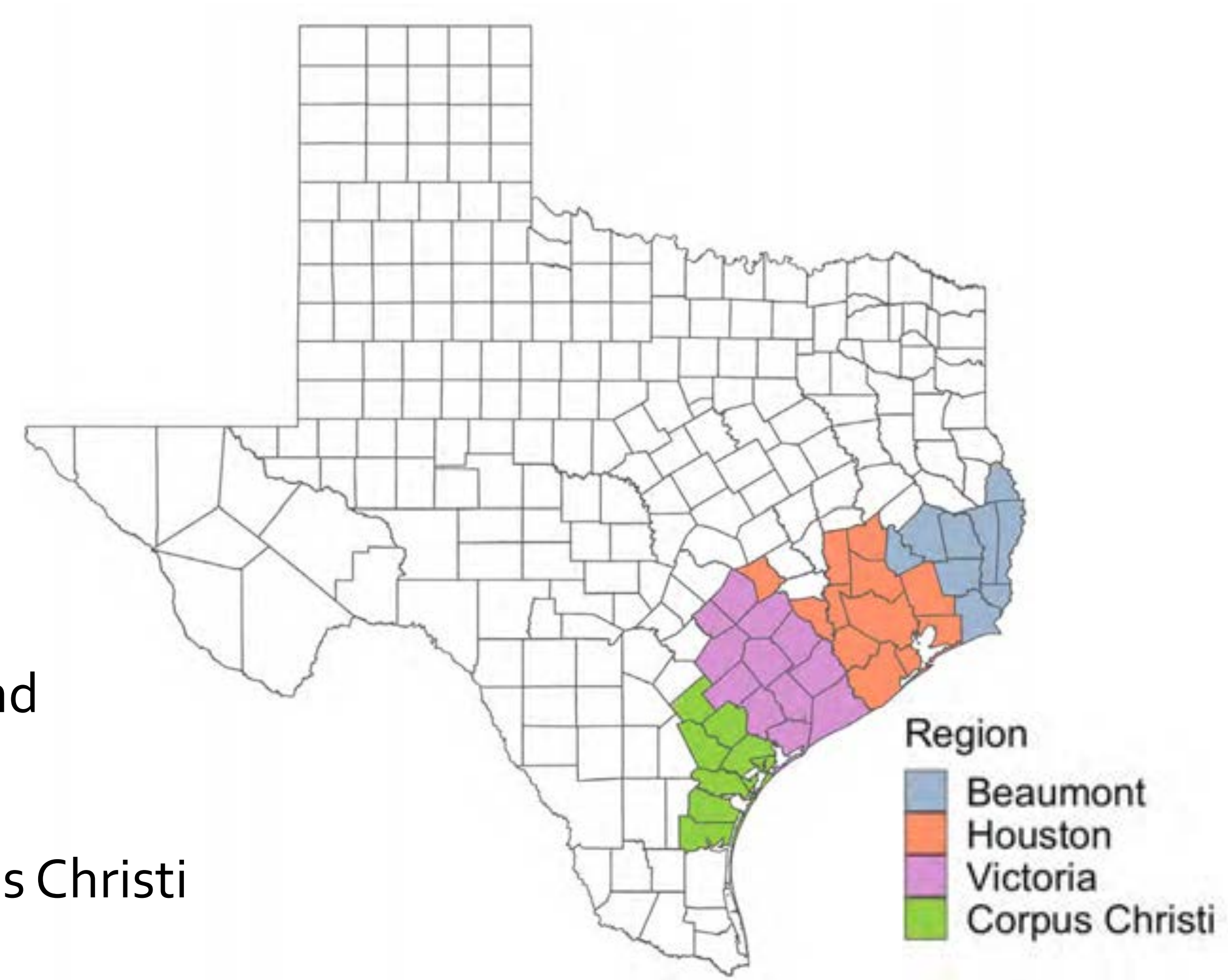
August 23 – September 10, 2017

Reference periods in 2015, 2016, 2018, 2019 include similar dates

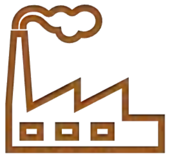
Study Area

41 Texas counties designated for individual and public relief assistance by FEMA

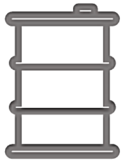
Regions: Beaumont, Houston, Victoria, Corpus Christi



Data Sources



Texas Commission on Environmental Quality's (TCEQ) Air Emissions and Maintenance Events (AEME) database: secondary data on the **location of excess air emissions** (2015-2019)



US Coast Guard's (USCG) National Response Center (NRC) Incident Reporting Information System (IRIS): secondary data on **accidental spills and chemical releases to land and water** (2015-2019)

American Community Survey (ACS): **sociodemographic information** (2015-2019) at the block group (BG) level

Excess contaminant releases

Extracted excess **air emissions incidents + accidental spills and chemical releases** attributable to Hurricane Harvey and compared to reference periods.

<u>**TCEQ's AEME**</u>
Excluded CO2 and methane incidents.
Geocoded incidents for which some locational info was not available.

<u>**USCG's NRC**</u>
Restricted to incidents caused by flood, tornado, hurricane, natural phenomenon or unknown reasons.

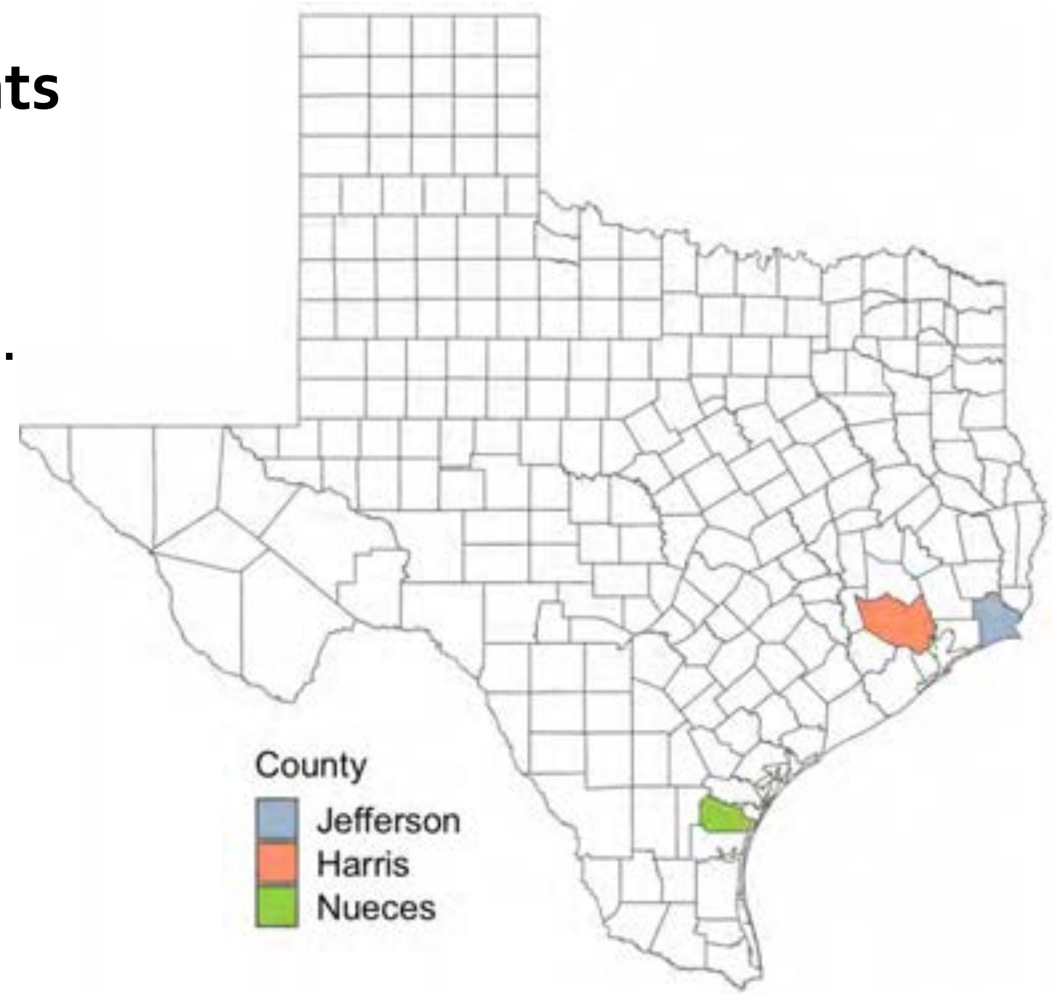
Port Arthur, Texas | *Thomson/Reuters*

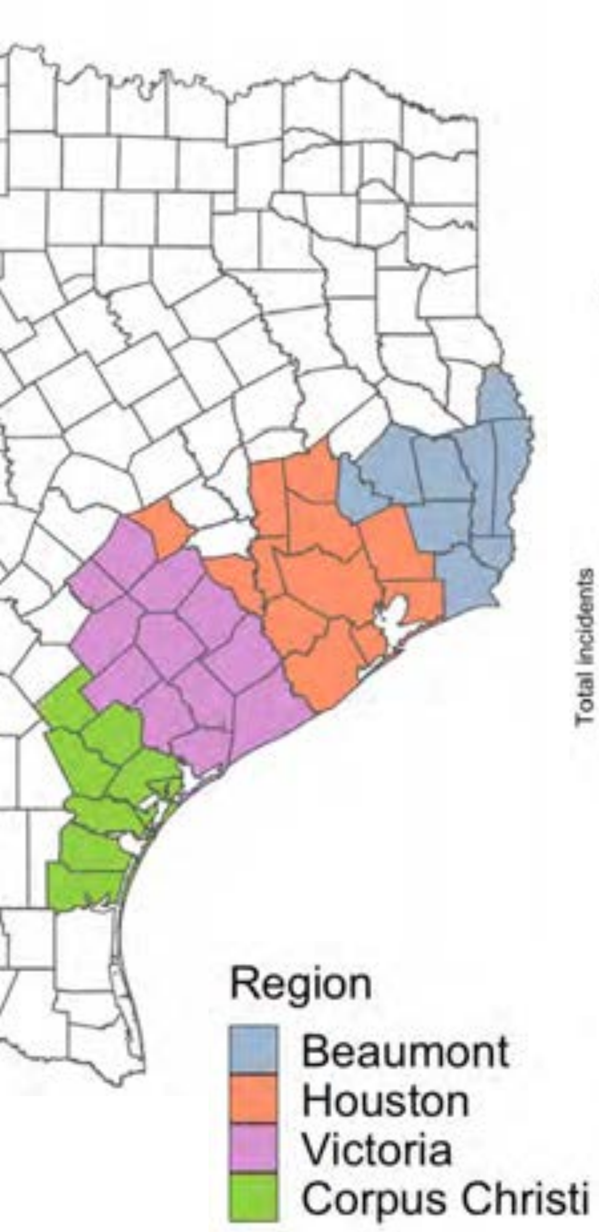
Demographic Analysis

Joined **locational data on air emissions incidents during Harvey (2017) with neighborhood demographics** to determine the distribution of incidents with respect to vulnerability indicators.

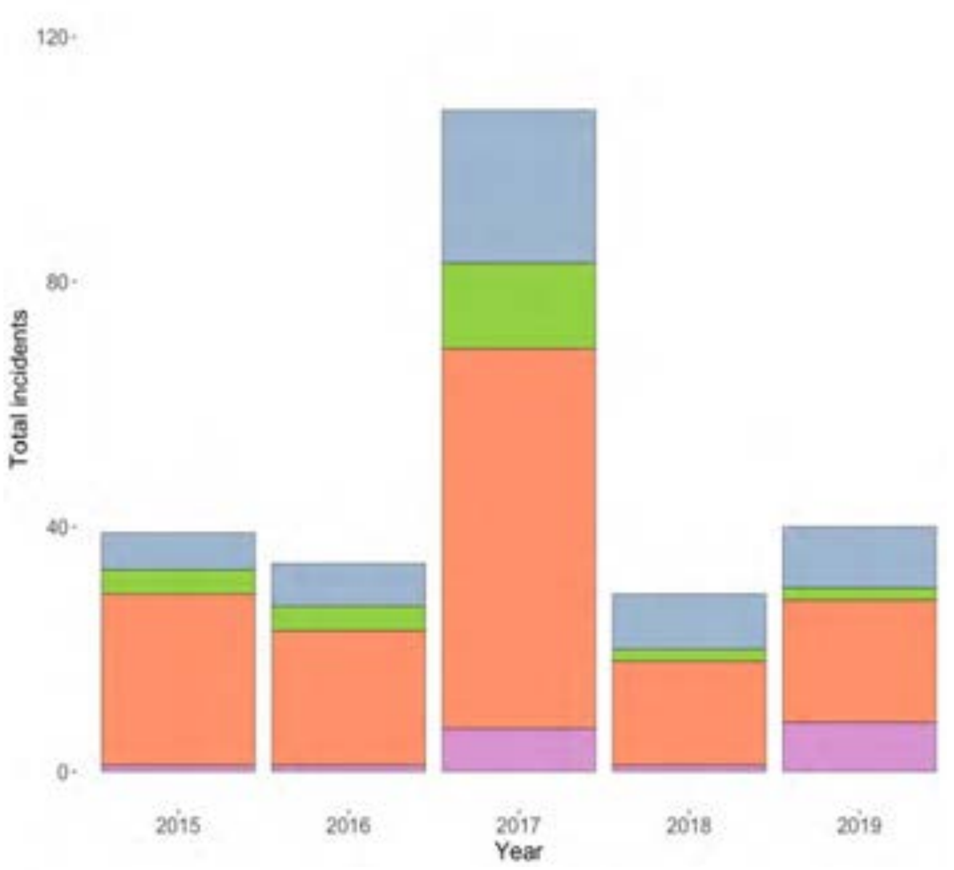
Compared demographics in **exposed** (within 3km) BGs to **unexposed** (within 5-10km) BGs in 3 counties.
(Note: results sensitive to different buffer distances)

Demographic variables: % people of color, % poverty, % renters, % linguistically isolated, % without a vehicle, median household income

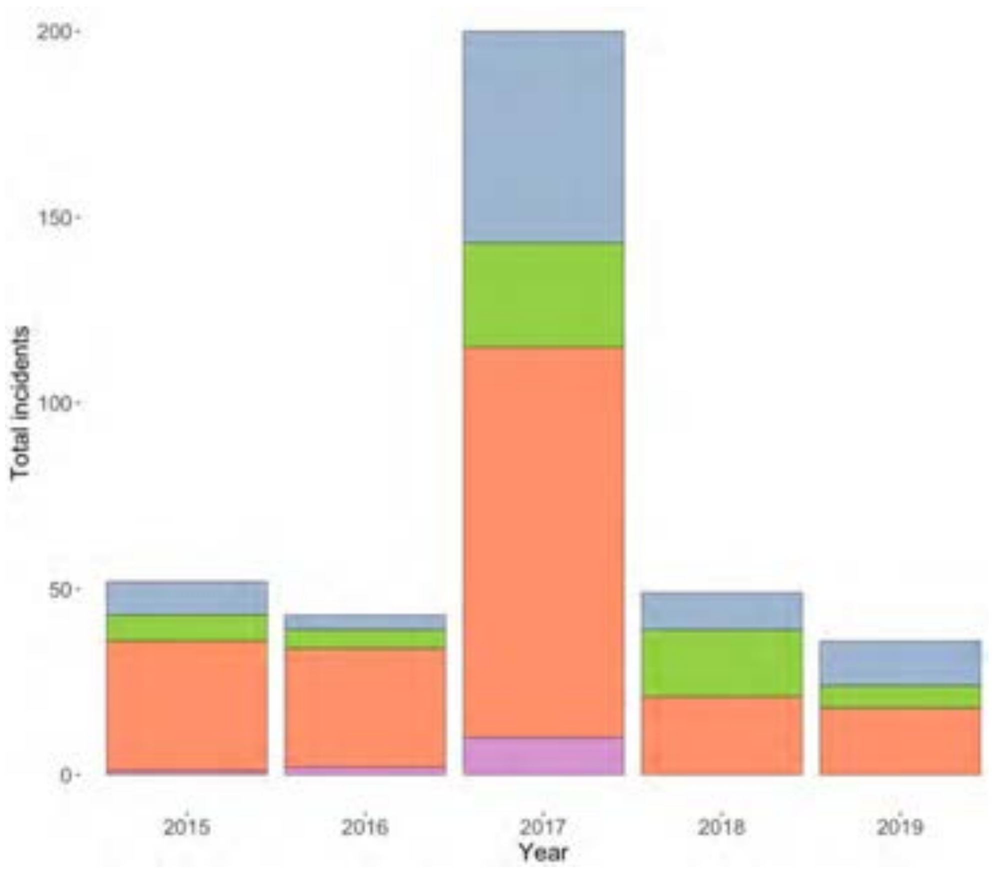




TCEQ Air Emissions Incidents by Region During Harvey (2017) Compared to Reference Periods



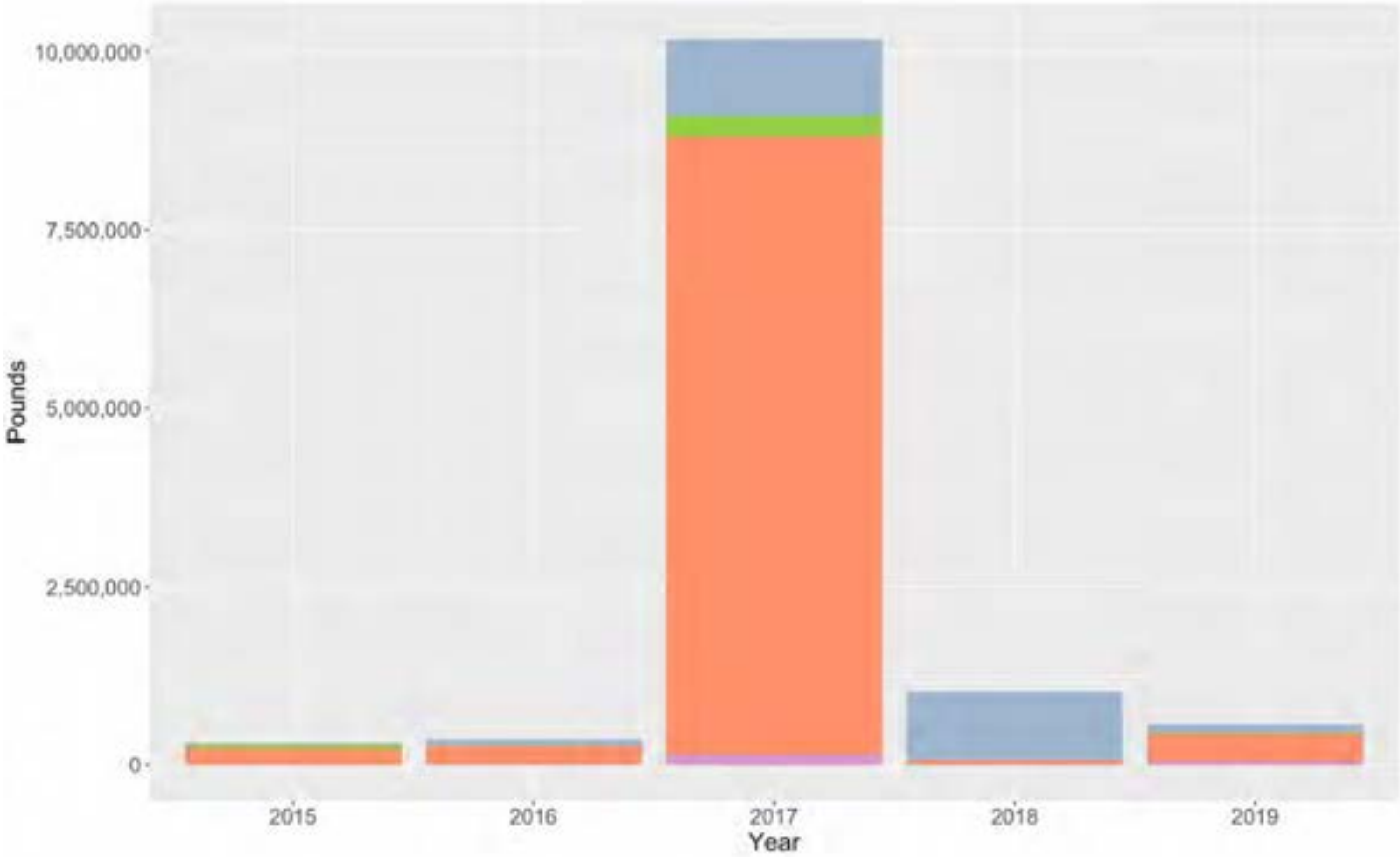
USCG NRC Incident Reports by Region During Harvey (2017) Compared to Reference Periods



PRELIMINARY REULTS. PLEASE DO NOT CITE.

Air Emissions in Pounds by Region During Harvey (2017) Compared to Reference Periods

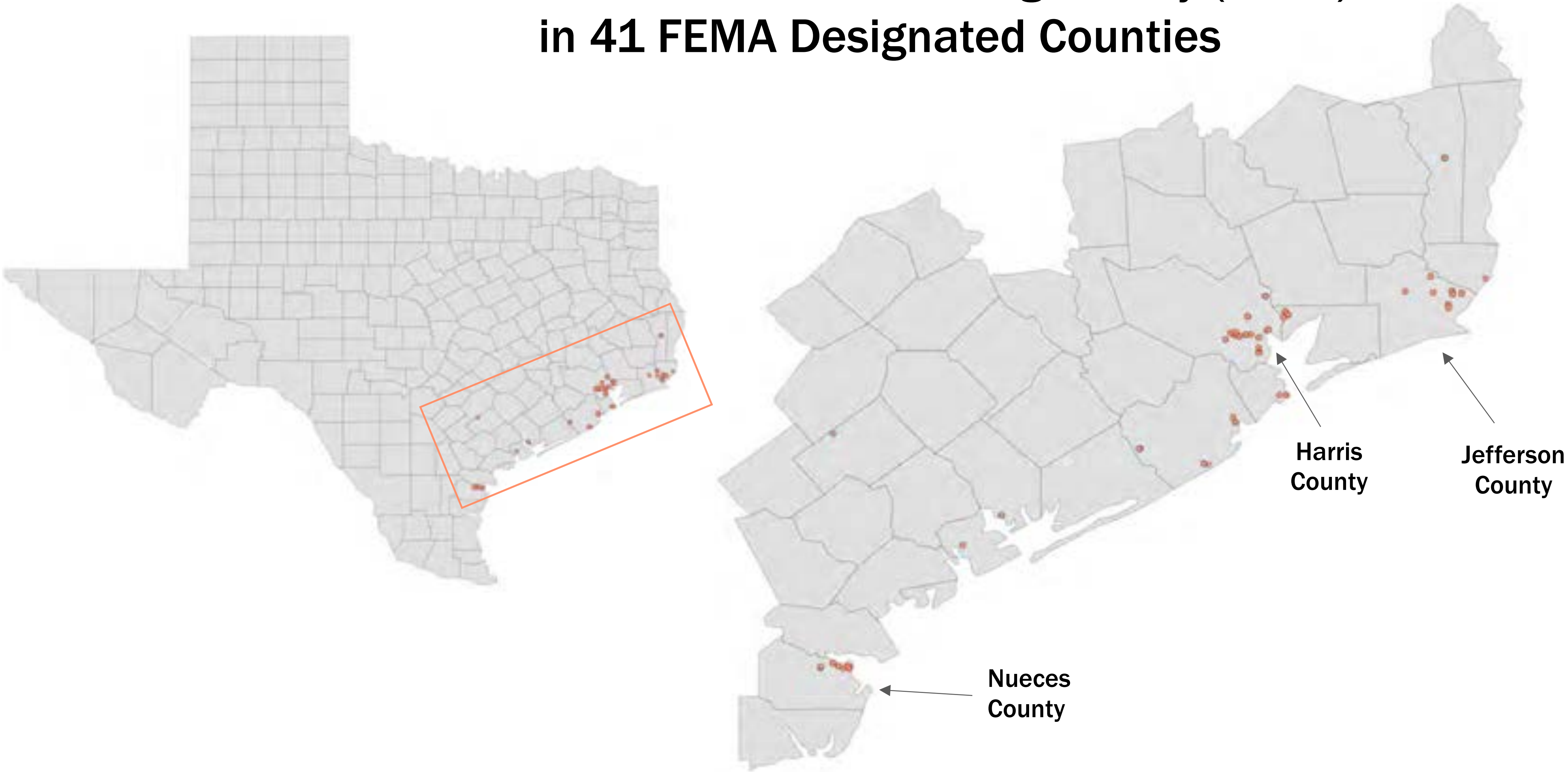
Data source: TCEQ



Introduction | Methods | **Results** | Conclusion

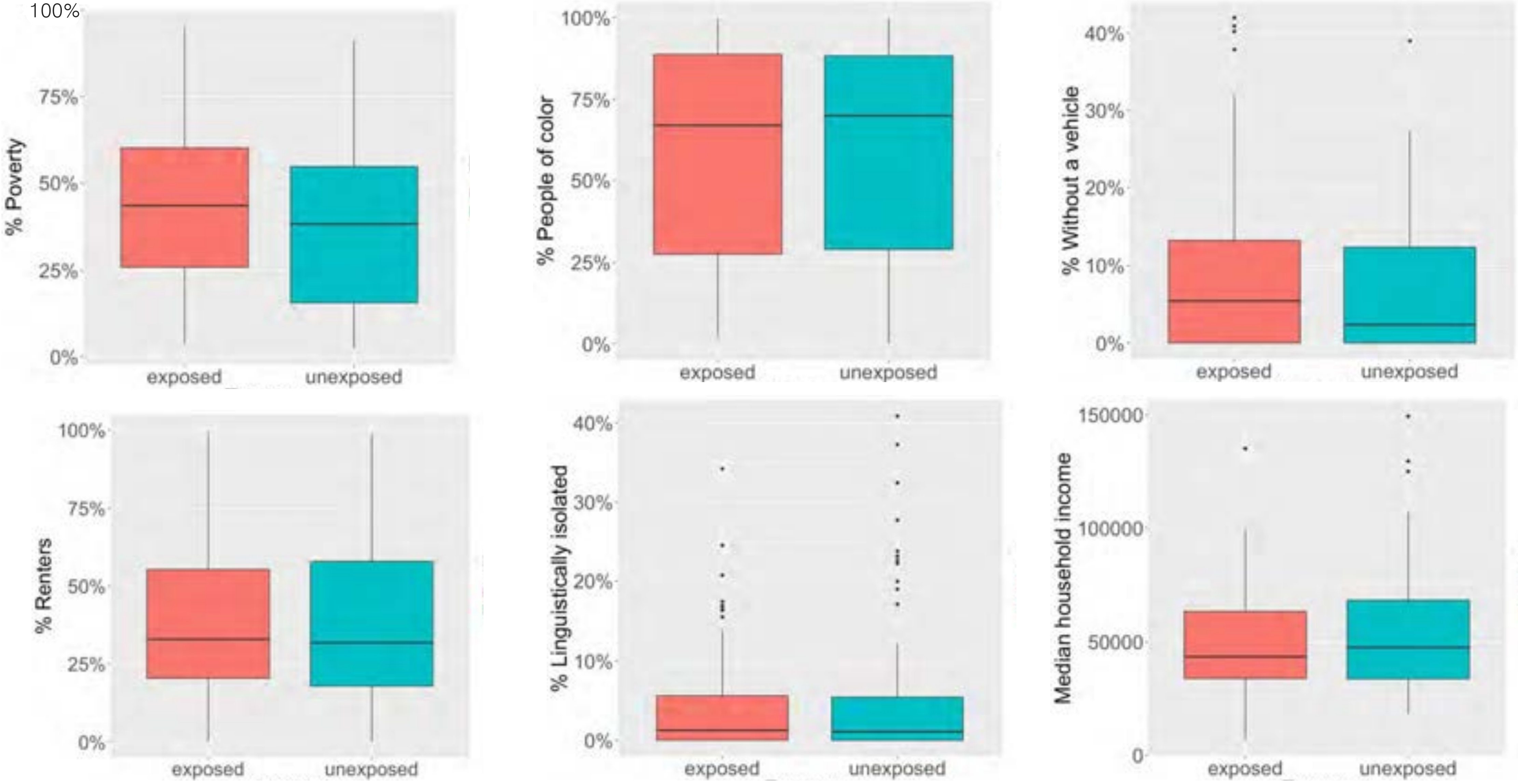
PRELIMINARY REULTS. PLEASE DO NOT CITE.

Air Emissions Incidents During Harvey (2017) in 41 FEMA Designated Counties



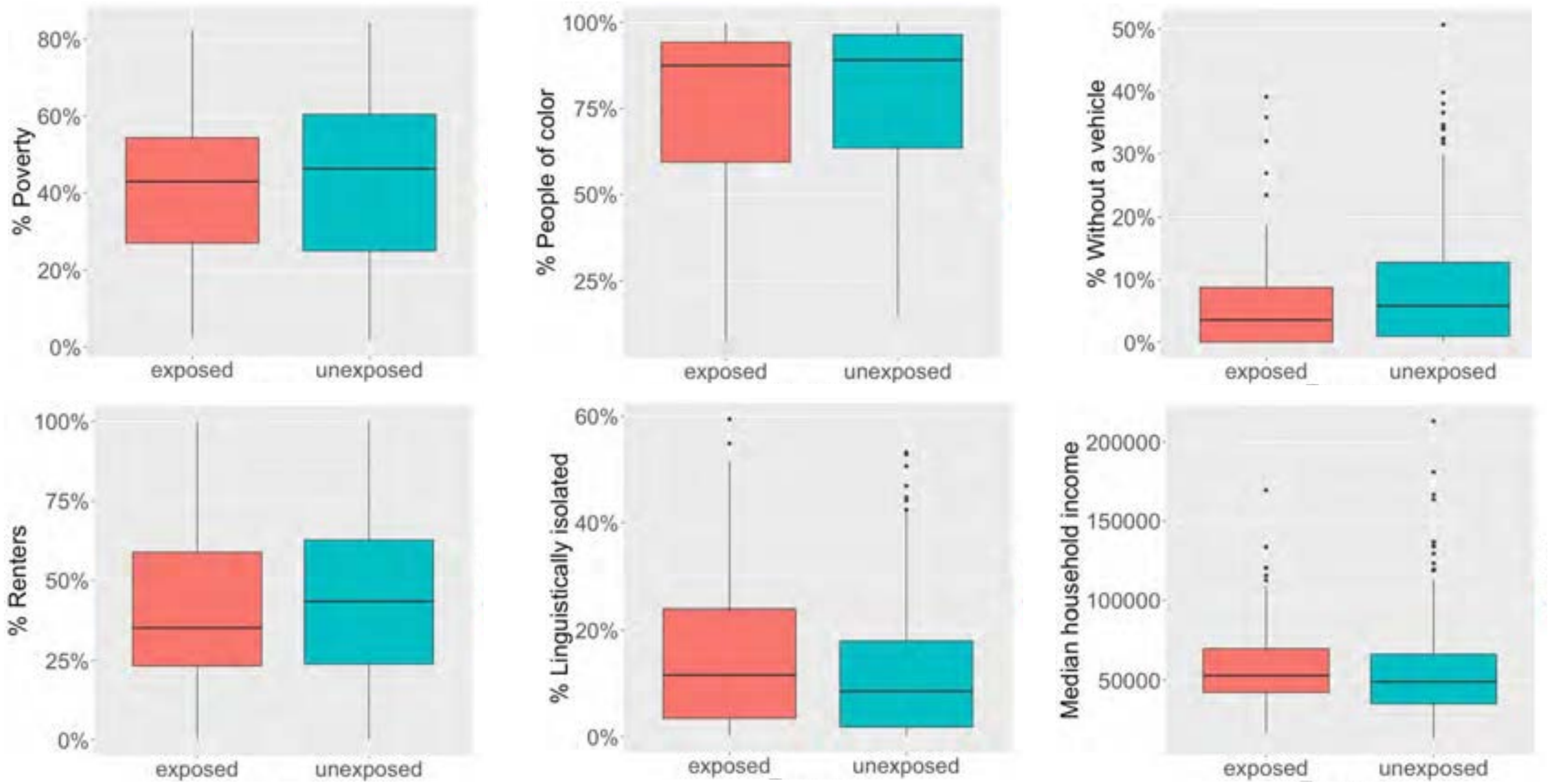
PRELIMINARY REULTS. PLEASE DO NOT CITE.

Jefferson County demographics in exposed vs. unexposed BGs



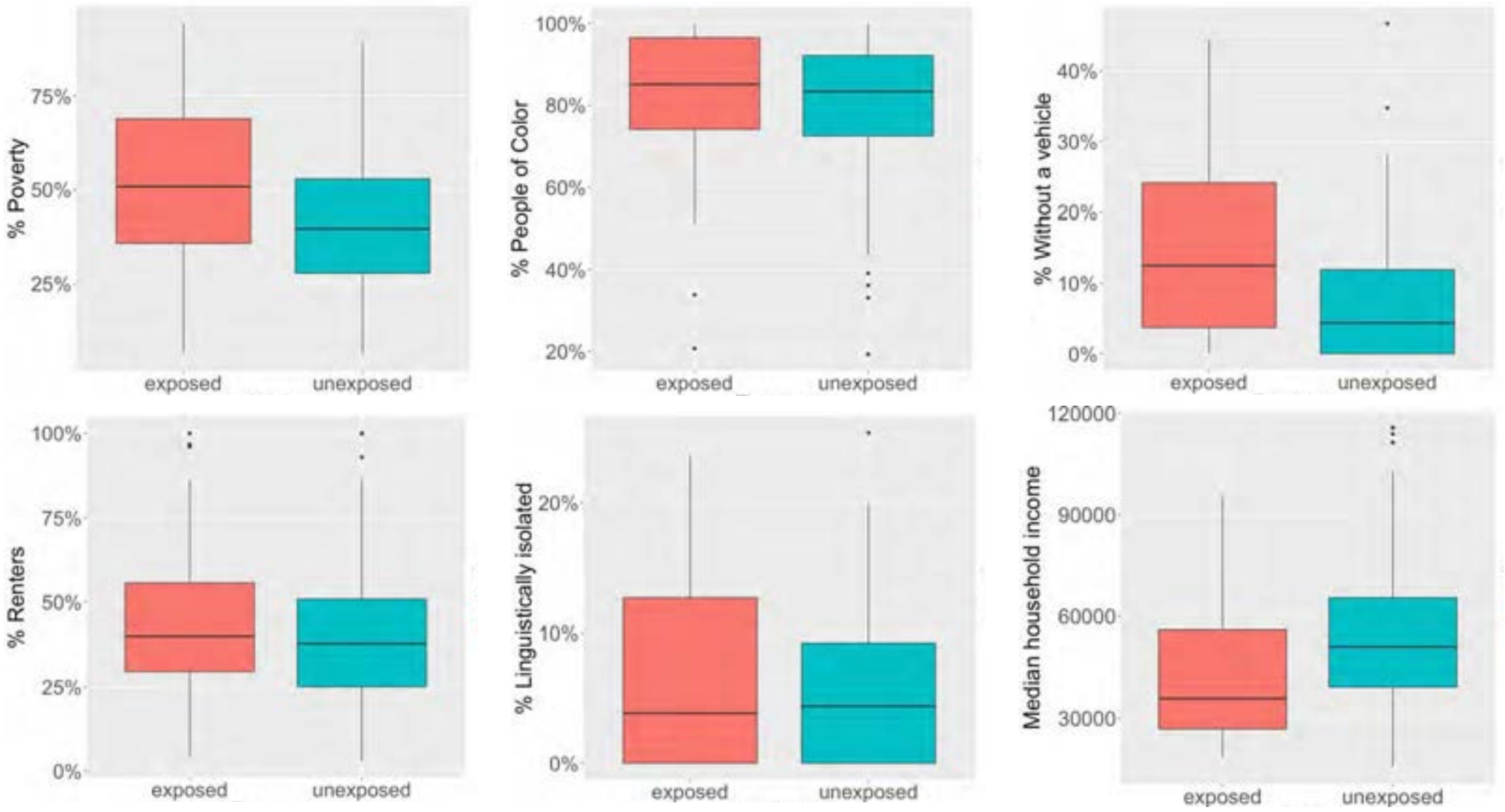
PRELIMINARY REULTS. PLEASE DO NOT CITE.

Harris County demographics in exposed vs. unexposed BGs



PRELIMINARY REULTS. PLEASE DO NOT CITE.

Nueces County demographics in exposed vs. unexposed BGs



PRELIMINARY REULTS. PLEASE DO NOT CITE.

Summary

- Reports of excess air emissions and other contaminant releases during Harvey far exceeded reports during the reference periods.

- Preliminary analyses of three Texas counties suggest that residential proximity to air emissions incidents during Harvey is associated with higher social vulnerability. Results should be interpreted with caution.

Citgo oil refinery, Corpus Christi, Texas | *Eddie Seal/Bloomberg*

Next Steps

- Join TCEQ and USCG NRC excess contaminant release datasets and accurately geocode incidents.

- Consider other buffer distances and additional vulnerability indicators for demographic analysis.

- Expand demographic analysis to include all 41 counties.

Downtown Houston | *Paul Jordan Anderson/DoubleHorn Photography*

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Lucas Zucker
Central Coast Alliance for a Sustainable Economy (CAUSE)

Research funded by US EPA STAR (#RD – 84003901)

Seigi Karasaki

Ph.D. Student, UC Berkeley

Toxic Tides and Environmental Justice: Social Vulnerability to Sealevel Rise and Flooding of Contaminated Sites in Coastal California

Toxic Tides:
Sea Level Rise, Hazardous Sites, & Environmental Justice in California

UCLA Climate Adaption Symposium
September 8 - 9, 2021

Seigi Karasaki, UC Berkeley

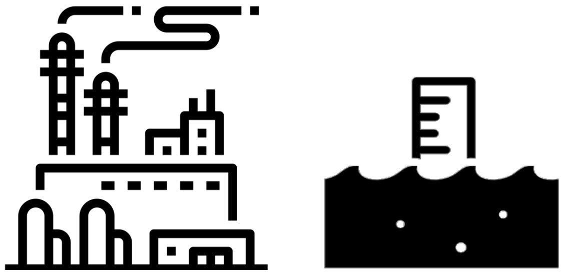
Motivation

The coming change
Climate change & rising sea levels

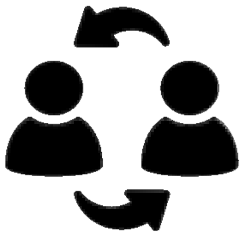
The hazards
Facilities with toxic chemicals near tideline

The people
Poor communities and communities of color are more likely to live near hazardous sites

Project Goals



Characterize the environmental health hazards for vulnerable populations in coastal California posed by projected sea level rise (SLR)-driven flooding of hazardous sites



Disseminate our findings through an online mapping interface and in-person roundtables

Assessing flood risk at hazardous sites due to sea level rise

Approach

flood extent | facilities | vulnerability

PSR LA Physicians for Social Responsibility Los Angeles

WE ACT FOR ENVIRONMENTAL JUSTICE

t.e.j.a.s Texas Environmental Justice Advocacy Services

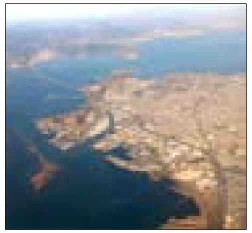
PUBLIC HEALTH INSTITUTE®

APEN ASIAN PACIFIC ENVIRONMENTAL NETWORK

CAUSE Central Coast Alliance United for A Sustainable Economy

Iteratively consult an advisory committee of EJ experts to inform study design & dissemination strategy

Identify the input variables of concern:



What are the numbers and types of hazardous facilities threatened by flooding due to SLR?

What are the baseline characteristics of populations in proximity to at-risk sites?

Approach

flood extent | facilities | vulnerability

Sea Level Rise (Year/Scenario)

Current Flood Height

Current Ground Elevation

Digital Elevation Model
(NOAA)

Approach

flood extent | facilities | vulnerability

Sea Level Rise (Year/Scenario)

Current Flood Height

Current High Tide Line
(NOAA)

Current Ground Elevation

Digital Elevation Model
(NOAA)

Approach

flood extent | facilities | vulnerability

Sea Level Rise (Year/Scenario)

Current Flood Height

Flood Level (Climate Central)

Current High Tide Line
(NOAA)

Current Ground Elevation

Digital Elevation Model
(NOAA)

Approach

flood extent | facilities | vulnerability

Source: Union of Concerned Scientists

Sea Level Rise (Year/Scenario)

Sea Level Rise
(Kopp et al 2014)

+

Current Flood Height

Flood Level (Climate Central)

Current High Tide Line
(NOAA)

vs.

Current Ground Elevation

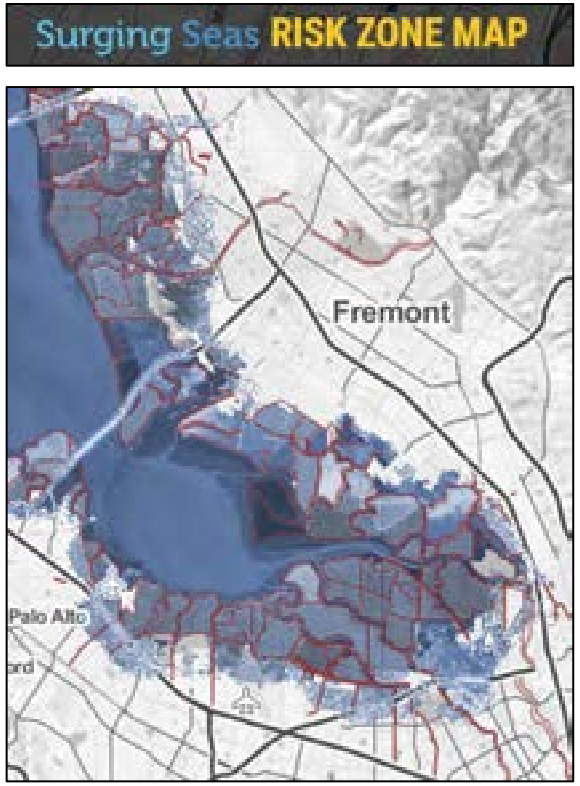
Digital Elevation Model
(NOAA)

Approach

flood extent | facilities | vulnerability

Time frames	Future emissions	Degree of uncertainty
2000 2050 2100	RCP 4.5 (low) + RCP 8.5 (high)	Best estimate (mean)

CLIMATE CENTRAL

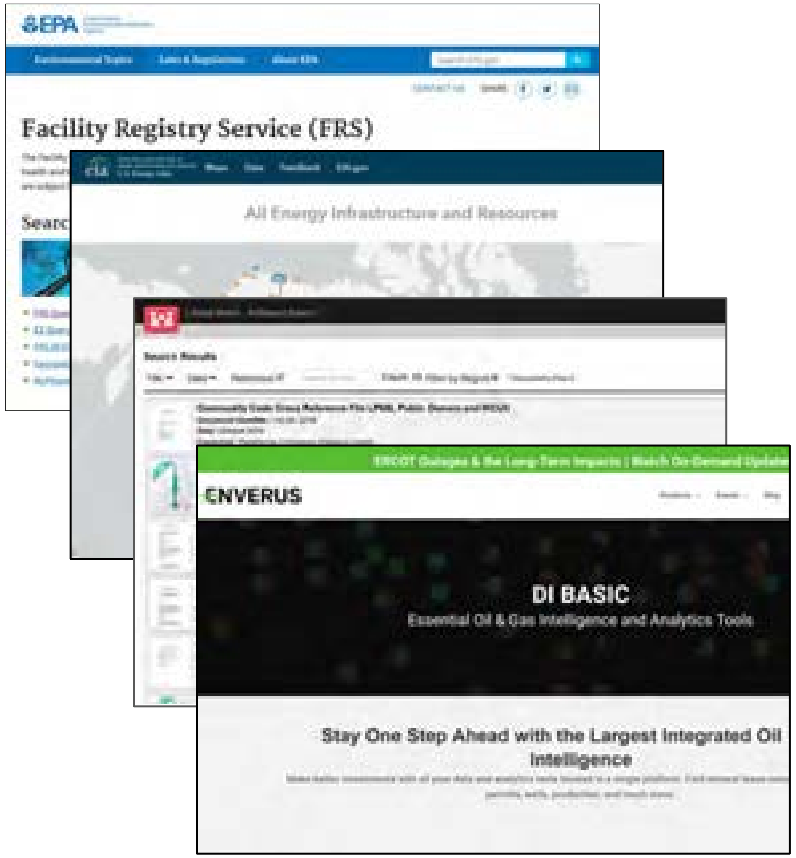


Water level with 3 ft. of sea level rise, San Francisco Bay

Levees

We estimate sea level rise using Kopp et al.'s 2014 Sea Level Rise Model

Approach | flood extent | **facilities** | vulnerability



FRS dataset with facility information (CA)
471,336

Remove facilities with vague or inaccurate location data
443,679

Filter for FRS facility types of interest
7,380

Further filtering and cleaning
5,758

Merge FRS dataset with ENVERUS
5,758 + 5,846

11,604 facilities total

Fossil fuel facilities from EIA and USACE
+ 102

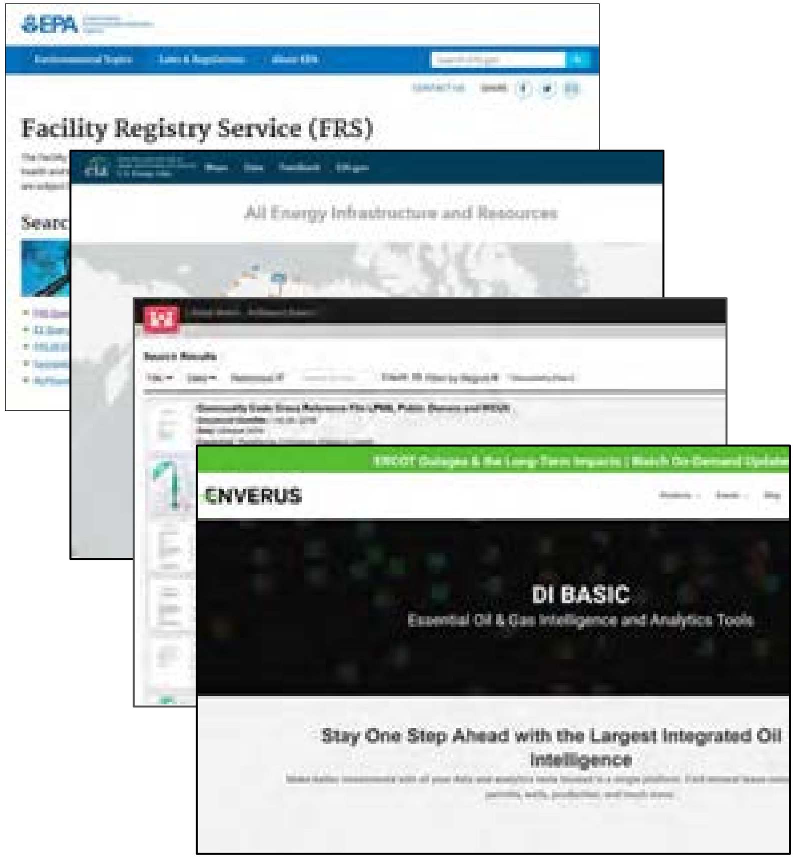
Remove facilities:
- without valid coordinates after geocoding process
- with duplicated lat/lon coordinates with other sites and no valid address information
- with clearly incorrect locational data (e.g. over the water)

Oil and gas wells from ENVERUS eligible for inclusion
+ 5,846

Cleaning and Categorization Process for Hazardous Facilities

Approach

flood extent | **facilities** | vulnerability



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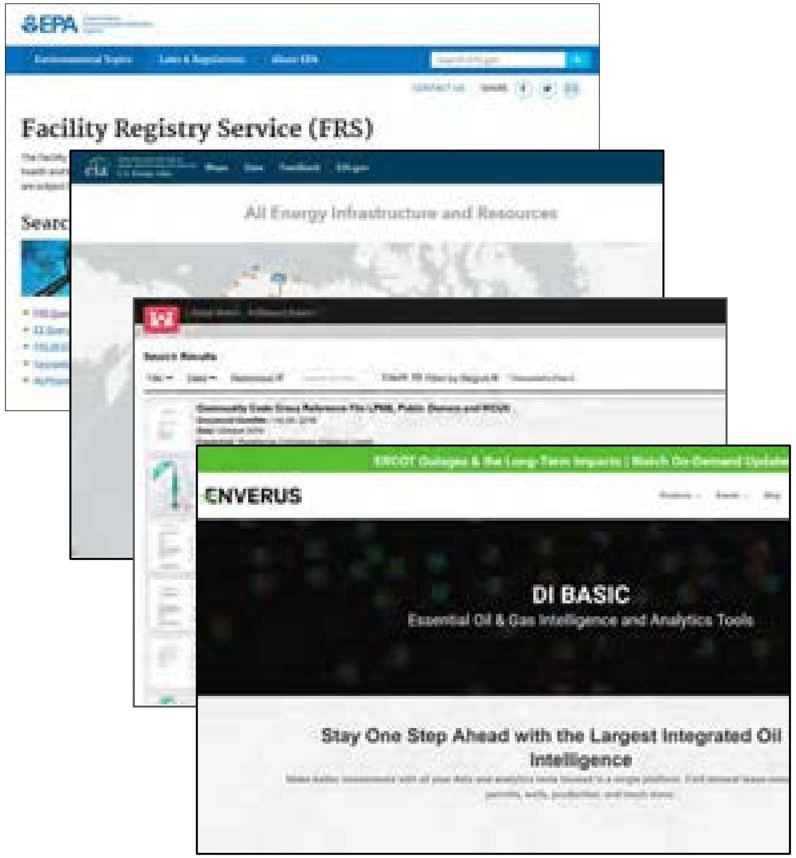
Approach | flood extent | **facilities** | vulnerability



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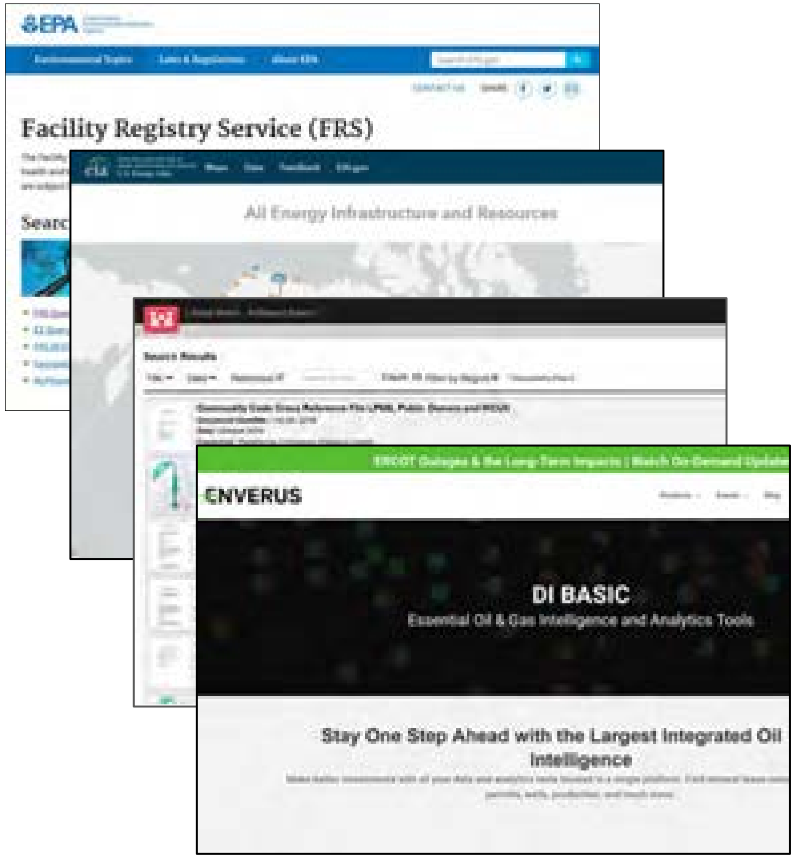

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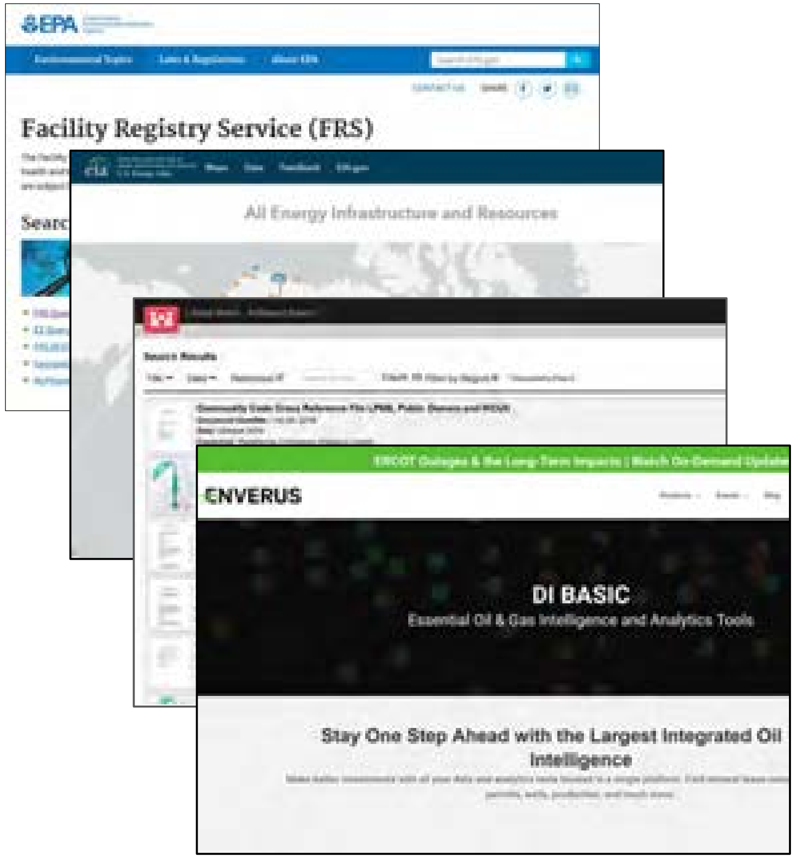

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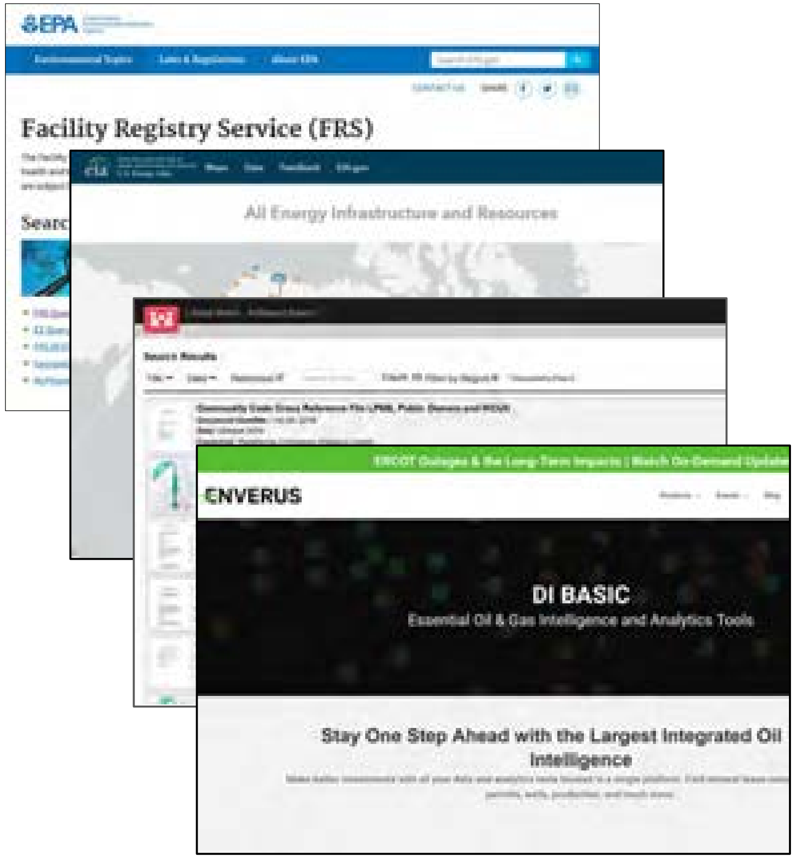
flood extent | **facilities** | vulnerability



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Cleaning and Categorization Process for Hazardous Facilities

Flood Exposure Metrics

Metric	Definition	Value range	Our threshold
Expected Annual Exposure (EAE)	Expected probability of a site being flooded at least once per year	0 - 1	> 0.01
% site flooded	Percent area of a site being flooded.	0 – 100%	> 25%

EAE = 0.01 corresponds to a 1-in-100-year flood.

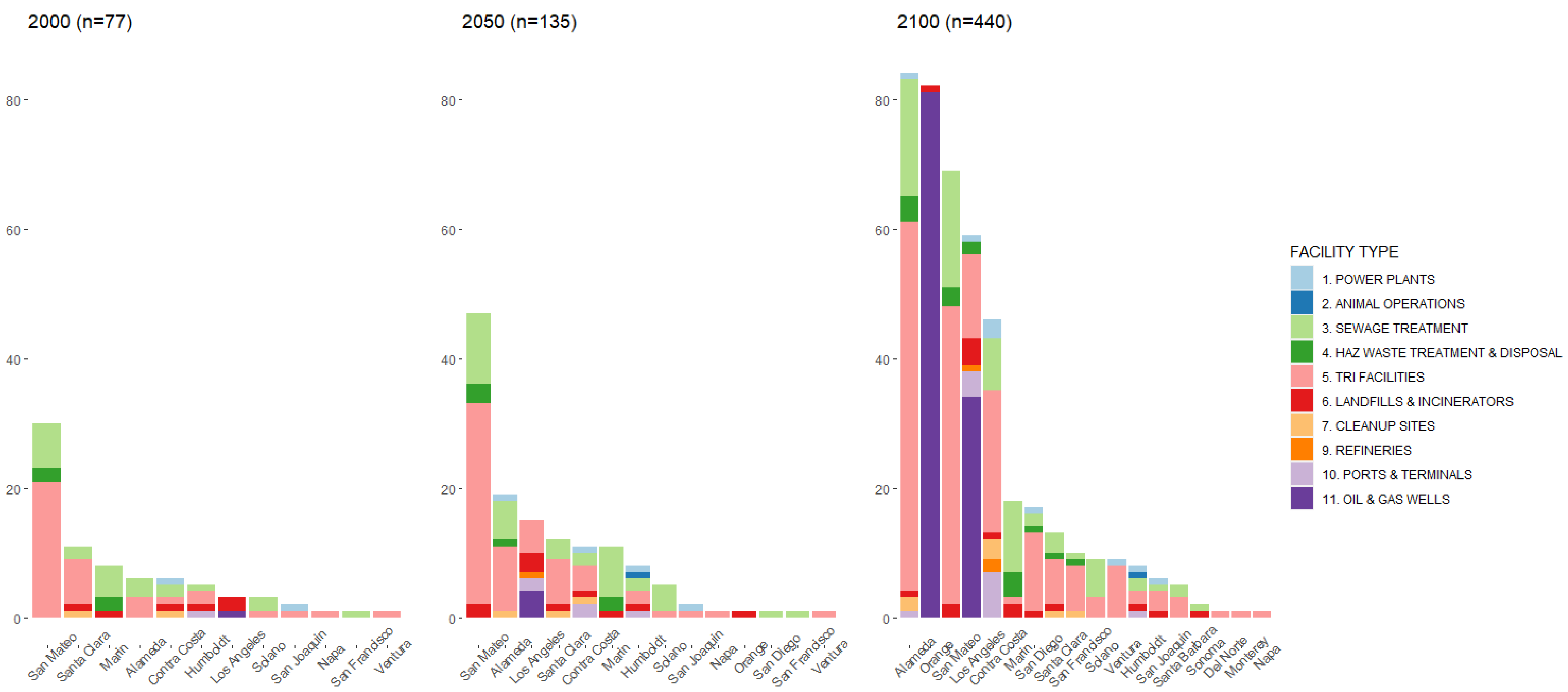
Approach | flood extent | **facilities** | vulnerability

Exposed facility count by category & year, coastal California metropolitan areas (RCP 8.5, ensemble mean)

Category	Total Number of Facilities	At-risk, 2000	At-risk, 2050	At-risk, 2100
POWER PLANTS (NUCLEAR AND FOSSIL FUEL)	79	2	4	9
ANIMAL OPERATIONS	42	0	1	1
SEWAGE TREATMENT FACILITIES	397	23	38	73
HAZARDOUS WASTE TREATMENT & DISPOSAL	110	4	6	16
TOXICS RELEASE INVENTORY FACILITIES	3668	38	63	187
SOLID WASTE LANDFILLS (INCLUDING INCINERATORS)	293	6	10	16
CLEANUP SITES & OTHER SITES WITH RADIOACTIVE MATERIAL	68	2	3	7
REFINERIES	13	0	1	3
FOSSIL FUEL PORTS AND TERMINALS	66	1	5	13
OIL & GAS WELLS	5808	1	4	115
Total	**10,544**	**77**	**135**	**440**

Approach

flood extent | **facilities** | vulnerability



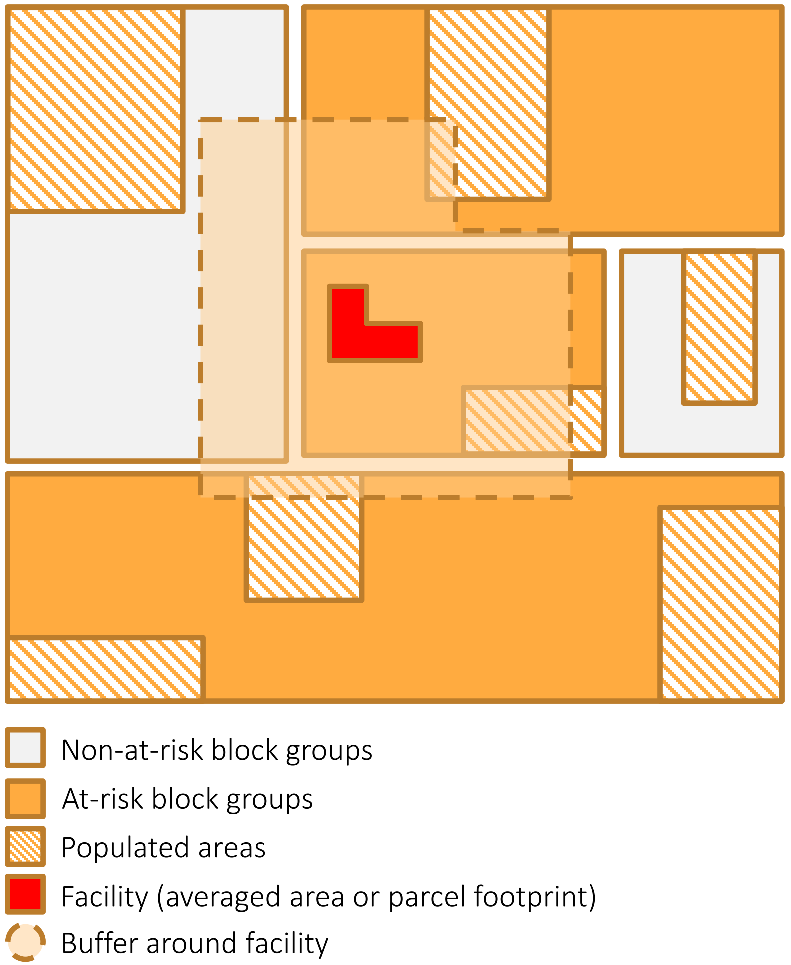
Approach

Dasymetric mapping for improved population estimates around facilities

→ Extrapolate 2010 census block population using 2015-19 5-year American Community Survey estimates

→ Distribute population estimates to residential tax parcels

Buffer based on actual parcel footprint



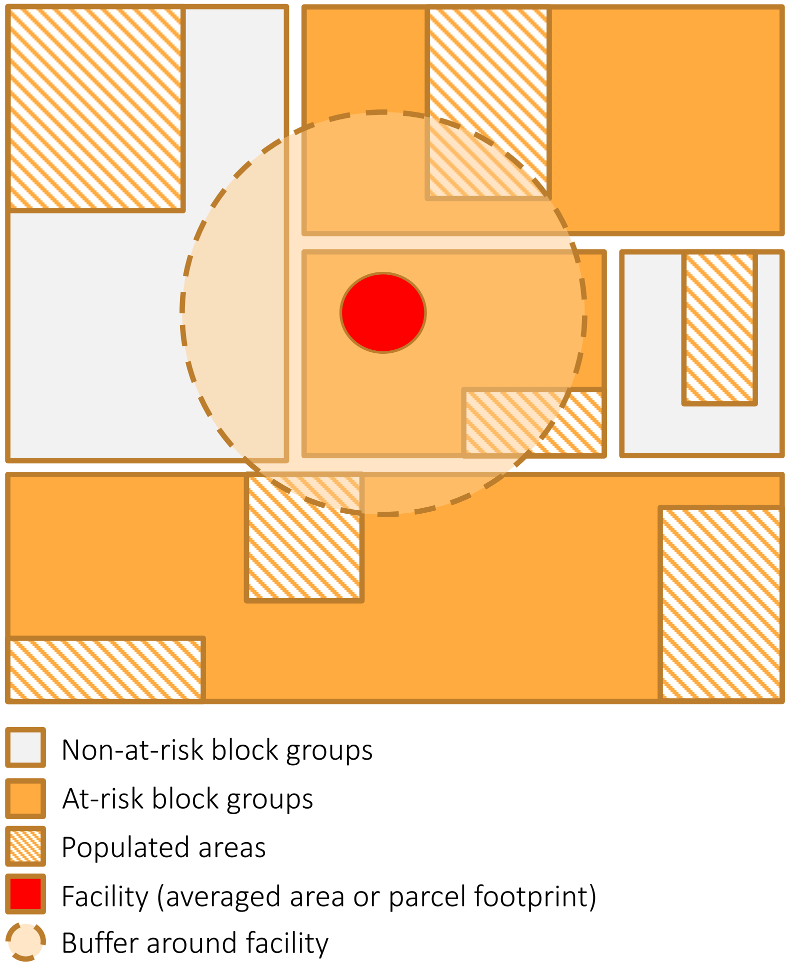
Approach | flood extent | facilities | **vulnerability**

Dasymetric mapping for improved population estimates around facilities

→ Extrapolate 2010 census block population using 2015-19 5-year American Community Survey estimates

→ Distribute population estimates to residential tax parcels

Buffer based on parcel footprint average



Approach

flood extent | facilities | **vulnerability**

VULNERABILITY FACTORS

1. Neighborhood demographics
2. Housing conditions and home ownership
3. Civic engagement capacity
4. Access to transportation
5. Access to material and social support, or disaster-related resources

KEY INDICATORS

1. Age; income; race / ethnicity; education; disadvantaged community status
2. Home ownership / affordable housing
3. Voter turnout
4. Vehicle ownership
5. Single-parent household; linguistic isolation

DATA SOURCES

2013 – 2017 American Community Survey five-year estimates (block-group level)
2017 CoStar Naturally Occurring Affordable Housing Analysis
2017 National Housing Trust Affordable Housing Programs
2012 – 2016 California statewide redistricting database / CalEnviroScreen

Bivariate model

$$Y_{ij} = \beta_0 + \beta_1 X_{ij} + \beta_1 n_{ij} + C_j + \varepsilon_{ij}$$

Bivariate model

$$Y_{ij} = \beta_0 + \beta_1 X_{ij} + \beta_1 n_{ij} + C_j + \varepsilon_{ij}$$

census block group i in county j

Bivariate model

measure of exposure

$$Y_{ij} = \beta_0 + \beta_1 X_{ij} + \beta_1 n_{ij} + C_j + \varepsilon_{ij}$$

census block group i in county j

Bivariate model

measure of exposure

$$Y_{ij} = \beta_0 + \beta_1 X_{ij} + \beta_1 n_{ij} + C_j + \varepsilon_{ij}$$

census block group i in county j

vulnerability indicator

Bivariate model

Number of hazardous facilities near census block group i in county j

measure of exposure

$$Y_{ij} = \beta_0 + \beta_1 X_{ij} + \beta_1 n_{ij} + C_j + \varepsilon_{ij}$$

census block group i in county j

vulnerability indicator

Bivariate model

$$Y_{ij} = \beta_0 + \beta_1 X_{ij} + \beta_1 n_{ij} + C_j + \varepsilon_{ij}$$

measure of exposure

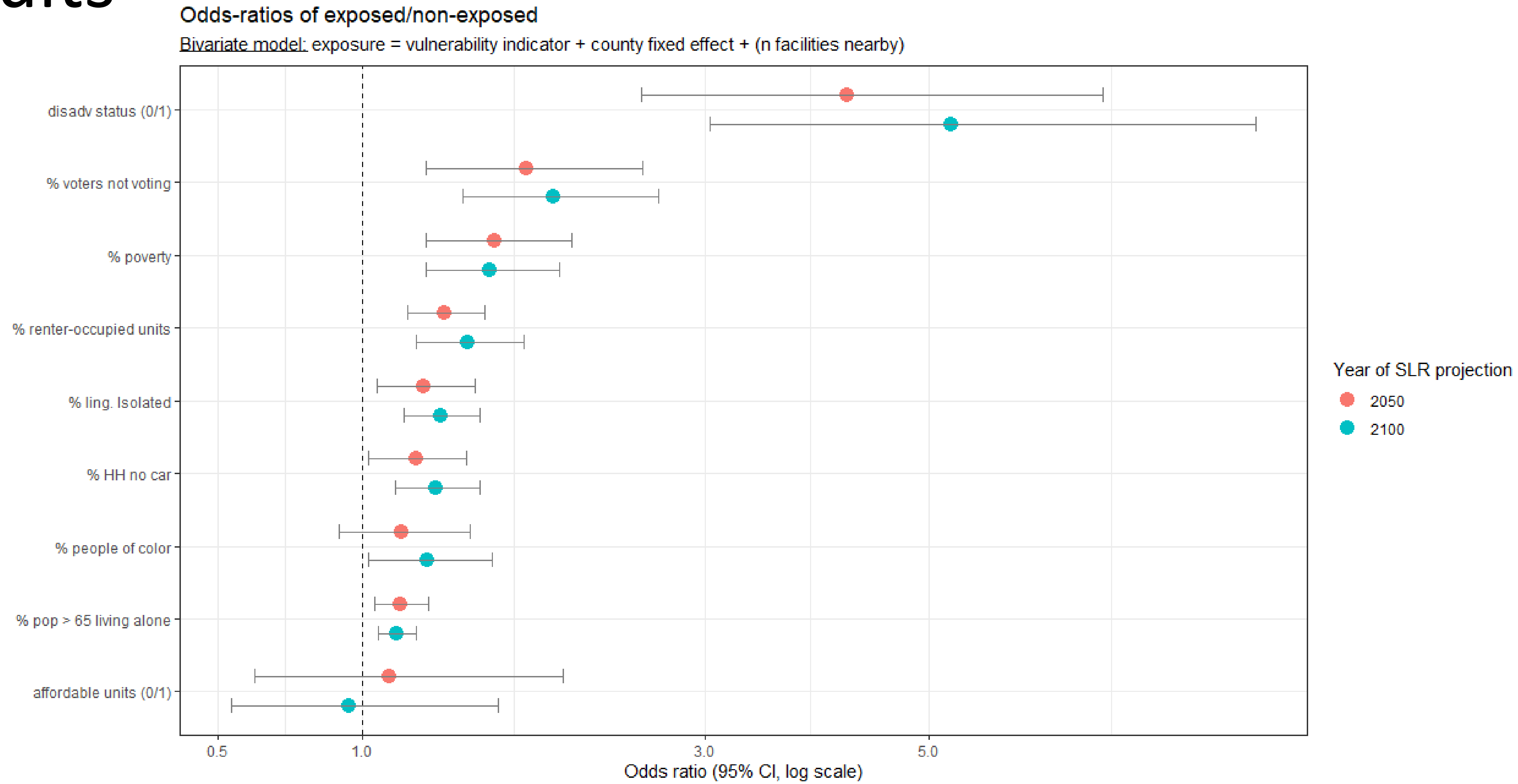
Number of hazardous facilities near census block group i in county j

census block group i in county j

vulnerability indicator

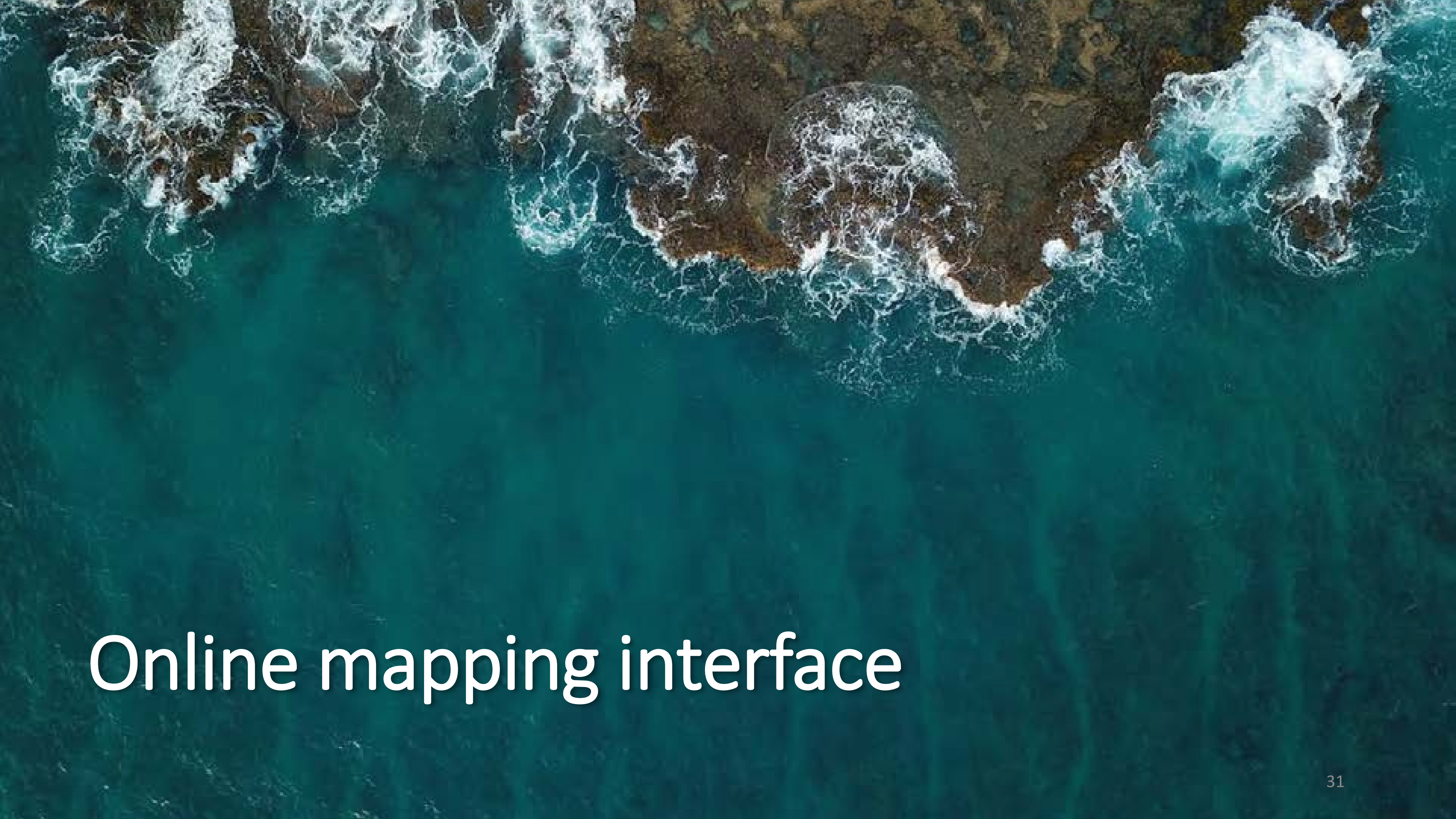
county fixed effect

Results


Odds-ratios of exposed/non-exposed
Bivariate model: exposure = vulnerability indicator + county fixed effect + (n facilities nearby)
disadv status (0/1)
% voters not voting
% poverty
% renter-occupied units
% ling. Isolated
% HH no car
% people of color
% pop > 65 living alone
affordable units (0/1)
0.5
1.0
3.0
5.0
Odds ratio (95% CI, log scale)
Year of SLR projection
2050
2100

Next steps

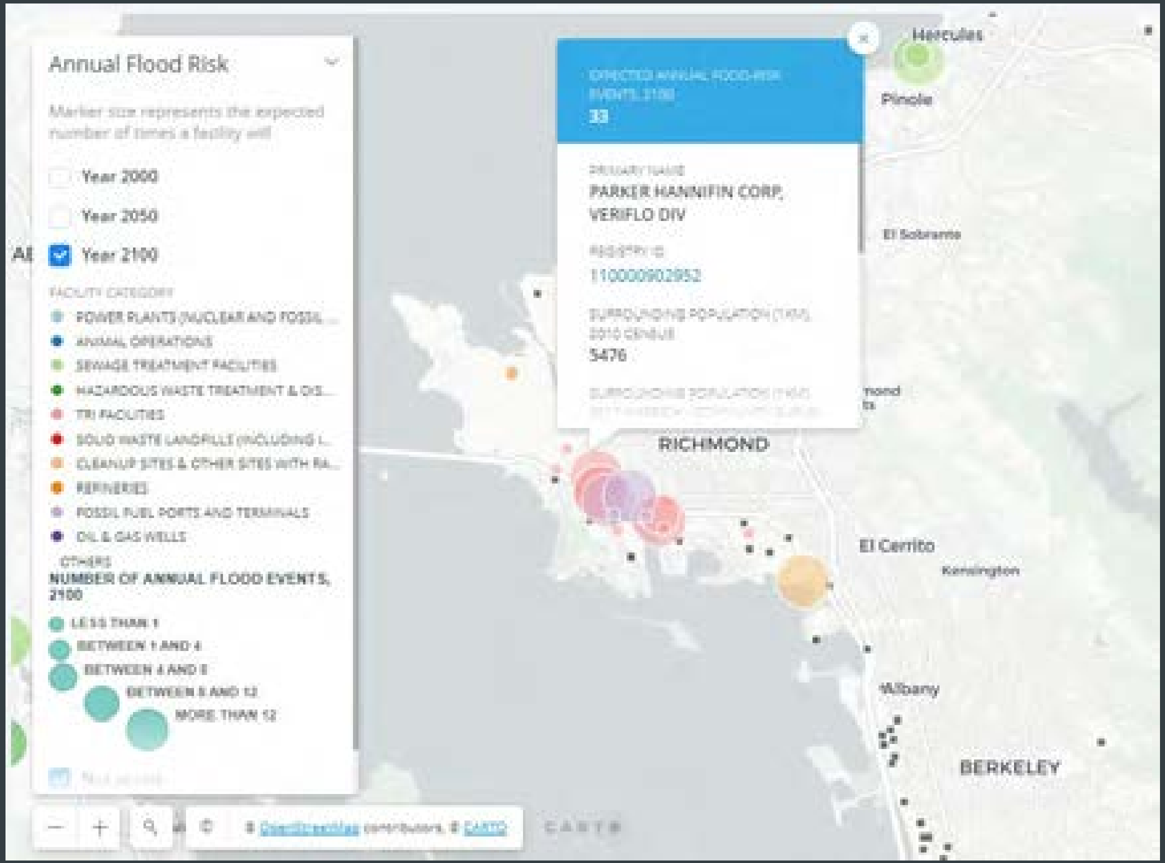
- Testing different model outcomes
- Testing for potential nonlinearity between variables and outcomes
- Conducting sensitivity analysis for above models
- Preparing for roundtables with community-based partners

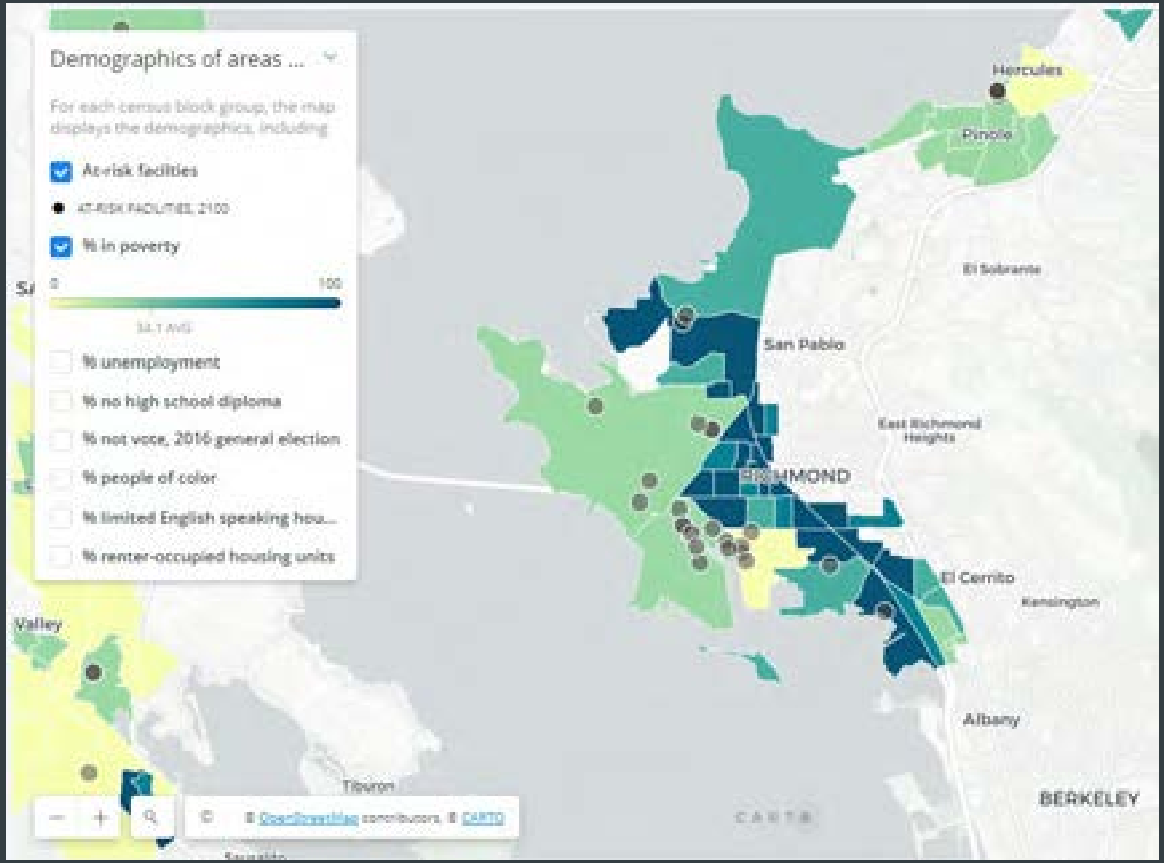


Online mapping interface

Toxic Tides:

Sea Level Rise, Hazardous Sites, and Environmental Justice in California





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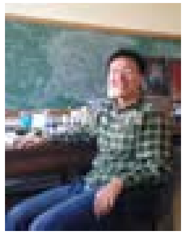

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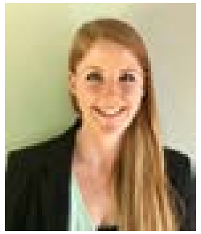

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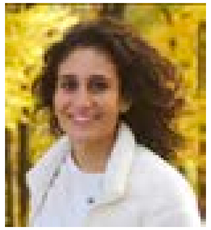

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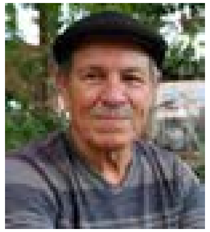

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Thank you!

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Varied Geographies of Flood Risk: Multi-scalar Analysis of Socio-Economic Vulnerability to Flooding Across the Contiguous United States

Varied geographies of vulnerability

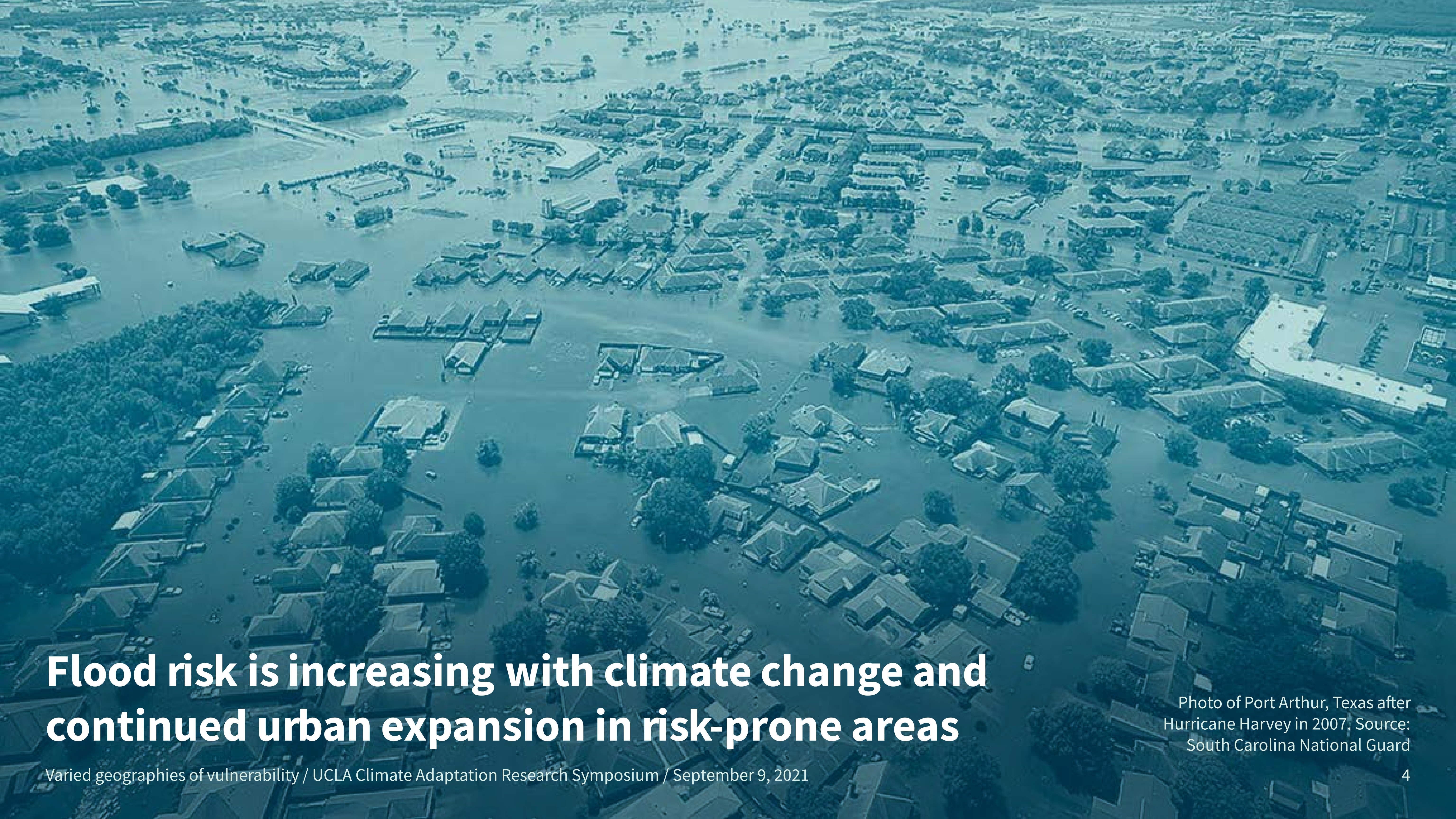
Multi-scalar analysis of socio-economic vulnerability to flooding across the contiguous United States

Justin Kollar, PhD Student, MIT

UCLA Climate Adaptation Research Symposium / September 9, 2021

Contents

Background and Overview



Flood risk is increasing with climate change and continued urban expansion in risk-prone areas

Photo of Port Arthur, Texas after Hurricane Harvey in 2007. Source: South Carolina National Guard

Assessments of flooding largely focus on the economic dimensions of flood risk such as property value which may reinforce inequalities in mitigation, adaptation, and response

The Big U project for Lower Manhattan. Source: BIG Architects

Flooding impacts people and communities differently based on socio-economic, historic, and systemic factors

Photo of Lower Ninth Ward in New Orleans after Hurricane Katrina in 2005. Source: Marvin Nauman/FEMA

Aims of Research

Explore the socio-economic vulnerability to flooding across the contiguous US (CONUS) to better understand:

Who is at risk? i.e. to describe the spatial and geographic unevenness of socio-economic vulnerability to flood risk.

Why and how are they at risk? i.e. to explain the underlying developmental and political economic factors related to flood risk exposure.

Key Findings

Describing who is at risk...

#1 Geographic variation of flood risk disparities across coastal and inland regions and MSAs

#2 High flood risk disparities across old age, social service access, and education-related vulnerabilities

#3 Higher flood risk disparity for low-income and below poverty households

Explaining why and how are they at risk...

#4 The legacy of redlining is still apparent and may overlap with areas of flood risk

#5 Continued development in the floodplain

#6 Growing flood risk disparities with demographic changes

Data and Methodology

Methodology

Identify Indicators of socio-economic vulnerability to flooding → **Perform** geospatial analysis of flood risk exposure → **Compare** results inside and outside flood zones at multiple scales

Method	Literature review	Dasymetric modeling	Direct comparison
Data Inputs	Census American Community Survey (ACS) 5-year Data 2015-2019 Census 2000 Census-based statistical boundaries (Block Groups, Tracts, Counties, MSAs)	FEMA National Flood Hazard Layer (NFHL) 1% Annual (100-year) Risk **Fathom 2020 Flood Zone 1% Annual (100-year) Risk* Microsoft Building Footprints	Input from #1 and #2 Redlining boundary data from the University of Richmond
Output	Vulnerability indicators tied to census statistical boundaries	Percent flood risk exposure per census block group	Multi-scale comparisons of flood risk exposure to assess disparities between floodplain and overall area

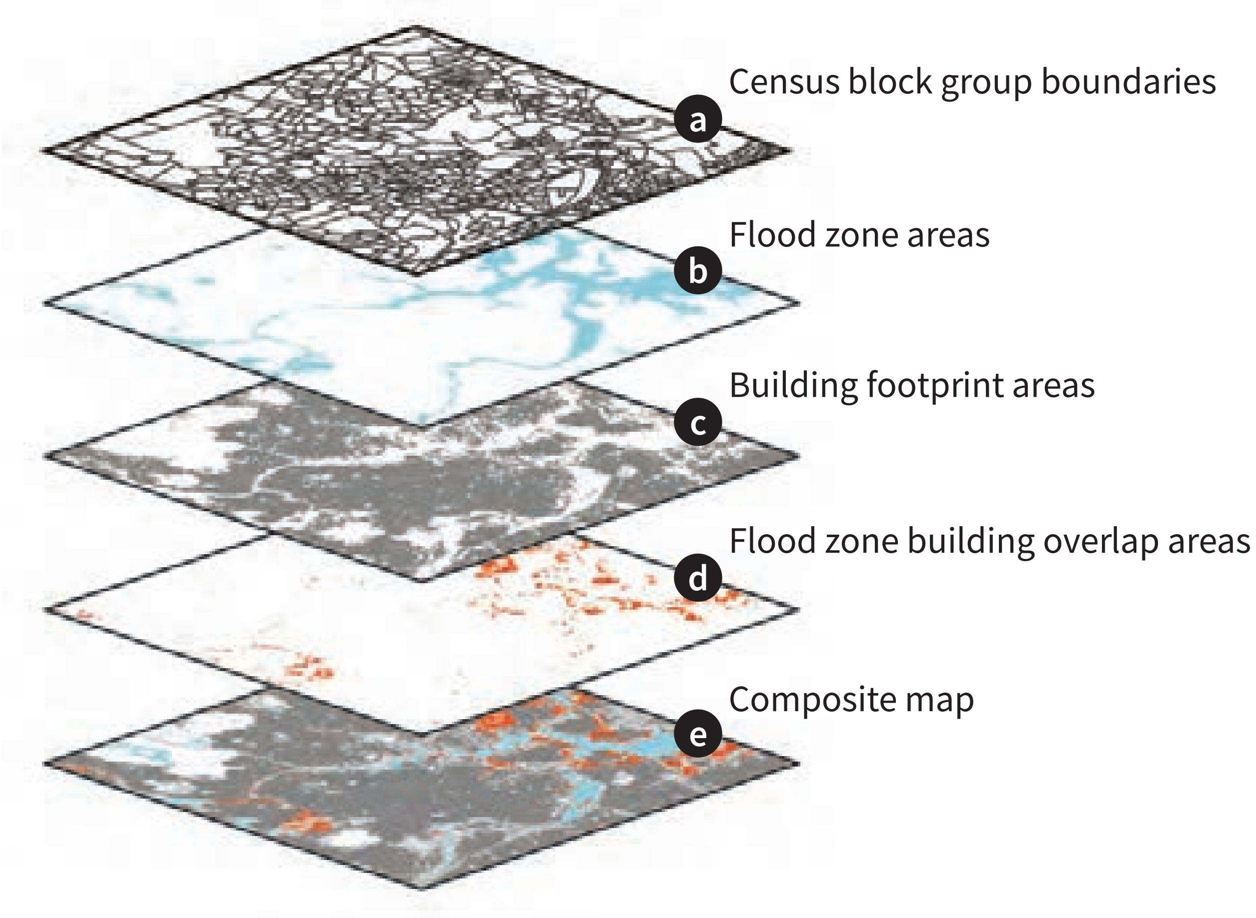
Identify Indicators of socio-economic vulnerability to flooding

Socio-economic Dimensions	Identified as Vulnerable	ACS/Census Indicators
General	-	Total population Total households
Age	Younger and older residents	Population Under 14 Years of Age Population Over 65 Years of Age
Gender	Female and families with single female head of household	Total Female Population Single Female-led Households
Race and Ethnicity	Non-white, black and hispanic	White (non-Hispanic) Non-white (and/or Hispanic)
Income and Poverty	Low-income households and households in poverty	Population without a High School Diploma (25 Years and Over)
Education	Adults without high school or advanced degree	Population Below Poverty Median household income in the past 12 months Per capita income in the past 12 months
Health and Functional Needs	Pre-existing health conditions and/or disabled	Noninstitutionalized Population with No Health Insurance Households with Social Security Income Noninstitutionalized Population with a Disability
Housing and Tenure	Older housing stock, public housing, new development, repetitive-loss properties, low-value neighborhoods	Total Housing Units Total Vacant Housing Units Total Owner Occupied Housing Units Total Renter Occupied Housing Units Housing Units Built Since 2000 Owner-occupied housing units with a mortgage or similar debt Cost-burdened Population

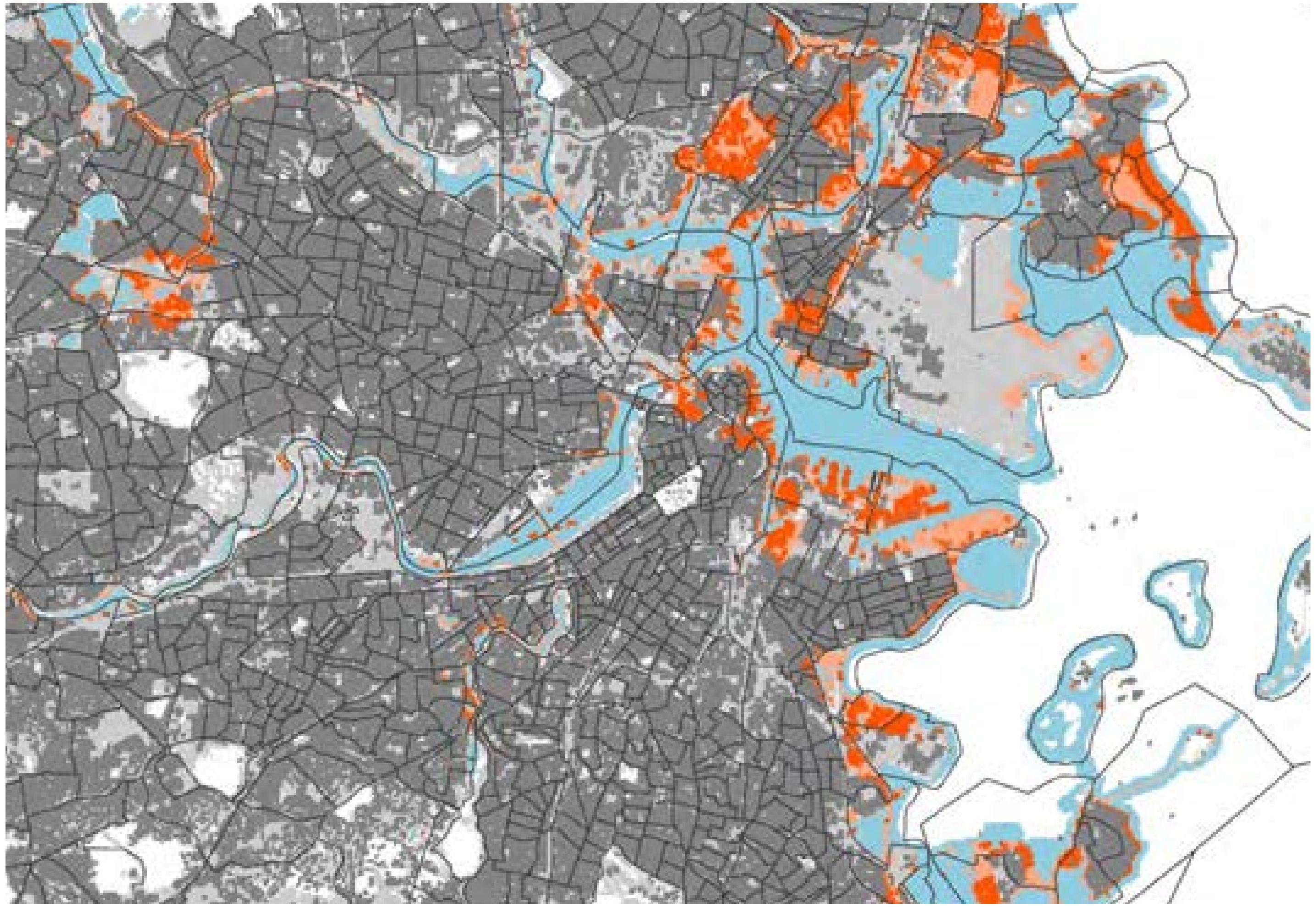
*Based on literature review

Perform geospatial analysis of flood risk exposure

Layers



Composite map of Boston/Cambridge MSA



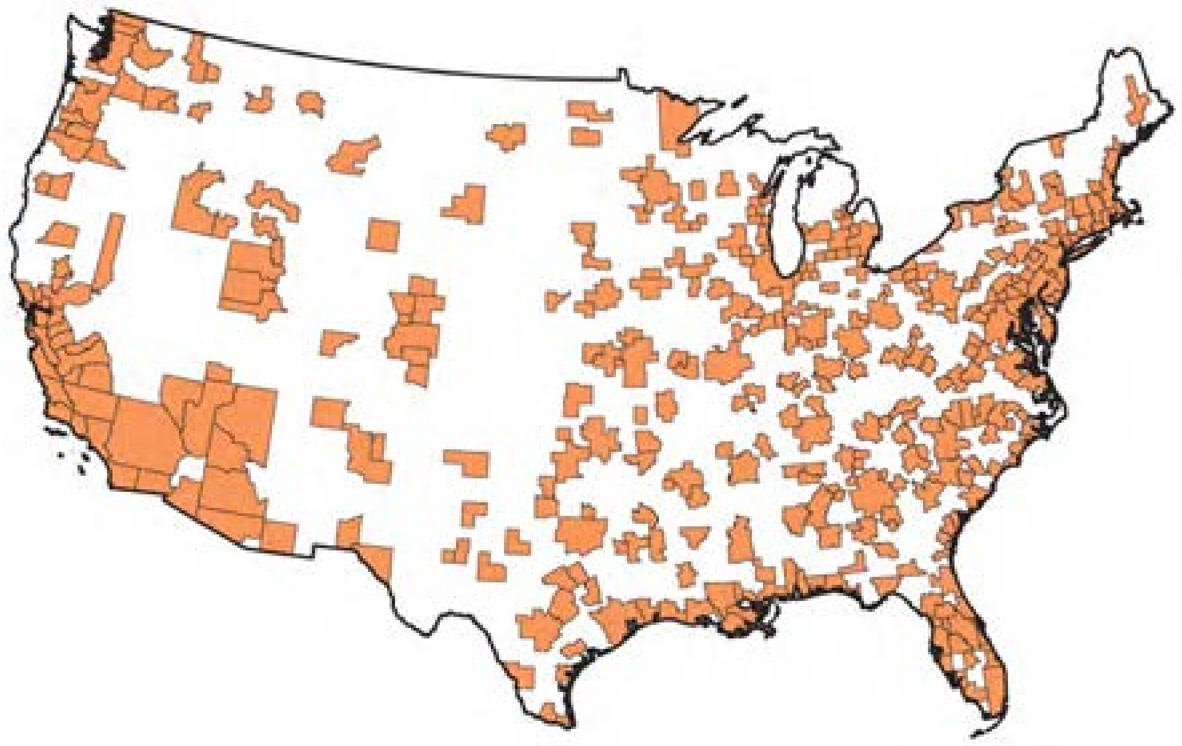
Total population within flood zone = $(a)_p \times [\,(d) / (c)\,]$

Compare results inside and outside flood zones at multiple scales

Climate regions with coastal and inland counties

(Climate regions with coastal and inland counties)

Metropolitan Statistical Areas (MSAs)



(n = 380)

Compare results inside and outside flood zones at multiple scales

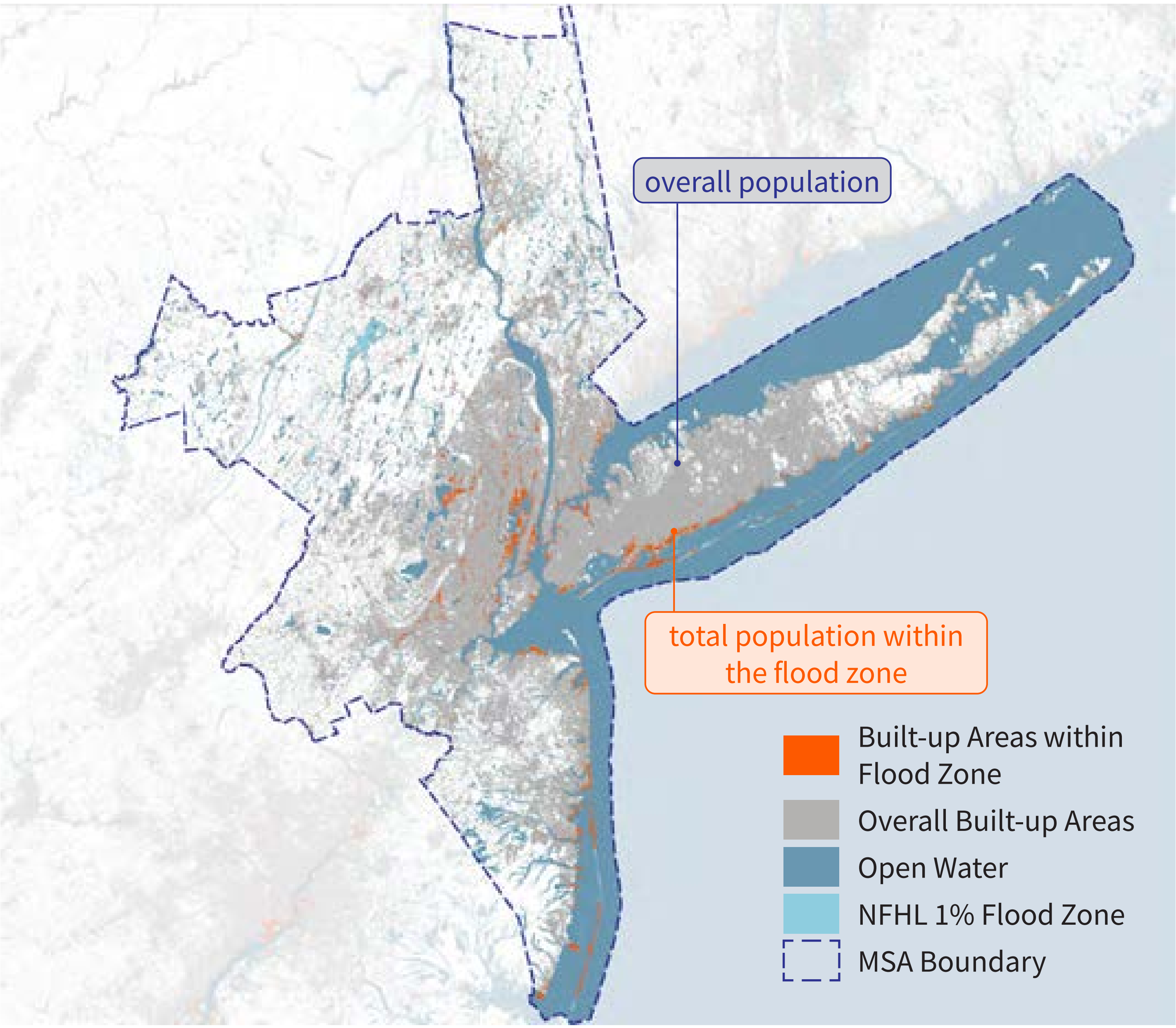
Calculation and comparison between inside flood zone and the overall population within the statistical area:

Proportionality (%) = estimated vulnerable population within the flood zone / total population within the flood zone

Disparity (ratio) = (estimated vulnerable population within the flood zone / total population within the flood zone) ÷ (overall estimated vulnerable population / overall population)

For example, a disparity ratio of 1.5 (30%/20%) means that a particular vulnerability dimension is 1.5 times more prevalent in the floodplain vs. overall.

New York City-Newark MSA



Limitations of data and methods

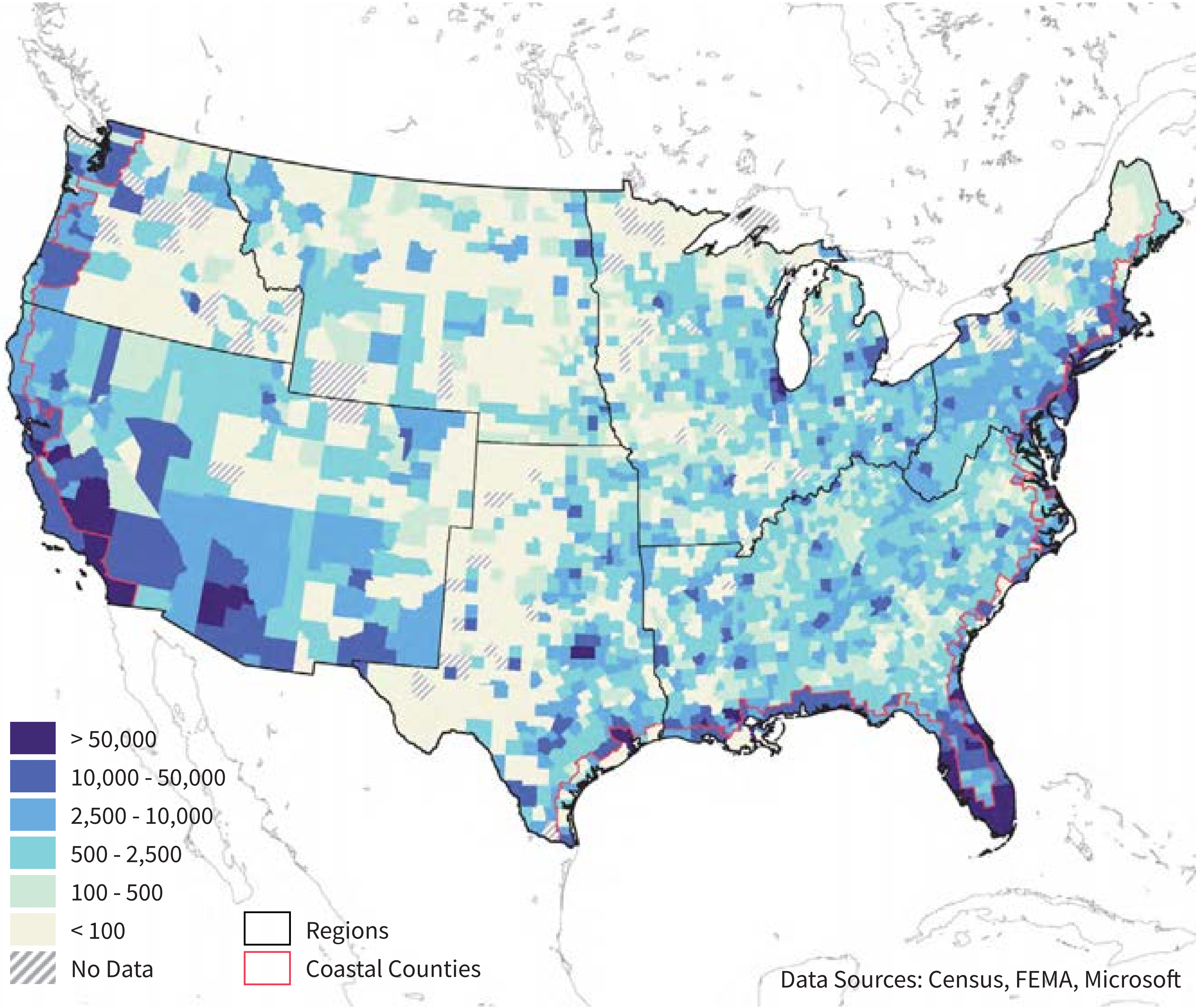
- Uses ACS 5-year 2015-2019 - the sampling methodology has been noted for margins of error, but is generally the best available for a number of metrics consistent across the national scale.
- Will replace with 2020 Census data when fully available.
- Race/ethnicity classifications present limited picture as proxies and will undergo classification change in 2020 Census.
- Dasymetric model uses all buildings regardless of whether they are non-residential (no national-level building use data is inconsistent from place to place and not available at a national scale).
- *But the overall results are consistent with other national scale studies of the population (Wing et al. 2015/Fathom) and housing (Furman NYU).

Key Findings

Overall, in the NFHL 1% flood risk model there are 14.3 million people and 6.8 million housing units at risk.

(Right) Total population located in FEMA's NFHL 1% Flood Zone in 2019

- Net change in population overall has been +15.2% with +3.9% change in the flood zone.
- Net change in housing units overall has been +18.6% with +17.8% in the flood zone - far outpacing population growth.



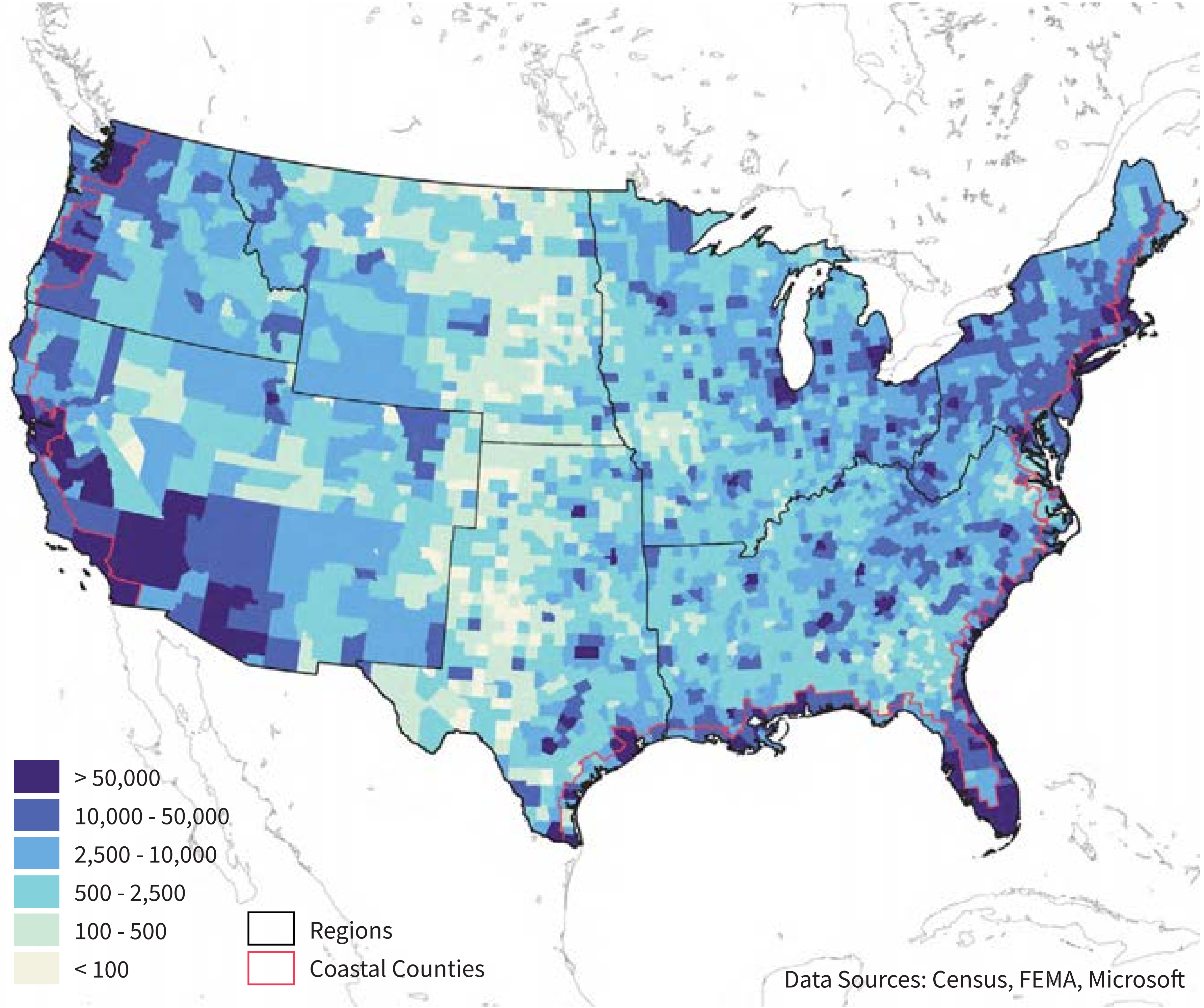
Fathom's flood risk model shows there are 32.8 million people and 14.9 million housing units at risk.

(Right) Total population located in Fathom's 1% Flood Zone in 2019

» Fathom's flood risk model includes pluvial flood risk (FEMA's NFHL doesn't)

» These estimates are over *double* the estimates of FEMA's NFHL

» Overall pictures of both flood risk models highlight significant flood risk *inland* - which is often overshadowed by emphasis on sea level rise on the coast

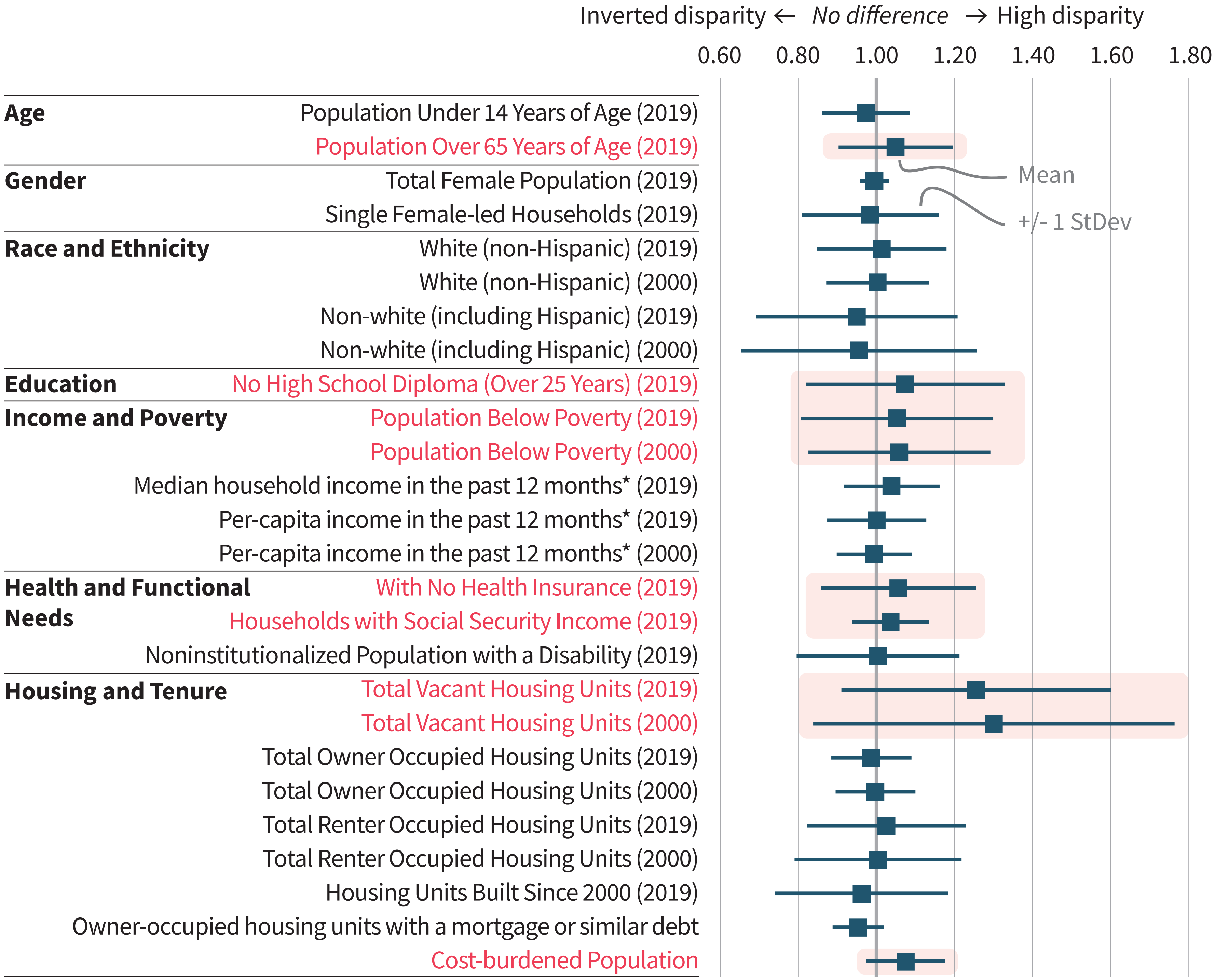


#1 Geographic variation of flood risk disparities across coastal and inland regions and MSAs

(Right) Comparison of disparity ratios for selected socio-economic indicators across all MSAs showing mean and +/-1 standard deviation

Geographic Distribution of MSAs

(n = 380)



Data Sources: Census, FEMA, Microsoft

#2 High flood risk disparities across old age, social service access, and education-related vulnerabilities

(Right) Overview of disparities between population in NFHL 1% flood zone vs.overall across coastal and inland regions

Compared to the overall average in most regions, there is a higher percentage of people in the floodplain who are

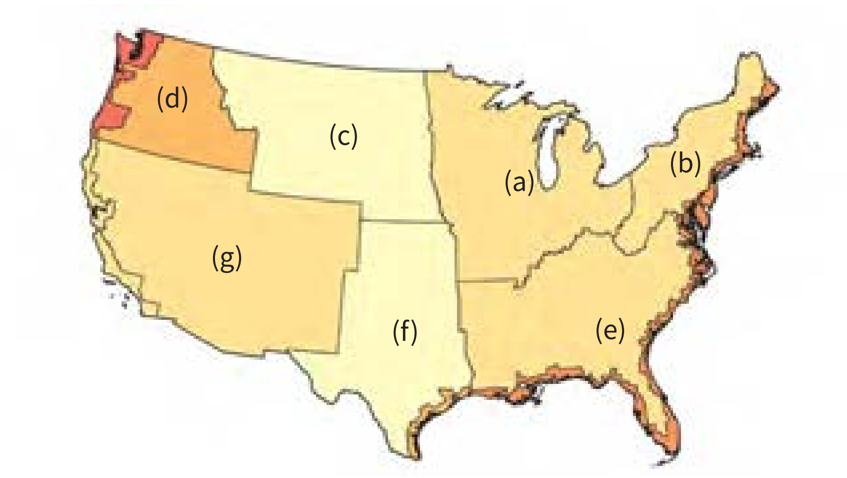
» over 65,

» are less educated,

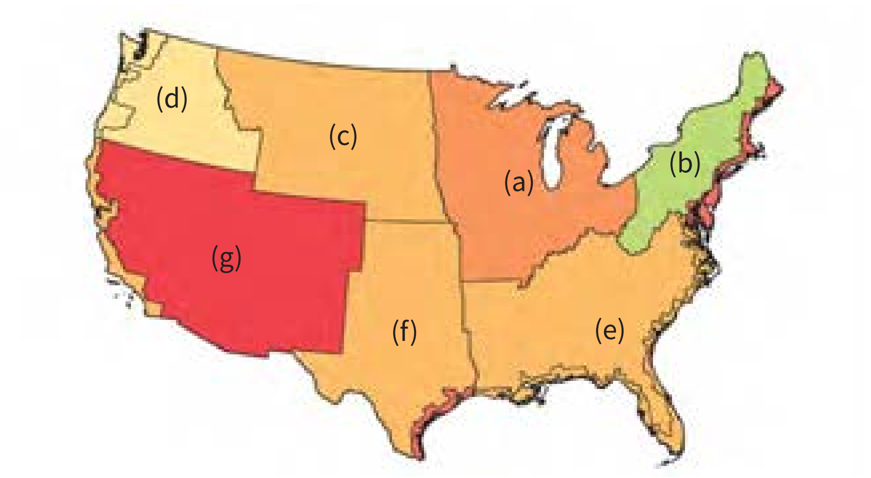
» do not have health insurance, and

» receive social security.

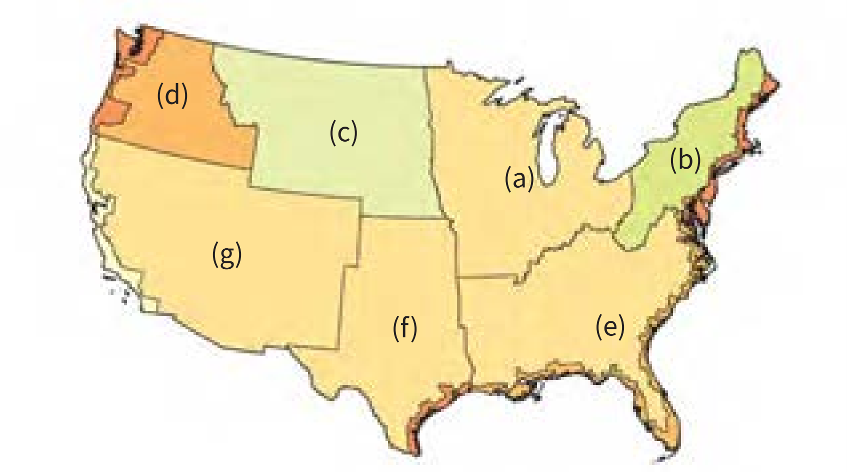
Disparity: Population Over 65 Years of Age (2019)



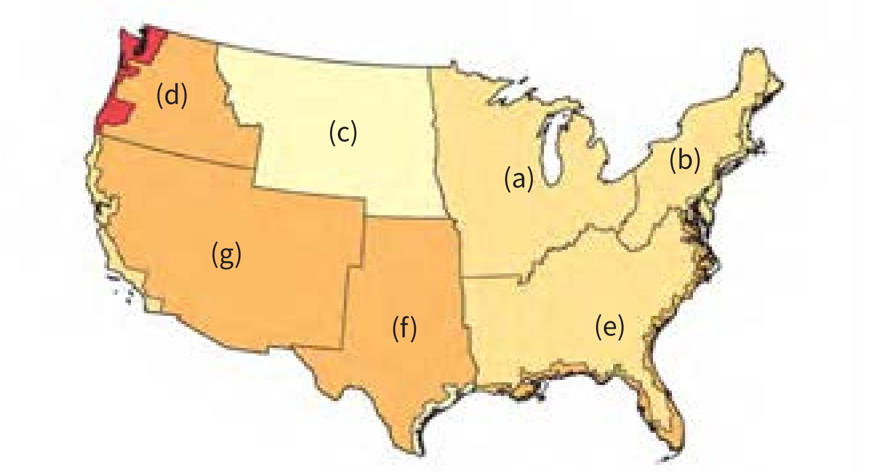
Disparity: Population without a High School Diploma (25 Years and Over) (2019)



Disparity: Noninstitutionalized Population with No Health Insurance (2019)



Disparity: Households with Social Security Income (2019)



Disparity Ratio

<0.75 1.00 >1.25

Inverted disparity ← *No difference* → High disparity

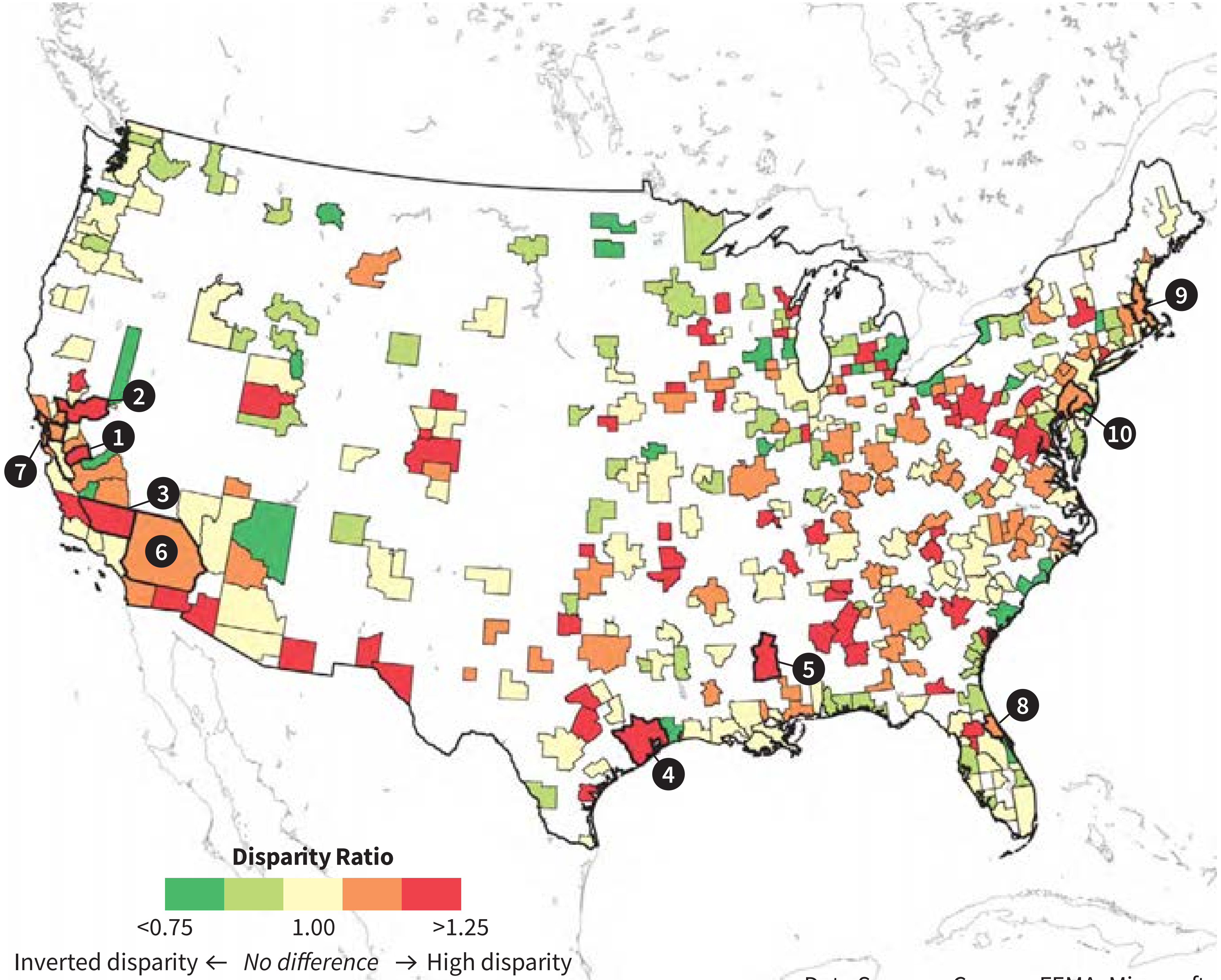
Climate regions with coastal and inland counties: (a) Midwest, (b) Northeast, (c) Northern Great Plains, (d) Northwest, (e) Southeast, (f) Southern Great Plains, and (g) Southwest

Data Sources: Census, FEMA, Microsoft

#3 Higher flood risk disparity for low-income and below poverty households

(Right, Below) Ranking of MSAs by Poverty Disparity in Flood Zone vs. Overall (2019)

Rank	Metro Area	Overall Pov. Rate	Pov. Rate in Flood Z.	Disparity
1	Merced, CA	20.7%	28.8%	**1.39**
2	Sacramento-Roseville-Folsom, CA	13.2%	18.3%	**1.38**
3	Bakersfield, CA	20.3%	27.2%	**1.34**
4	Houston-The Woodlands-Sugar Land, TX	13.5%	17.6%	**1.30**
5	Jackson, MS	16.3%	20.7%	**1.27**
6	Riverside-San Bernardino-Ontario, CA	14.4%	17.6%	**1.22**
7	San Francisco-Oakland-Berkeley, CA	8.9%	10.8%	**1.21**
8	Deltona-Daytona Beach-Ormond Beach, FL	13.7%	16.2%	**1.18**
9	Boston-Cambridge-Newton, MA-NH	9.0%	10.6%	**1.17**
10	Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	12.1%	14.0%	**1.16**



Data Sources: Census, FEMA, Microsoft

#3 Higher flood risk disparity for low-income and below poverty households

(Right) Average percentage makeup of population by household income levels inside the flood zone vs. overall across MSAs (2019)

» Higher income households on average are less exposed to flood risk compared to low-income households.

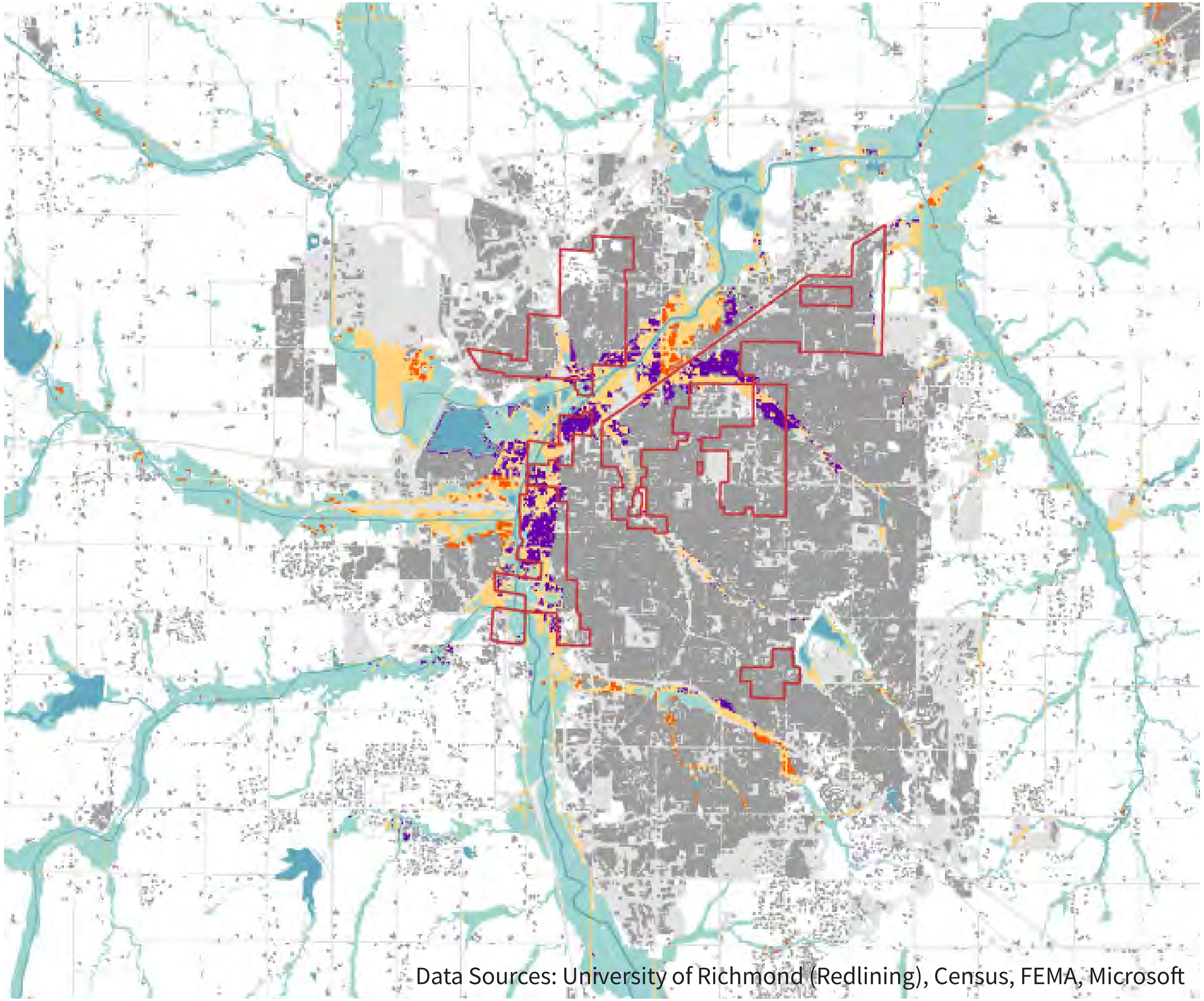
Data Sources: Census, FEMA, Microsoft

#4 The legacy of redlining is still apparent and may overlap with areas of flood risk

(Right) Example of Lincoln, NE: Overlap of Redlining and Population within NFIP 1% Flood Zone (2019)

» 43.8% of the floodplain population in Lincoln, NE is also located in redlined areas (HOLC C/D) where a significant proportion of the black population still lives.

- Built-up Areas
- Impervious Surfaces
- Perennial Water Bodies
- C/D Redlining
- NFIP 1% Flood Zone
- Impervious Surfaces in Flood Zone
- Presence of Black Population in Flood Zone
- Other Populations in Flood Zone

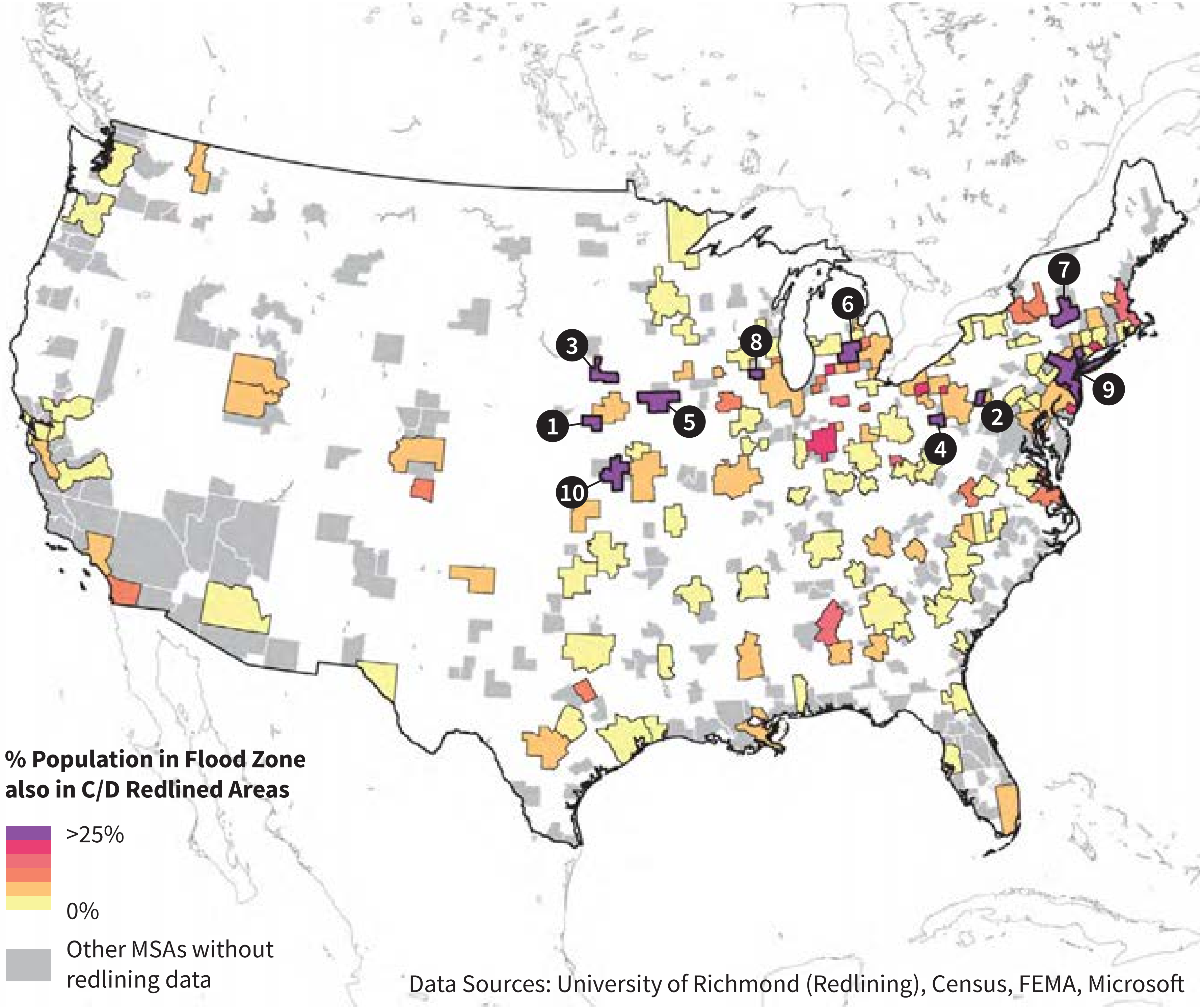


Data Sources: University of Richmond (Redlining), Census, FEMA, Microsoft

#4 The legacy of redlining is still apparent and may overlap with areas of flood risk

(Right, Below) Ranking of MSAs by % Population in Flood Zone also in Prior C/D Redlined Areas (2019)

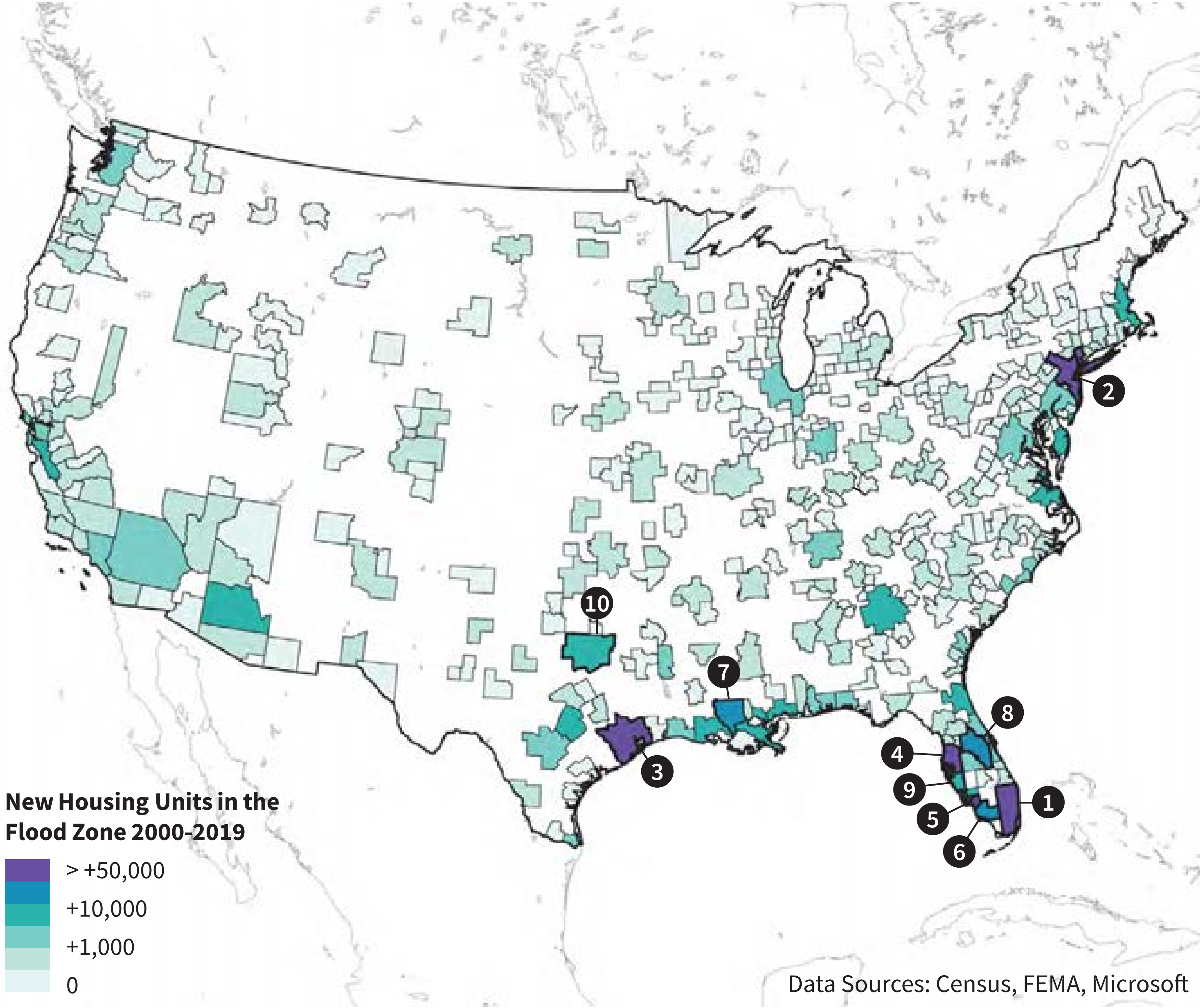
Rank	Metro Area	% Population in Flood Zone also in C/D Redlined Areas
1	Lincoln, NE	**43.8%**
2	Johnstown, PA	**38.1%**
3	Sioux City, IA-NE-SD	**34.1%**
4	Wheeling, WV-OH	**32.5%**
5	Des Moines-West Des Moines, IA	**30.6%**
6	Lansing-East Lansing, MI	**29.2%**
7	Albany-Schenectady-Troy, NY	**29.0%**
8	Rockford, IL	**28.7%**
9	New York-Newark-Jersey City, NY-NJ-PA	**26.2%**
10	Topeka, KS	**25.8%**



#5 Continued development in the floodplain

(Right, Below) Ranking of MSAs by Total New Housing Units in NFHL 1% Flood Zone 2000-2019

Rank	Metro Area	New Units in Flood Zone 2000-2019	% of Overall New Units
1	Miami-Fort Lauderdale-Pompano Beach, FL	**143,051**	33.0%
2	New York-Newark-Jersey City, NY-NJ-PA	**74,151**	10.1%
3	Houston-The Woodlands-Sugar Land, TX	**69,003**	7.9%
4	Tampa-St. Petersburg-Clearwater, FL	**61,984**	19.8%
5	Cape Coral-Fort Myers, FL	**53,933**	37.0%
6	Naples-Marco Island, FL	**45,889**	63.9%
7	Baton Rouge, LA	**32,516**	30.5%
8	Orlando-Kissimmee-Sanford, FL	**25,774**	7.7%
9	North Port-Sarasota-Bradenton, FL	**21,816**	18.7%
10	Dallas-Fort Worth-Arlington, TX	**18,589**	2.2%



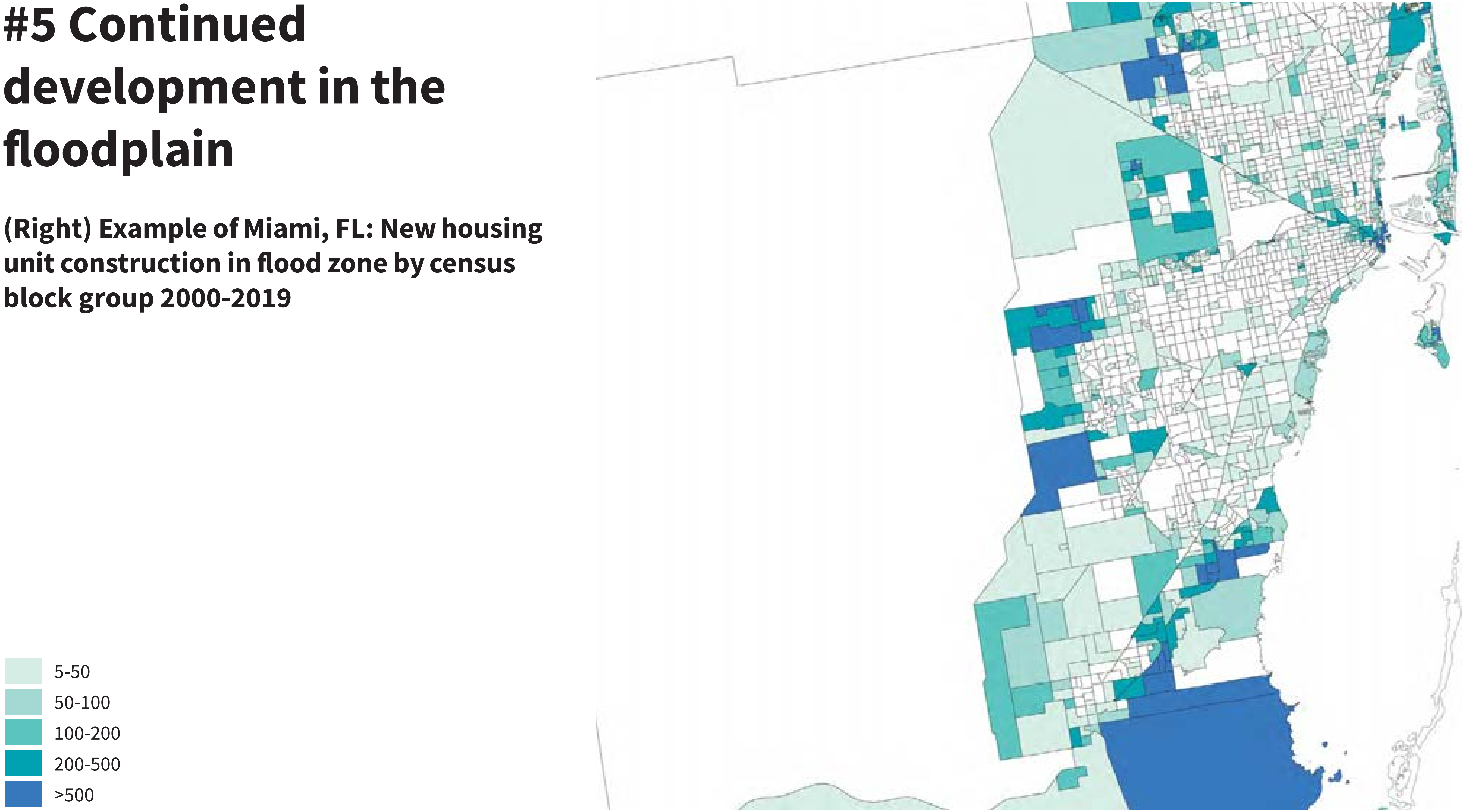
#5 Continued development in the floodplain

(Right) Example of Miami, FL: Composite map of flood risk and built-up areas including expansion 2000-2019

- Built-up Areas
- Impervious Surface
- Perennial Waterbodies
- Wetlands
- Flood Zone
- Built-up Areas in Flood Zone
- Impervious Surfaces in Flood Zone
- New Built-up Areas since 2000
- New Impervious Surfaces Since 2000
- New Built-up Areas since 2000
- New Impervious Surfaces Since 2000

#5 Continued development in the floodplain

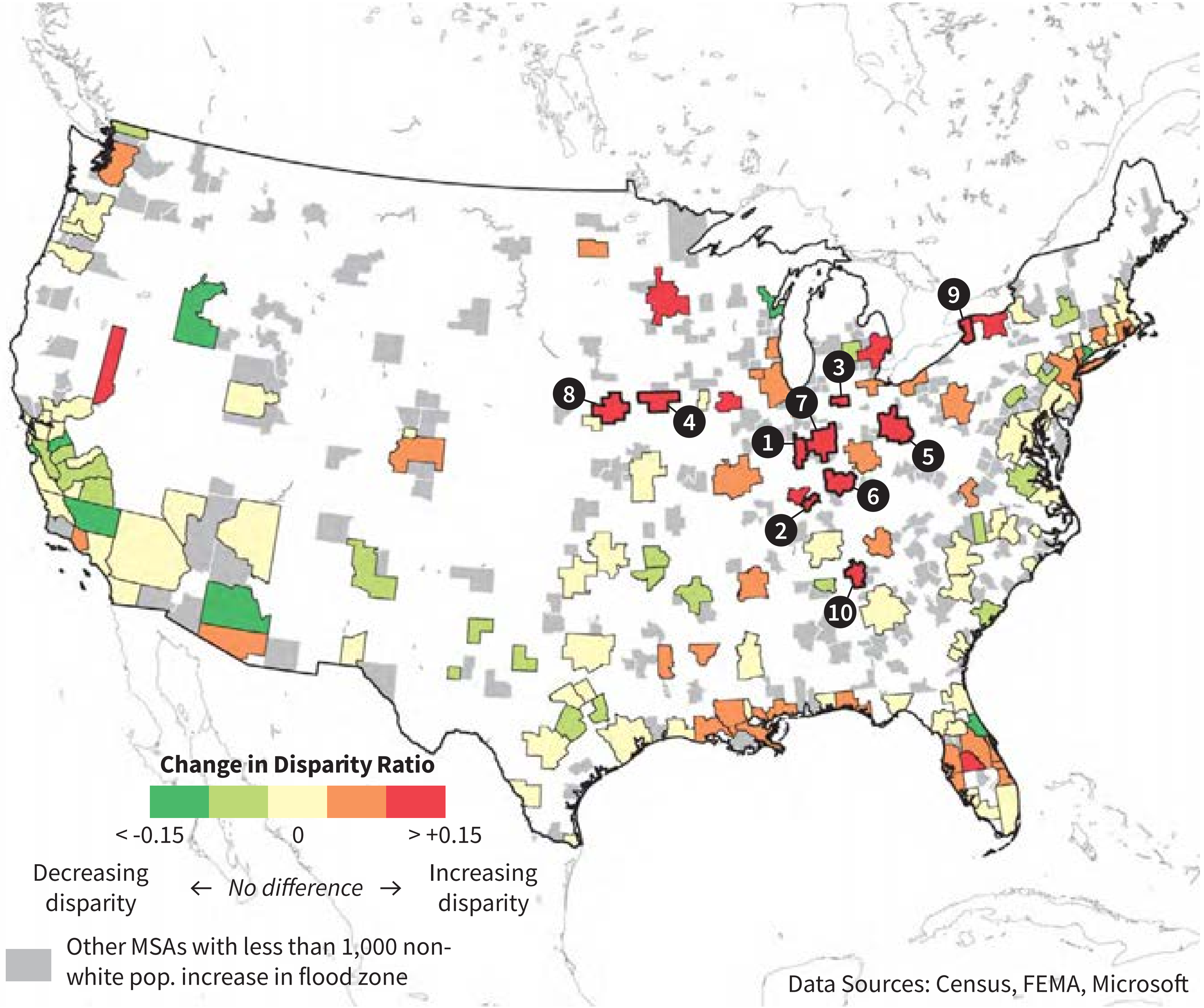
(Right) Example of Miami, FL: New housing unit construction in flood zone by census block group 2000-2019



#6 Growing flood risk disparities with demographic changes

(Right, Below) Ranking of MSAs by Non-white Population Disparity Increase in Flood Zone vs. Overall (2000-2019)

Rank	Metro Area	2000 Disparity	2019 Disparity	Change
1	Terre Haute, IN	0.94	1.92	**+0.98**
2	Owensboro, KY	0.74	1.16	**+0.42**
3	Fort Wayne, IN	0.82	1.19	**+0.38**
4	Des Moines-West Des Moines, IA	0.91	1.25	**+0.34**
5	Columbus, OH	0.63	0.93	**+0.29**
6	Louisville/Jefferson County, KY-IN	0.87	1.10	**+0.23**
7	Indianapolis-Carmel-Anderson, IN	0.70	0.93	**+0.23**
8	Omaha-Council Bluffs, NE-IA	0.50	0.73	**+0.23**
9	Buffalo-Cheektowaga, NY	0.36	0.57	**+0.21**
10	Chattanooga, TN-GA	0.85	1.03	**+0.18**

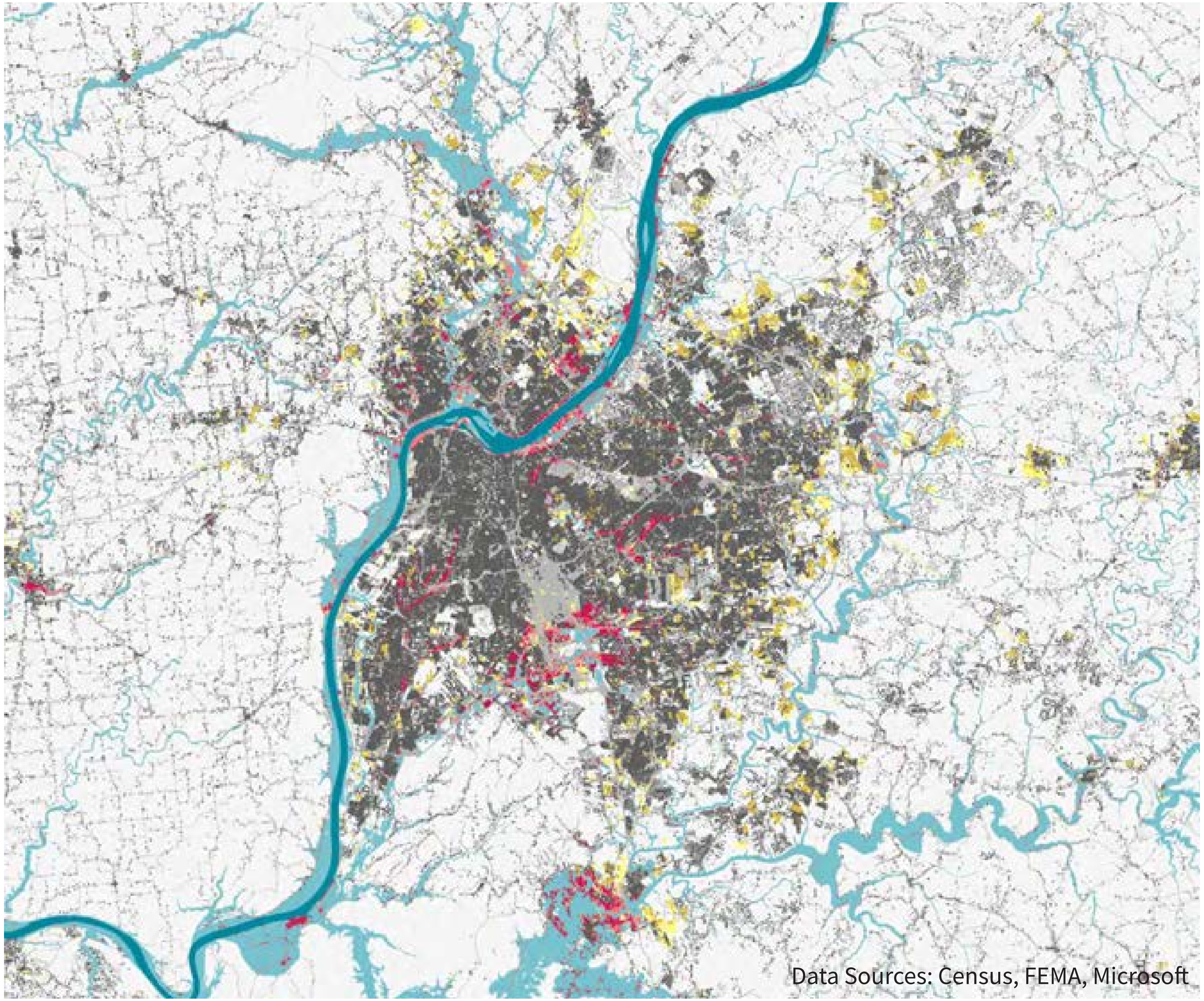


#6 Growing flood risk disparities with demographic changes

(Right) Example of Louisville, KY: Urban Expansion and Flood Risk Exposure (2000-2019)

» Outward urban expansion, but also growth in core neighborhoods with significant non-white populations

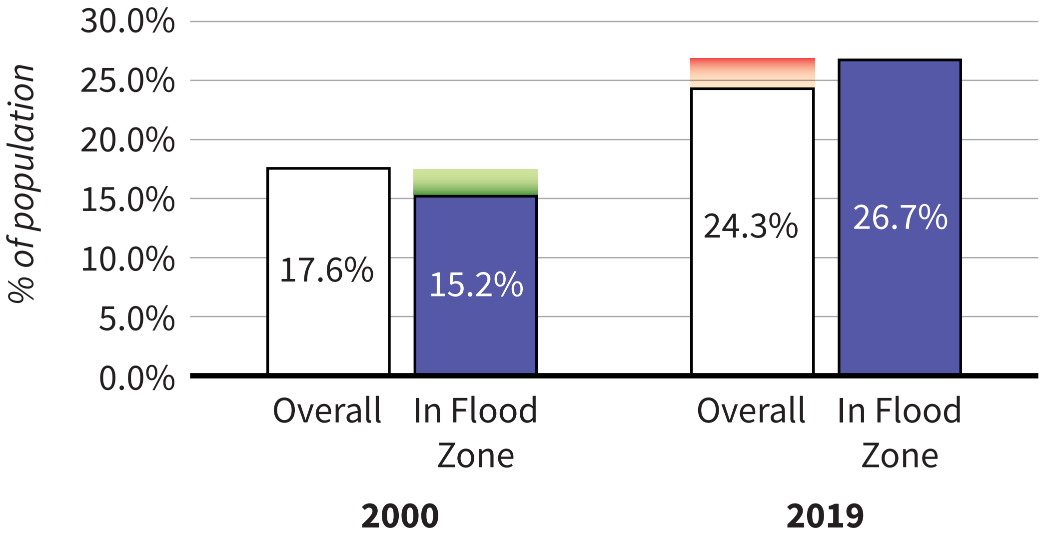
- Built-up Areas
- Impervious Surface
- Perennial Waterbodies
- Flood Zone
- Built-up Areas in Flood Zone
- Impervious Surfaces in Flood Zone
- New Built-up Areas since 2000
- New Impervious Surfaces Since 2000

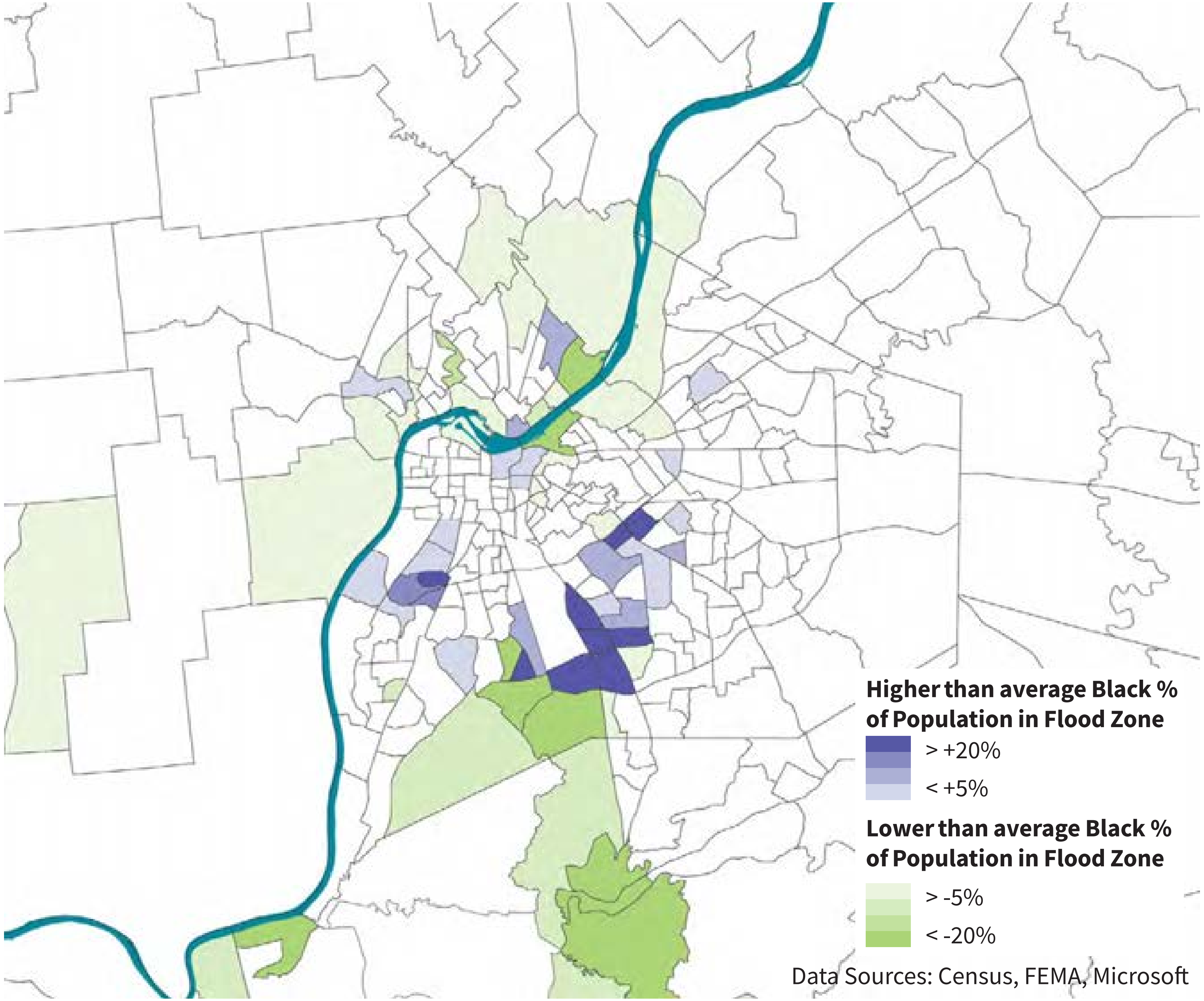


#6 Growing flood risk disparities with demographic changes

(Right) Example of Louisville, KY: Population composition of the NFHL 1% flood zone by race (2019)

(Below) Example of Louisville, KY: Non-white population growth as percentage in flood zone vs. overall (2000-2019)





IV

Conclusion and Future Research Goals

Summary of Key Findings

Describing who is at risk...

#1 Geographic variation of flood risk disparities across coastal and inland regions and MSAs

#2 High flood risk disparities across old age, social service access, and education-related vulnerabilities

#3 Higher flood risk disparity for low-income and below poverty households

Explaining why and how are they at risk...

#4 The legacy of redlining is still apparent and may overlap with areas of flood risk

#5 Continued development in the floodplain

#6 Growing flood risk disparities with demographic changes

Future Research Goals

» Incorporate and refine with 2020 Census data release.

» Publish online interactive map with multiple scales and visualizations of data.

» Release data for all scales based on FEMA NFHL 1% flood zone.

» Identy new case study areas to study the historic and future development trends and their link to socio-spatial vulnerability to flooding.

Thank You!

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CLIMATE ADAPTATION
RESEARCH SYMPOSIUM

MEASURING & REDUCING SOCIETAL IMPACTS

Thanks for tuning in!

UCLA Luskin Center for Innovation