



MILWAUKEE

Urban Development

Assessing the Drivers of Urban Flood Vulnerability in
Milwaukee using the Integrated Valuation of
Ecosystem Services and Tradeoffs Urban Flood Risk
Mitigation Model (InVEST)

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MEET THE TEAM



Madeleine Tango



Jack Acomb



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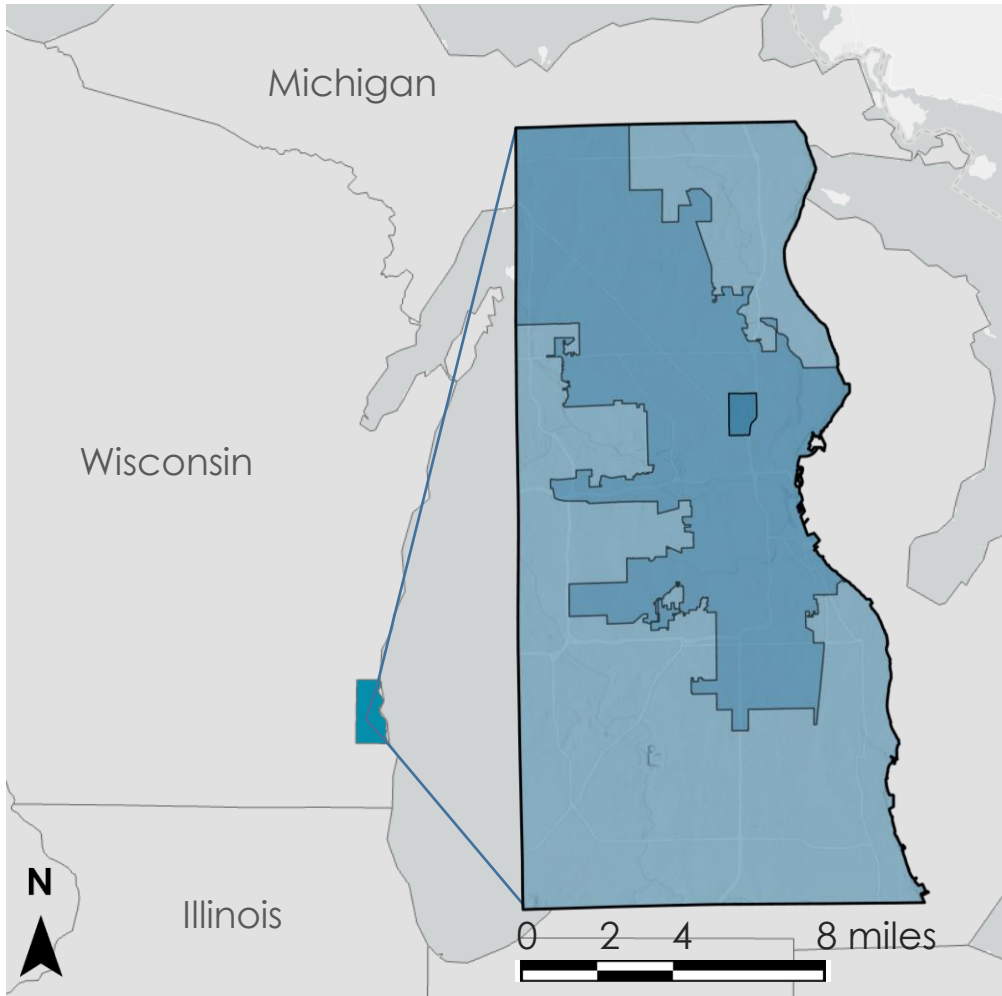
Annika Harrington






An aerial photograph of a city, likely San Francisco, showing a dense urban grid, highways, and a waterfront area. The image is overlaid with a semi-transparent blue filter. The word "BACKGROUND" is written in large, white, sans-serif capital letters across the center of the image.

BACKGROUND

STUDY AREA AND PERIOD



Milwaukee County, WI

-  Lindsay Heights
-  City of Milwaukee
-  Milwaukee County

January 1
2010

 **July 22, 2010**
5.6 inches / 142 mm

 **April 9, 2015**
3.2 inches / 81 mm

 **August 2, 2020**
4.8 inches / 122 mm

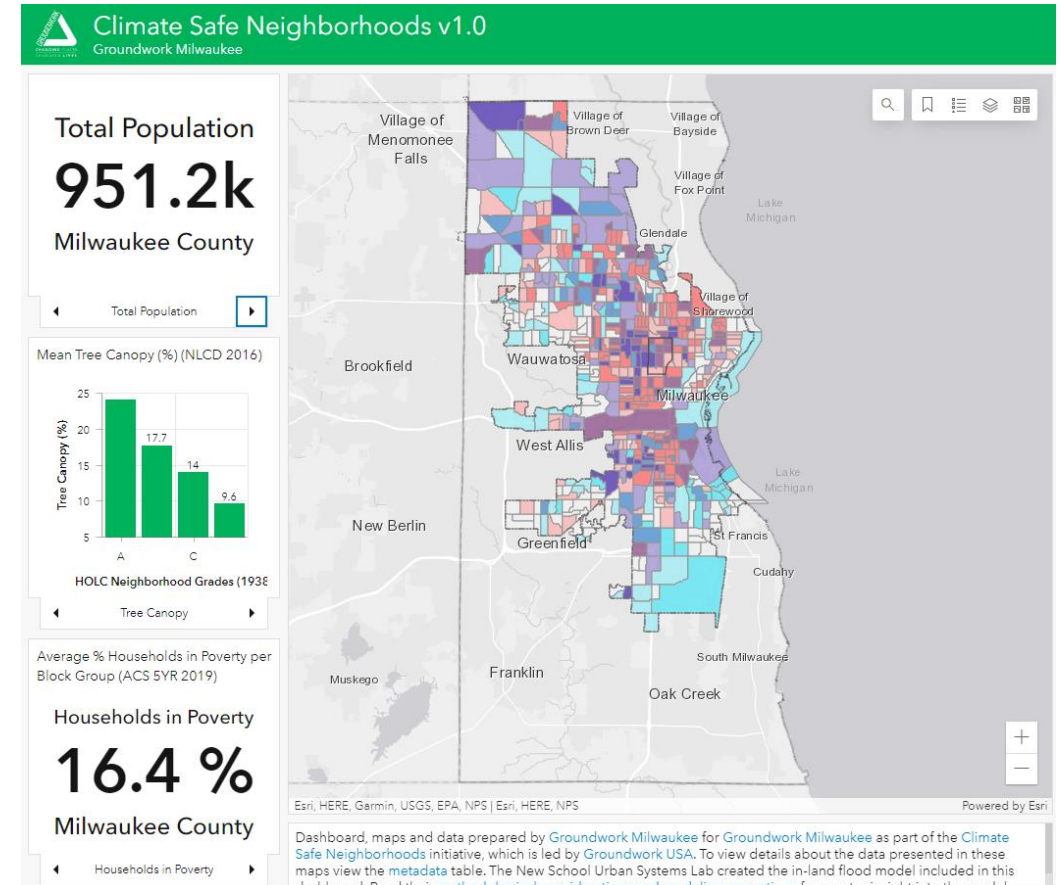
December 31
2020



PARTNER ORGANIZATIONS

Groundwork USA & Groundwork MKE

- ▶ Environmental Justice
 - ▶ Environmental, social, and economic conditions
 - ▶ Community engagement
- ▶ Climate Safe Neighborhoods (CSN)
 - ▶ Housing discrimination and climate change
 - ▶ Lindsay Heights
 - ▶ Basement flooding
- ▶ Community Flood Resiliency
- ▶ CityCAT Model



Groundwork Milwaukee Dashboard
Image Credit: Groundwork Milwaukee



KEY CONCEPTS



ENVIRONMENTAL INJUSTICE

- ▶ The disproportionate impact of environmental hazards on marginalized communities



ENVIRONMENTAL JUSTICE

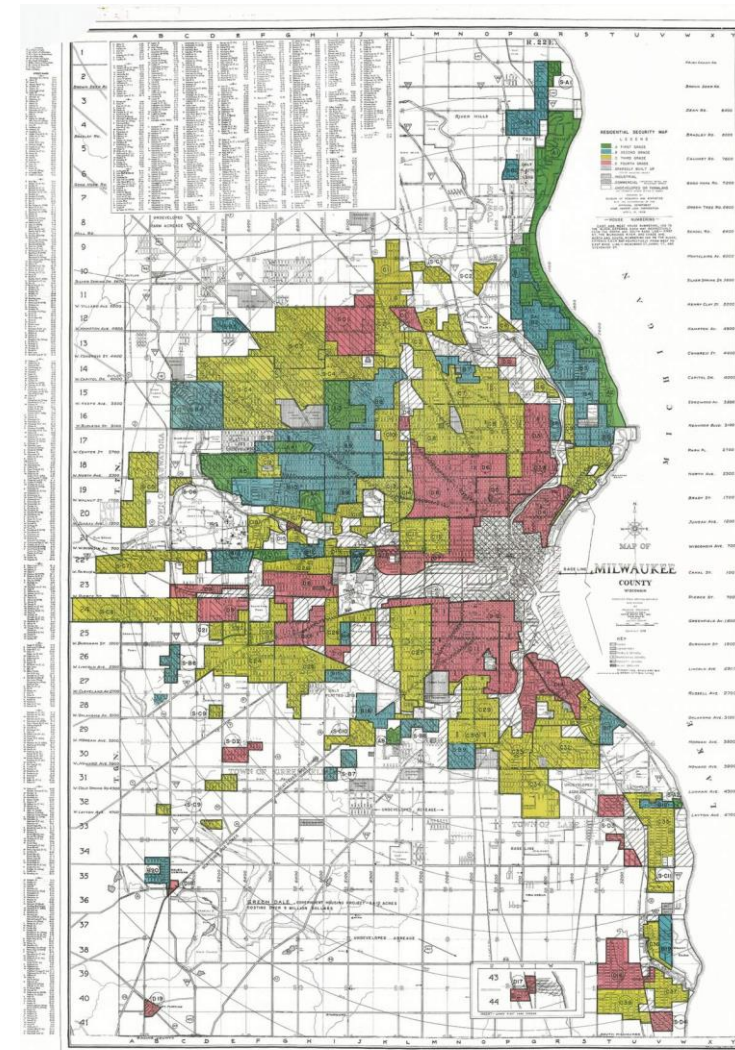
- ▶ Links social and environmental exploitation
- ▶ Movement against oppressive structures
- ▶ Involvement of marginalized communities
- ▶ Resource extraction, hazardous waste, disasters



MILWAUKEE REDLINING

Home Owners' Loan Corporation (HOLC) created surveys of Milwaukee's neighborhoods in 1938. Each neighborhood was assigned a letter grade and color to indicate mortgage security risk.

- ▶ **A-Green**: ethnically homogeneous (white), developing
- ▶ **B-Blue**: ethnically homogeneous (white), developed
- ▶ **C-Yellow**: bordering diverse neighborhoods (non-white), declining
- ▶ **D-Red**: diverse neighborhoods (non-white) and low-income, declined



1938 Redlining Map

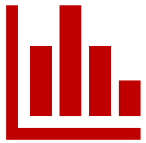
Image Credit: National Archives



OBJECTIVES



Quantify the spatial distribution of pluvial flood risk using the InVEST Urban Flood Risk Mitigation Model's runoff retention, nominal flood depth, and economic damage outputs



Analyze the relationship between flood risk and historic redlining, racial demographics, green spaces, and community resilience estimates



Contextualize the InVEST Model's results using the CityCAT flood risk map, NDWI, and DEM-derived streams



An aerial photograph of a city, likely San Francisco, is shown with a semi-transparent blue overlay. The city's grid of streets, parks, and waterfront areas are visible. The text 'InVEST MODEL' is centered in white, bold, sans-serif font.

InVEST MODEL

METHODOLOGY

INPUTS



Rainfall Depth (*IMERG & NWS*)



Land Cover (*NLCD*)



Hydrological Soil Type (*gNATSGO*)



Area Polygons (*Census Block Groups*)



Building Footprints (*County LiDAR*)



Damage Loss Table (*FEMA HAZUS*)

MODEL

Physical

Economic

OUTPUTS

Runoff Retention Percentage

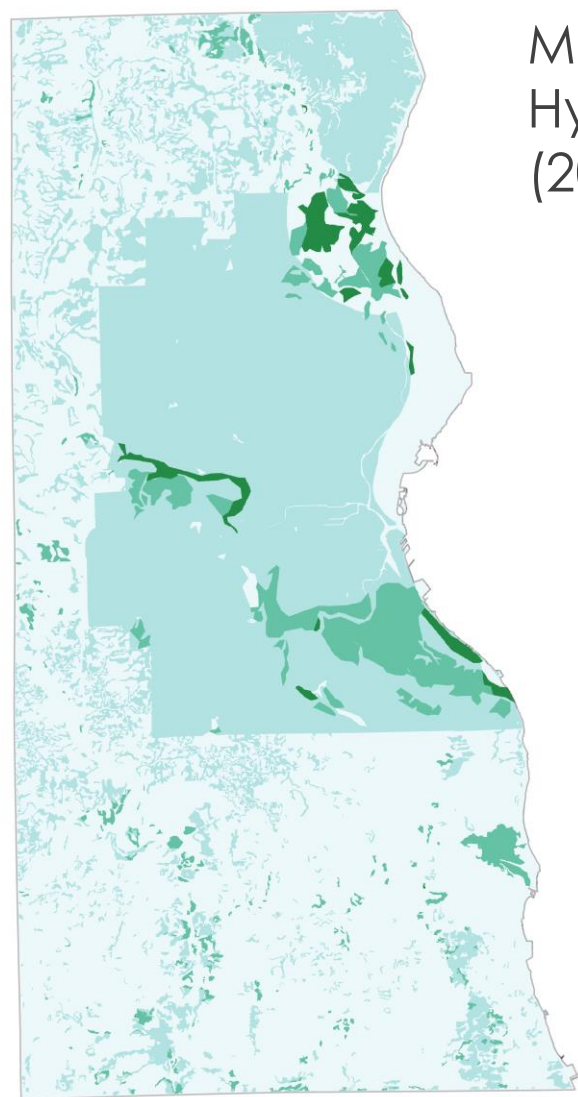
Nominal Flood Depth

Potential Damage in Dollars

Avoided Damage in Dollars



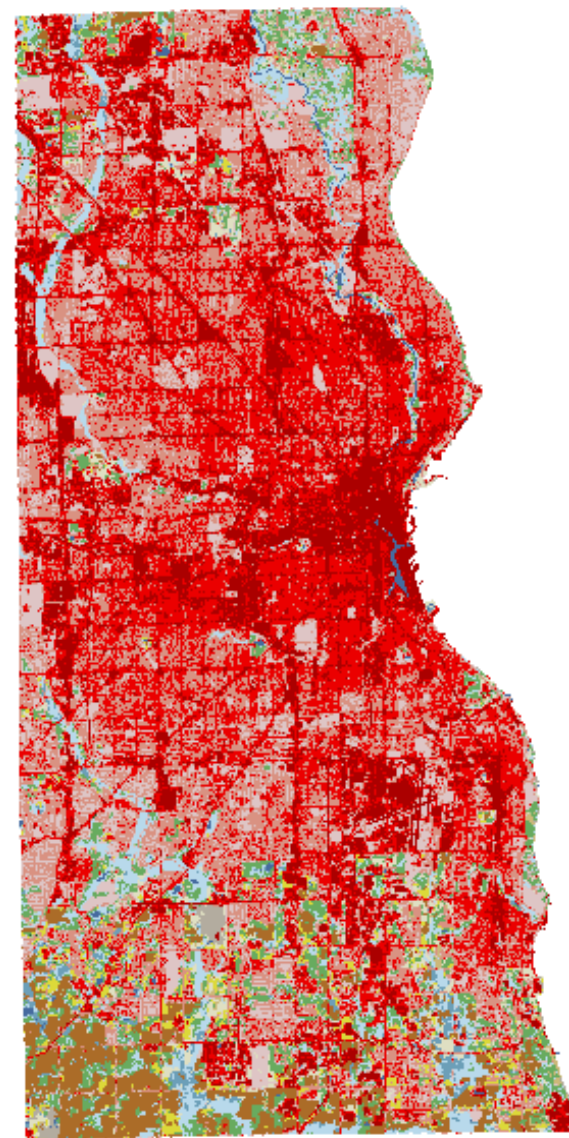
DATA INPUTS



Milwaukee County, WI
Hydrologic Soil Groups
(2021)

- Hydrologic Group A
- Hydrologic Group B
- Hydrologic Group C
- Hydrologic Group D

0 2 4 8 miles



Milwaukee County, WI
Land Cover (2019)

- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Mid Intensity
- Developed, High Intensity
- Barren Land
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrub / Scrub
- Herbaceous
- Hay/Pasture
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaceous

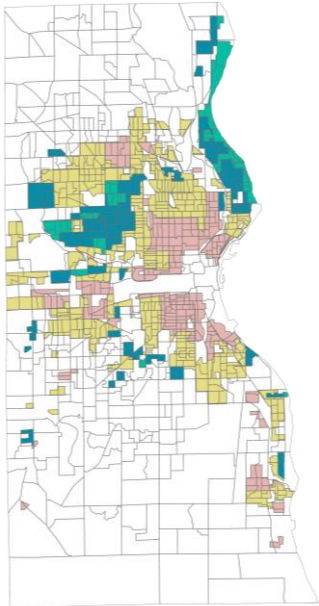
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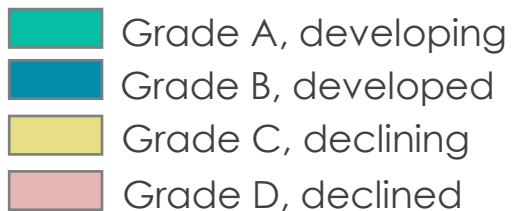
METHODOLOGY

ENVIRONMENTAL JUSTICE GEOSPATIAL DATA ANALYSIS

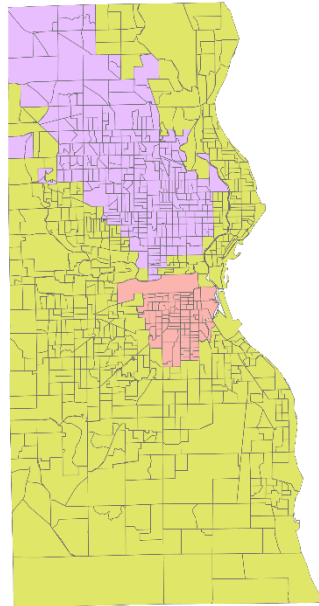
Historic Redlining



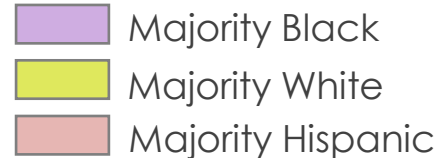
0 2 4 8 miles



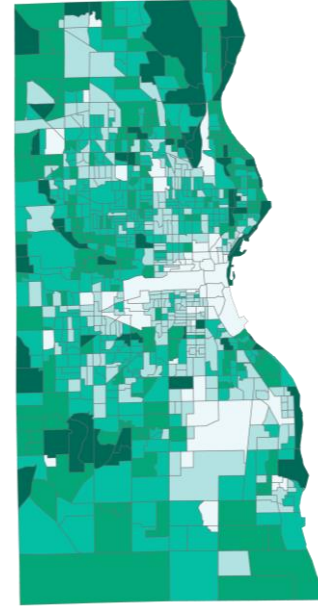
Racial Demographics



0 2 4 8 miles



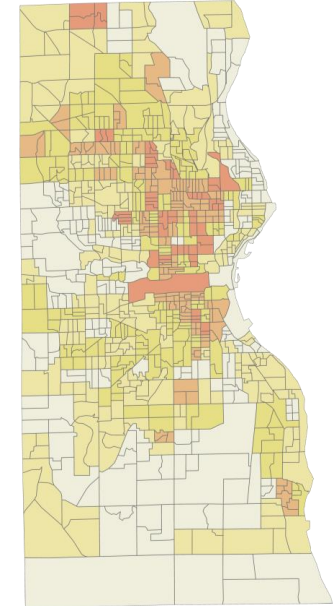
Green Space



0 2 4 8 miles



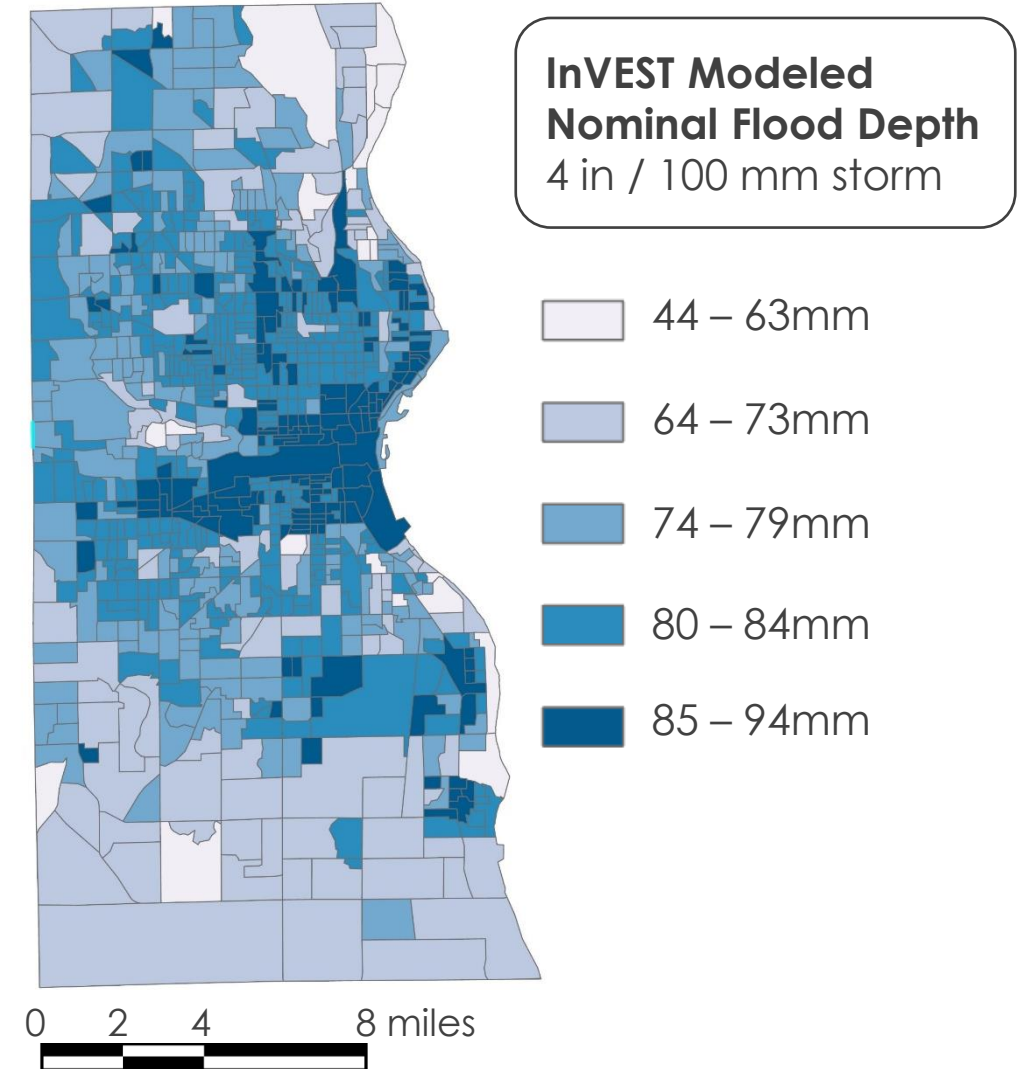
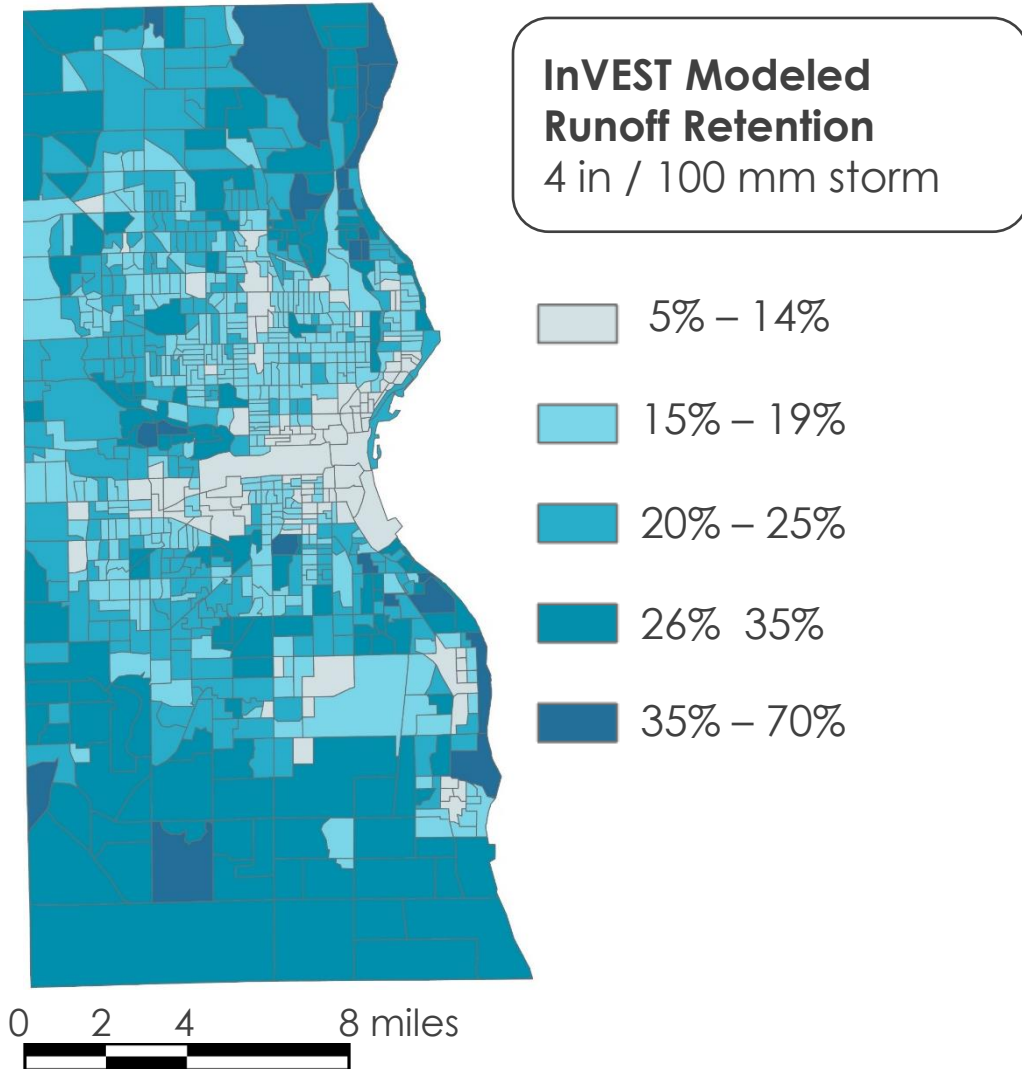
Community Resiliency



0 2 4 8 miles

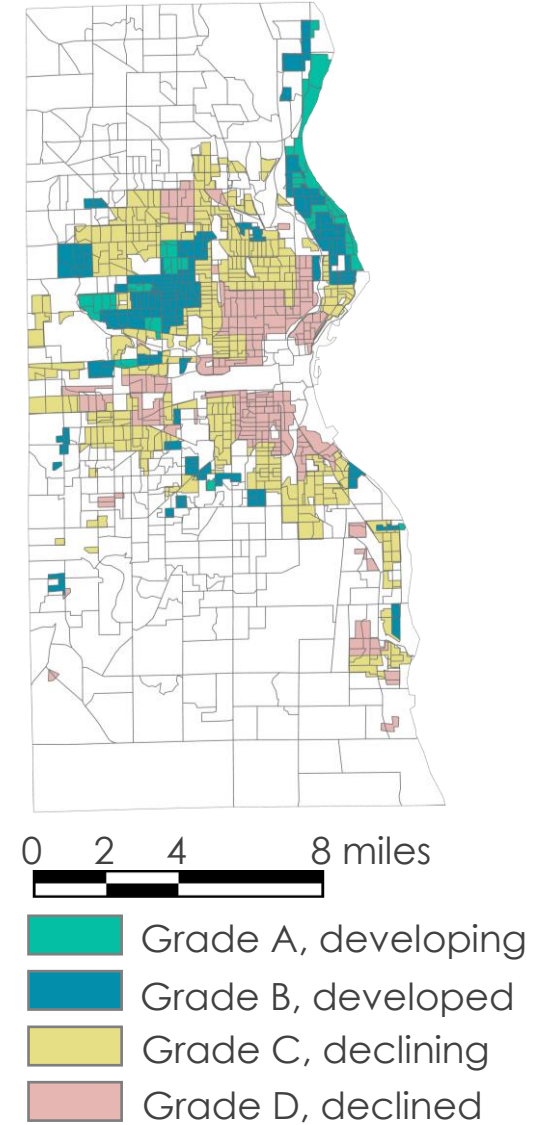
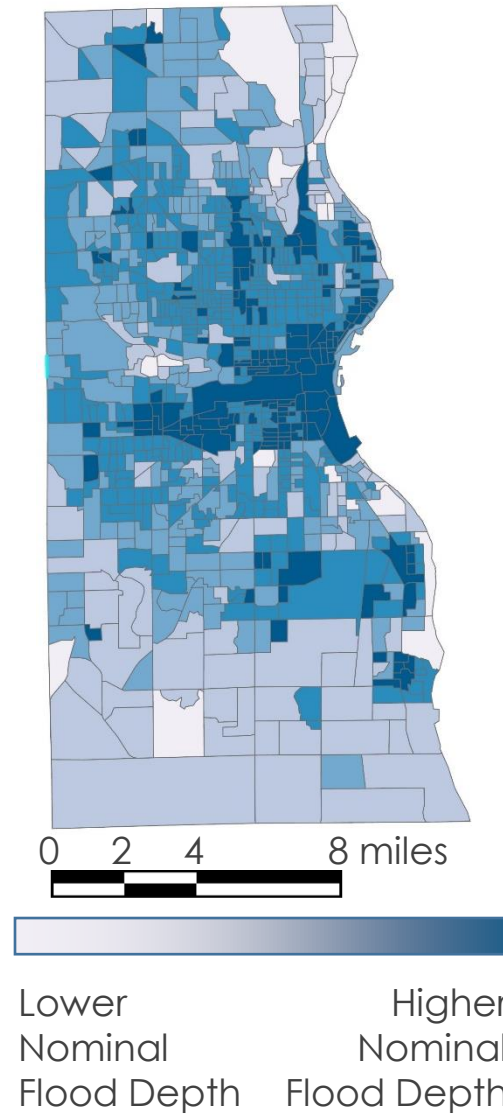
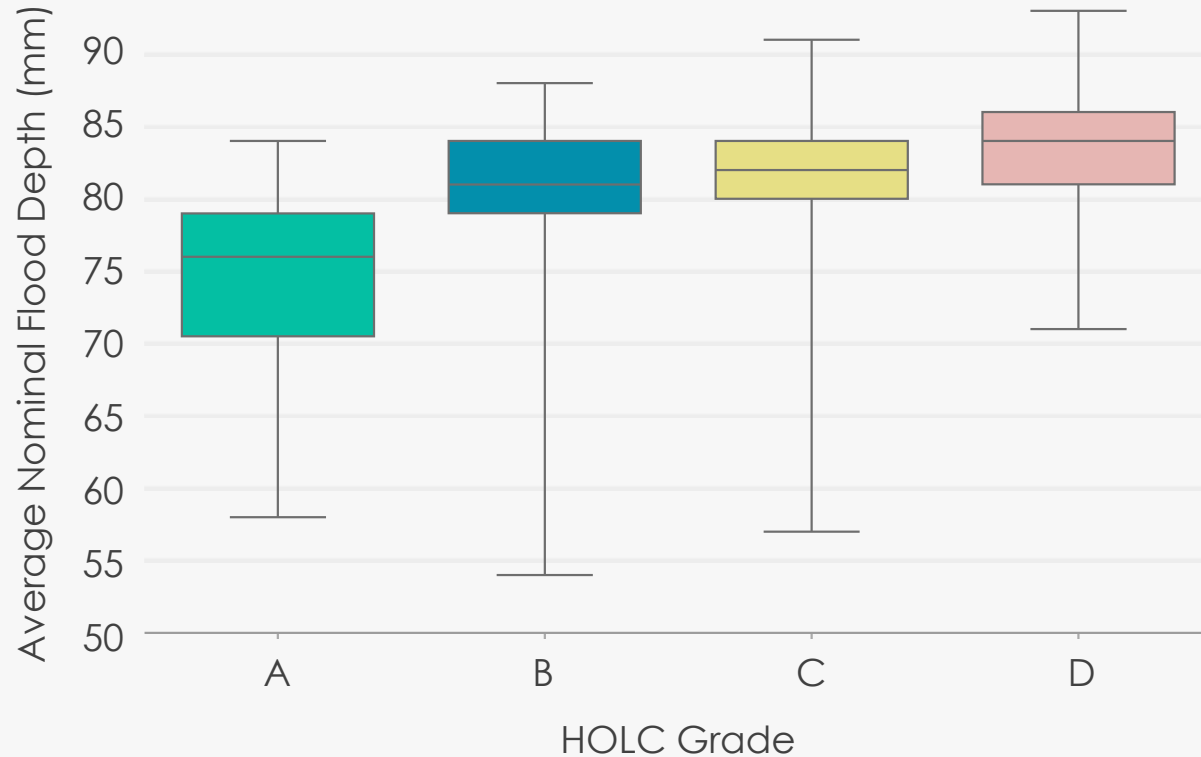


RUNOFF RETENTION VS NOMINAL FLOOD DEPTH



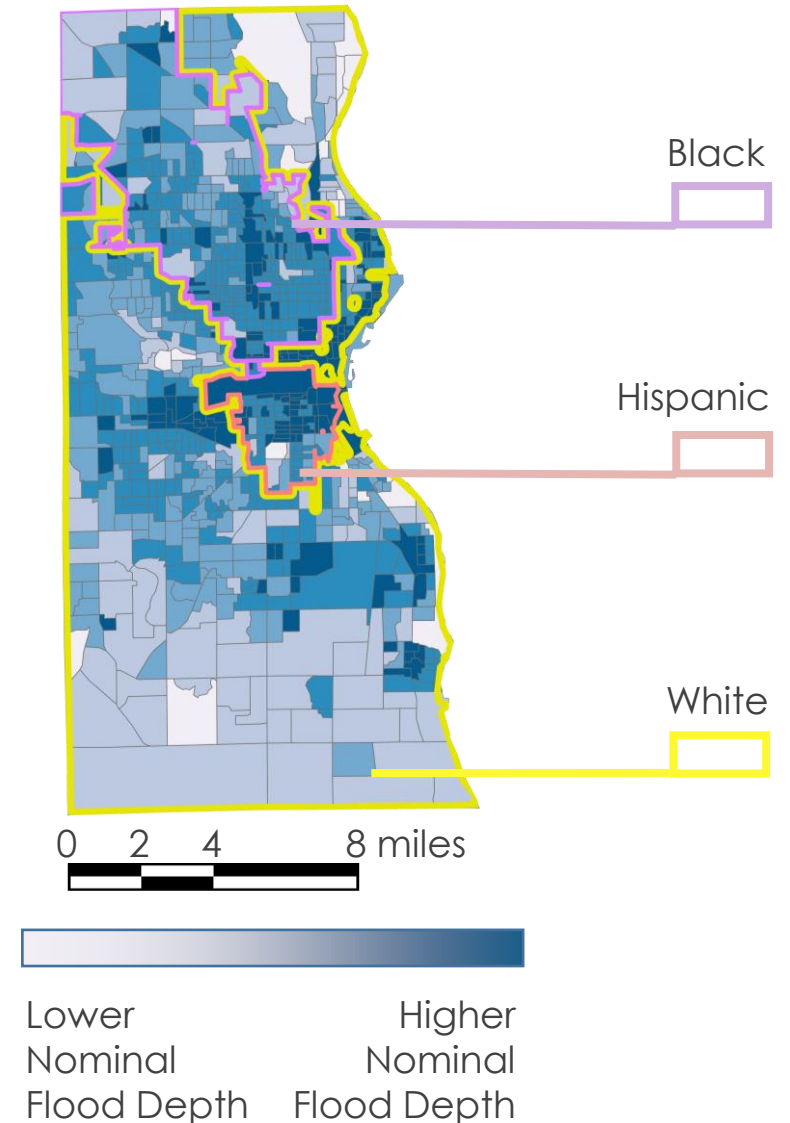
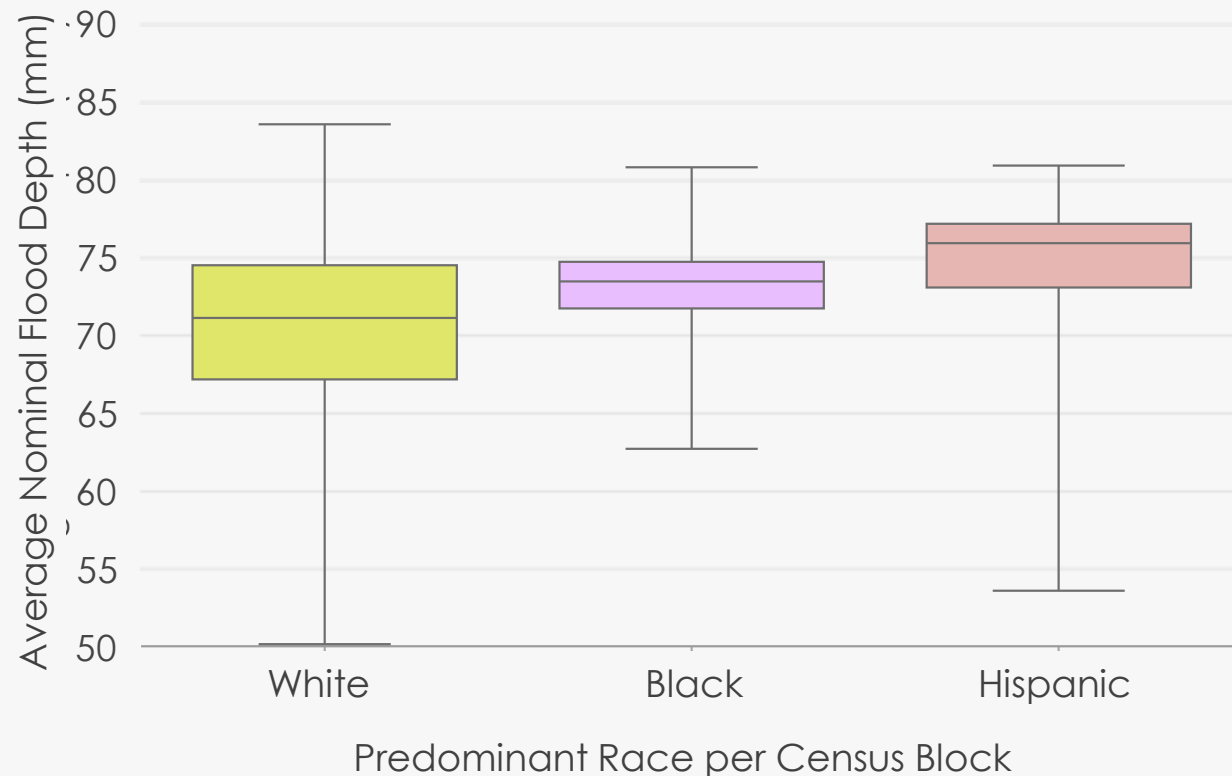
RESULTS: HISTORIC REDLINING

Historically redlined neighborhoods are associated with higher flood depths.



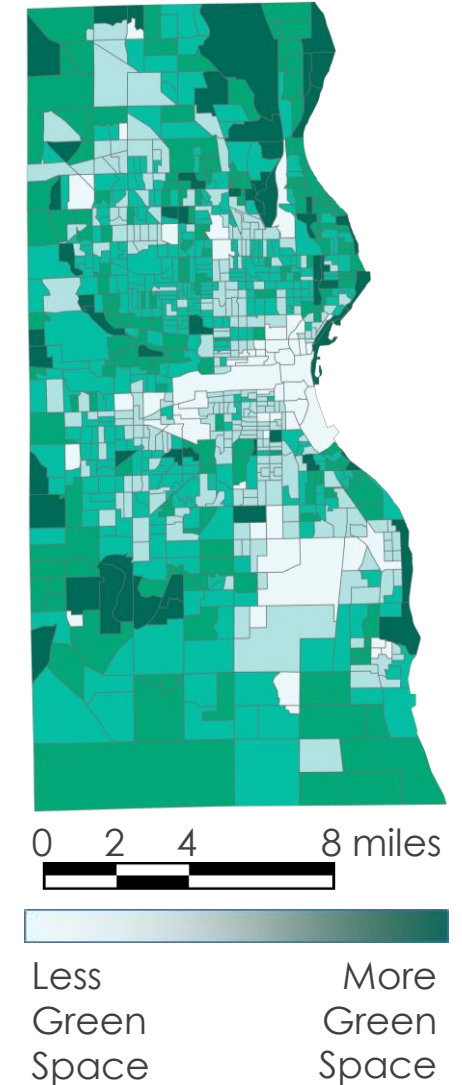
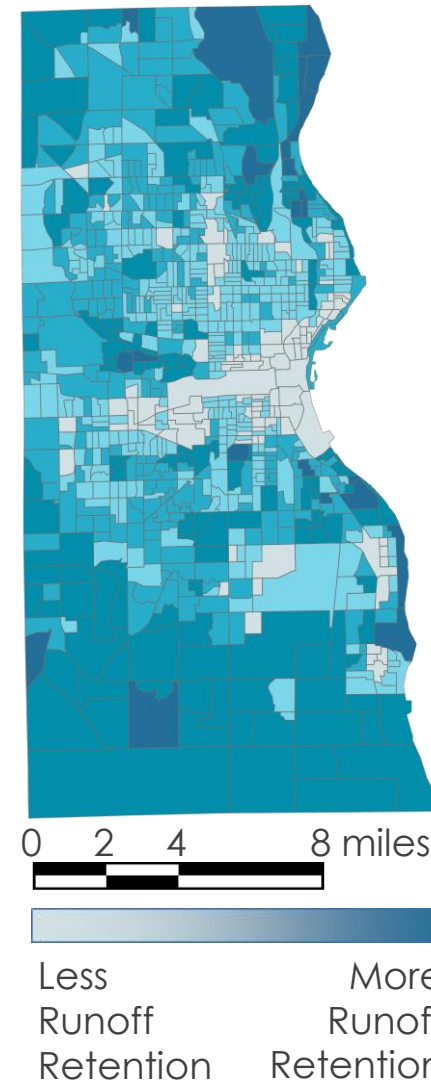
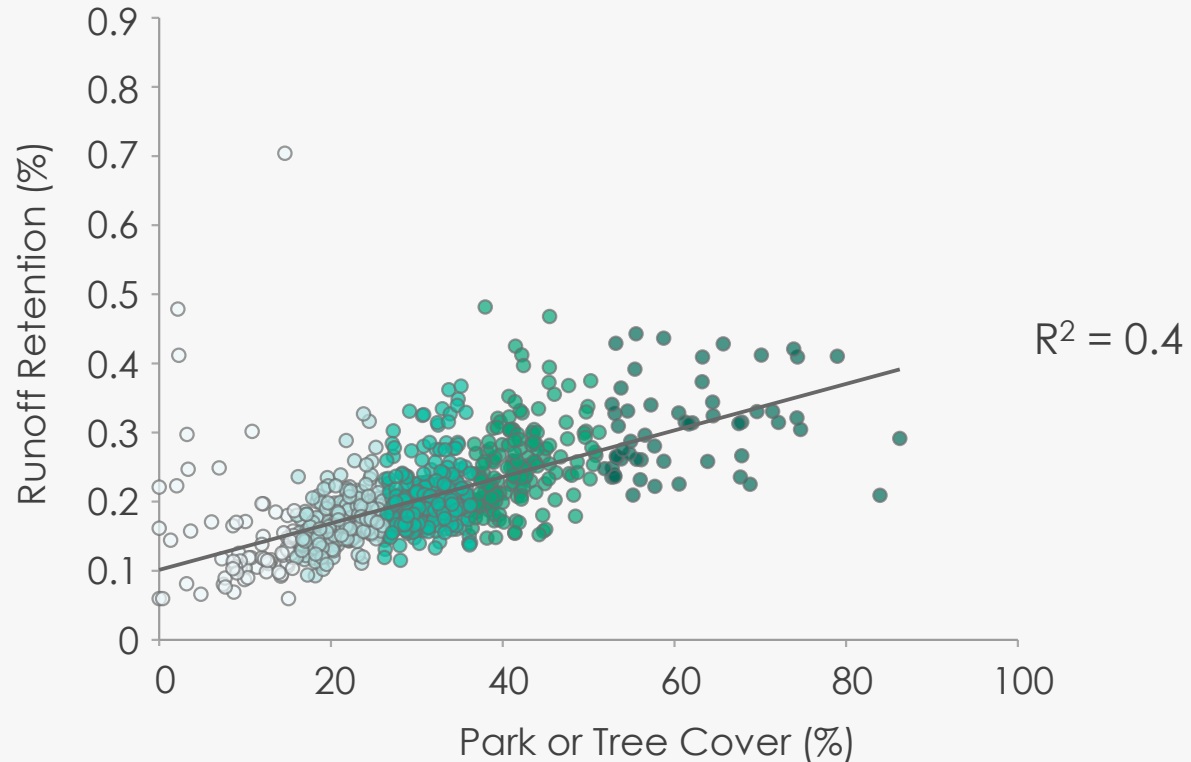
RESULTS: RACIAL DEMOGRAPHICS

Flood depth is 3.3% higher in predominantly Black census blocks & 6.8% higher in predominantly Hispanic census blocks than in predominantly White census blocks



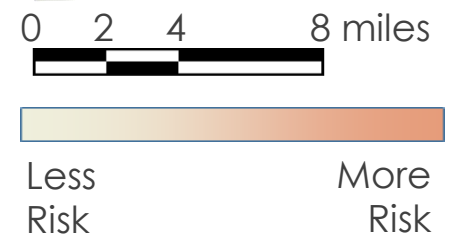
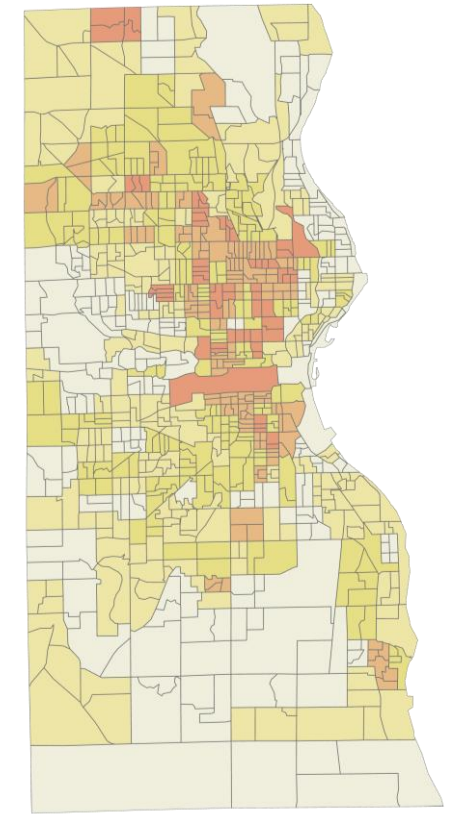
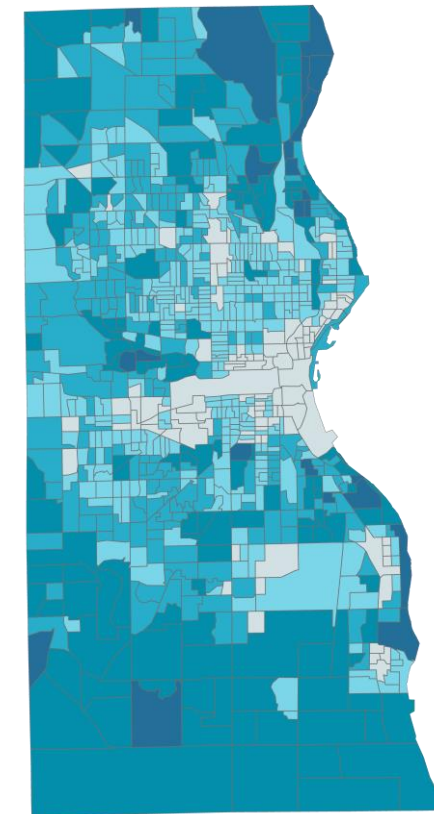
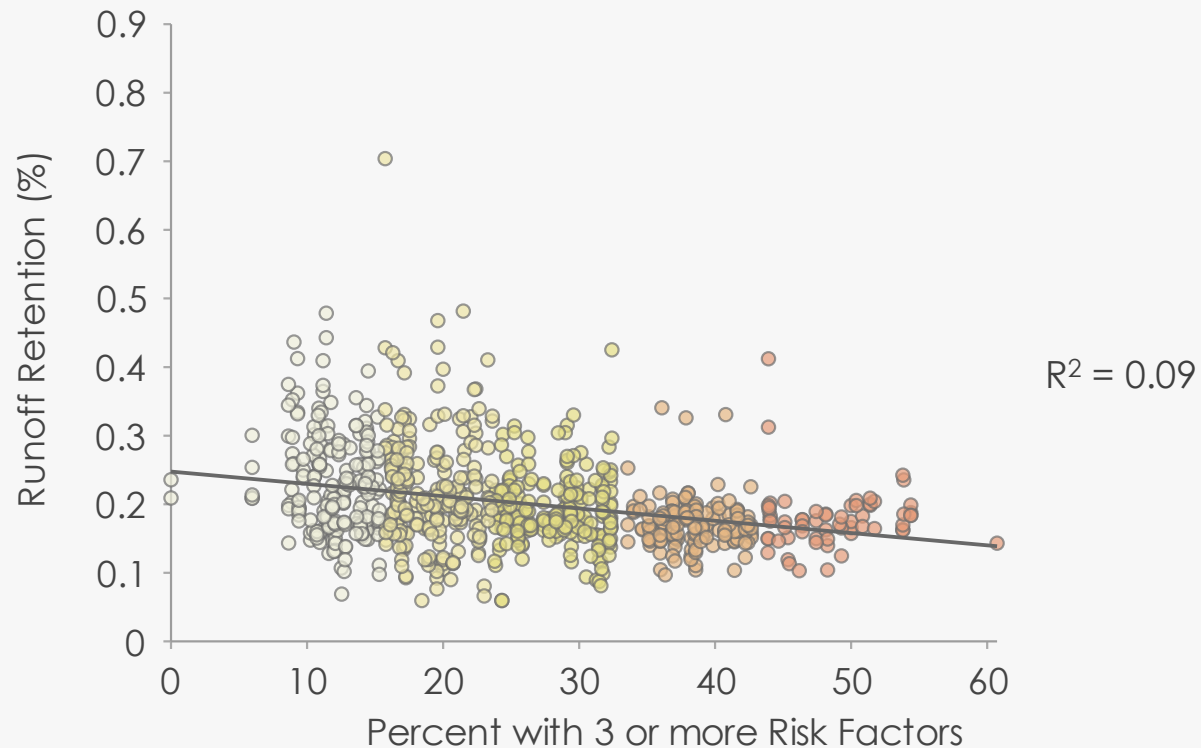
RESULTS: GREEN SPACE

Runoff retention increases with higher park or tree cover per block group



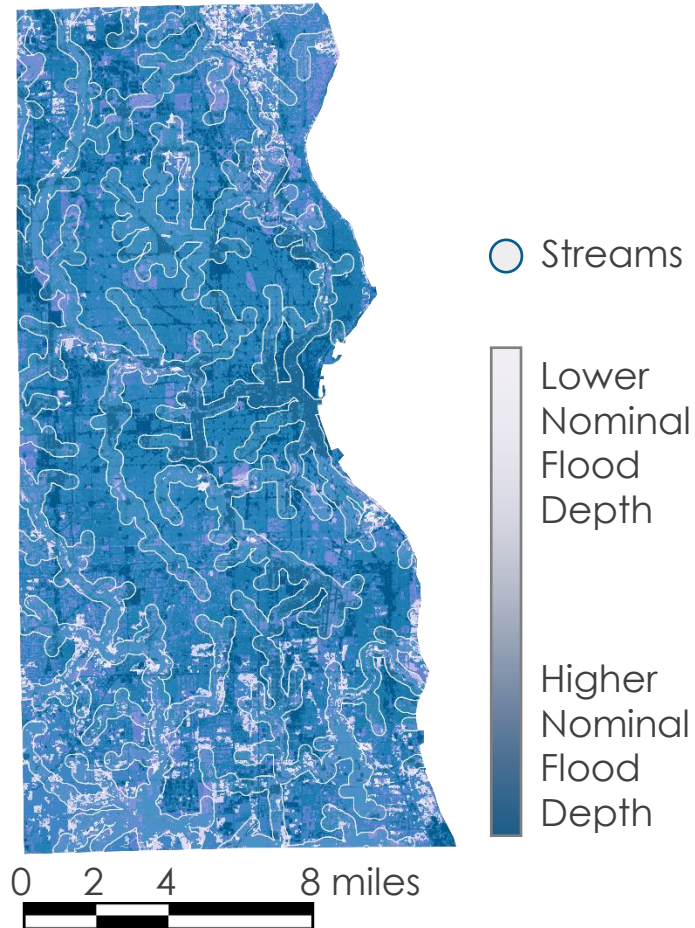
RESULTS: COMMUNITY RESILIENCY

Runoff retention is slightly worse in areas of low community resiliency, compounding the dangers of a flood disaster.

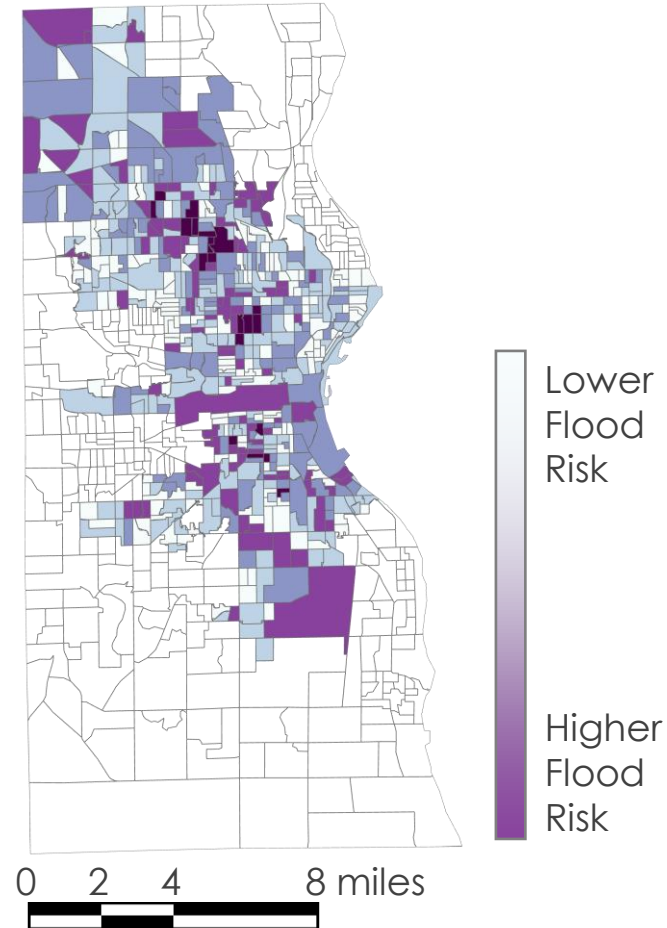


InVEST CONTEXT

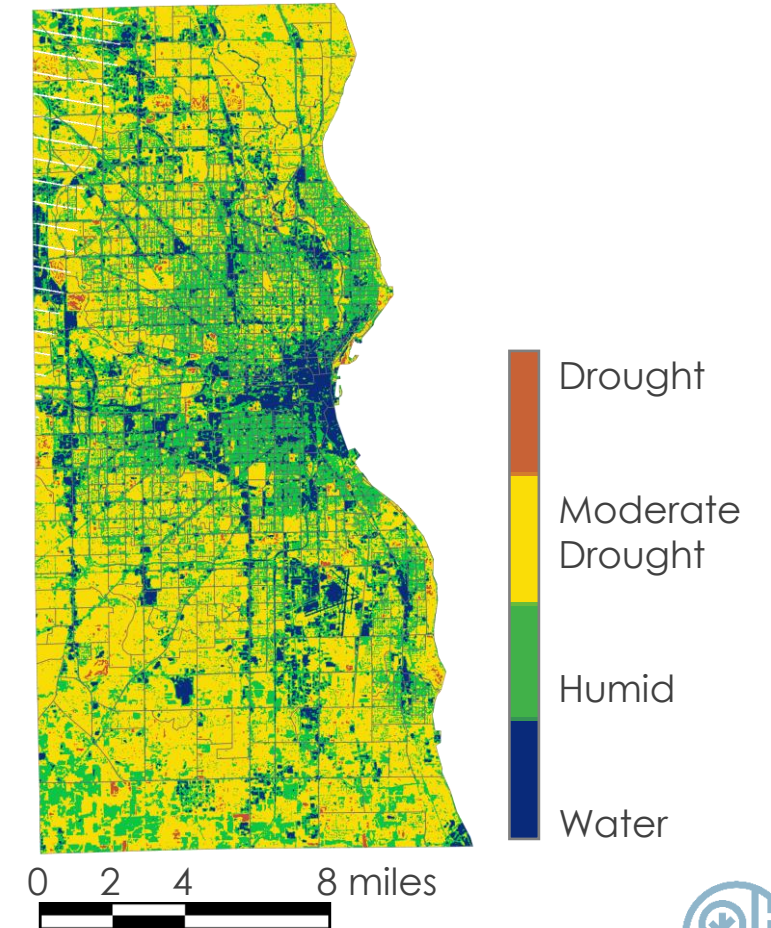
DEM Modeled Streams



CityCAT Flood Model

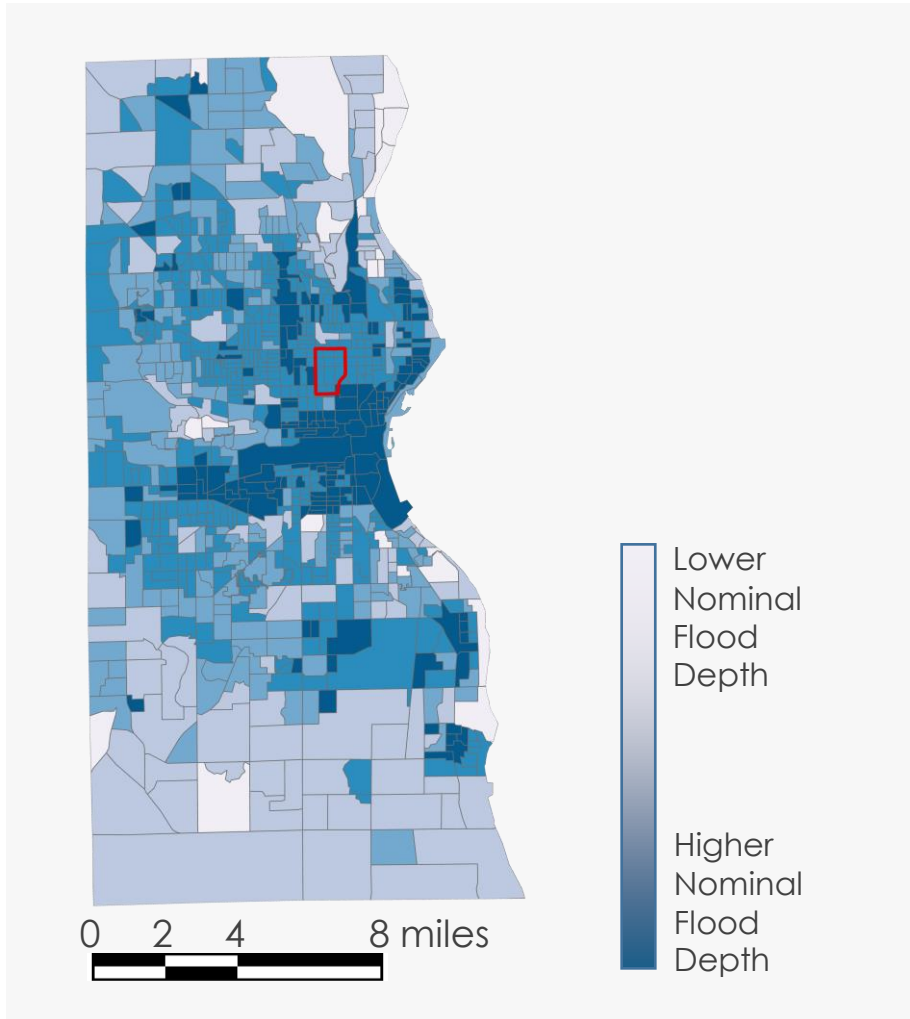


NDWI

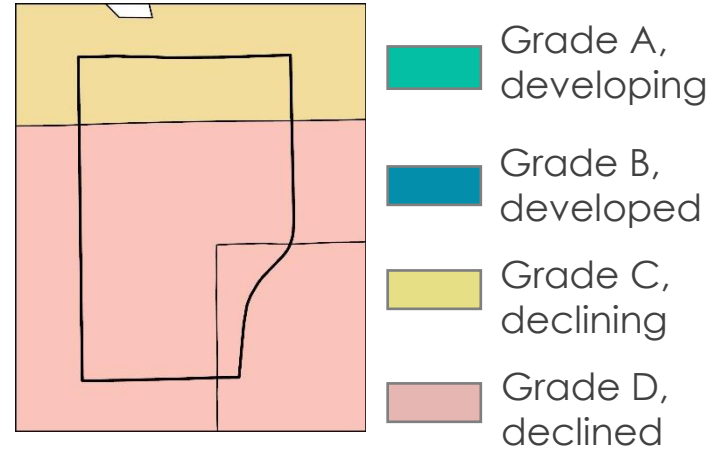


SPOTLIGHT ON LINDSAY HEIGHTS

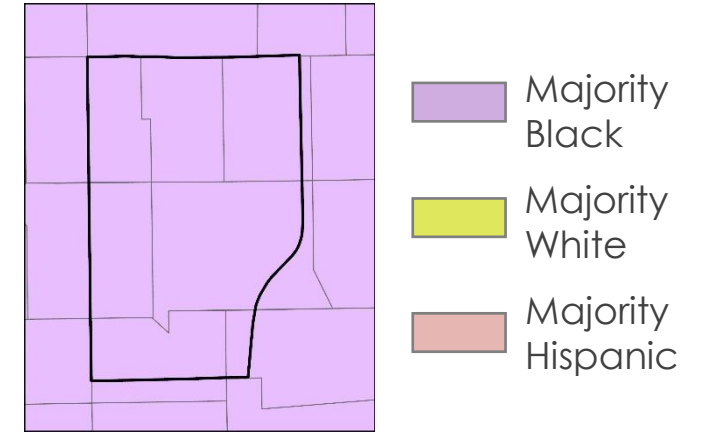
Nominal Flood Depth



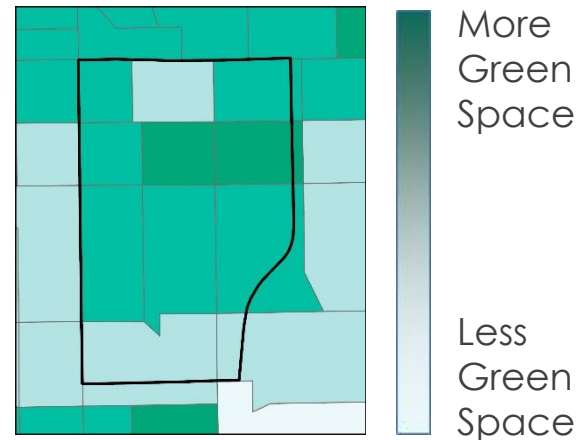
Historic Redlining



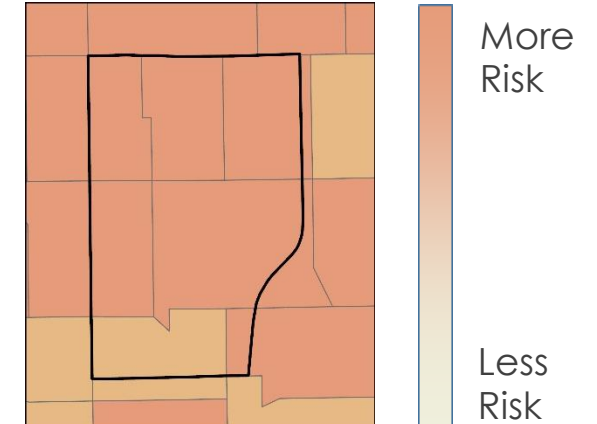
Racial Demographics



Green Space



Community Resiliency



An aerial photograph of a city, likely San Francisco, showing a dense urban grid, highways, and a waterfront area. The image is overlaid with a semi-transparent blue filter. The word "CONCLUSIONS" is centered in white, bold, sans-serif capital letters.

CONCLUSIONS

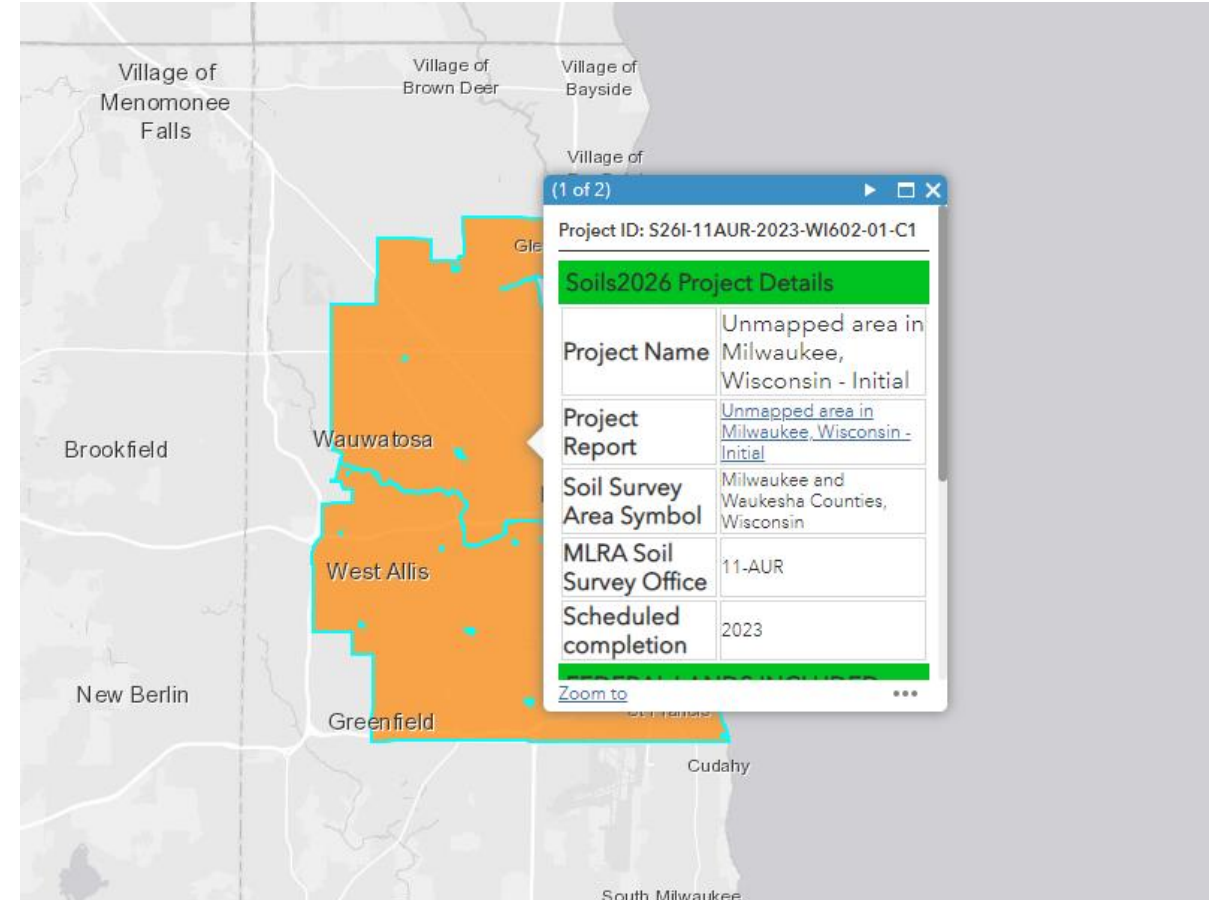
CONCLUSIONS

- ▶ InVEST does not account for:
 - ▶ Hydrologic flow
 - ▶ Elevation
 - ▶ Sewer infrastructure
 - ▶ Riverine (fluvial) flooding
 - ▶ Social vulnerability
- ▶ InVEST corroborates the known phenomenon that flood risk disproportionately impacts marginalized groups due to decades of infrastructure disinvestment
- ▶ InVEST is useful as a tool to evaluate community flood risk, but potentially challenging to implement



ERRORS & UNCERTAINTIES

- ▶ Data input
 - ▶ Economic damage estimates are not specific to the Milwaukee region
 - ▶ Incomplete Milwaukee soil survey data
- ▶ Community input
 - ▶ Time constraints
 - ▶ Remote work



Unmapped soil areas in Milwaukee

Image Credit: Soils2026 Initial Soil Survey Projects



FUTURE WORK

- ▶ Additional analysis variables
 - ▶ Toxic waste sites/brownfields
 - ▶ Historic waterbodies and vegetation
 - ▶ Closed depressions
 - ▶ Flooding survey results (sewer backups and wet basements)
- ▶ Investment and ecosystem services assessments
- ▶ Damage valuation
- ▶ Sensitivity analysis of InVEST using precipitation and year
- ▶ Milwaukee Urban Development II



ACKNOWLEDGEMENTS

▶ Project Partners

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 - ▶ Lauren Childs-Gleason, Science Manager
- ▶ NASA DEVELOP
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 - ▶ Remi Work, VEJ Assistant Fellow

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An aerial photograph of a city, likely San Francisco, showing a dense urban grid, a major highway interchange, and a body of water (the bay) on the right side. The entire image is covered with a semi-transparent blue overlay.

THANK YOU FOR ATTENDING!

QUESTIONS & COMMENTS WELCOME