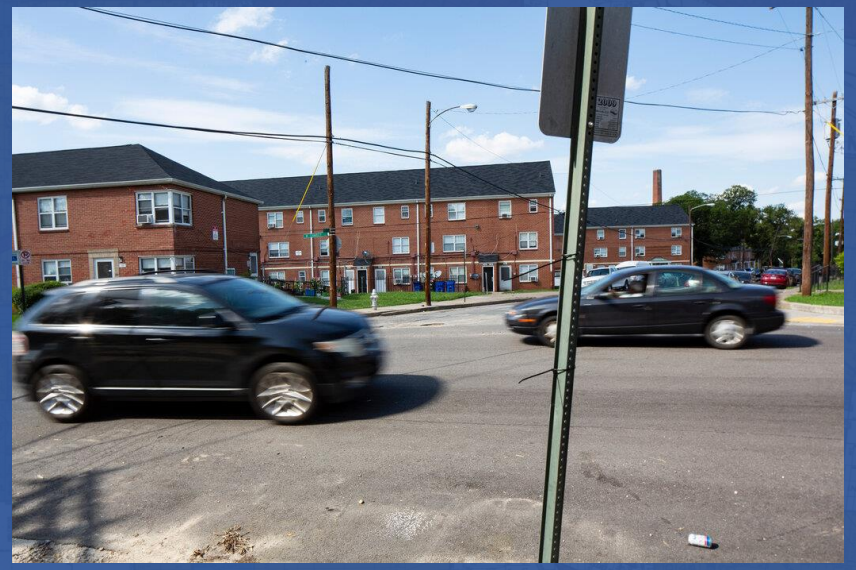
Redlining and Environmental Health Outcomes: Addressing Historical Injustices as we Create a Climate-Resilient Future

Climate change and urban heat

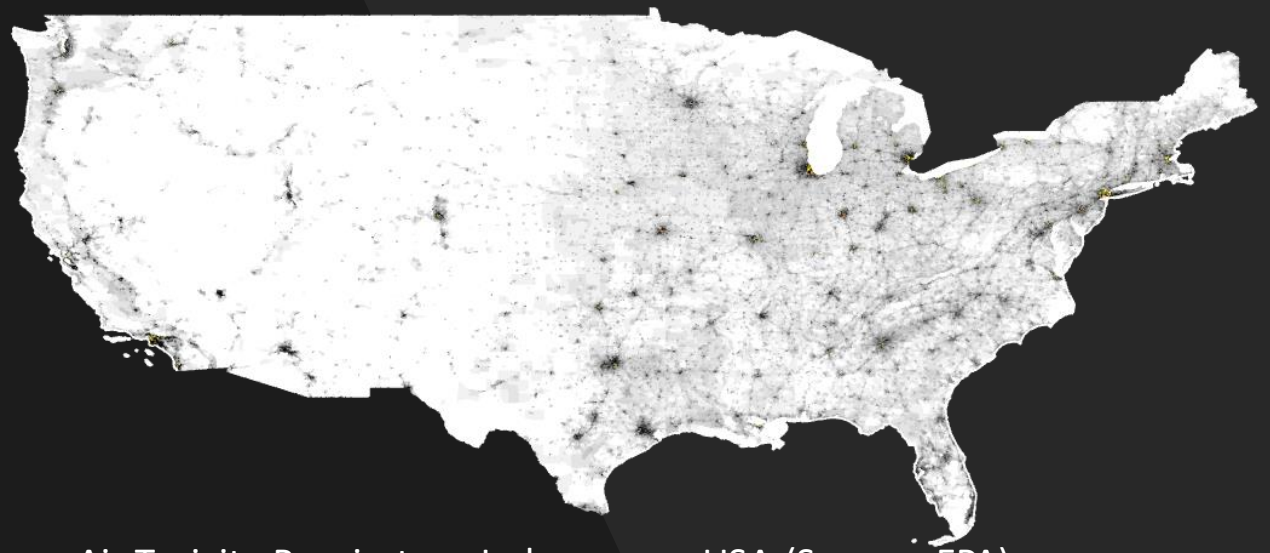
- The intensity of heat waves is increasing worldwide
- Temperate climates are not prepared
- Heat and other environmental risks lead to poorer health outcomes
- Urban heat can vary dramatically across a city by as much as 20°F (Shandas 2020)
- Communities are affected unequally

- Black and minority people were segregated into ‘redlined’ areas and denied home loans in the 1930s.
- These areas have higher temperatures today (Shandas 2020).

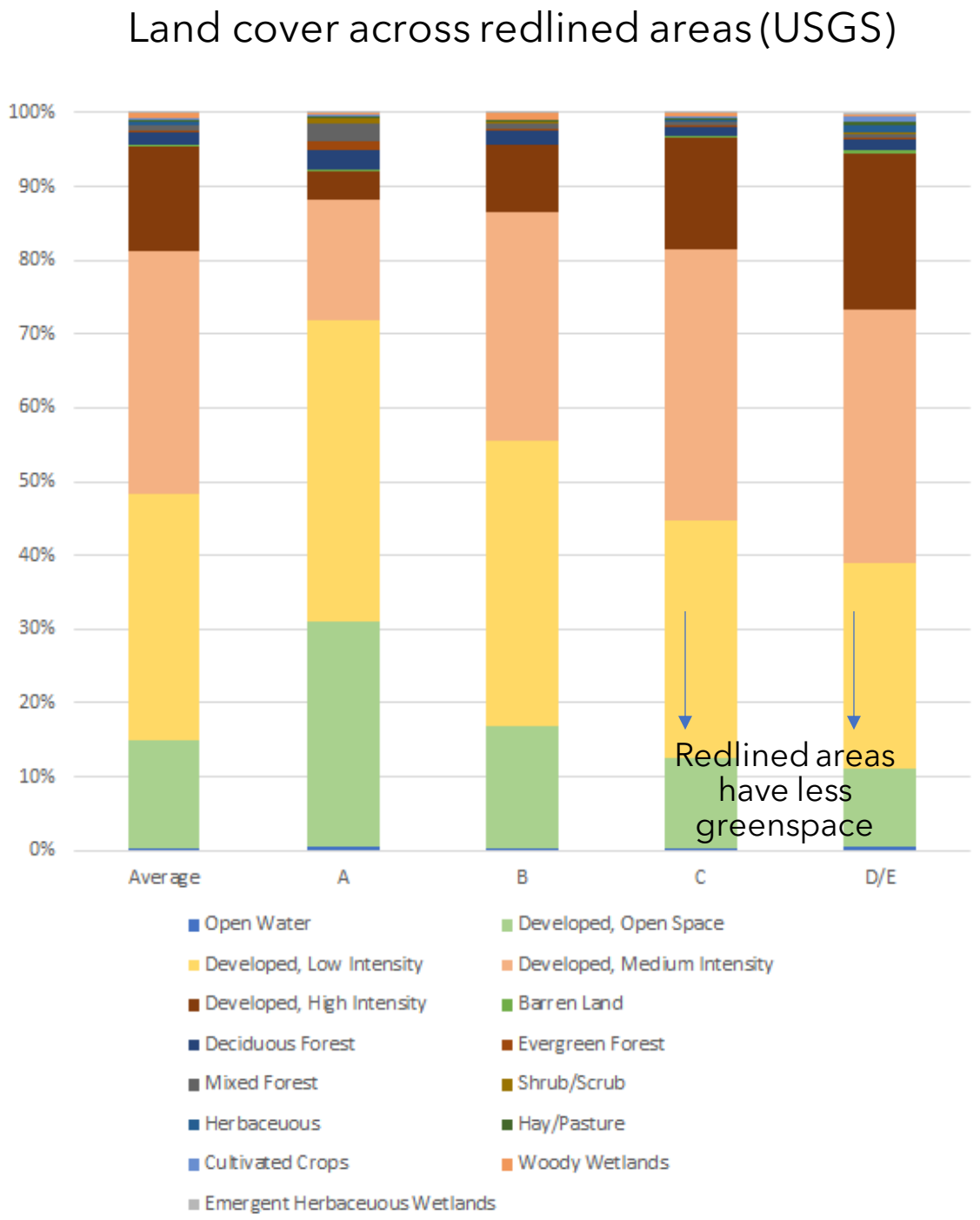


Our study on national disparities in environmental health

- Redlined areas tend to have more minority populations, diesel particulate matter, PM25, asthma and cancer.
- Outside of redlined areas, these disparities continue: minority populations are correlated with diesel particulate matter, impervious area and asthma and cancer rates.



Air Toxicity Respiratory Index across USA (Source: EPA)



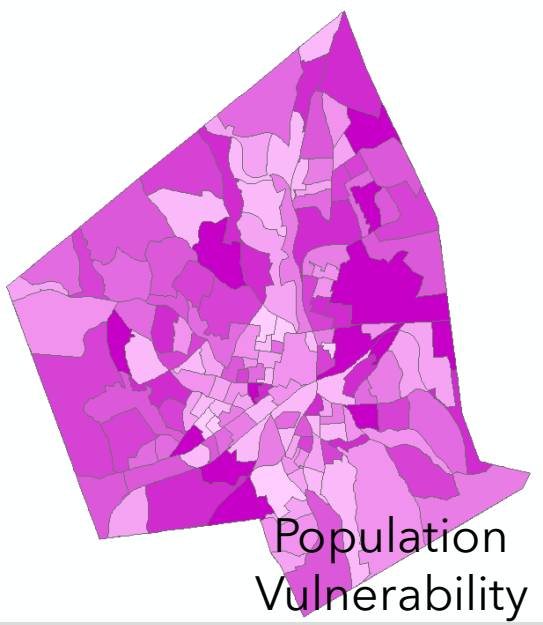
Think global, act local

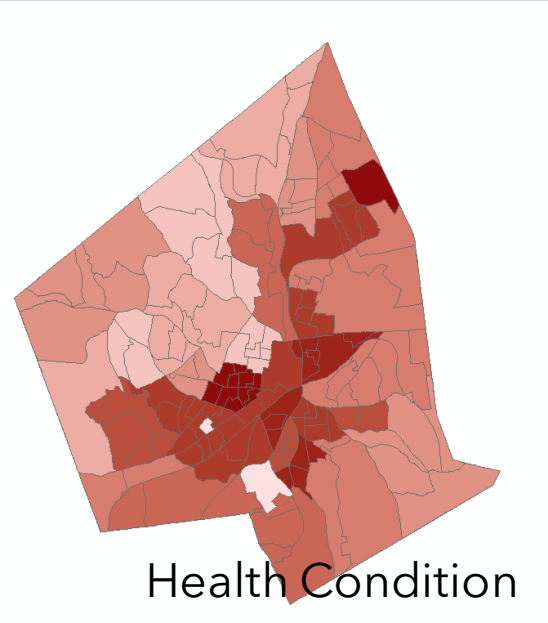
- How can street tree planting in Worcester create climate resilience and address historical inequity?
  - What communities experience most heat vulnerability?
  - Where is greenspace lacking?
- Urban heat and other environmental exposures is caused by impervious area and less park area.

What communities experience the most heat vulnerability?

Percent younger than 65

Percent younger than 5





Asthma rates

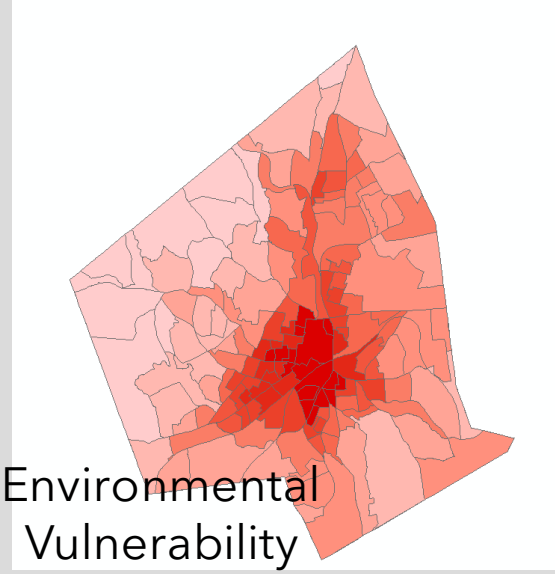
Diabetes rates

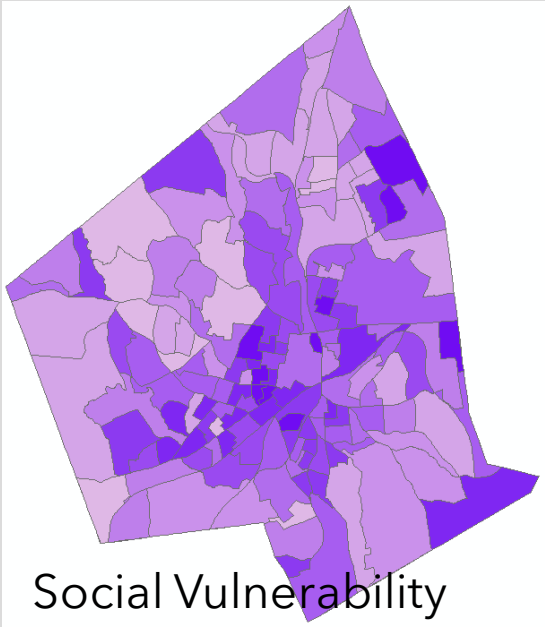
High Blood Pressure rates

Obesity Rates

Urban heat measurements

Impervious area measurements





Percent low income

Percent having no high school diploma

Percent of population older than 65 living alone

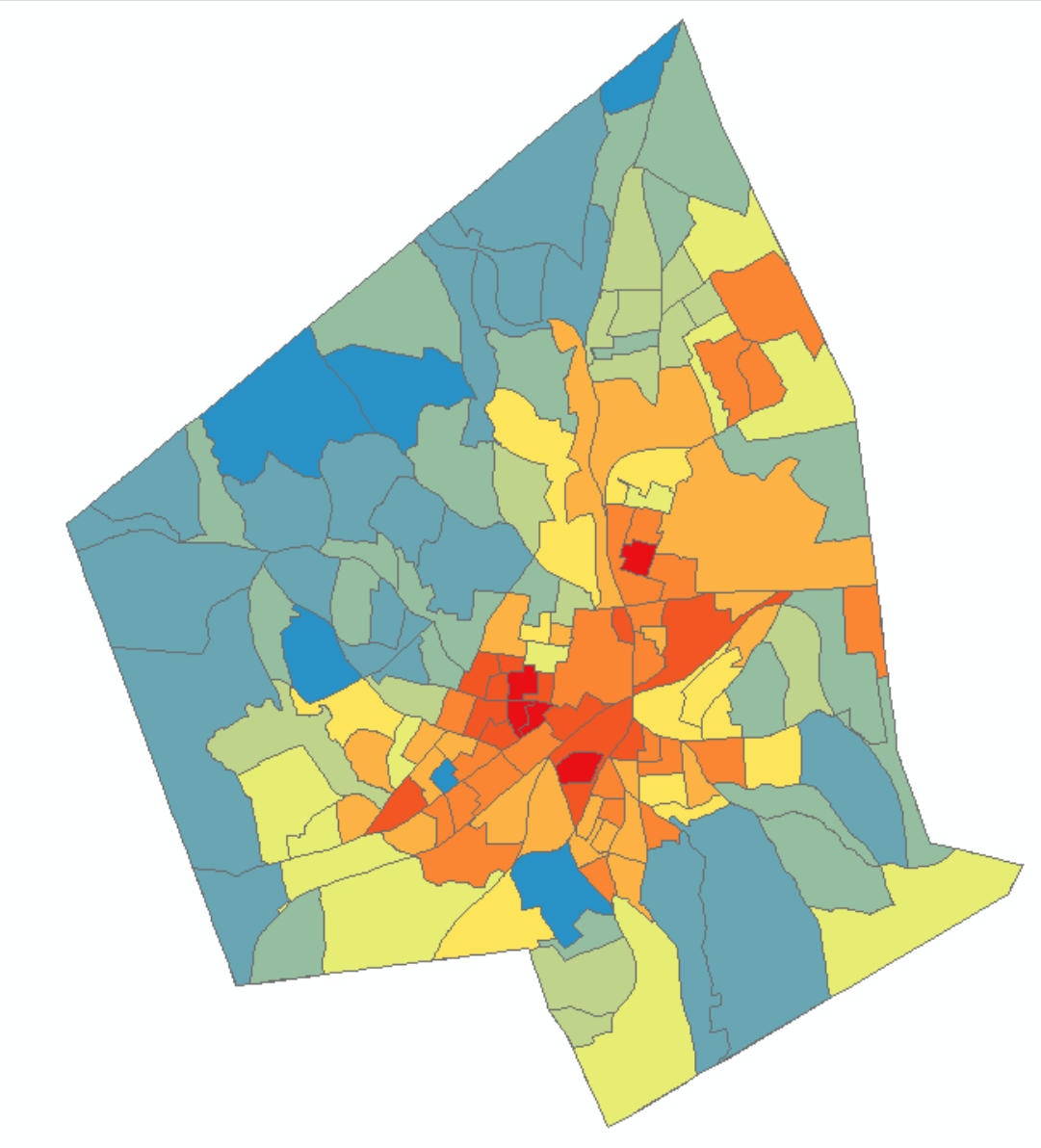
Percent with no health insurance

What communities experience the most heat vulnerability?

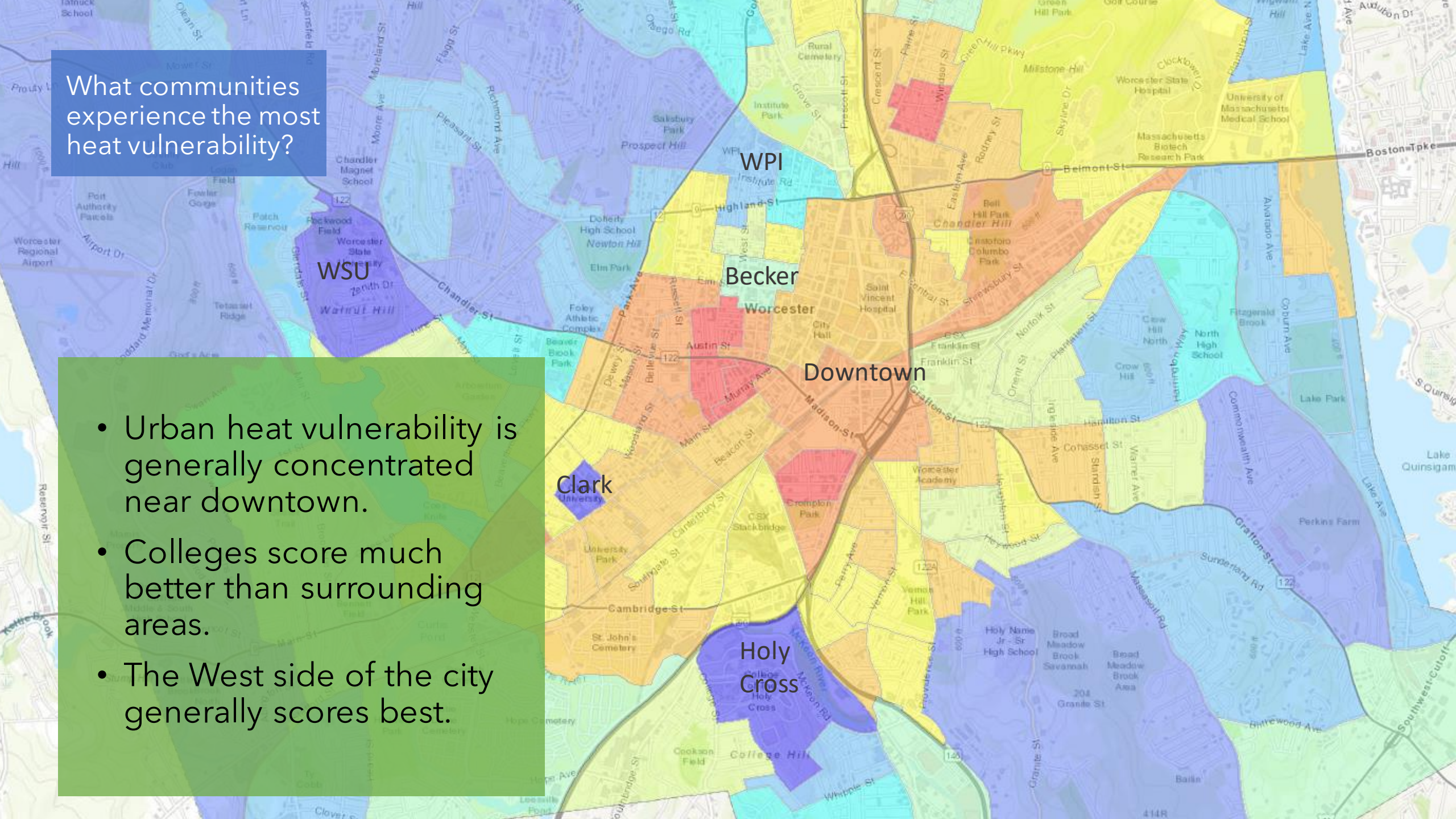
The Worcester heat index combines these indices:

- Population
- Environmental
- Health
- Social

Based off a Heat Vulnerability study in Vermont.



What communities experience the most heat vulnerability?



- Urban heat vulnerability is generally concentrated near downtown.
- Colleges score much better than surrounding areas.
- The West side of the city generally scores best.

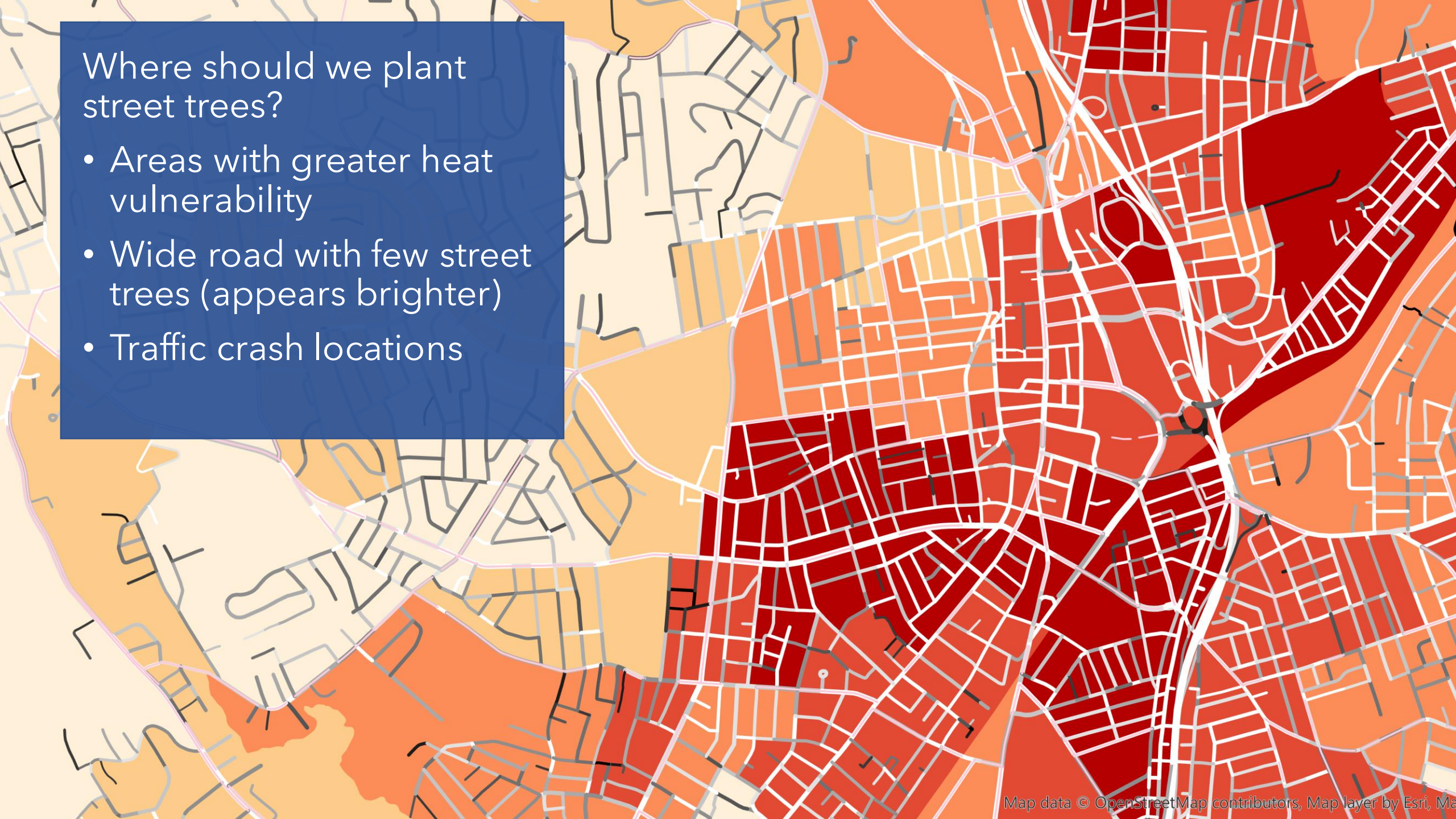
Racial disparities in heat vulnerability

The urban heat vulnerability index has a strong negative correlation with percentage white populations and positive correlation with Hispanic and Black populations, even though redlining maps were not made for Worcester.

White	Black	Native Am.	Asian	Hispanic
-0.446	0.245	0.147	0.003	0.688

Where should we plant street trees?

- Areas with greater heat vulnerability
- Wide road with few street trees (appears brighter)
- Traffic crash locations



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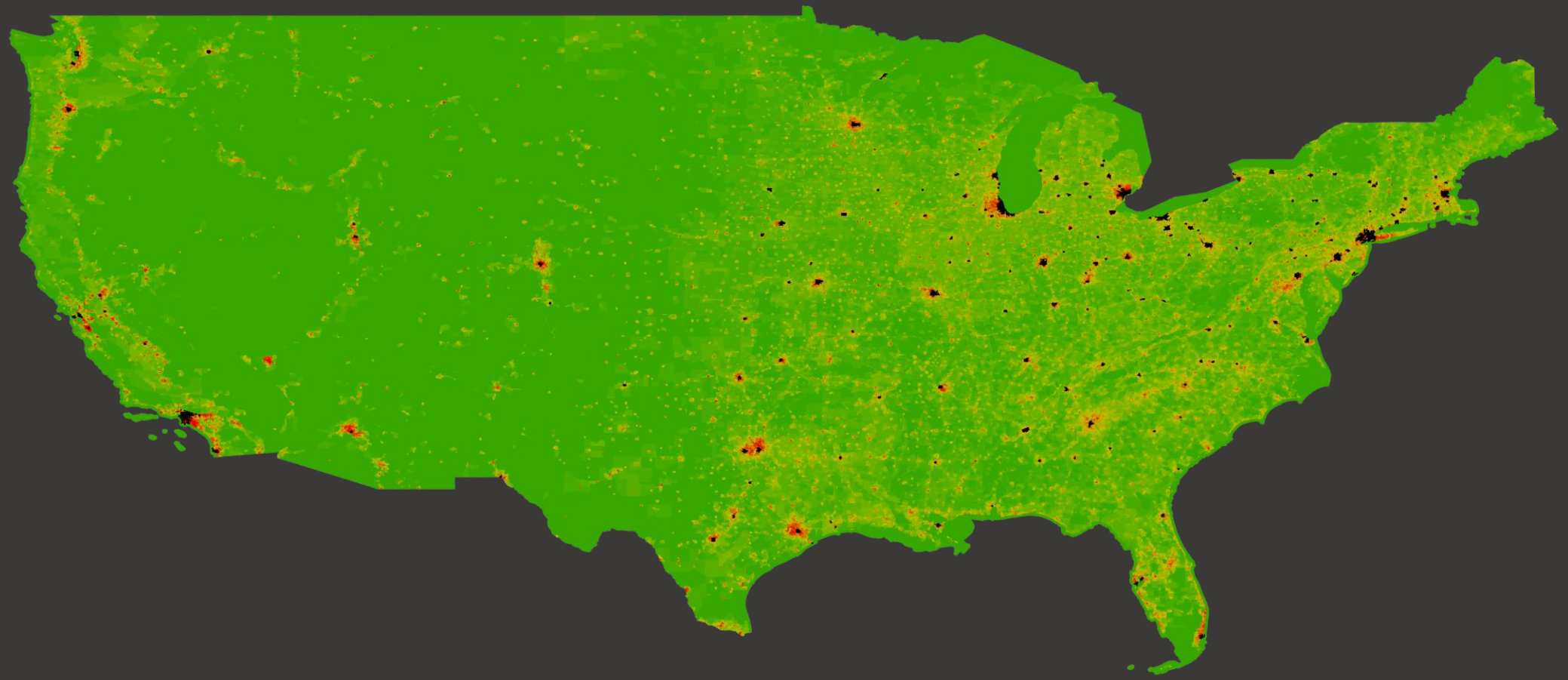
- Areas with greater heat vulnerability
- Wide road with few street trees (appears brighter)
- Traffic crash locations

Chandler street. Most dangerous roadway in Worcester by crash data.

Francis McGrath Blvd

Shrewsbury street

Nationwide… locally!



Map and Research Sources

Population data: US Census Bureau, census.gov

IPUMS NHGIS, University of Minnesota, www.nhgis.org

Redlining Map data: Robert K. Nelson, LaDale Winling, Richard Marciano, Nathan Connolly, et al., "Mapping Inequality," American Panorama, ed. Robert K. Nelson and Edward L. Ayers, accessed April 26, 2021, https://dsl.richmond.edu/panorama/redlining/

Eviction Data: Princeton University, Eviction Lab, evictionlab.org

Environmental Indicators: US EPA, epa.gov/ejscreen

Health Indicators: US CDC, cdc.gov/places

Impervious area: USGS NLCD, www.usgs.gov/centers/eros/science/national-land-cover-database

Roadway area and greenery along roadways: MassGIS (Bureau of Geographic Information), Commonwealth of Massachusetts EOTSS

Hoffman, J. S., Shandas, V., & Pendleton, N. (2020). The Effects of Historical Housing Policies on Resident Exposure to Intra-Urban Heat: A Study of 108 US Urban Areas. Climate, 8(1), 12.

Image Sources

Title Slide: Photo by Terragorge https://en.wikipedia.org/wiki/File:Downtown_Worcester,_Massachusetts.jpg

Redlining map: Robert K. Nelson, LaDale Winling, Richard Marciano, Nathan Connolly, et al., "Mapping Inequality," American Panorama, ed. Robert K. Nelson and Edward L. Ayers, accessed April 26, 2021, https://dsl.richmond.edu/panorama/redlining/#loc=10/34.005/-118.562&city=los-angeles-ca&area=C125&text=downloads

Photograph of people in heat wave: https://press.uchicago.edu/Misc/Chicago/443213in.html

Washington Square Worcester: https://www.telegram.com/news/20171125/remaking-worcester-next-year-will-be-crucial-for-citysquare

Pearson's Correlation Matrix for Census Block Groups across Continental United States			Minority	Low-income	Linguistic Isolation	Under 5	Over 64	White	Af.Am.	Hispanic	American Indian	Asian	Impervious Area
Diesel Particulate Matter	Posterior	Mode	0.352	0.034	0.208	0.050	-0.164	-0.351	0.199	0.248	-0.079	0.242	0.658
		Mean	0.352	0.034	0.208	0.050	-0.164	-0.351	0.199	0.248	-0.079	0.242	0.658
		Variance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	95% Credible Interval	Lower Bound	0.348	0.030	0.204	0.046	-0.168	-0.354	0.195	0.244	-0.083	0.239	0.656
		Upper Bound	0.355	0.038	0.212	0.054	-0.160	-0.347	0.203	0.252	-0.075	0.246	0.661
Cancer	Posterior	Mode	0.267	0.089	0.061	0.059	-0.098	-0.243	0.217	0.179	-0.063	0.093	0.281
		Mean	0.267	0.089	0.061	0.059	-0.098	-0.243	0.217	0.179	-0.063	0.093	0.281
		Variance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	95% Credible Interval	Lower Bound	0.263	0.085	0.057	0.055	-0.103	-0.247	0.213	0.175	-0.067	0.089	0.277
		Upper Bound	0.271	0.093	0.065	0.063	-0.094	-0.239	0.221	0.183	-0.059	0.098	0.284
Respiratory Index	Posterior	Mode	0.384	0.133	0.139	0.074	-0.133	-0.361	0.260	0.263	-0.070	0.180	0.416
		Mean	0.384	0.133	0.139	0.074	-0.133	-0.361	0.260	0.263	-0.070	0.180	0.416
		Variance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	95% Credible Interval	Lower Bound	0.380	0.129	0.135	0.070	-0.137	-0.364	0.256	0.259	-0.074	0.176	0.412
		Upper Bound	0.387	0.137	0.143	0.078	-0.129	-0.357	0.264	0.267	-0.066	0.184	0.419
Traffic volumes on roads nearby	Posterior	Mode	0.259	0.070	0.174	0.016	-0.108	-0.253	0.065	0.220	-0.036	0.232	0.443
		Mean	0.258	0.070	0.174	0.016	-0.108	-0.253	0.065	0.220	-0.036	0.232	0.443
		Variance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	95% Credible Interval	Lower Bound	0.255	0.066	0.170	0.012	-0.112	-0.257	0.061	0.216	-0.040	0.229	0.440
		Upper Bound	0.262	0.074	0.178	0.020	-0.104	-0.249	0.069	0.224	-0.032	0.236	0.446
PM25	Posterior	Mode	0.141	-0.002	-0.186	0.083	-0.119	-0.114	0.152	0.256	-0.099	0.113	0.329
		Mean	0.141	-0.002	-0.186	0.083	-0.119	-0.114	0.152	0.256	-0.099	0.113	0.329
		Variance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	95% Credible Interval	Lower Bound	0.137	-0.006	-0.190	0.079	-0.123	-0.118	0.148	0.252	-0.103	0.109	0.326
		Upper Bound	0.145	0.003	-0.182	0.088	-0.115	-0.110	0.156	0.260	-0.095	0.117	0.333
Asthma	Posterior	Mode	0.074	0.337	-0.319	0.120	-0.081	-0.028	0.423	0.004	0.099	-0.240	0.150
		Mean	0.074	0.337	-0.319	0.120	-0.081	-0.028	0.423	0.004	0.099	-0.240	0.150
		Variance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	95% Credible Interval	Lower Bound	0.070	0.334	-0.322	0.115	-0.085	-0.032	0.420	-0.001	0.094	-0.244	0.146
		Upper Bound	0.078	0.341	-0.315	0.124	-0.077	-0.024	0.426	0.008	0.103	-0.236	0.154
Diabetes	Posterior	Mode	0.304	0.474	-0.077	0.097	0.129	-0.277	0.505	0.159	0.057	-0.186	0.049
		Mean	0.304	0.474	-0.077	0.097	0.129	-0.277	0.505	0.159	0.057	-0.186	0.049
		Variance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	95% Credible Interval	Lower Bound	0.301	0.471	-0.081	0.092	0.125	-0.281	0.502	0.155	0.053	-0.190	0.044
		Upper Bound	0.308	0.477	-0.073	0.101	0.133	-0.274	0.508	0.163	0.061	-0.182	0.053
Stroke	Posterior	Mode	0.161	0.433	-0.167	0.058	0.213	-0.137	0.483	-0.022	0.082	-0.250	-0.016
		Mean	0.161	0.433	-0.167	0.058	0.213	-0.137	0.483	-0.022	0.082	-0.250	-0.016
		Variance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	95% Credible Interval	Lower Bound	0.157	0.429	-0.171	0.054	0.209	-0.141	0.480	-0.026	0.078	-0.254	-0.020
		Upper Bound	0.165	0.436	-0.163	0.062	0.217	-0.133	0.487	-0.018	0.086	-0.246	-0.012
Impervious Area	Posterior	Mode	0.447	0.174	0.217	0.101	-0.226	-0.429	0.200	0.384	-0.078	0.278	
		Mean	0.447	0.174	0.217	0.101	-0.226	-0.429	0.200	0.384	-0.078	0.278	
		Variance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	95% Credible Interval	Lower Bound	0.444	0.170	0.213	0.096	-0.230	-0.432	0.196	0.381	-0.082	0.274	
		Upper Bound	0.451	0.178	0.221	0.105	-0.222	-0.425	0.204	0.388	-0.074	0.281	

Box Plot: Diesel Particulate Matter and redlining