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International Geography Championships
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Urban Heat Island Inequity in Durham County, North Carolina

Introduction

Urban heat islands (UHIs) are urban areas in which surfaces such as pavement and roofs retain solar energy resulting in much higher temperatures than surrounding rural areas.[1] This issue in Durham County, North Carolina is an expanding problem that is tied to race and poverty. The neighborhoods that heat up most have everything to do with inequality — less tree cover, greater poverty rates and a history of redlining. Redlining was a federal practice in the 1930's where the Home Owners' Loan Corporation excluded residents of majority Black neighborhoods from mortgages. These neighborhoods were denied the access to the trees or infrastructure that the wealthier parts of the town enjoyed.[2] If you map summer surface temperatures across Durham County today, the same majority African-American neighborhoods come out as the hottest and most vulnerable almost every time.

The five neighborhoods that were compared for patterns of UHI in this study are the Hayti District, Merrick Moore Community, Bragtown Community, Northgate Mall Corridor and NCCU Campus Area. Using ArcGIS Online and by conducting spatial analysis, my key conclusion is that Durham heat inequality isn't random whatsoever. Instead, it goes back to decisions made almost 100 years ago and without intervention, it will continue getting worse.

Methodology

This analysis was performed using ArcGIS Online, by stacking four datasets across all five neighborhoods: HOLC Neighborhood Redlining grade boundaries, 2010-2014 ACS Census Poverty Status by tract, Urban Heat Island Severity for U.S. Cities (2019), and Durham County Community boundaries.[3] I started by looking at the whole county through NC State's Climate Office HeatWatch data.[4] Then I focused on each neighborhood and noted peak UHI severity values and nearby infrastructure like schools, public housing, health centers, and commercial properties.

The most significant pattern I found was that HOLC Grade D boundaries from the 1930s predict almost exactly where heat is worst today. Every time I overlaid the redlining layer with the UHI severity layer, the Grade D zones lined up with the hottest areas on the map. This was

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[1] "What Is an Urban Heat Island?" *NASA Science*, NASA, science.nasa.gov/kids/earth/what-is-an-urban-heat-island/. Accessed 15 Nov. 2025.

[2] "Mapping Inequality: Redlining in New Deal America." *DSL Richmond*, University of Richmond, dsl.richmond.edu/panorama/redlining/. Accessed 15 Nov. 2025.

[3] "Durham, NC Open Data Portal." *Durham Open Data Portal*, City and County of Durham, NC, live-durhamnc.opendata.arcgis.com/. Accessed 17 Nov. 2025.

[4] "Urban Heat Island Temperature Mapping Campaign." *North Carolina State Climate Office*, NC State University, climate.ncsu.edu/research/uhi/. Accessed 17 Nov. 2025.

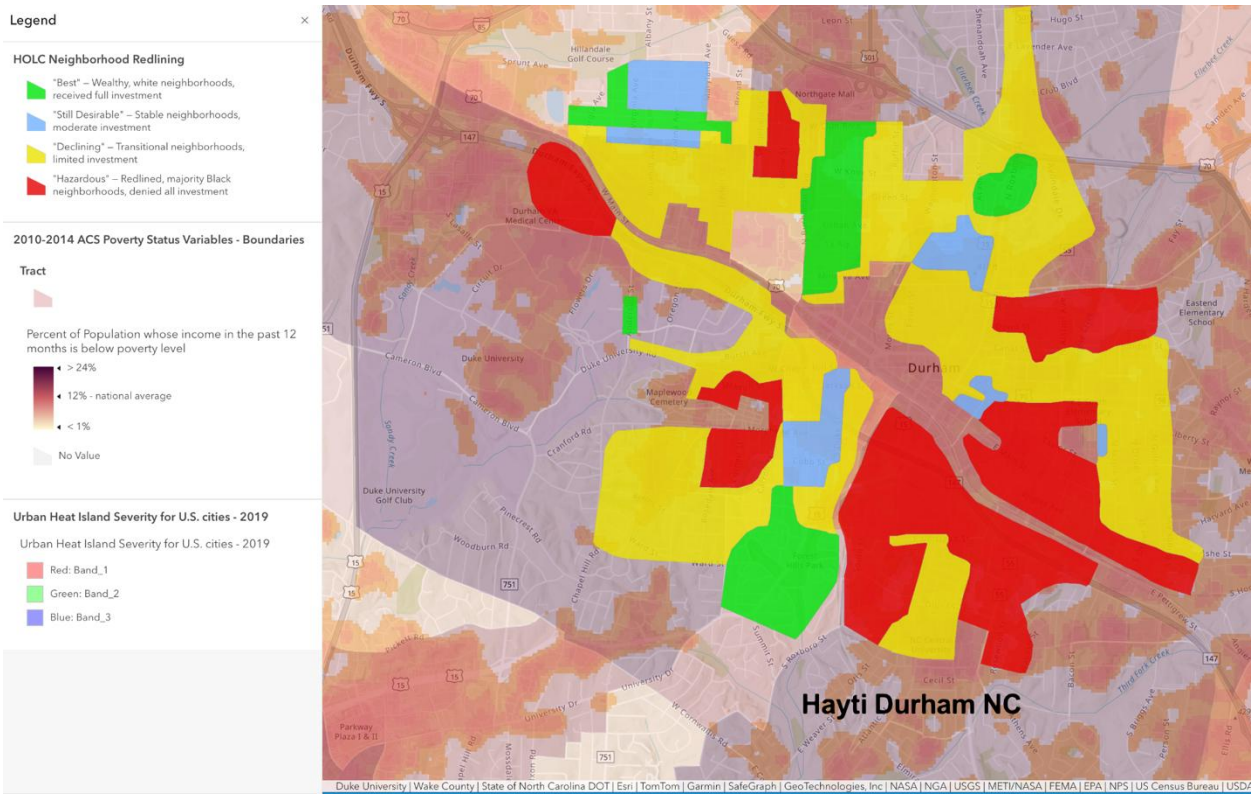
true across all five neighborhoods, and it shows how decades of disinvestment in tree canopy and infrastructure still affects these neighborhoods and communities today.

Spatial Findings by Neighborhood

A. Hayti District

Hayti District is around +8 to +10°F warmer compared to rural baselines. That specific area is where Hayti's historic Black neighborhood stood before it was demolished in the 1970s to build Highway 147, which paved over most of the community and replaced it with asphalt that traps heat.[5] The narrow patch of green space adjacent to Third Fork Creek in the southwest corner has a somewhat beneficial effect on temperatures.

[Figure 1 — Buffer Zone Map: Hayti District]



https://www.arcgis.com/apps/mapviewer/index.html?webmap=347313c794014e78a3bcb219dec0926c&center=-78.902074%2C35.996389&scale=36111.909643

[5] Atwater, Will et al. "Rising Temperatures in Durham Leaving Many Behind." *NC Health News*, NC Health News, 28 Oct. 2024, www.northcarolinahealthnews.org/2024/10/28/rising-temperatures-in-durham-leaving-many-behind/.

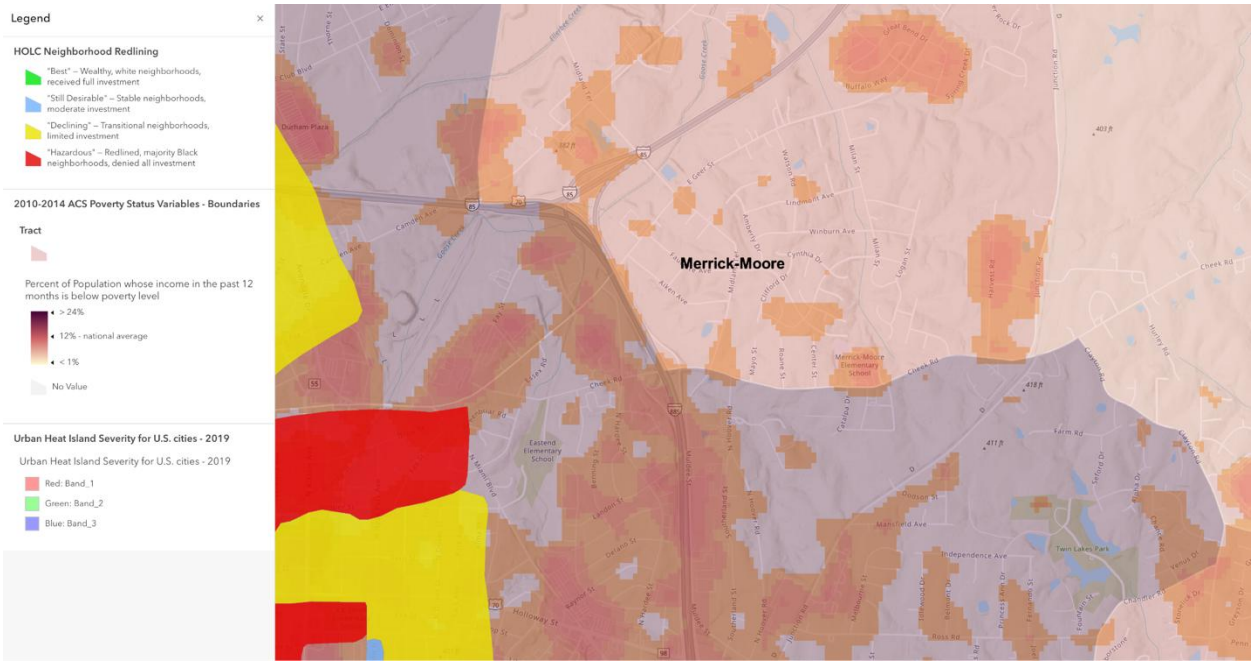
Figure 1: HOLC redlining boundaries were overlaid with UHI severity and census poverty data and the Grade D zones correspond with the maximum heat intensity.

Most of Hayti's readings cluster between +8 and +10°F above rural baselines, with the hottest concentrations along the Highway 147 corridor.

B. Merrick Moore Community

Merrick Moore is on South Roxboro Street in southeastern Durham. Residents endure significant heat exposure on a daily basis with little shelter from the extreme temperatures in an area where childhood poverty is 30.2% and there is virtually no tree cover.

[Figure 2 — Buffer Zone Map: Merrick Moore Community]



https://www.arcgis.com/apps/mapviewer/index.html?webmap=347313c794014e78a3bcb219dec0926c&center=-78.85699%2C36.007077&scale=18055.954822

Figure 2: HOLC grades and UHI severity overlaid for Merrick Moore. High impervious surface coverage correlates with elevated afternoon temperatures.

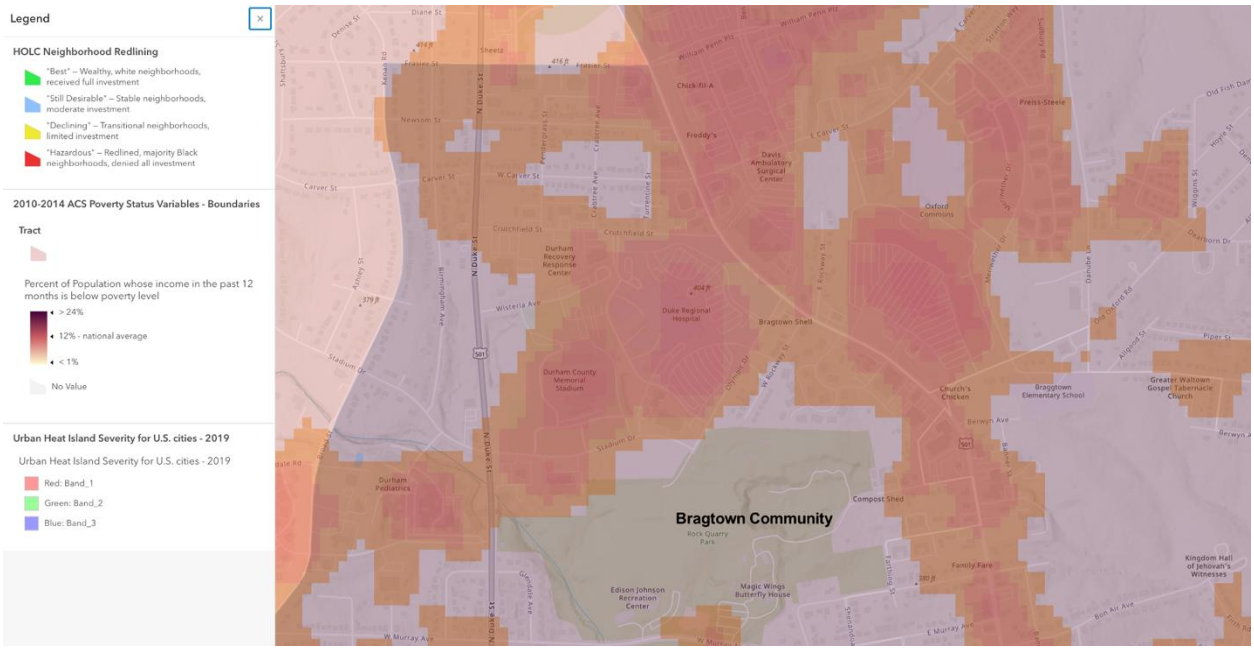
Most of the neighborhood clusters between +6 and +8°F above rural baseline. The only outlier is at the elementary school block reaching +10.4°F.

C. Bragtown Community

Bragtown and Census Tract 11 are located in East Durham and they show the biggest heat divide in the entire county. Nighttime temperatures in this area reach up to 91°F, which is 1.7 times

hotter than Haven Hill, a mostly white neighborhood less than 30 minutes away with 75% canopy coverage and only 2% impervious surface.[6] Bragtown's impervious surface coverage is over 22 times higher than Haven Hill's, and its tree canopy is about one-fifth the size.[7] Because of the inadequate insulation, residents pay $200-$300 a month in summer bills.

[Figure 3 — Buffer Zone Map: Bragtown Community]



https://www.arcgis.com/apps/mapviewer/index.html?webmap=db4c87508102423bac54b748a6cfe6c6&center=-78.896612%2C36.036284&scale=9027.977411

Figure 3: The most interesting thing about Bragtown compared to the other neighborhoods is how uniformly hot it gets.

Heat across Bragtown is consistently between +6 and +10°F. It is spread evenly across the entire community rather than concentrated in one spot.

D. Northgate Mall Corridor

This mall is the only one out of the five areas where the heat is caused by a commercial source rather than disinvestment in the residential areas. The large asphalt parking lot and flat dark

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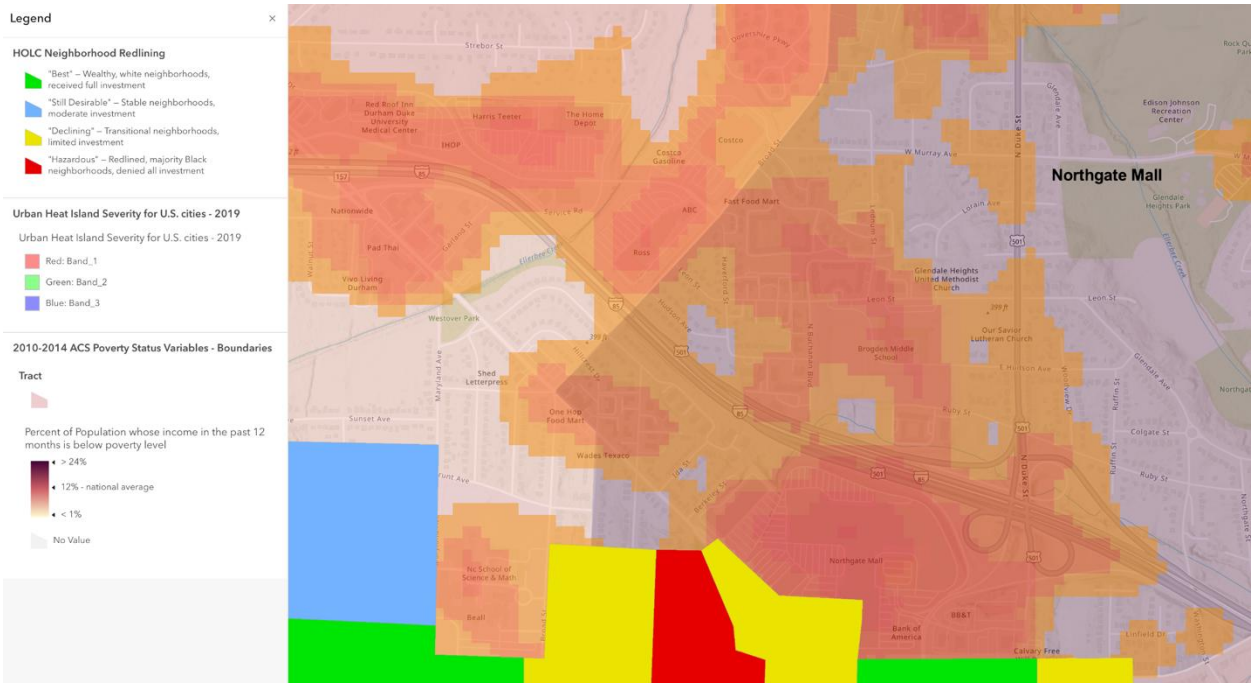
[6] City and County of Durham, "Impervious Surfaces," *NC Open Data Portal*, 2024, https://live-durhamnc.opendata.arcgis.com/datasets/impervious-surfaces/explore. Accessed 20 Nov. 2025.

[7] City and County of Durham, "Impervious Surfaces," *NC Open Data Portal*, 2024, https://live-durhamnc.opendata.arcgis.com/datasets/impervious-surfaces/explore. Accessed 20 Nov. 2025.

rooftops absorb heat and release it into nearby low-income neighborhoods at night. This makes conditions worse for residents who don't have air conditioning.

[Figure 4 — Buffer Zone Map: Northgate Mall Corridor]



https://www.arcgis.com/apps/mapviewer/index.html?webmap=3d83b946f2e644d79d8950feffb65975&center=-78.911023%2C36.024309&scale=9027.977411

Figure 4: Commercial UHI source at Northgate Mall, with heat radiation extending into adjacent low-income residential blocks.

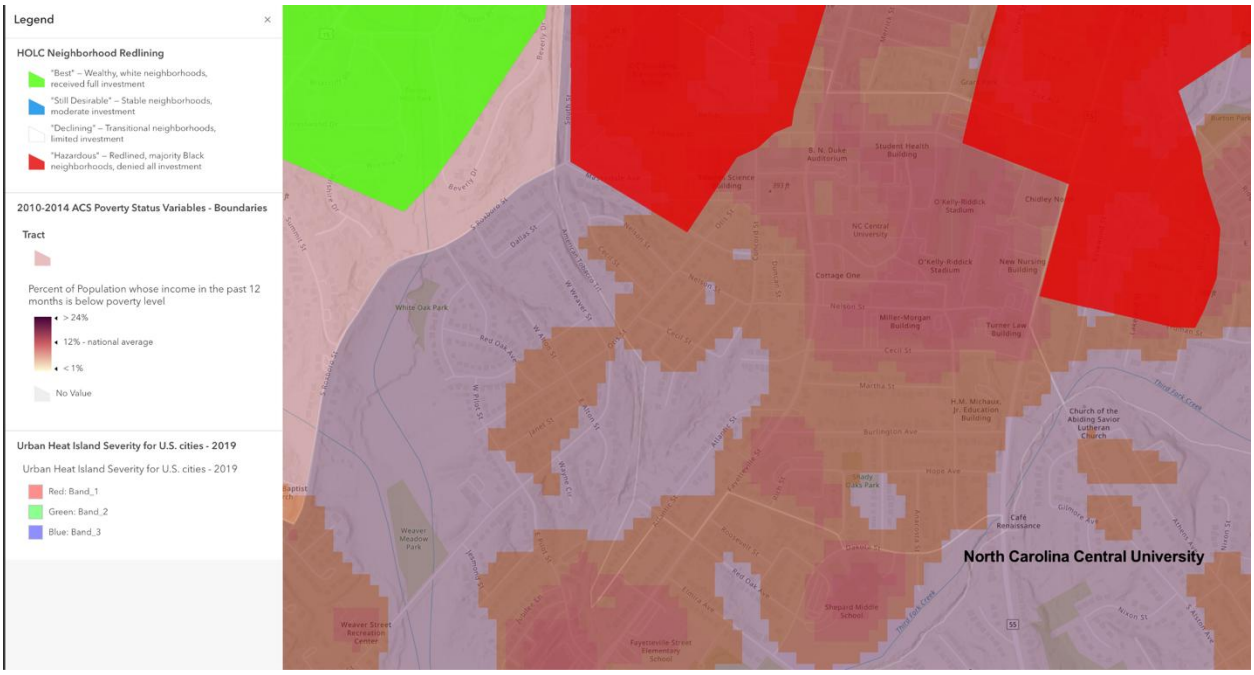
The heat distribution here is bimodal as there is one cluster between +2 and +6°F in the surrounding residential areas and another between +8 and +10.4°F at the mall's core.

E. North Carolina Central University Campus Area

The NCCU Campus Area sits directly adjacent to the Hayti District on Fayetteville Street, with Highway 147 to the north. The 2021 NOAA CAPA HeatWatch campaign confirmed it as one of Durham's hottest afternoon locations.[8] Lincoln Community Health Center's 2.6-acre asphalt parking lot, which has no tree cover, is within 500 feet of the campus center. McDougald Terrace, Durham's largest public housing complex with 360 units, is within 1,000 feet.

[8] "Urban Heat Island Temperature Mapping Campaign." *North Carolina State Climate Office*, NC State University, climate.ncsu.edu/research/uhi/. Accessed 17 Nov. 2025.

[Figure 5 — Buffer Zone Map: NCCU Campus Area]



https://www.arcgis.com/apps/mapviewer/index.html?webmap=2dc6e93eb2ed4e8ca9e0157f5b7e8d72&center=-78.901342%2C35.97142&scale=9027.977411

Figure 5: NCCU corridor sits within Durham's most heat-vulnerable redlined zone, which is made worse by institutional and commercial land use.

Temperatures across the corridor mostly fall between +6 and +10°F. The hottest point is the Lincoln Community Health Center's parking lot at +10.3°F.

Climate Projections for Durham County

Climate projections from NC State's Climate Office show that the number of days above 95°F in Durham County has been increasing since 1950 and is expected to continue rising.[9] is projected to have roughly two months of extreme heat days per year by 2030 and about two and a half months by 2080.

[Figure 6 — Projected Days Per Year Above 95°F, Durham County, 1950–2100]

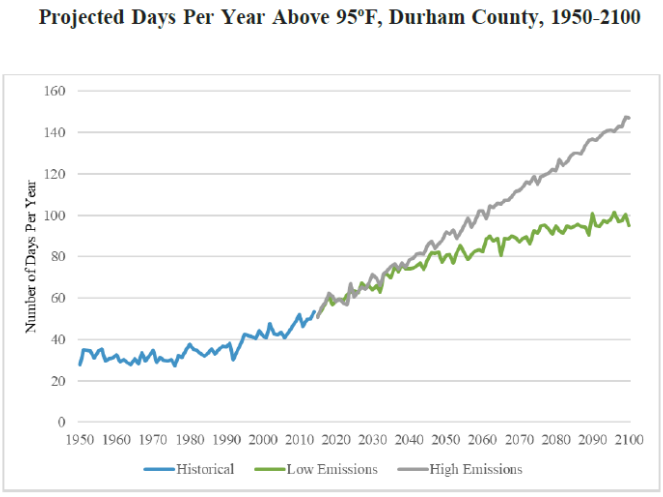


Figure 11.01(b): Projected Days in Durham County over 95 Degrees Fahrenheit

Figure 6: Historical trend and projected increase in extreme heat days (NC State Climate Office).

Equitable Solutions

Tree Canopy Expansion

Trees cool the air around them through evaporation and transpiration, reducing surface temperatures in nearby areas.[10] In Durham's hottest neighborhoods, canopy coverage is as low as 34%, compared to the city average of 52% and significantly higher in wealthier areas.[11] That gap is the result of zoning decisions that kept green areas and space out of Black and low-income neighborhoods for decades.

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[9] NOAA National Centers for Environmental Information, "Climate at a Glance: County Mapping," https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/county/mapping/31/tavg/202208/3/rank. Accessed 19 Nov. 2025.

[10] "What Is an Urban Heat Island?" *NASA Science*, NASA, science.nasa.gov/kids/earth/what-is-an-urban-heat-island/. Accessed 15 Nov. 2025.

[11] Hancock, Grace, et al., "Planning a Sustainable Tree Canopy for Durham." *DukeSpace*, Duke University Libraries, 24 Apr. 2020, dukespace.lib.duke.edu/items/698cb8e5-d8b1-4c6f-985d-e5d82e38fc25.

Targeted tree planting in the five priority zones could reduce surface temperatures by up to 9°F.[12]

[Figure 7 — Urban Tree Canopy Benefit Diagram]

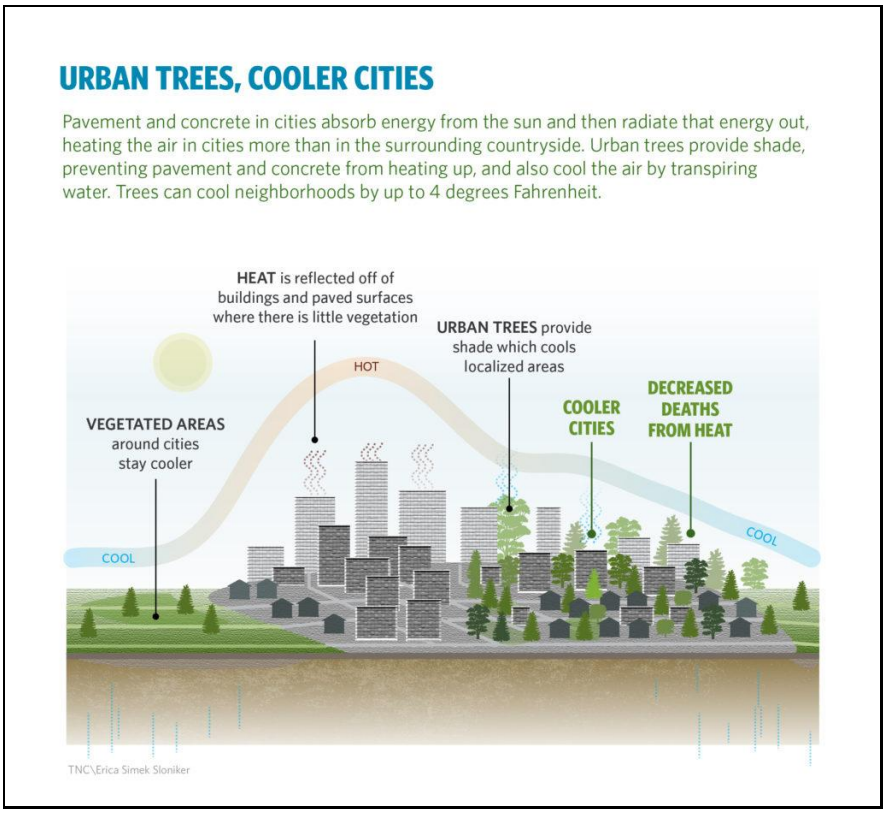

Figure 7: Urban trees cool cities through shade and evapotranspiration which helps reduce heat-related mortality and surface temperatures.

Cool Roofs

Dark rooftops absorb heat throughout the day and release it into surrounding areas at night, which is a major reason temperatures stay elevated after sunset. Cool roofs reflect sunlight instead of absorbing it, keeping buildings cooler without any additional energy use.[13] Requiring cool roofs, starting with Northgate Mall, is one of the most affordable ways to bring heat down in these areas.

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[12] Zhenzhu Zheng et al., "A Systematic Review of Urban Heat Island (UHI) Impacts and Zheng, Zhenzhu, et al. “A Systematic Review of Urban Heat Island (UHI) Impacts and Mitigation: Health, Equity, and Policy.” *Systems*, MDPI, 12 Jan. 2026, www.mdpi.com/2079-8954/14/1/82.

[13] Zhenzhu Zheng et al., "A Systematic Review of Urban Heat Island (UHI) Impacts and Zheng, Zhenzhu, et al. “A Systematic Review of Urban Heat Island (UHI) Impacts and Mitigation: Health, Equity, and Policy.” *Systems*, MDPI, 12 Jan. 2026, www.mdpi.com/2079-8954/14/1/82.

[Figure 8 — Dark Roof vs. Cool Roof Comparison Diagram]

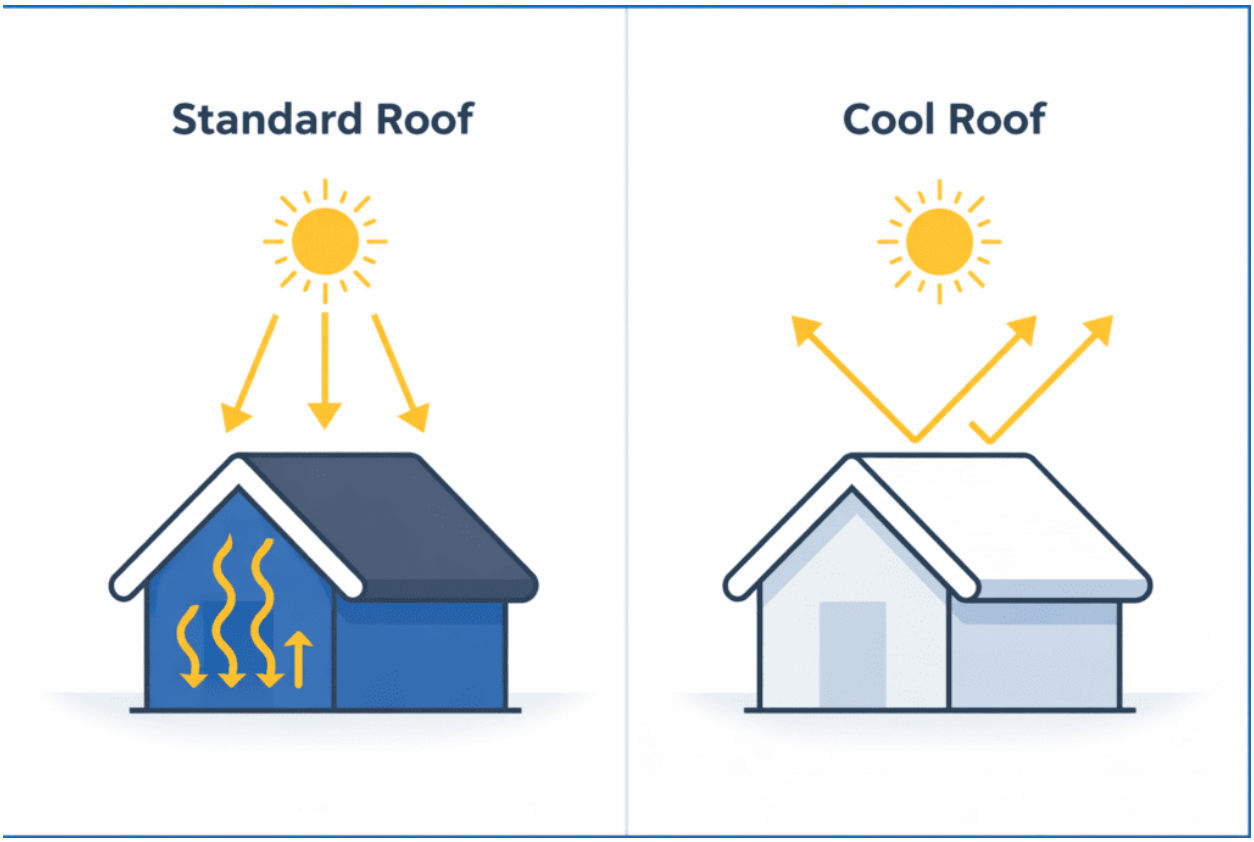


Figure 8: Dark roofs absorb and radiate solar heat. Cool roofs reflect it, reducing building temperatures and surrounding heat.

Reflective Pavement

Dark asphalt absorbs heat through the day and releases it slowly at night, which keeps temperatures high in neighborhoods like Bragtown even at night. Reflective pavement bounces solar energy away from the surface instead of trapping it, which keeps streets cooler during the day and at night.[14] To lower temperatures in the surrounding residential areas, replacing pavement at areas like the Northgate parking lot and the Lincoln Health Center would help a lot.

[14] "What Are Cool Pavements?" *Cool Roof Rating Council*, Cool Roof Rating Council, coolroofs.org/resources/what-are-cool-pavements. Accessed 30 Nov. 2025.

[Figure 9 — Reflective Pavement Solar Reflectance Diagram]

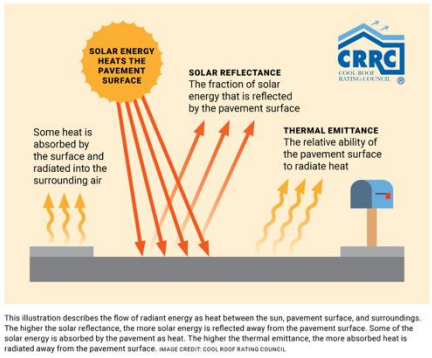
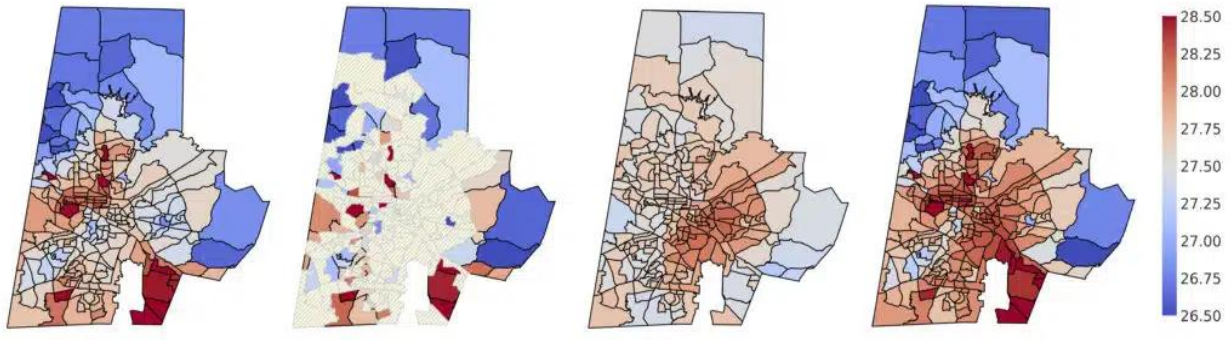


Figure 9: Reflective pavement reduces thermal emittance by bouncing solar energy away from the surface.

Local Sensor Networks

An analysis of temperature sensor coverage across Durham shows that the hottest neighborhoods are also the ones with the fewest ground-level weather stations (Figures 10, 11).[15] When a heat emergency occurs, these communities lack the data required for heat warnings. The people most at risk end up being the last to hear about it. Adding sensors to these neighborhoods would help make sure residents get warnings when they need them.

[Figure 10 — Four-Panel Sensor Correction Map]



Map 1 (Far Left) - Initial Sensor Data
Map 2 (Middle Left) - The "Data Deserts"
Map 3 (Middle Right) - Raw Heat Distribution
Map 4 (Far Right) - Corrected Heat Estimates

[15] Kingery, Ken. "For Many Urban Residents, It's Even Hotter Than Their Weather App Says." *Duke Pratt School of Engineering*, Duke University, 25 June 2024, pratt.duke.edu/news/heat-island-corrections/.

Figure 10: Sensor data gap analysis. Hottest zones (deep red) overlap with areas lacking ground-level monitoring infrastructure.

[Figure 11 — Distribution of Black Residents in Durham County (%) and Existing Tree Canopy Coverage]

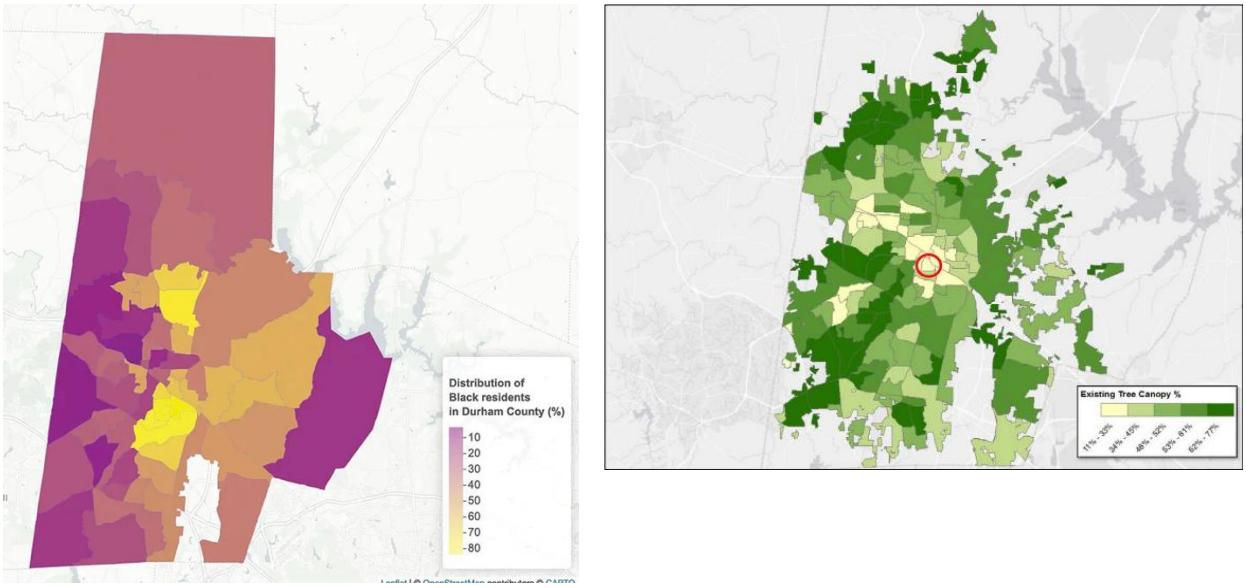


Figure 11: Minimal vegetation and maximum heat exposure align with neighborhoods where Black residents make up 70-80% of the population.

Estimated Costs and Economic Case for Intervention

Residents in vulnerable neighborhoods pay $200-$300 a month in summer utility bills because of heat and poor insulation. Heat-related illness also drives emergency room visits and lost work hours, which are all costs that fall on the same neighborhoods this study identifies as most at risk.

Tree planting is one of the most cost-effective urban interventions available. The US Forest Service estimates that every dollar invested in urban tree canopy returns $1.89 in benefits.[16] For Durham's priority zones, a canopy expansion program covering the five study neighborhoods would require significant upfront investment but would begin reducing utility costs and cooling demand within the next few years.

Cool roofs for commercial buildings cost between $0.75 and $1.50 per square foot, which is significantly less than fully replacing the roof.[17] At Northgate Mall, where the roof surface

[16] "Value of Urban Forests." *USDA Forest Service*, U.S. Forest Service, Pacific Southwest Research Station, research.fs.usda.gov/psw/projects/value-urban-forests. Accessed 15 Dec. 2025.

[17] Coatings, Roof. "Cool Roofs Can Revolutionize Your Customer's Facilities to Beat the Heat." *Waterproof! Magazine*, Waterproof! Magazine,

affects surrounding blocks, the investment would be highly beneficial. Several cities including Los Angeles and Chicago have already implemented cool roof programs that offset costs for building owners while producing reductions in neighborhood temperatures.

Reflective pavement is more expensive upfront than standard asphalt, typically running 10-20% higher in installation costs. But the benefit is that it lasts longer and reduces the urban heat load that drives up cooling energy demand across surrounding properties. On the other hand sensor network installation is relatively inexpensive. It is usually a very small investment relative to the emergency response costs those sensors would help reduce.

Durham in the Context of North Carolina

Durham is not the only North Carolina city dealing with urban heat islands, but it is one of the most striking examples of how bad the problem can get when it goes unaddressed. The data from Raleigh and Charlotte show similar patterns — hotter temperatures in lower-income areas and less tree cover where Black and Hispanic populations are concentrated.

Charlotte was actually selected in 2024 to join a federal study specifically focused on identifying urban heat islands, which shows that policymakers and researchers are starting to take this seriously at a national level.[18] Yet, what makes Durham different is how clearly the redlining history shows up in the temperature data. The overlap between the 1930s HOLC maps and today's heat readings is sharper in Durham than in most comparable cities, which suggests that the disinvestment here was particularly concentrated and has had unusually lasting effects on the physical landscape.

That matters because it means Durham cannot just copy what other cities are doing and expect the same results. The interventions here need to be focused specifically at the neighborhoods that redlining hurt most, not spread evenly across the city. If Durham gets this right, it could actually become a model for how other North Carolina cities approach heat equity. If it doesn't, the gap is only going to grow.

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www.waterproofmag.com/2024/09/cool-roofs-can-revolutionize-your-customers-facilities-to-beat-the-heat/. Accessed 29 Nov. 2025.

[18] Turner, Zachary. "Charlotte Selected to Join Federal Study to Find Urban Heat Islands." *WFAE*, WFAE, 16 Apr. 2024, www.wfae.org/energy-environment/2024-04-16/charlotte-selected-to-join-federal-study-to-find-urban-heat-islands.

Conclusion

Across all five neighborhoods, the mean UHI severity is +8.9°F above rural baselines. Some Durham neighborhoods could see peak surface temperatures above 100°F within 25 years. Without action, the current 10.4°F heat gap between Durham's hottest and wealthiest neighborhoods is projected to grow to 15.8°F by 2100.

Durham's heat problem is serious, and this heat disparity needs to be addressed immediately. In Hayti, Merrick Moore, Bragtown, Northgate, and the NCCU area, the neighborhoods that were redlined in the 1930s are the same ones dealing with the worst heat today. When neighborhoods are denied trees and infrastructure for decades, this is the result. The data has shown us everything we need to see but without acting the problem will continue getting worse. It is time to take action toward protecting the future of Durham County.

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