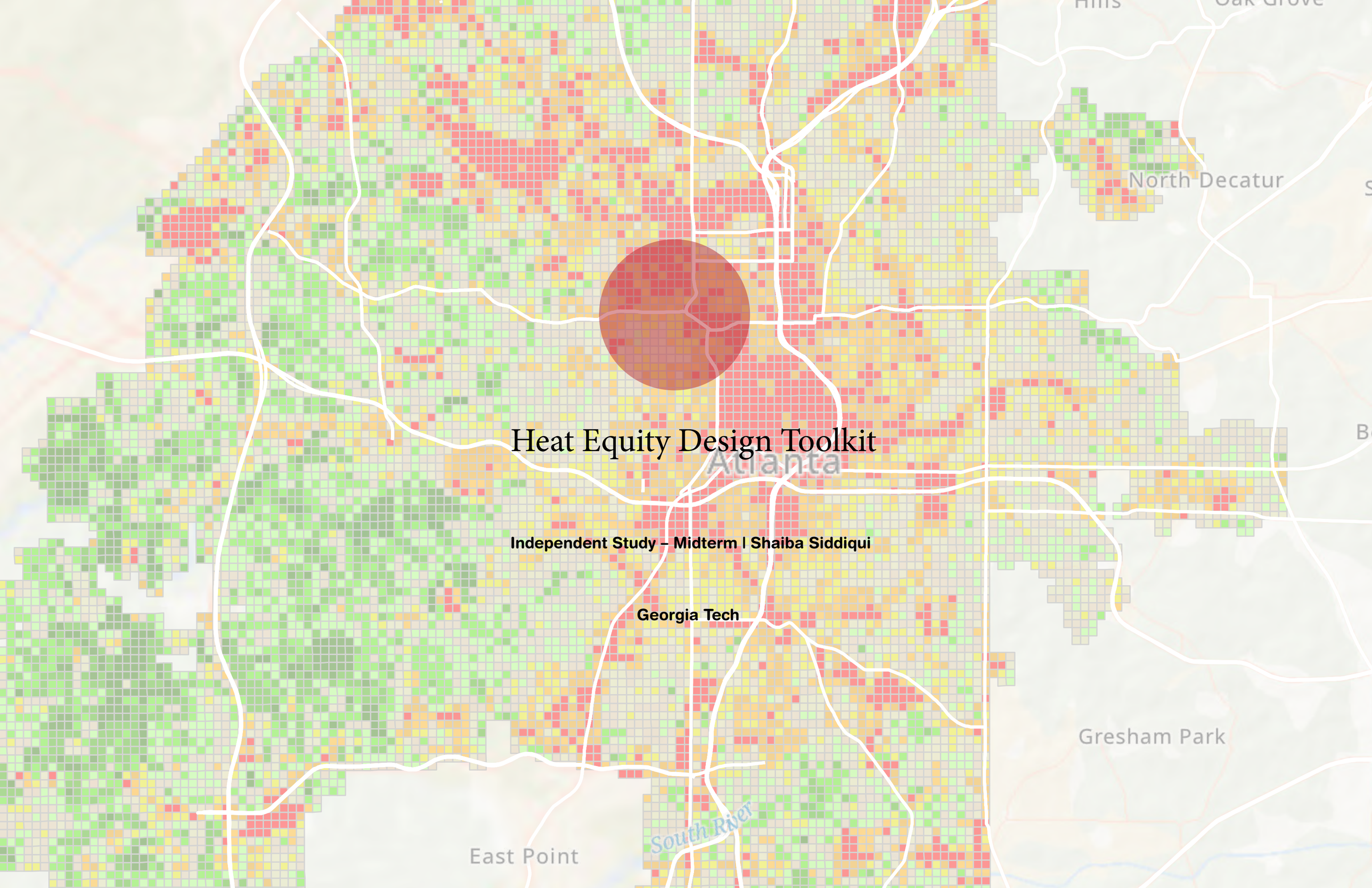
Heat Equity Design Toolkit

Independent Study – Midterm | Shaiba Siddiqui



Key Research Question

How does the spatial configuration of street-tree canopy (spacing, side placement, clustering) reduce heat exposure for pedestrians and transit users in low-income neighborhoods across Atlanta ?

Contents

1. Introduction & Research Context
Goal: Set up the issue of heat inequity in urban environments and why street-tree canopy configuration matters.
2. Literature Review
Goal: Summarize key theories and precedents linking tree canopy and heat reduction
3. Methodology
Goal: Outlining data and analytical approach clearly.
4. Case Studies / Reference Projects
Goal: Real examples that guide or validate approach.
5. Analysis & Preliminary Findings
Goal: Present early results or analytical progress.
6. Design Toolkit
Goal :Research into actionable, scalable urban design guidelines

Introduction and Literature Review

Urban heat exposure disproportionately affects low-income and transit-dependent communities, where limited tree canopy amplifies discomfort and vulnerability. While urban trees are known to reduce temperatures through shading and evapotranspiration, recent studies emphasize that canopy configuration-its spacing, clustering, and placement,determines how effectively it cools pedestrian environments. Examples from Medellín, Singapore, and Los Angeles show that continuous or clustered canopies can lower street-level heat by up to 5°C. In Atlanta, the contrast between the lush, cooler northern neighborhoods and the hotter, low-income southwestern areas reveals a clear canopy–heat–equity gap. This research examines how street-tree spatial patterns can mitigate heat exposure and promote climate-responsive, equitable urban design.

Policy literature review - Atlanta (street trees, heat, and equity)

1. Institutional framework & regulatory context

Atlanta has an established institutional structure for urban trees: the Arborist Division (Office of Buildings / City Planning) enforces the City's Tree Protection Ordinance and manages permitting and enforcement for tree removal and preservation on public and private property. The City also maintains public-facing tree reports and data to track canopy change. These institutions are the primary actors for regulating and implementing street-tree policies.

2. City plans & targets that reference trees and heat

The **Atlanta Climate Action Plan** explicitly names urban trees and green space as key strategies to mitigate the urban heat island and reduce energy use through shading and evapotranspiration. The city has periodically commissioned full **Urban Tree Canopy (UTC) assessments (2008, 2014, 2018)** to measure canopy extent and change, providing the empirical baseline that planners use to target plantings and monitor outcomes.
atlantaclimateactionplan.files.wordpress.com

3. Non-profits & community science: Trees Atlanta + UrbanHeatATL

Local NGOs and community projects play a major role in data, outreach, and implementation. **Trees Atlanta** publishes UTC research and prioritization tools; community science projects like **UrbanHeatATL** map neighborhood temperature variability with community participation and generate datasets that highlight heat inequities at fine spatial scales. These organizations both supplement municipal capacity and create civilian pressure for equitable canopy investments.
treesatlanta.org

5. Data infrastructure available to planners & researchers

Atlanta's periodic UTC studies (Georgia Tech / City partnership) provide mapped canopy cover and change analysis, and the City publishes tree activity reports and other data useful for monitoring. UrbanHeatATL and university projects (e.g., Georgia Tech urban-heat student projects) also produce high-resolution temperature maps that can be combined with canopy and socioeconomic data for vulnerability analysis. These data assets make Atlanta particularly well suited for corridor-scale, equity-focused research.
geospatial.gatech.edu

6. Policy gaps

Scale & specificity gap: City plans and UTC targets are typically framed at the city / neighborhood scale (percent canopy targets), **not at the corridor or transit-stop scale** where pedestrian thermal comfort actually matters. This leaves planners with little empirical guidance on optimal tree spacing, side placement, or clustering at bus stops and sidewalks.

Literature Gap

While Atlanta has clear canopy inventories, translating those inventories into prioritized corridor-level plantings for low-income, high-heat tracts (rather than broad neighborhood targets) is still limited.

Implementation gap: Policy instruments (ordinances, fees, grant programs) often prioritize tree counts and canopy goals; they rarely specify configuration guidelines (e.g., planting offsets from curb, target spacing for continuous sidewalk shade, or prioritization rules for stops/corridors).

The corridor-scale composite (LST + canopy + income) and Outdoor plus scenario will work directly fill these gaps by quantifying the cooling/comfort gains associated with specific configurations and identifying the highest-impact locations for investment.

Methodology

Data Sources:
Tree Canopy (UTC 2018)
Urban Heat Index (Raster 1–5)
Median Family Income (ACS 2022)

Data Processing:
Standardized layers to Atlanta boundary and same projection.
Used Zonal Statistics to extract mean heat per census tract.
Joined canopy, heat, and income data by tract ID (GEOID).

Spatial Analysis:
Created individual maps (canopy, heat, income) and an overlay map.
Identified hotspots: low canopy + high heat + low income.

Quantitative Analysis:
Correlation between canopy %, heat, and income.
Conceptual scatter graphs to show relationships.

Interpretation:
Highlighted inequity in canopy distribution and heat exposure.
Suggested design strategies for shade enhancement along pedestrian and transit corridors.

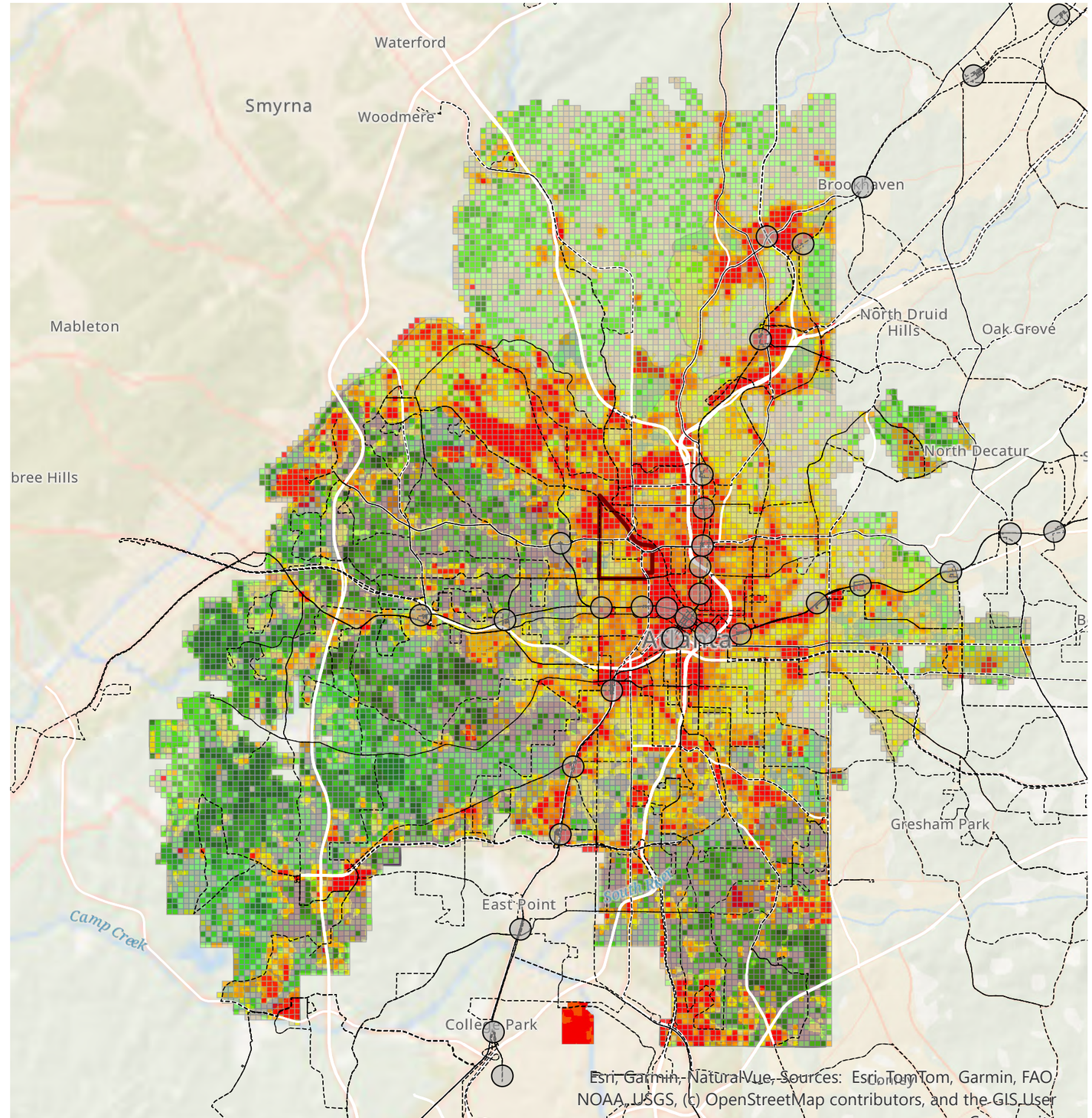


Figure 1-Citywide Heat–Canopy–Equity Basemap-This map illustrates Atlanta's baseline heat intensity, tree canopy, and income distribution used for vulnerability analysis. Created by the author (2025).

Case Studies

To understand how street-tree configuration impacts thermal comfort and pedestrian experience, several global and local precedents were analyzed. These case studies highlight strategies for tree spacing, clustering, and side placement that effectively reduce surface and air temperatures while enhancing walkability and transit comfort. The selected projects span diverse climates and urban morphologies, providing adaptable lessons for Atlanta's low-income neighborhoods.

Medellín Green Corridors, Colombia

Type: Urban Retrofit

Firm/Organization: Medellín Mayor's Office, Jardín Botánico de Medellín
Climate Context: Tropical, humid

Aim:
To mitigate urban heat and improve pedestrian comfort by introducing continuous vegetation along major streets, waterways, and transit corridors.

Challenges:
Medellín experienced urban heat island effects of up to +5°C, limited pedestrian shading, and deteriorating air quality, particularly along transit-heavy avenues.

Strategies:
•Continuous canopy planting along bus and BRT corridors.
•Dense clustering of native species to achieve overlapping shade crowns.
•Integration of bioswales and understory vegetation to enhance evapotranspiration.
•Minimal spacing between trees (4–6 m) to create shaded microclimates.

Outcome:
•Average surface temperature reduction of 2–3°C along shaded corridors.
•Significant increase in pedestrian activity and perceived comfort.
•Reduced stormwater runoff and improved air quality.

Relevance to Atlanta:
Demonstrates the cooling potential of clustered and continuous canopy configurations, applicable to low-income neighborhoods along high-heat transit routes like Campbellton Road or Metropolitan Parkway.

Dense clustered canopy and continuous green corridors along transit routes in Medellín drastically reduce surface temperatures and improve walkability in high-heat neighborhoods.

Cooling Singapore Project- Cool Street Program

Type: Urban Pilot Project

Firm/Organization: Urban Redevelopment Authority (URA), NParks Singapore
Climate Context: Equatorial

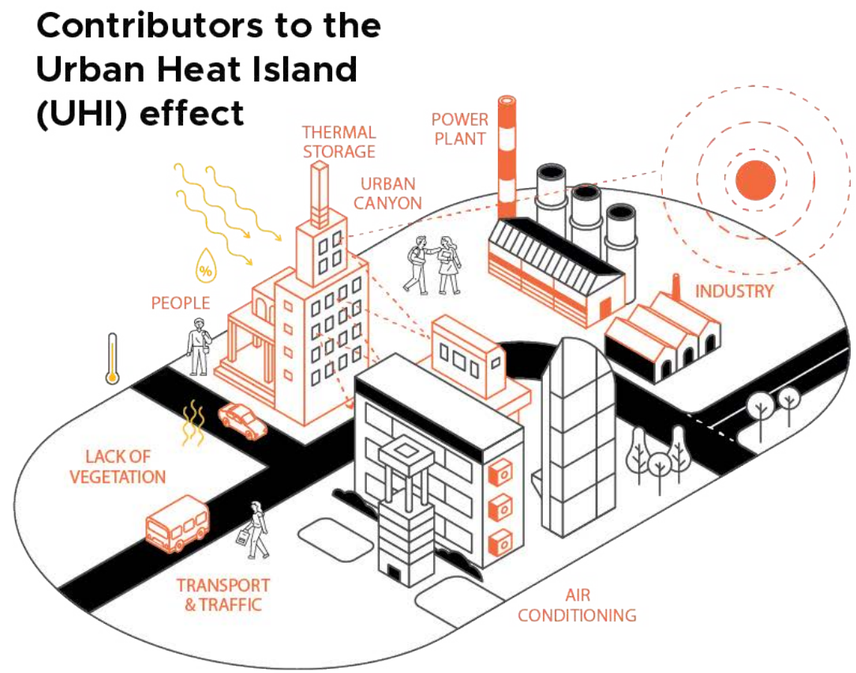
Aim:
To create thermally comfortable pedestrian streets by integrating street trees, cool paving materials, and vertical greening in high-density districts.

Challenges:
Highly compact street canyons with limited right-of-way and high pedestrian density led to excessive radiant heat exposure.

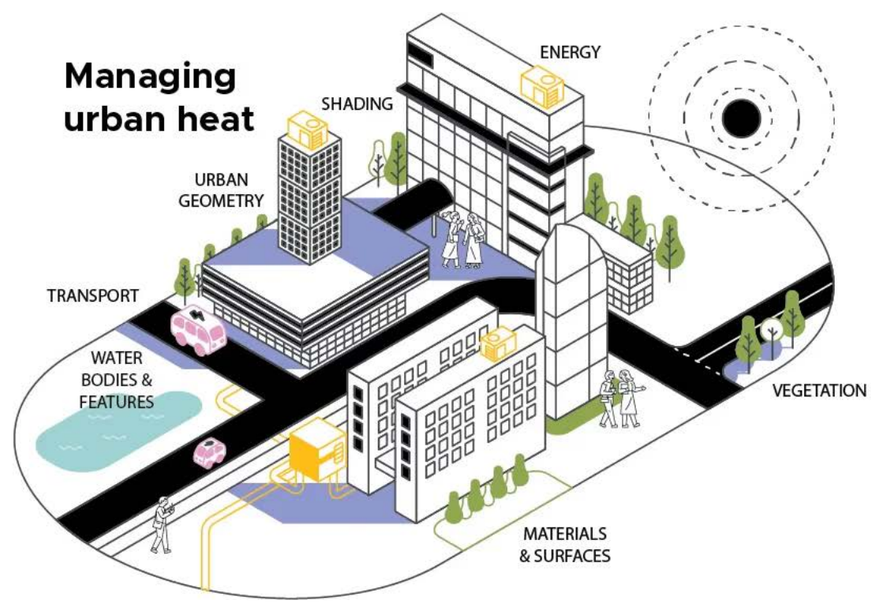
Strategies:
•Alternating double-sided canopy with average spacing of 8 m to balance shade and airflow.
•Use of fast-growing shade species (e.g., rain trees) with high leaf area density.
•Reflective pavements and permeable surfaces to complement tree shading.
•Monitoring through ENVI-met simulation for optimization.

Outcome:
•Mean radiant temperature reduction of 5–6°C in shaded zones.
•Enhanced walkability and increased use of outdoor spaces.

Relevance to Atlanta:
Shows how side placement and species selection can be optimized in constrained urban rights-of-way, such as near MARTA stations or dense corridors like Lee Street.



The simulation platform is equipped with datasets to represent Singapore's climate and anthropogenic heat emissions in its current state.



DUCT will enable policymakers to assess the combined impact of various heat management strategies at an island wide scale.

Source: Singapore-ETH Centre

Los Angeles Urban Cooling Program (Cool Streets LA), USA

Type: Citywide Implementation

Firm/Organization: Los Angeles Bureau of Street Services
Climate Context: Arid/Subtropical

Aim:
To lower surface and ambient temperatures in heat-vulnerable neighborhoods using cool coatings and expanded tree canopy.

Challenges:
Communities with the lowest canopy cover coincided with the highest poverty rates and highest land surface temperatures.

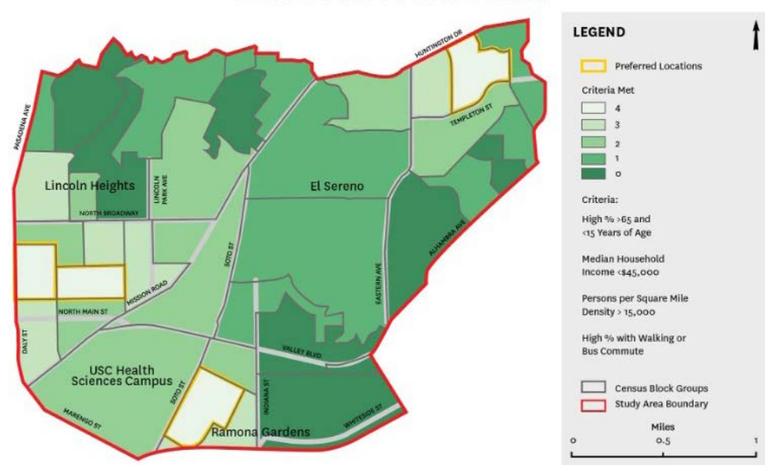
Strategies:
•Combination of clustered canopy planting at intersections and bus stops.
•Tree-lined median strips for symmetrical shading on both sides of the street.
•Integration with cool pavement technologies for maximum thermal relief.

Outcome:
•Surface temperature reduction of 10–12°F (≈5–6°C) in target corridors.
•Reduced heat-related illness reports and improved community perception.

Relevance to Atlanta:
Provides a strong model for equitable canopy intervention, where combining clustered trees with reflective infrastructure can enhance comfort for transit-dependent populations.

An example of potential tree-planting locations in an L.A. Eastside community. (Illustration/Esther Margulies and Yuliang Jiang)

USC researchers identified four preferred locations most suitable for planting trees in the L.A. Eastside communities of Lincoln Heights, El Sereno and Ramona Gardens.



Plan View Diagram:
"Street sections upgraded through a mix of clustered trees, median plantings, and cool pavement surfaces under the Cool Streets LA program."

Neighborhood Cooling Map:
"Citywide prioritization map identifying heat-vulnerable neighborhoods where cooling interventions were implemented."

Construction Image:
"Application of reflective coatings on asphalt surfaces as part of LA's integrated cooling strategy.

Atlanta BeltLine Arboretum, USA

Type: Local Precedent

Firm/Organization: Trees Atlanta, Atlanta BeltLine Inc.
Climate Context: Humid Subtropical
Aim:

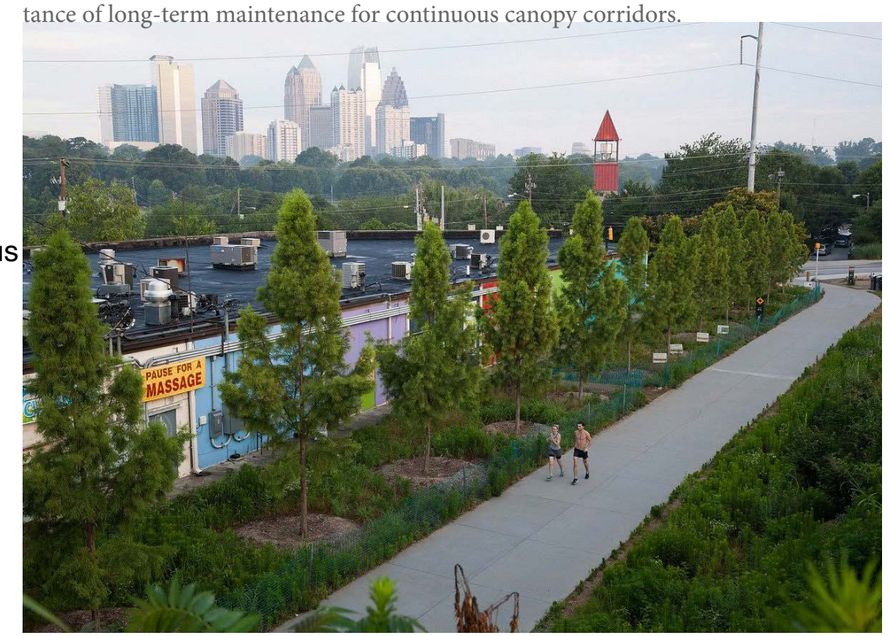
To demonstrate the ecological and cooling benefits of continuous tree canopy along a high-traffic urban trail system.

Challenges:
Sections of the BeltLine traverse previously industrial, treeless zones with high heat exposure and limited shade.
Strategies:
•Continuous dual-side canopy alignment with native shade species.
•Layered planting approach: canopy trees + understory + groundcover.
•Maintenance partnerships with local communities for long-term care.

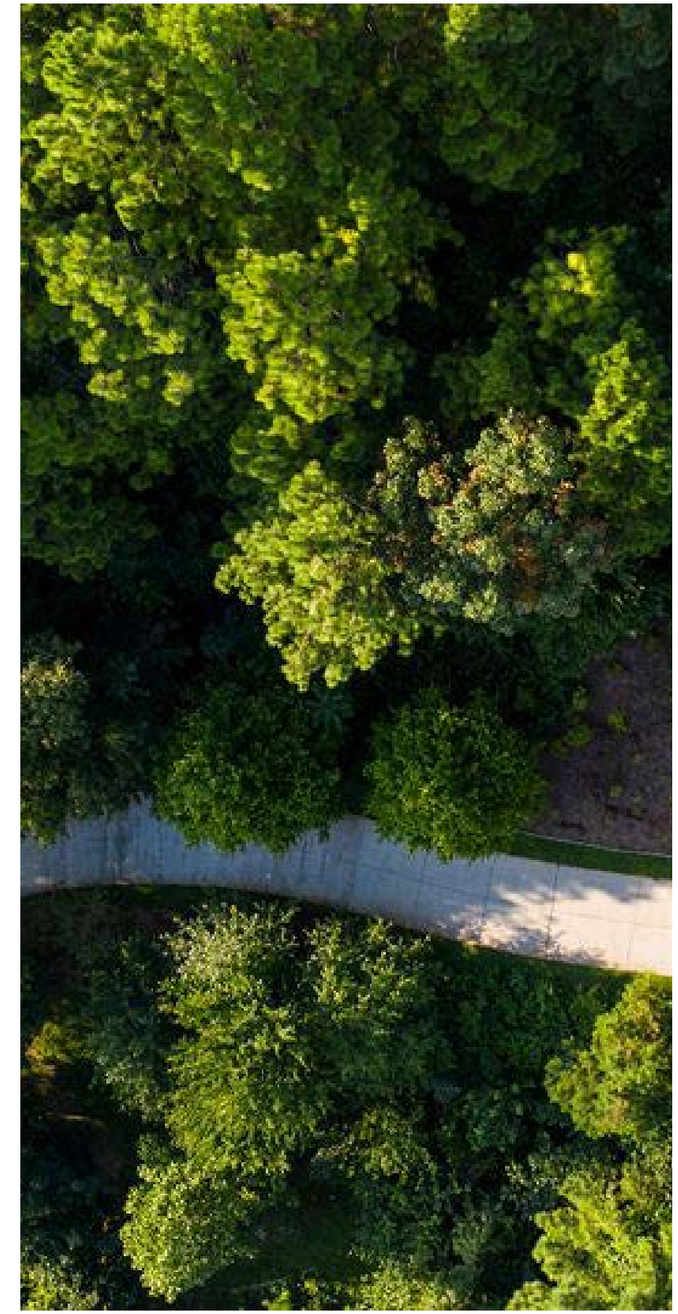
Outcome:
•Reduction in trail surface temperatures by 4–5°C during peak summer.
•Enhanced user comfort and biodiversity corridor creation.

Relevance to Research:
Provides empirical local data to support the dual-sided continuous canopy model as an effective strategy for cooling high-activity pedestrian and transit routes in Atlanta.

Community-engaged stewardship of the BeltLine Arboretum highlights the importance of long-term maintenance for continuous canopy corridors.



Continuous dual-row canopy and layered vegetation along the BeltLine providing measurable cooling benefits during peak summer.


Shaded trail sections exhibit 4–5°C temperature reductions compared to adjacent unshaded areas

Community-Led Climate Resilience Pilot

Climate Context: Desert / Extreme Heat
Firm/Organization: The Nature Conservancy + City of Phoenix

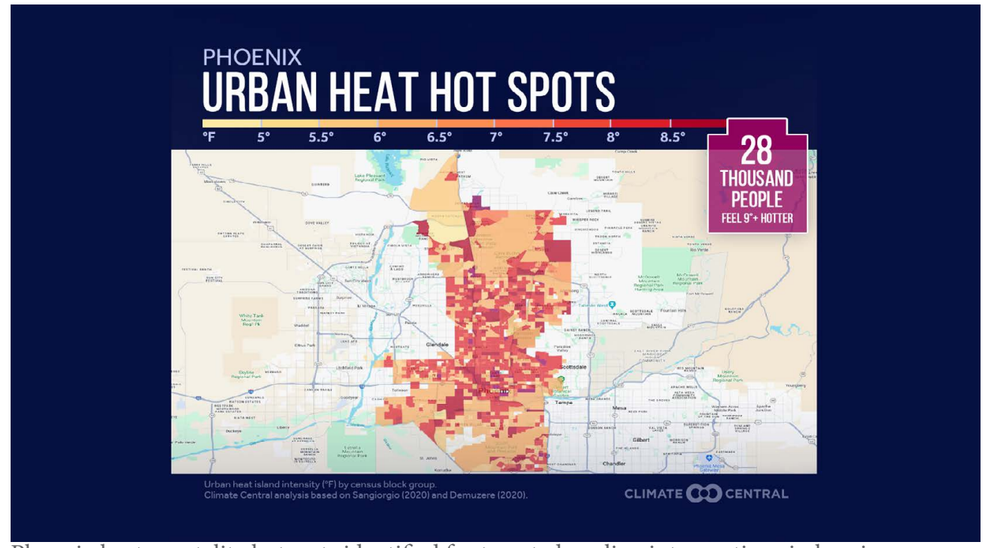
Aim:
To cool high-heat, low-income neighborhoods such as Maryvale through street trees, shaded transit stops, and community engagement while addressing inequitable heat burdens.

Challenges:
Some of the nation's highest heat mortality rates concentrated in historically marginalized neighborhoods.
Large arterial streets lacked shade entirely, creating dangerous walking conditions.
Residents feared that improvements might drive up rents ("green gentrification threat").

Strategies:
• Planting dense, continuous tree canopies along key pedestrian and school routes.
• Designing shade-first mobility corridors that integrate bus shelters, street trees, and reflective pavements.
• Community hiring for tree maintenance, ensuring economic benefits remain local.
• Anti-displacement education and policy consultation.

Outcome:
Modeled reductions of ambient temperatures by 3–5°C, with significantly cooler walking routes during peak afternoon heat.
• Strengthened community ownership, reducing concerns about displacement.
• Demonstrated that continuous canopy performs better than fragmented or alternate-spacing trees in extreme heat

Relevance to Atlanta:
Shows how tree canopy + community stewardship + anti-displacement planning can protect heat-vulnerable residents in rapidly developing areas like Vine City, English Avenue, and Pittsburgh. Useful precedent for integrating social equity directly into canopy-placement decisions along corridors like Joseph E. Boone Blvd.



Phoenix heat-mortality hotspots identified for targeted cooling interventions in low-income neighborhoods like Maryvale

Community-led tree planting and stewardship ensure long-term care and reduce fears of green gentrification.

Continuous canopy along mobility corridors in Phoenix demonstrates strong performance in lowering MRT and improving thermal safety.

Scale–Strategy Relationship

Scale	Medellín Green Corridors (Clustered, Continuous Canopy)	Singapore "Cool Streets" (Alternating Dual-Sided Canopy)	Los Angeles Cool Streets (Clustered Nodes + Reflective Surfaces)	Atlanta BeltLine Arboretum (Continuous Native Corridor)
City / Regional	Integrated network of shaded corridors linking transit & ecological systems.	Street greening integrated into national "City in a Garden" cooling plan.	Citywide rollout of "Cool Streets LA" in heat-vulnerable zones.	BeltLine as regional cooling infrastructure & biodiversity link.
Neighborhood	Dense native clusters along BRT & river corridors; community stewardship.	Localized cooling pilots in mixed-use districts; high pedestrian volumes.	Prioritization of underserved neighborhoods for canopy & cool pavement investment.	Green spines connecting parks, schools, and transit within neighborhoods.
Block / Corridor	4–6 m spacing; overlapping canopies create continuous shade band.	Alternating canopy for airflow and light penetration in narrow streets.	Median strips and intersections with clustered shade trees.	Dual-side planting along trail edges for complete canopy coverage.
Street	Clustered, double-row canopy with understory planting for evapotranspiration.	Alternating double-sided planting using high leaf-area species.	Clustered nodes at bus stops & crosswalks; reflective surfacing.	Continuous dual-side native canopy with shrubs and permeable trails.
Site / Node (Transit Stop)	Pocket groves and shaded bus shelters using native species.	Integrated green shelters with tree shade & vertical greening.	Trees clustered at transit nodes; "cool pavements" to reduce radiant heat.	Shade trees framing entrances and seating areas near stations/trailheads.

Strategic Takeaways for Atlanta

1.Clustered + Continuous Hybrid Strategy:
Combine Medellín's density with BeltLine's continuity for maximum cooling effect.

2.Street Typology Integration:
Arterial roads: Dual-sided canopy with wide median planting (LA model).
Neighborhood streets: Alternating canopy to maintain airflow (Singapore model).
Transit corridors: Clustered groves near stops and crossings (Medellín model).

3.Equity Lens:
Prioritize low-income and heat-vulnerable neighborhoods for pilot implementation using data-driven canopy placement.

Urban Heat Intensity

Observation:
Heat intensity peaks (values 3–5) in southwest and central Atlanta, aligning with older, industrial, or highly paved neighborhoods such as Adair Park, Mechanicsville, and West End.
Lower heat zones (1–2) occur in the north and east, overlapping with heavily treed suburban areas.

Interpretation:
A clear inverse spatial relationship emerges: neighborhoods with lower canopy coverage experience higher surface and radiant temperatures.
The UHI pattern reflects the combined effects of sparse trees, large impervious surfaces, and reduced evapotranspiration.
Relevance:
Confirms the cooling role of street-tree canopies- where canopy is sparse, heat exposure for pedestrians and transit users increases dramatically.

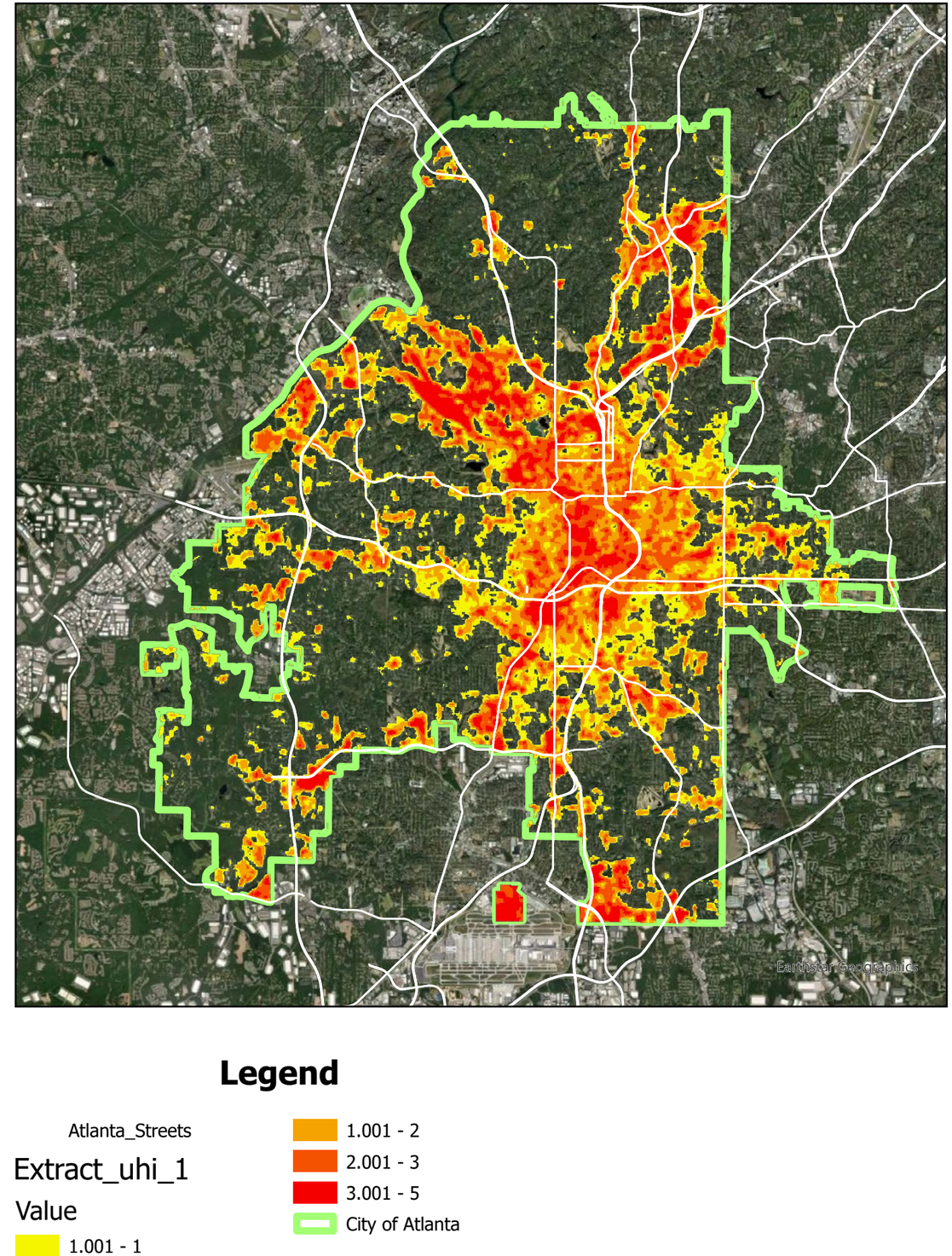


Figure 2-Urban Heat Island Raster (2018).Surface temperature intensity across Atlanta, categorized from low to extreme. Data source: City of Atlanta Urban Heat Analysis (2018). Created by the author (2025).

Median Family Income (ACS 2022)

Observation:
Median family income ranges from below $50,000 in the south and west to above $150,000 in the north and northeast.
The economic divide closely mirrors the environmental divide visible in canopy and heat maps.

Interpretation:
Lower-income communities are concentrated in the same areas with low canopy and high heat intensity, highlighting environmental and thermal inequity across the city.

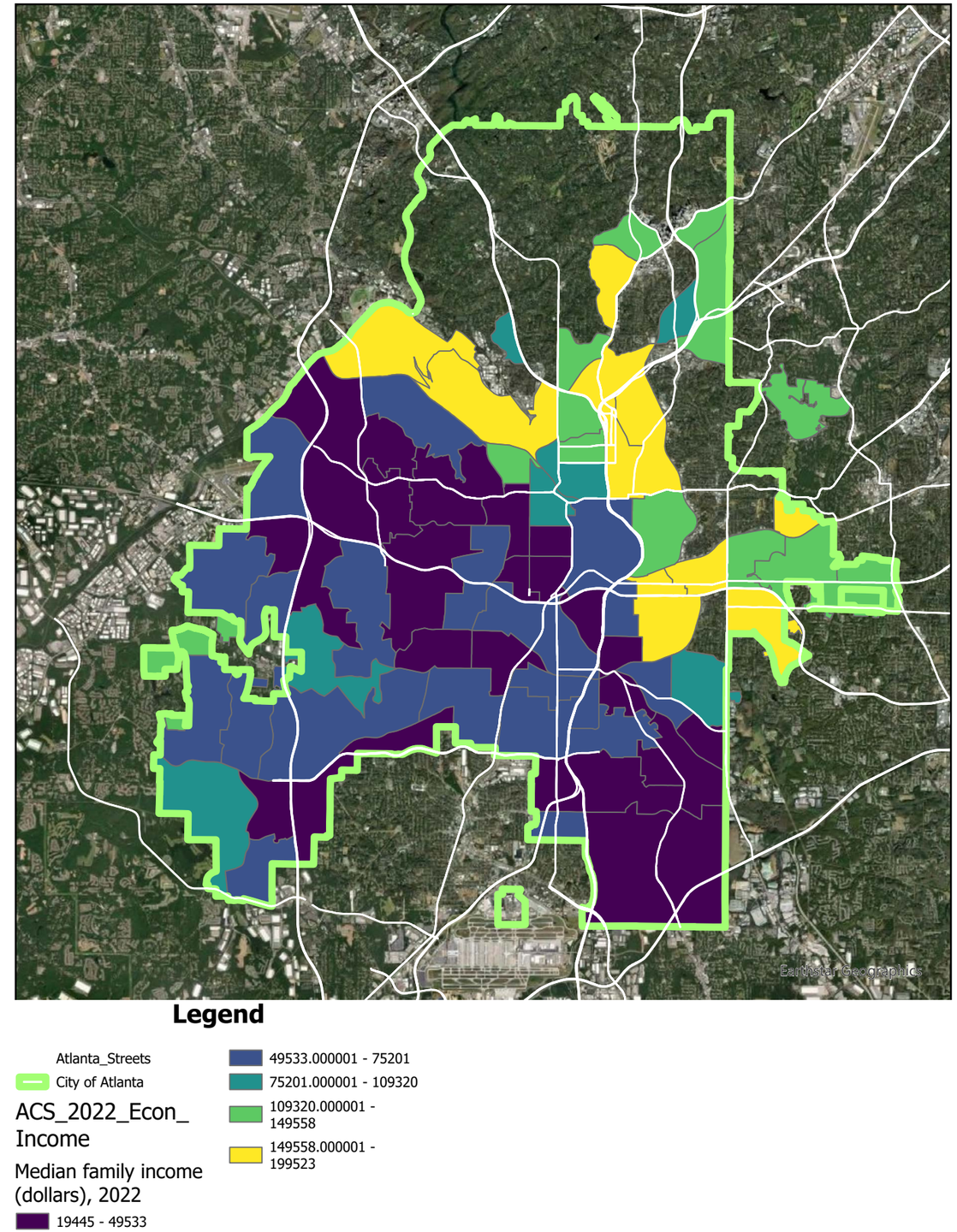


Figure 3-Median Household Income by Census Tract. Lower-income tracts are concentrated in the Westside. Data source: U.S. Census Bureau, ACS 5-Year Estimates (2023). Map created by the author (2025).

Spatial Distribution of Urban Tree Canopy, Atlanta (2018)

Observation:
The map shows canopy coverage across Atlanta ranging from below 10% to above 90%. Dense tree canopy (60–90%) dominates northern and eastern neighborhoods such as Buckhead and Druid Hills, where residential blocks are larger and more vegetated.
In contrast, southwestern and western tracts-including Oakland City, Pittsburgh, and West End-show sparse canopy (below 20%), particularly along major roads and transit corridors.

Interpretation:
The spatial pattern indicates a significant canopy inequity between high- and low-income zones.
Areas with limited canopy coincide with higher impervious surface cover and more exposed pedestrian routes, making them priority sites for street-tree interventions.

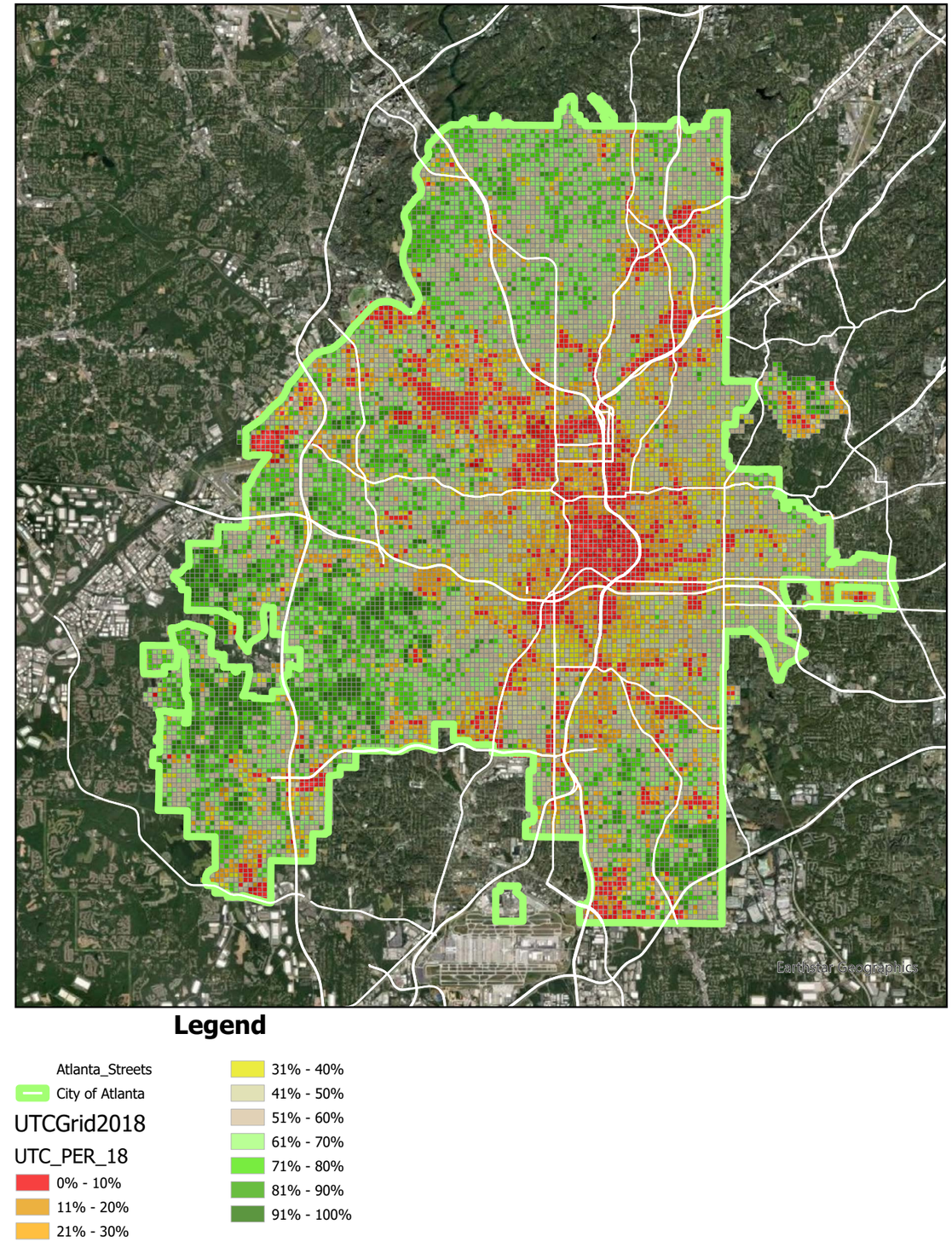


Figure 4-Urban Tree Canopy Coverage (2018). Map of canopy density across Atlanta showing major gaps in Vine City and English Avenue. City of Atlanta UTC (2018). Created by the author (2025).

Overlay Map: Intersecting Patterns of Tree Canopy, Heat Intensity, and Income

Observation:
When all three datasets are overlaid, a clear tri-variable spatial pattern emerges:
•High-income northern zones: dense canopy, low heat intensity.
•Low-income southwestern zones: sparse canopy, high heat intensity.
•Mid-income central zones: moderate canopy and heat values but fragmented shade patterns near transit routes.
Key intersections occur along transit corridors such as the MARTA South Line and Murphy Crossing, where limited street-tree presence coincides with high pedestrian exposure and low-income housing.

Interpretation:
The overlay visualizes a heat–canopy–income nexus: environmental conditions and social vulnerability reinforce one another.
Low-income neighborhoods face the double burden of less shade and greater heat exposure, particularly in pedestrian-heavy areas.

Neighborhood Selection
•English Avenue / Vine City (Westside) - Highest vulnerability score in city HVI; aging housing, low shade; close to GT for potential field checks
•Pittsburgh - South-side neighborhood with low canopy and high heat exposure cited in west/south clusters.
•Washington Park - Westside area flagged alongside English Avenue for heat inequity.

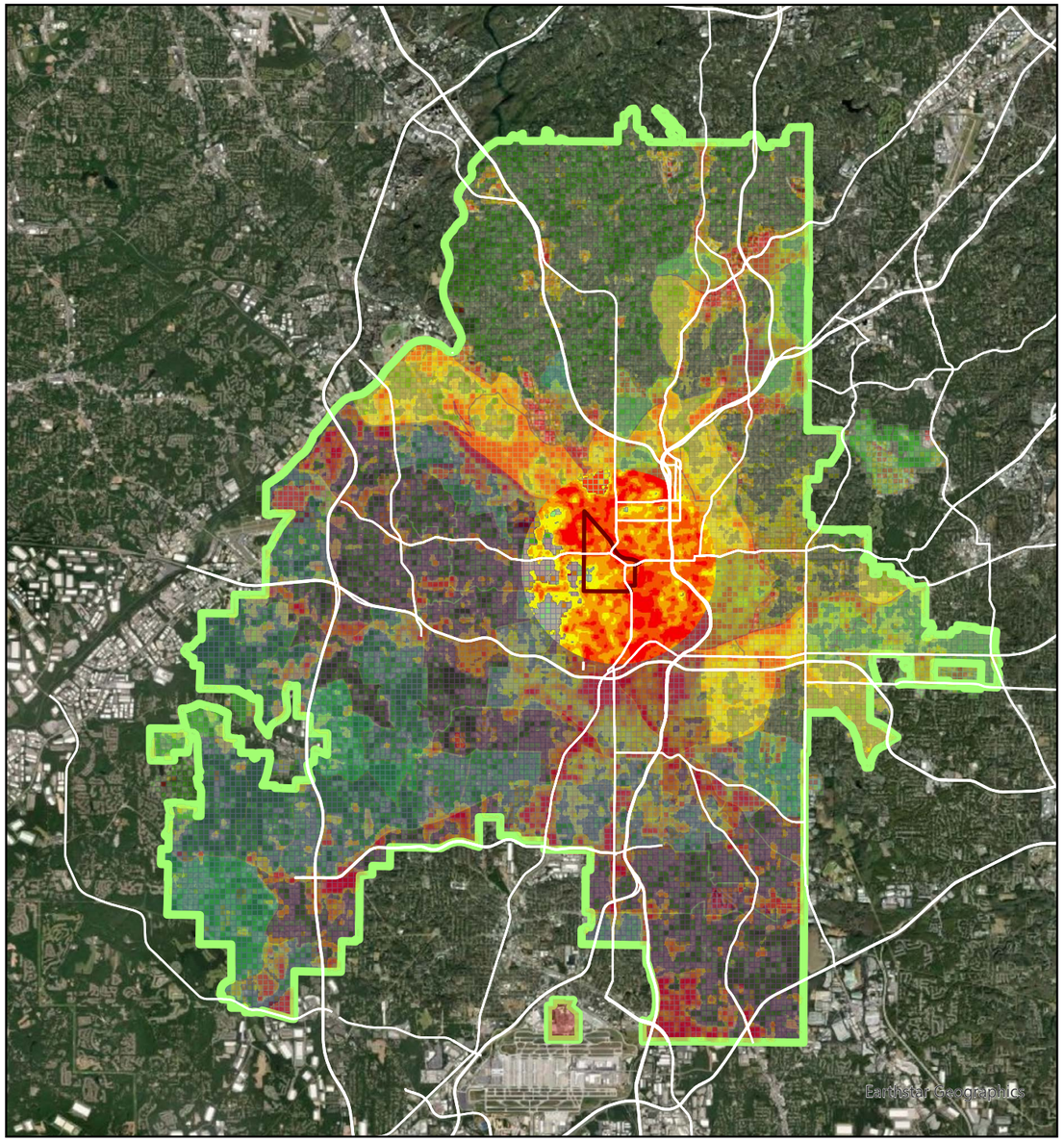


Figure 5 -Vulnerability Overlay (Heat + Canopy + Income).
Composite map identifying priority zones for intervention. Created by the author (2025).

Tri-variable overlay showing the intersection of heat intensity, canopy cover, and income levels. Low-income neighborhoods with low canopy and high heat appear as high-priority vulnerability zones.

Equity, Heat Vulnerability & Gentrification Risk

Context

Joseph E. Boone Boulevard runs through one of Atlanta's historically Black neighborhoods, where decades of underinvestment have resulted in lower tree canopy, higher surface temperatures, and limited public realm quality. These environmental conditions overlap with socioeconomic vulnerabilities, including lower household incomes and a higher proportion of cost-burdened renters. As a result, this corridor experiences both elevated heat exposure and a heightened risk of displacement as new development pressure increases along the Westside BeltLine and Vine City.

Heat Exposure & Environmental Inequity

Recent heat vulnerability studies for Atlanta identify the Westside as one of the neighborhoods with the largest temperature disparities, often 4–7°F hotter than canopy-rich areas such as Midtown or Inman Park. The lack of continuous tree cover, sparse shading opportunities, and wide asphalt surfaces create a microclimate where pedestrians experience significant thermal discomfort during summer months. These environmental deficits are not only design issues, they reflect a structural inequity in which historically marginalized communities have less access to cooling infrastructure and green space.

Climate Upgrades & the Risk of Green Gentrification

Microclimate improvements, such as street trees, structured shade, permeable surfaces, and cooling corridors, play a critical role in mitigating heat stress. However, national research shows that environmental upgrades often correlate with rising property values and increased desirability, especially in walkable corridors close to transit.
This dynamic, known as green gentrification, occurs when public-realm improvements make an area more attractive to higher-income households and investors, unintentionally increasing rents and displacement pressure on long-term residents.

As Boone Boulevard becomes cooler and more comfortable, the corridor's improved environmental quality could amplify development interest,particularly given its proximity to the BeltLine, Centennial Park, and Vine City MARTA Station. Therefore, microclimate interventions must be designed in tandem with anti-displacement strategies, ensuring that the cooling benefits are shared equitably by the existing community.

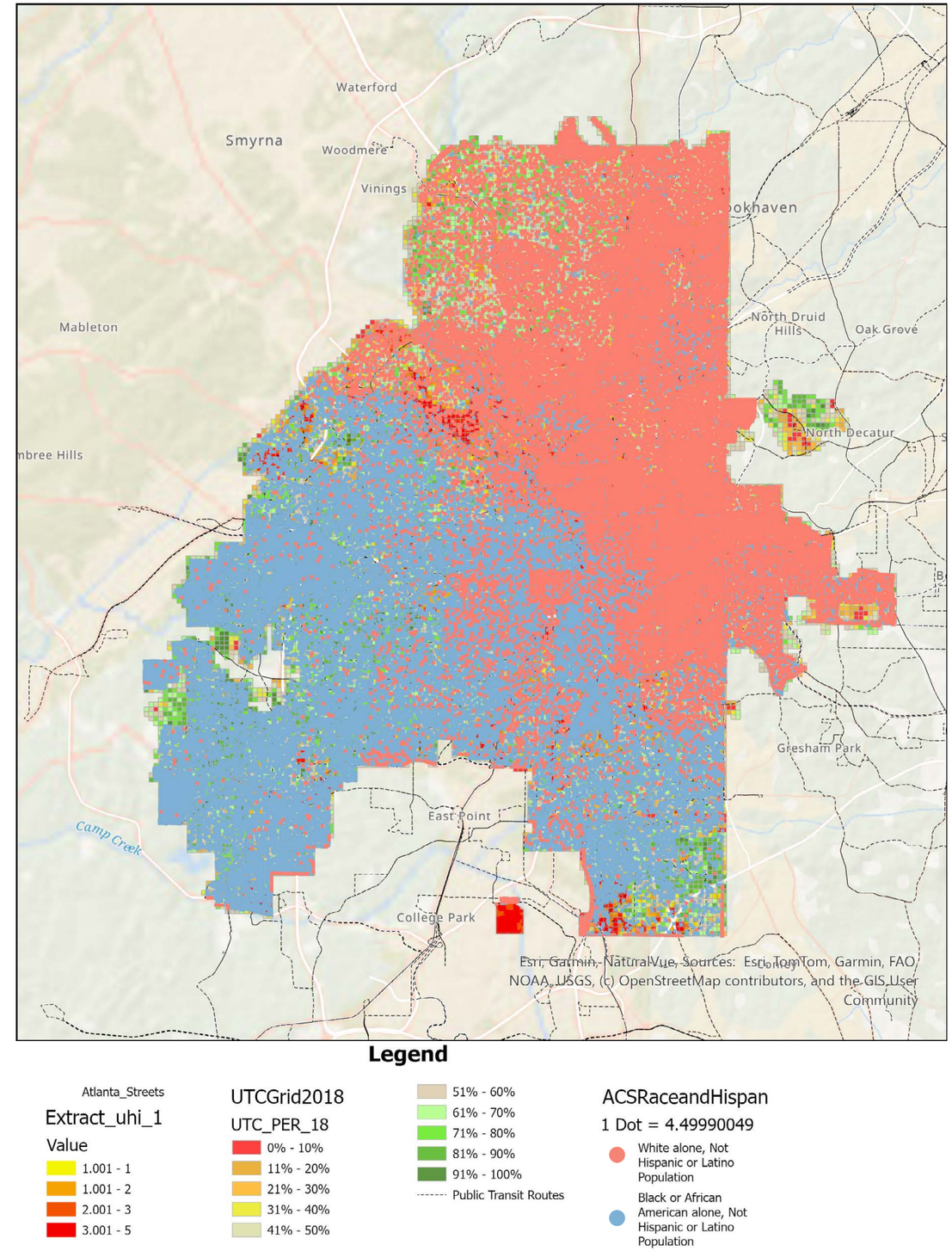
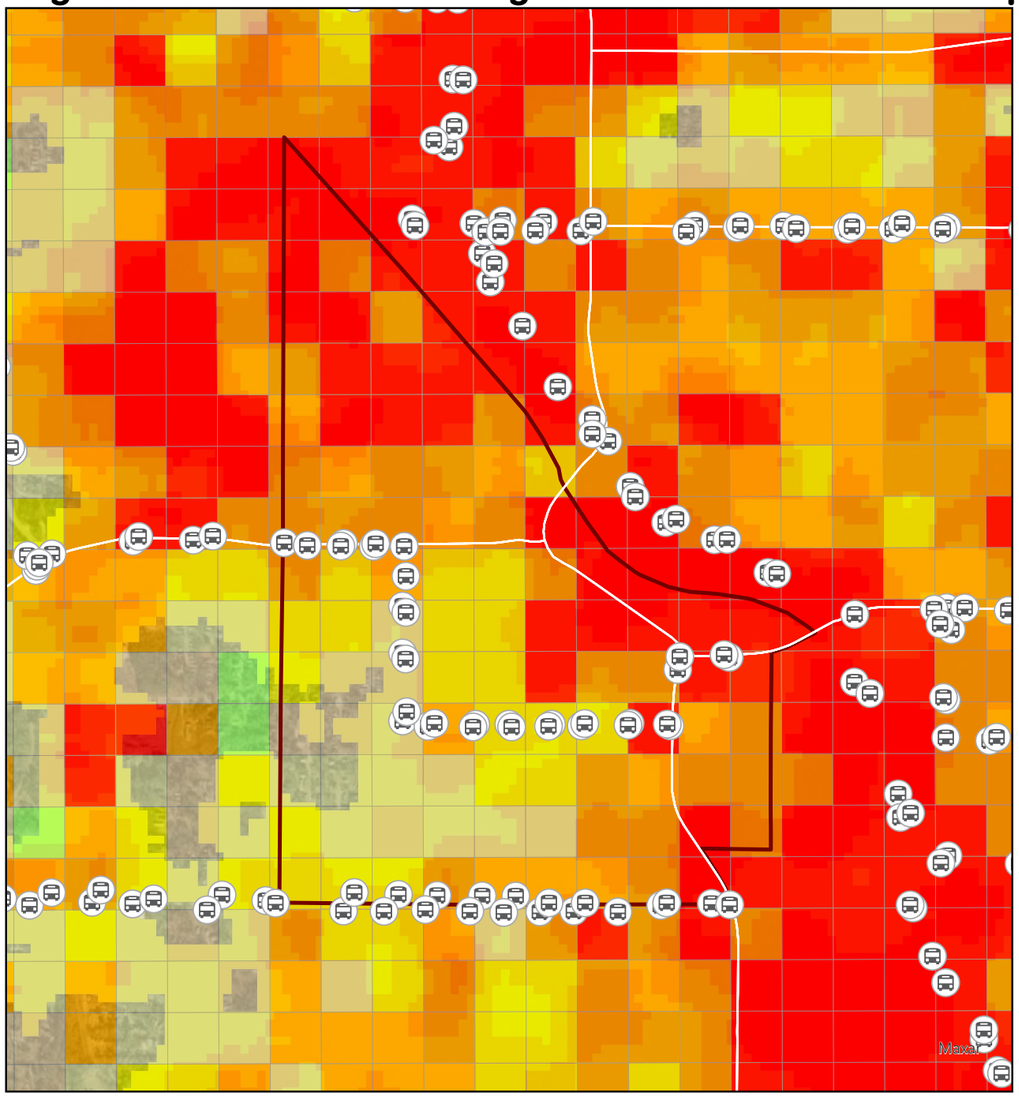


Figure 6 - Composite Map of Race in Atlanta and UHI map Overlay. Created by author (2025)

Neighborhood Selection: English Avenue - A Low-Canopy, High-Heat Transit Corridor



Legend

- Stops
- Atlanta_Streets
- EnglishAvenue

Extract_uhi_1

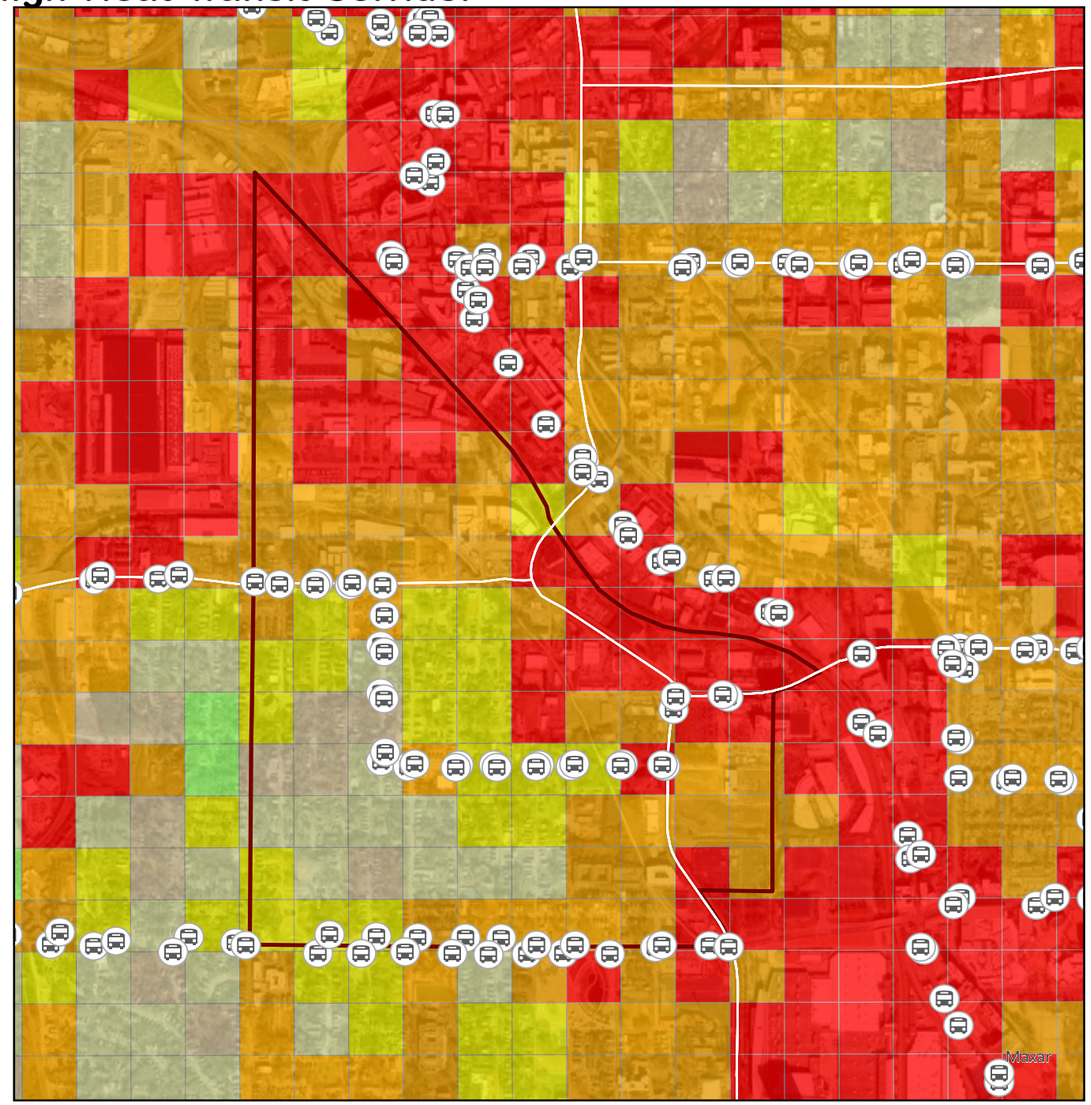
Value

- 1.001 - 1
- 1.001 - 2
- 2.001 - 3
- 3.001 - 5
- City of Atlanta

UTCGrid2018

UTC_PER_18

- 0% - 10%
- 11% - 20%
- 21% - 30%
- 31% - 40%
- 41% - 50%
- 51% - 60%
- 61% - 70%
- 71% - 80%
- 81% - 90%
- 91% - 100%



Legend

- Stops
- Atlanta_Streets
- EnglishAvenue
- City of Atlanta

UTCGrid2018

UTC_PER_18

- 0% - 10%
- 11% - 20%
- 21% - 30%
- 31% - 40%
- 41% - 50%
- 51% - 60%
- 61% - 70%
- 71% - 80%
- 81% - 90%
- 91% - 100%

Block-scale canopy and heat maps highlighting two priority study areas: Antioch Baptist transit stop and Rodney Cook Sr. Park edge, selected for contrasting microclimatic conditions and transit exposure.

Neighborhood Selection: English Avenue - A Low-Canopy, High-Heat Transit Corridor

1. Antioch Baptist Church Transit Stop (Vine City)

Selected for its close proximity to a major bus stop and pedestrian corridor, making it a high-exposure zone for transit users.

Located within a low-canopy, high-heat intensity area, as identified in the overlay analysis.

The surrounding streets show fragmented or minimal tree cover, offering limited shade for waiting passengers.

Serves as a representative site to study how strategic tree placement (clustered or dual-sided canopies) could improve thermal comfort at and around bus stops.

2. Rodney Cook Sr. Park Block, Historic Vine City

Chosen for its adjacency to Antioch Baptist Church and its role as a key public open space within a vulnerable neighborhood.

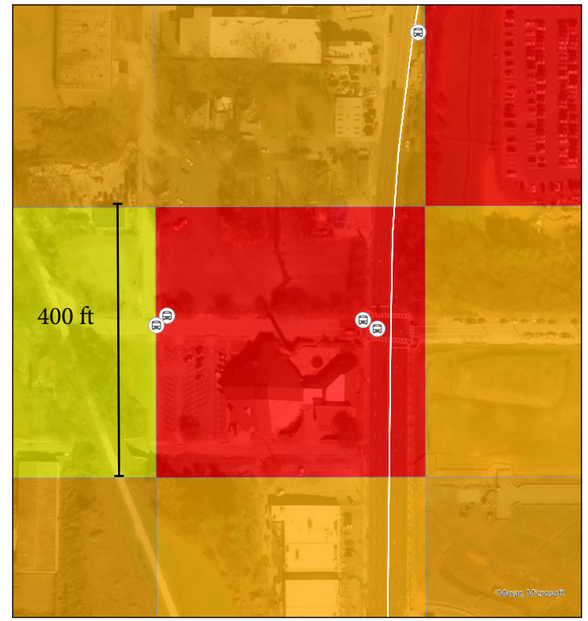
Despite being a newly developed park with green infrastructure, the edges and connecting streets exhibit variable canopy coverage.

Offers a contrast between open green space cooling and adjacent urban heat pockets.

Serves as a comparative block to understand how street-tree continuity and spacing influence pedestrian comfort between park edges and transit nodes.

Block 1

Antioch Baptist Church



Legend

Stops
Atlanta_Streets
EnglishAvenue
City of Atlanta

UTCGrid2018
UTC_PER_18
0% - 10%
11% - 20%
21% - 30%
31% - 40%
41% - 50%
51% - 60%
61% - 70%
71% - 80%
81% - 90%
91% - 100%

Corridor Analysis -
Tree spacing, side placement, clustering metrics.

Bus stop shading & exposure.

Block 2

Rodney Cook Sr. Park in Historic Vine City

Legend

Stops
Atlanta_Streets
UTCGrid2018
UTC_PER_18
0% - 10%
11% - 20%
21% - 30%
31% - 40%
41% - 50%
51% - 60%
61% - 70%
71% - 80%
81% - 90%
91% - 100%

Aerial and contextual map of Joseph E. Boone Blvd showing existing sparse tree canopy and wide unshaded sidewalks, supporting its selection as a high-exposure, high-need cooling corridor.

Neighborhood Selection: English Avenue - A Low-Canopy, High-Heat Transit Corridor

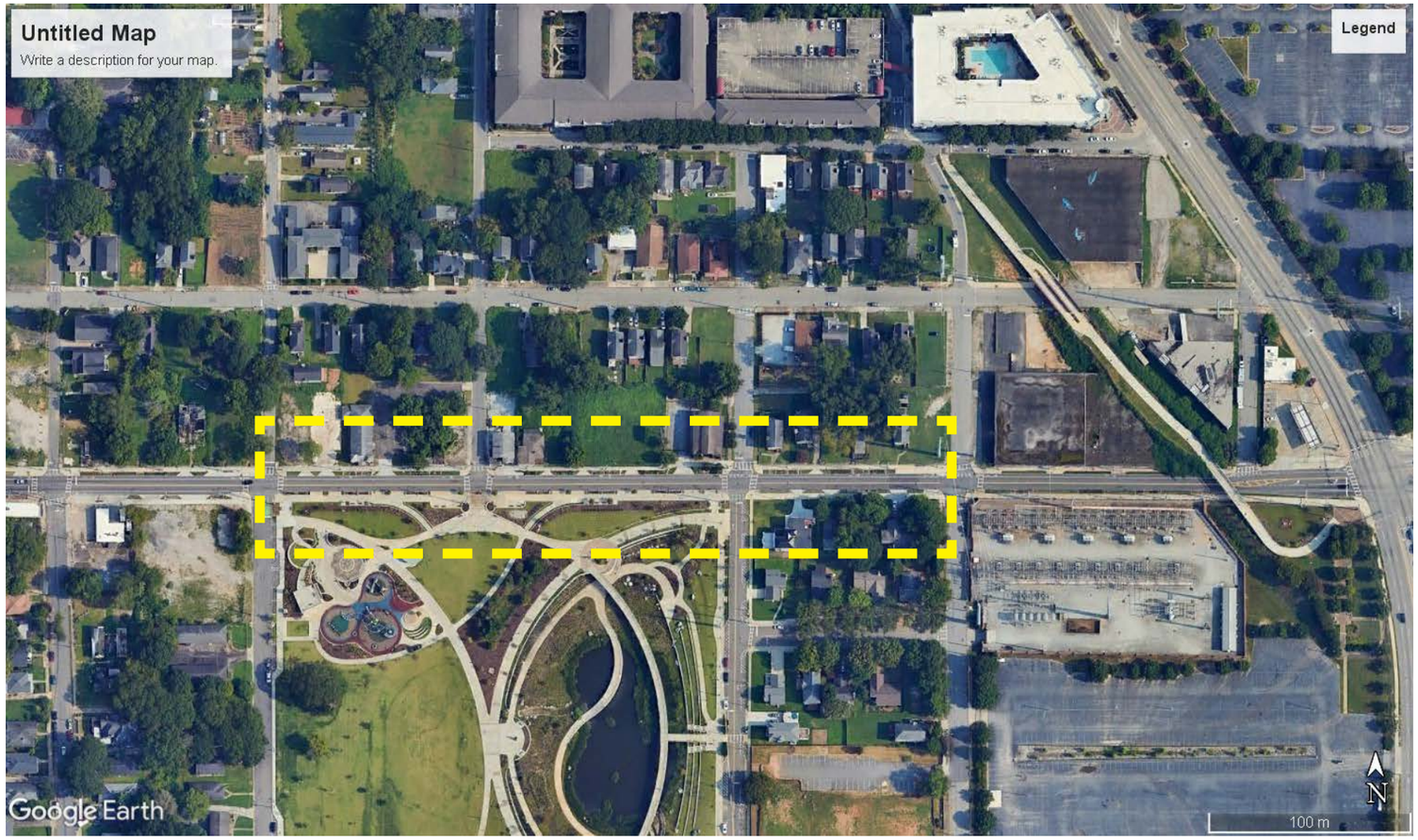
1. Joseph E. Boone Boulevard Corridor (Westside Atlanta)

Selected for its role as a major east–west connector serving residential blocks, community institutions, and transit users, making it a high-exposure zone for pedestrians throughout the day.

Located within a high heat-vulnerability tract, characterized by wide asphalt surfaces, limited shade, and elevated surface temperatures identified in the overlay analysis.

The corridor exhibits fragmented and sparse tree canopy, with long stretches of unshaded sidewalks and bus stops, increasing heat exposure for residents walking, waiting for transit, or accessing community services.

Serves as a representative study area to test how street-tree configurations (continuous canopy, staggered rows, or clustered planting) can reduce thermal load, improve pedestrian comfort, and support equitable cooling strategies in historically under-resourced neighborhoods.



Aerial and contextual map of Joseph E. Boone Blvd showing existing sparse tree canopy and wide unshaded sidewalks, supporting its selection as a high-exposure, high-need cooling corridor.

Microclimate Simulation – Eddy3D Outdoor+

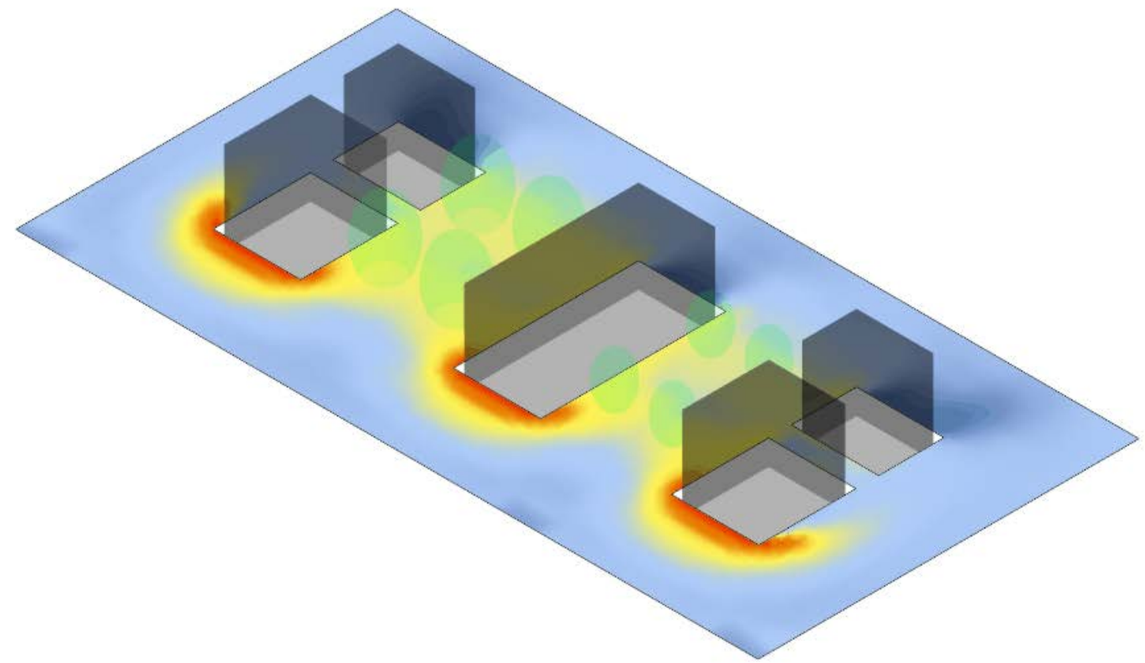
Tool: Eddy3D Outdoor+ (Rhino + Grasshopper) used to simulate microclimate and pedestrian heat exposure.

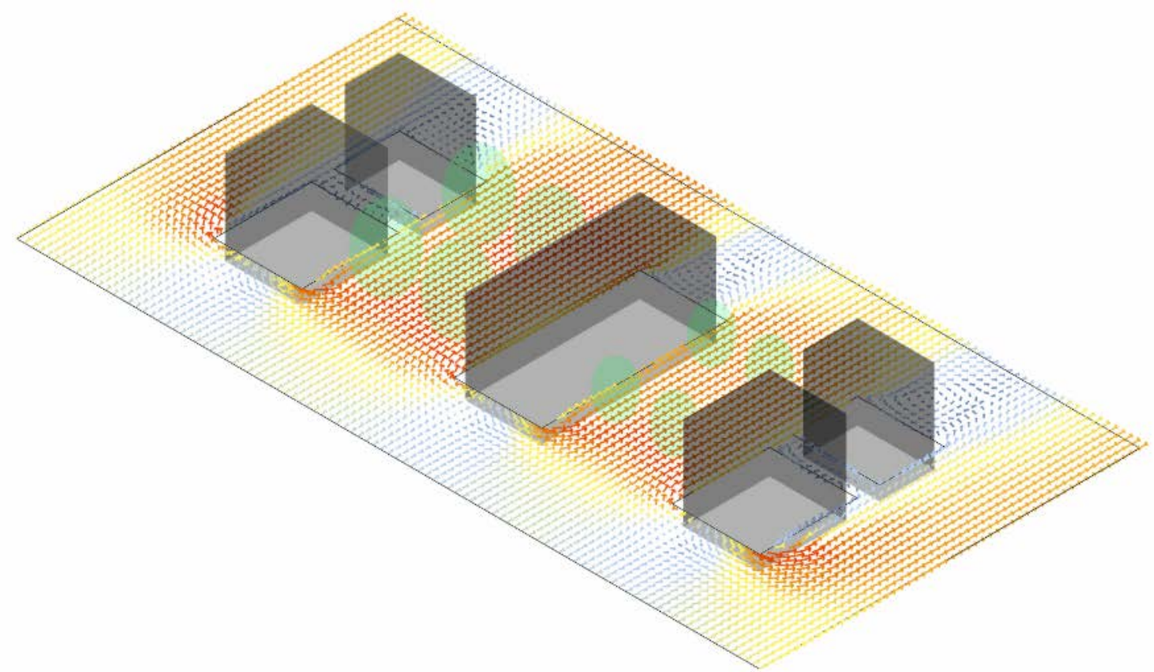
Study Blocks: Antioch Baptist Church transit stop and Rodney Cook Sr. Park edge in English Avenue.

Parameters Simulated: Mean Radiant Temperature (MRT), air temperature, surface temperature, solar access, and wind flow.

Scenarios Tested:
1.Existing condition
2.Dual-sided continuous canopy
3.Clustered tree placement near transit zones

Outcome: Identified how canopy density and configuration reduce localized heat and enhance pedestrian comfort in low-income, high-heat corridors





Microclimate Simulation – Eddy3D Outdoor+ (Joseph E. Boone Blvd)

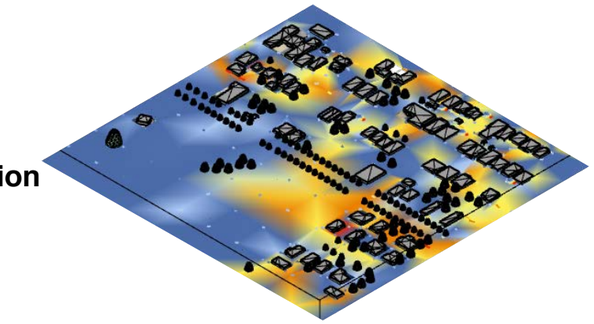
To assess how strategic street-tree placement influences pedestrian thermal comfort along Joseph E. Boone Blvd, a set of new canopy configurations was introduced into the simulation model. Tree locations and spacing were based on precedents from Rodriguez et al. (2025), who tested different street-canyon tree arrangements, including one-sided rows, dual-sided rows, and clustered groupings,to quantify heat reduction at pedestrian level. Following this approach, trees were spaced at approximately 10–12 meters (30–40 ft) along both sides of the corridor, reflecting typical municipal planting standards and maximizing shade continuity.

The updated canopy geometry was then integrated into the Outdoor+ microclimate model. Simulations were conducted for two critical time periods—morning (10:00) and afternoon (14:00)-aligning with the hours of highest human exposure and strongest solar loads. The resulting Mean Radiant Temperature (MRT) and wind-flow maps show that added trees significantly reduce heat intensity near sidewalks and bus stops, especially in areas where continuous canopy cover is achieved. This confirms the role of tree placement and spacing as key determinants of cooling performance in low-canopy neighborhoods like Vine City.

Scenario	Start Day	Start Time	Duration	Reason
Morning cool phase	172–174	7	2hrs	Low sun → long shadows → testing if trees help commuters
Afternoon peak heat	172–174	14	2hrs	MOST critical MRT exposure
Evening cooling period	172–174	18	2hrs	Trees help delay heat release

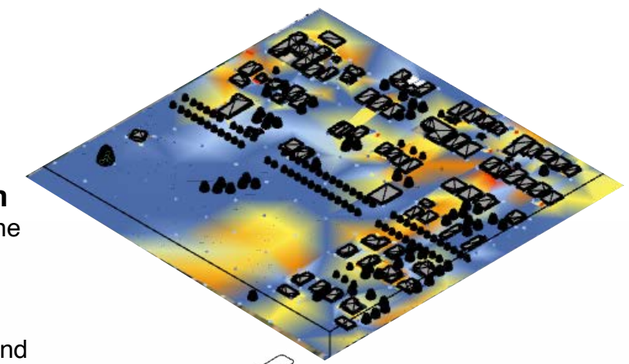
Figure 4. Mean Radiant Temperature (MRT) distribution for Joseph E. Boone Blvd corridor under existing conditions, shown for morning (7–9 AM) and afternoon (2–4 PM) in Peak Summer June - July Month . Simulations conducted using Outdoor+ microclimate modeling.

Afternoon Simulation (Peak Heat)
Start Day: 172–174
Start Time: 14 (2 PM)
Duration: 2 hours
2 PM to 4 PM



Afternoon

Morning Simulation
Start Day: 172–174 (June 21–23)
Start Time: 7
Duration: 2 hours
-Covers 7 AM to 9 AM and 4-7 PM



Morning and Evening

Geometry Reference Layer

Site Base Map (Aerial)

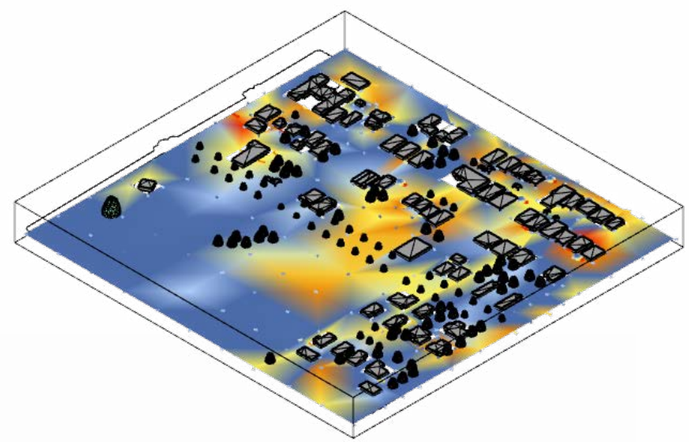
Aerial and contextual map of Joseph E. Boone Blvd showing existing sparse tree canopy and wide unshaded sidewalks, supporting its selection as a high-exposure, high-need cooling corridor.

Microclimate Simulation – Eddy3D Outdoor+ (Joseph E. Boone Blvd)

In this scenario, an alternating street-tree configuration was applied along the Joseph E. Boone Boulevard corridor to test how staggered placement affects microclimate performance. Instead of placing all trees in a single aligned row, trees were intentionally offset, creating a left-right zig-zag pattern across the pedestrian realm.

This configuration promotes better canopy interlock, allowing shade patches from each tree to overlap and cover a wider ground area during morning hours. The Outdoor+ simulation confirms this effect: cooler temperature zones (blue gradients) expand into the central walkway, while localized hot spots are reduced.

Alternating tree placement is especially effective in corridors with variable building setbacks and shifting sun angles, making it a practical strategy for heat-vulnerable, transit-dependent neighborhoods like Vine City.



Morning and Evening

Geometry Reference Layer

Site Base Map (Aerial)

Microclimate simulation of the alternating (staggered) tree configuration showing expanded morning shade zones and reduced localized heat spots across the corridor.

Southern Red Oak (Quercus falcata)
Broad canopy with excellent afternoon shade.
Tolerates compacted, dry soils typical of Vine City corridors.

Loblolly Pine (Pinus taeda)
Evergreen shade for winter conditions.
Effective wind-breaking and diffused shading.

Sweetgum (Liquidambar styraciflua)
Strong heat tolerance; thrives in tough urban conditions.
Dense canopy helps reduce ground temperature.

American Elm (Ulmus americana – Dutch Elm–resistant cultivars)
Vase shape ideal for forming shaded "street canyons."
High cooling impact due to large leaf area.

Willow Oak (Quercus phellos)
Most common street tree in Atlanta.
Tall, slender trunk with roomy canopy spacing = good for sidewalks.
Fast-growing, excellent cooling performance.

Blackgum / Tupelo (Nyssa sylvatica)
High drought tolerance, excellent red fall foliage.
Deep root structure = sidewalks remain protected.

Eastern Redbud (Cercis canadensis)
(Small-medium understory tree)
Works well under powerlines and at bus stops.
Adds visual character + biodiversity.

Microclimate Simulation – Eddy3D Outdoor+ (Joseph E. Boone Blvd)

Comparison of Tree Configurations on Joseph E. Boone Blvd
Alternate Spacing vs. Uniform 20 ft Spacing

For the Joseph Street corridor, two street-tree configurations were simulated to analyze their cooling performance and shading distribution:

1. Uniform 20 ft Spacing (Trees on Both Sides)

Description:
Trees are placed consistently at every 20 ft on both sides of the corridor. The spacing is regular, forming a continuous canopy rhythm along the street.
Effects:
Creates a more continuous shade canopy over the pedestrian zone.
Reduces heat exposure along the entire sidewalk length, not just isolated pockets.
More effective at blocking afternoon solar radiation due to canopy overlap.
Provides a predictable and even cooling gradient across the street.
Best for transit users because bus stops receive more consistent shading.

2. Alternate Tree Placement (Staggered Pattern)

Description:
Trees are placed alternately- not directly across from each other- reducing canopy overlap.
Effects:
Produces patchy shading, especially in morning and afternoon hours.
Cooling occurs in pockets rather than continuously along the corridor.
Works well on narrower streets but is less effective on a 150 ft corridor like Joseph Street.
Reduces construction cost but also reduces the impact on thermal comfort.

Conclusion: Which Configuration Performs Better?
Uniform 20 ft spacing on both sides performs better for heat-exposure reduction on Joseph St.

Because Joseph E. Boone Blvd is a wide corridor (150 ft) with high sun exposure, the uniform 20 ft spacing:
Reduces surface temperatures more consistently
Creates shaded walking conditions for longer periods of the day
Lowers MRT (Mean Radiant Temperature) across the street rather than in isolated patches
Supports equitable cooling for transit riders, children, and pedestrians
Better aligns with research on optimal canopy spacing for UHI mitigation
Helps create a “cool corridor” effect, especially between parks and residences
Staggered placement still provides cooling, but it does not produce the same continuous canopy coverage, leaving significant heat gaps along the southern sidewalk.

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